SUBJECT DESCRIPTION FORMS

Subjects offered by the

Department of Electronic & Information Engineering

Subjects Code	Subject Title
EIE509	Satellite Communications - Technology and Applications
EIE511	VLSI System Design
EIE515	Advanced Optical Communication Systems
EIE522	Pattern Recognition: Theory and Applications
EIE529	Digital Image Processing
EIE546	Video Technology
EIE553	Security in Data Communication
EIE557	Computational Intelligence and its Applications
EIE558	Speech Processing and Recognition
EIE563	Digital Audio Processing
EIE566	Wireless Communications
EIE567	Wireless Power Transfer Technologies
EIE568	IoT – Tools and Applications
EIE569	Sensor Networks
EIE570	Deep Learning with Photonics
EIE571	Photonic System Analysis
EIE572	Information Photonics
EIE573	Mobile Edge Computing
EIE575	Vehicular Communications and Inter-Networking Technologies
EIE577	Optoelectronic Devices
EIE579	Advanced Telecommunication Systems
EIE580	Radio Frequency and Microwave Integrated Circuits for Communication System Applications
EIE587	Channel Coding
EIE589	Wireless Data Network

Subject Description Form

Subject Code	EIE509
Subject Title	Satellite Communications – Technology and Applications
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The students are expected to have some basic knowledge about digital communication systems. 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	This subject will introduce students with the conventional and advanced technologies used in satellite communication systems. The students will study the design parameters of the transceiver on the performance of the link quality. Various multiple access techniques and resource allocation strategies will be compared to point out their relative merits and demerits. The multib*e*am and regenerative satellites networks, which render the use of small size earth station terminals possible, will also be discussed. Examples on global mobile satellite services will be given.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** a. Understand and describe the basic theories and principles in satellite communication systems. b. Analyze, design, and evaluate satellite communication systems. **(2) Attributes for all-roundedness** c. Communicate effectively. d. Think critically and creatively. e. Assimilate new technological development in related field.
Subject Synopsis/ Indicative Syllabus	1. Introduction Historical background of satellite technology development; organisation of a satellite communication system. 2. Orbits Overview of orbits; orbit dynamics and Keppler's laws; relative movement of two point bodies; orbital parameters; Earth-satellite geometry. 3. Link Analysis Basic satellite link analysis; effect of rain on link performance. 4. Multiple Access Traffic routing; frequency division multiple access; time division multiple access; code division multiple access; fixed and on-demand assignment. 5. Multibeam Satellite Networks Advantages and disadvantages; transponder hopping; on-board switching; beam scanning; intersatellite links. 6. Regenerative Satellite Networks Transparent and regenerative repeaters; comparison of link budgets; on-board processing; effect on Earth stations. 7. Global Mobile Satellite Services GEO mobile satellite systems, Inmarsat.

Teaching/Learning Methodology

The theories and applications of satellite communication systems will be described and explained in lectures. Techniques and parameters for evaluating satellite communication systems will be presented in tutorials. A site visit to a satellite earth station will further provide an opportunity for students to understand the various components of a commercial satellite communication system as well as the operations of the ground unit. Students will also be requested to study in detail some selected satellite communication or space exploration systems, share their findings with other classmates through two presentations and write a report summarizing their findings.

Teaching/Learning Methodology	Intended Subject Learning Outcomes				
	a	b	c	d	e
Lectures	✓	✓			✓
Tutorials	✓	✓		✓	
Mini-project			✓		✓
Site visit	✓				✓

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	e
1. Assignments/	25%	✓	✓	✓	✓	
2. Tests	20%	✓	✓	✓	✓	
3. Mini-project	55%			✓		✓
Total	100%					

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

Assignments and tests let students review the taught materials, do further reading for deeper learning and apply the learnt materials to solving common satellite communication system problems

Mini-project requires the student to do further reading, search for information, keep abreast of current development, give presentations and write a report

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial/Presentation	36 Hrs.
▪ Site visit	3 Hrs.
Other student study effort:	
▪ Lecture: further reading, doing homework/ assignment	30 Hrs.
▪ Mini-project: studying, writing a report, preparing two presentations	38 Hrs.
Total student study effort	107 Hrs.

Reading List and References

Text book:

1. G. Maral, M. Bousquet and Zhili Sun, *Satellite Communications Systems*, 6th ed., John Wiley, 2020.

Reference books:

1. Dennis Roddy, *Satellite Communications*, 4th ed., McGraw-Hill, 2006.
2. A.K. Maini and V. Agrawal, *Satellite Technology,* John Wiley and Sons, 2007.
3. B. Elbert, *Introduction to Satellite Communication,* 3rd ed., Artech House, 2008.

	4. Daniel Minoli, *Innovations in Satellite Communications and Satellite Technology*, Wiley, 2015. 5. Louis J. Ippolito, *Satellite Communications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance*, 2nd ed., Wiley, 2017. Others: 1. *IEEE Transactions* and other journals.

Subject Description Form

Subject Code	EIE511
Subject Title	VLSI System Design
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Logic Design
Objectives	To provide an understanding of various aspects of VLSI system design. In particular, to look at how different design methodologies and styles are utilized to achieve high-performance, cost-effective integrated circuits.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. master the fundamental principles behind the design methodologies of digital systems in VLSI; b. know what the current state-of-the-art digital design technologies can offer; c. apply top-down, systematic design approach for high performance digital CMOS VLSI integrated circuit with HDL and electronic design automation software; d. design the digital VLSI systems to meet performance and time-to-market goals; e. derive feasible and efficient testing and design-for-testability structures to achieve high quality and short design turnaround.
Subject Synopsis/ Indicative Syllabus	**Part I: Fundamental Concepts** 1. Overview 1.1 Overview of different design methodologies. 1.2 Design styles (Gate Arrays, Standard Cells, Custom); future technology trends. 2. Semiconductor Technologies 2.1 Technology comparison - CMOS, BIPOLAR, NMOS, and Bipolar-CMOS. 2.2 Static and dynamic CMOS circuit design. 2.3 Basic elements of logic design. **Part 2: Design Methodology, Performance Evaluation and Testing** 3. Digital System Design 3.1 HDL design for arithmetic components: adders and related functions, binary counters, and multipliers. 3.2 HDL design for simple systems of computer arithmetic. 3.3 HDL design for real digital systems. 4. Major Design Issues 4.1 Logic levels, delay calculations, layout and parasitics. 4.2 Clocking methodologies, clock distribution and driving large load. 4.3 Layout consideration - importance of good floor-planning and its effect on overall chip performance. 4.4 Wiring strategies, device scaling, and power estimates; and low power design techniques. 4.5 Testability: Fault models and fault simulation. 5. Electronic Design Automation 5.1 Logic Synthesis and floor-planning. 5.2 Placement and routing.

Teaching/Learning Methodology

The theories and applications of various digital system design techniques will be discussed and explain in lectures. Laboratory sessions will be provided to strengthen students' understanding on the theories and hands-on design experiences on the applications. Students will also be requested to practise the implementation of a digital system in the project. Class discussion can help the students to have better understand of VLSI application among the discussions. Project can allow the students to design, implement and test a VLSI system.

Teaching/Learning Methodology	Intended Subject Learning Outcomes				
	a	b	c	d	e
Lectures	✓	✓	✓	✓	
Project			✓	✓	✓
Class discussion		✓	✓	✓	
Laboratory sessions			✓	✓	✓

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	e
1. Laboratory exercises	10%	✓		✓	✓	
2. Assignments	20%	✓	✓			
3. Project	30%	✓		✓	✓	
4. Tests	40%	✓	✓		✓	✓
Total	100%					

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

1. **Laboratory Exercises**: For each lab session, students will need to understand the fundamental concepts [Outcome (a)] before they can complete the lab exercises. Because the lab sessions involve the digital design technologies [Outcome (c)], students' ability to apply these technologies should be reflected based on the performance [Outcome (d)] of their design.
2. **Assignments:** Students will need to do the assignments in order to understand the fundamental concepts [Outcome (a)] and the current design methodologies [Outcome (b)] of digital VLSI system.
3. **Projects:** In the project, students will need to understand the fundamental concepts [Outcome (a)] before they can complete the project. Because the project involves the digital design technologies [Outcome (c)], students' ability to apply these technologies should be reflected based on the performance [Outcome (d)] of their design.
4. **Tests:** Students will need to answer questions about the fundamental concepts [Outcome (a)] of various design technologies and their applications [Outcome (b)]. Limitations, performance [Outcome (d)] and testing procedure [Outcome (e)] of current digital system design technologies will also be asked in the test.

Student Study Effort Expected

Class contact:	
▪ Lectures	26 Hrs.
▪ Laboratory exercises	13 Hrs.
Other student study effort:	
▪ Project	44 Hrs.
▪ Revision and completion of assignments	30 Hrs.

	Total student study effort	113 Hrs.
Reading List and References	1. W. Wolf, *Modern VLSI Design – System-on-Chip Design*, Prentice Hall International, 2002. 2. Kenneth L. Short, *VHDL for Engineers*, Pearson Education, 2009 3. S. Yalamanchili, *VHDL – A Starter's Guide*, 2nd edition, Prentice Hall International. 4. N. Weste, K. Eshraghian, *Principles of CMOS VLSI Design - A Systems Perspective*, 2nd edition, Addison-Wesley, 1993.	

July 2021

Subject Description Form

Subject Code	EIE515
Subject Title	Advanced Optical Communication Systems
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	<u>Pre-requisite</u>: Nil <u>Mutual exclusions</u>: EIE4449
Objectives	<u>Objectives</u>: The subject aims to introduce (i) Optical networking, principles and challenges: current and future optical networks. (ii) Enabling technologies: Principles and device physics of optical components that form the building blocks of optical networks (e.g., WDM); Transmission technology for optical networks. (iii) Optical communication networks
Intended Learning Outcomes	Upon completion of the subject, the student will be a. Equipped with the tools and ideas of selecting, designing, installing, testing and maintaining an optical system providing data communication in a broadband local access, metro or wide-area network. b. Understand the key components of optical communication networks. c. Be able to design a simple optical transmission link.
Subject Synopsis/ Indicative Syllabus	**<u>Detailed subject contents</u>:** 1. <u>Basic Concepts in Optical Networks: Principles and Challenges</u> 1.1 What is an optical network? 1.2 Optical networks: needs and challenges 2. <u>Enabling Technologies</u> 2.1 Optical fiber (fundamental principles) 2.2 Optical transmitters 2.3 Optical receivers and filters 2.4 Optical amplifiers 2.5 Optical transmission link design 2.6 Optical switching elements 3. <u>Optical Link Design</u> 3.1 Optical amplified multispan link design 3.2 OSNR and Q factor 3.3 Power penalty due to dispersion and fibre nonlinearity 3.4 Advanced modulation formats 3.5 Coherent detection systems 4. <u>Optical Communication Networks</u> 4.1 Optical access networks 4.1.1 PON technologies 4.1.2 Ethernet PON access network 4.1.3 Wavelength division multiplexing (WDM) PON 4.2 Optical Networking Elements 4.2.1 Optical switches and add/drop multiplexers

	4.2.2 Reconfigurable add/drop multiplexer (ROADM)

Teaching/Learning Methodology

Method	Remarks
Lectures	Fundamental principles and key concepts of the subject are delivered to students.
Tutorials	Supplementary to lectures and are conducted with smaller class size if possible; Students will be able to clarify concepts and to have a deeper understanding of the lecture material; Problems and application examples are given and discussed.
Assignment	Students will be given an opportunity to learn some of important and related techniques.

Teaching/Learning Methodology	Intended Subject Learning Outcomes		
	a	b	c
Lectures	✓	✓	✓
Tutorials	✓	✓	✓
Assignment	✓	✓	✓

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
1. Test	25%	✓	✓	
2. Assignment	25%	✓	✓	✓
3. Examination	50%	✓	✓	✓
Total	100%			

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

1. **Test:** Students will need to answer questions about fundamental concepts of optical fiber communications, optical network technologies and their applications.
2. **Assignment:** Students will be given an assignment, which requires students to do further reading, search for information, keep a breast of current developments, write a report, and give an oral presentation.
3. **Examination:** Students will need to answer questions about concepts of optical fiber communications, optical network technologies, and also the components, designs and applications.

<table>
<tr><td rowspan="7">Student Study Effort Expected</td><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lectures and Tutorials</td><td>33 Hrs.</td></tr>
<tr><td>▪ Assignment and Test</td><td>6 Hrs.</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Self-study</td><td>55 Hrs.</td></tr>
<tr><td>▪ Report writing</td><td>15 Hrs.</td></tr>
<tr><td>Total student study effort</td><td>109 Hrs.</td></tr>
<tr><td>Reading List and References</td><td colspan="2"><u>References</u>
1. G. Keiser, Optical Fiber Communications, 5th ed., McGraw-Hill, 2015.
2. M Cvijetic, I B Djordjevic, Advanced Optical Communication Systems and Networks, Artech House, 2013.
3. John Senior, Optical Fiber Communications: Principles and Practice, 3rd ed., Pearson Education, 2009.
4. Jeff Hecht, Understanding Fiber Optics, 4th ed., Prentice-Hall, 2002.</td></tr>
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July 2021

Subject Description Form

Subject Code	EIE522
Subject Title	Pattern Recognition: Theory and Applications
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	This course offers an up-to-date review of the state of the art in pattern recognition. In particular, it outlines the need for pattern recognition, its different algorithms, decision theoretic, syntactic, and neural network approaches including learning algorithms, and different classical image processing and character recognition techniques. The course will emphasize practical techniques for implementing useful pattern recognition systems. It will also provide a base for practice and progress in matters related to research.
Intended Learning Outcomes	Upon completion of the subject, students shall be able to a. Understand and analyze methods for automatic training of classification systems based on typical statistical, syntactic and neural network approaches; b. Understand common feature extraction methods for pattern recognition; c. Design systems and algorithms for pattern recognition; d. Implement typical pattern recognition algorithms in MATLAB; e. Present ideas and findings effectively; and f. Think critically and learn independently.
Subject Synopsis/ Indicative Syllabus	1. <u>Introduction</u> 1.1 The Subproblems of Pattern Recognition 1.2 Structure of a Pattern Recognition System 1.3 Patterns and Pattern Vectors 2. <u>Feature Extraction and Applications</u> 2.1 Edge-Detection Methods 2.2 Shape Characterization 2.3 Texture Analysis 2.4 Colour Features 2.5 People Detection and Face Recognition 3. <u>Statistical Approaches to Pattern Recognition</u> 3.1 Approaches to Developing StatPR Classifier 3.2 Bayesian Theorem and Bayesian Classifier 3.3 Supervised Learning Using Parametric & Nonparametric Approaches 3.4 Unsupervised Learning and Clustering 3.5 Case Studies 4. <u>Subspace Analysis</u> 4.1 Principal Component Analysis 4.2 Linear Discriminant Analysis 4.3 Applications to Face Detection and Recognition

	5. <u>Support Vector Machines</u> 5.1 SVM Principles 5.2 Linear SVM 5.3 Nonlinear SVM 5.4 Applications of SVM 6. <u>Random Forest</u> 6.1 Decision Tree 6.2 Random-forest Training 6.3 Forest Ensemble 6.4 Applications of Random Forests 7. <u>Neural Networks and Their Applications to Pattern Recognition</u> 7.1 Artificial Neural Networks: Architectures, Output Characteristics, and Learning Algorithms 7.2 Neural Network Structures for Pattern Recognition 7.3 Multilayer Feedforward Networks and Backpropagation Training Algorithms 7.4 Unsupervised Feature Learning and Deep Learning 7.5 Case Studies **<u>Laboratory Exercises</u>:** (1) Face Image Analysis and Representation Using Principal Component Analysis (2) Design of Neural Network PR Systems
Teaching/Learning Methodology	Lecture (leaning outcomes a, b, and c) • fundamental principles and key concepts of the subject are delivered to students; • guidance on further readings, applications and implementation is given. Tutorial (learning outcomes a, b, c and f) • students will be able to clarify concepts and to have a deeper understanding of the lecture material; • problems and application examples are given and discussed. Laboratory exercises (learning outcomes a - f) Students will make use of the software tools and MATLAB to develop simple pattern recognition systems. Assignments (learning outcomes a – c , e, and f) • end-of chapter type problems are used to evaluate students' ability in applying concepts and skills learnt in the classroom; • students need to think critically and creatively in order to come with an alternate solution for an existing problem.

Teaching/Learning Methodology	Intended Subject Learning Outcomes					
	a	b	c	d	e	f
Lectures	✓	✓	✓			
Tutorials	✓	✓	✓			✓
Laboratories	✓	✓	✓	✓	✓	✓
Assignments	✓	✓	✓		✓	✓

Assessment Methods in Alignment with Intended Learning Outcomes	(see table below)

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (Please tick as appropriate)					
		a	b	c	d	e	f
1. Tests	25%	✓	✓	✓		✓	✓
2. Final examination	50%	✓	✓	✓		✓	✓
3. Assignments	10%	✓	✓	✓		✓	✓
4. Laboratories (including report writing)	15%	✓	✓	✓	✓	✓	✓
Total	100%						

Student Study Effort Expected		
	Class contact:	
	▪ Lecture	26 Hrs.
	▪ Tutorial	7 Hrs.
	▪ Laboratory	6 Hrs.
	Other student study effort:	
	▪ Self-learning	45 Hrs.
	▪ Assignments, laboratory report writing	24 Hrs.
	Total student study effort	108 Hrs.

Reading List and References

1. C.M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
2. R.O. Duda, P.E. Hart and D.G. Stork, *Pattern Classification*, 2nd Edition, John Wiley, 2001.
3. R.C. Gonzalez and R.E. Wood, *Digital Image Processing*, 4th Edition, Pearson Prentice Hall, 2018.
4. C.C. Aggarwal, *Neural Networks and Deep Learning*, 1st Edition, Springer, 2018.
5. R. Schalkoff, *Pattern Recognition – Statistical, Structural & Neural Approaches*, John Wiley, 1992.
6. S.T. Bow, *Pattern Recognition and Image Preprocessing*, 2nd Edition, Marcel Dekker, 2002.
7. M. Sonka, V. Hlavac, and R. Boyle, *Image Processing, Analysis and Machine Vision*, 3rd Ed., Thompson Learning, 2008.
8. J.M. Zurada, *Introduction to Artificial Neural Systems*, West Publishing, 1992.
9. M. Nadler and E.P. Smith, *Pattern Recognition Engineering*, John Wiley, 1993.
10. I. Goodfellow, Y. Bengio and A. Courville, *Deep Learning*, MIT Press, 2016.
11. R.M. Bolle, *Guide to Biometrics*, Springer, 2010.
12. A. Webb, *Statistical Pattern Recognition*, 3rd Ed., Wiley-Blackwell, 2011.
13. Selected papers from Pattern Recognition, Pattern Recognition Letters, IEEE Transactions on Pattern Analysis and Machine Intelligence, and other journals on pattern recognition.

Subject Description Form

Subject Code	EIE529
Subject Title	Digital Image Processing
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Calculus, linear algebra and basic statistics. Some programming (preferably MATLAB). Basic understanding of Digital Signal Processing.
Objectives	This subject is to enable students to learn a number of important applications of digital image processing. After the completion of the subject, students should be able to appreciate and master some image and vision techniques for industrial applications. This subject is also suitable for students who are preparing to carry out research in related areas.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Understand the fundamentals of image processing and associated techniques. b. Solve practical problems with basic image processing techniques. c. Design simple systems for realizing applications with basic image processing techniques.
Subject Synopsis/ Indicative Syllabus	1. Introduction: Digital image representation and visual perception. Review on the Fourier transform and linear time-invariant systems. Discrete Fourier analysis of multi-dimensional signals, multi-dimensional filtering. 2. Introduction to the Wavelet Transform: Discrete wavelet transform for one-dimensional and two-dimensional signals, choices of wavelet filters, applications of the wavelet transform in image processing. 3. Image Enhancement: Simple intensity transformation, histogram processing. Spatial filtering. Bilateral filtering. 4. Image Restoration: Degradation model, noise model. Wiener filter. Block matching method for image denoising. Deconvolution and inverse filtering, constrained least square method for image deblurring. Introduction to blind deconvolution. 5. Image Coding and Compression Techniques: Transform image coding, Karhunen-Loeve transform (KLT), discrete cosine transform (DCT), blocking effect. Scalar and vector quantization. Codeword assignment, entropy coding. Industrial standard: JPEG. 6. Image Segmentation: Optimum thresholding. Morphological watershed method. K-means clustering. Segmentation with superpixels. Graph cuts method. 7. Feature Extraction: Shape descriptors, Freeman chain code, Fourier descriptor. Region descriptors, feature vector and feature space, statistical approach for texture description. Scale-invariant feature transform (SIFT).

Teaching/Learning Methodology	

Method	Remarks
Lectures	Fundamental principles and key concepts of the subject are delivered to students.
Tutorials	Students will be able to clarify concepts and have a deeper understanding of the lecture material; problems and application examples are given and discussed.
Laboratory sessions	Students will make use of the software MATLAB to simulate various image processing techniques and evaluate their performance.
Mini-Project	Students will do further reading, search for information, keep abreast of current development, share their findings with other classmates through presentations, and write a report.

Teaching/Learning Methodology	Intended Subject Learning Outcomes		
	a	b	c
Lectures	✓	✓	✓
Tutorials	✓	✓	✓
Laboratory sessions	✓	✓	✓
Mini-Project	✓	✓	✓

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
1. Assignments	15%	✓	✓	✓
2. Laboratory demonstration and reports	15%	✓	✓	✓
3. Test/Quizzes	40%	✓	✓	✓
4. Mini-Project	30%	✓	✓	✓
Total	100%			

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial/Laboratory	39 Hrs.
Other student study effort:	
▪ Homework, lab report, and self-study	36 Hrs.
▪ Mini-project: Studying, writing a report, and preparing presentations	30 Hrs.
Total student study effort	105 Hrs.

Reading List and

1. R.C. Gonzalez and P. Wintz, *Digital Image Processing*, 4th ed., Pearson, 2018.

References	2. R.C. Gonzalez, R. E. Woods and S. L. Eddins, *Digital Image Processing using Matlab*, Prentice Hall, 2004. 3. Bovik, *Handbook of Image and Video Processing*, Academic Press, 2000. 4. Selected Reading from recent issues of *IEEE Transactions on Acoustics, Speech, and Signal Processing, IEEE Transactions on Image Processing, etc*.

Subject Description Form

Subject Code	EIE546
Subject Title	Video Technology
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Pre-requisite: Nil Recommended background knowledge: The student is expected to have background knowledge of Digital Signal Processing, and some programming skills (preferably C++) in his undergraduate studies. Mutual exclusions: Nil
Objectives	Objectives: This subject provides an in-depth discussion on a wide range of important and current techniques on digital videos.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. describe the basic principles of video technologies, such as video coding, video standards, video surveillance, 3D videos, video communications, video processing for IoT applications; b. describe the operational principles of one or two advanced topics of video technology and give evaluations; c. perform literature survey; give professional report, analysis, and/or carry out practical realization of video processing algorithms; d. appreciate and take up the related engineering work on video technology, and e. carry out initial research work on video technology.
Subject Synopsis/ Indicative Syllabus	**Keyword syllabus:** 1. Revision on entropy coding and digital video: Huffman coding and arithmetic coding, digitization, raster scanning, luminance & chrominance, composite video, RGB and YUV formats. 2. Basic image coding techniques applied to videos: transform coding, zigzag scan and run-level code. 3. Video coding: Block based video coding, Integer DCT coding, inter- & intra-frames, quantization and entropy coding; hybrid video coding scheme; motion estimation and compensation, frame types, fast motion estimation, and quality control. 4. Advanced video coding, sub-pixel motion estimation, mode decision, rate-distortion control, interpolation filters, multiple reference frames, variable block size, concepts of Prediction Unit, Coding Unit and Transform Unit; concepts of QoE (Quality of Experience). 5. Video coding standards: H.261-4, MPEG-1, 2 and 4, Scalable video coding, levels and profiles, advanced and future standards: HEVC (H.265).

6. Video streaming, architecture for video streaming, video streaming considerations for Internet of Things (IoT); statistical characteristics of signals, Constant Bit-Rate (CBR) and Variable Bit-Rate (VBR); video transmission systems, Quality of Service (QOS) requirement for video transmission; Error control and error concealment for digital video communication.

Due to the limitation in time, only 1 or 2 of the following topics will be covered:

7. A brief review on analogue TV. Introduction to digital TV; High definition TV (HDTV), standards and current development.
8. An Introduction to 3D Video coding, depth coding, 3DV/FTV (free video TV).
9. Video Transcoding, Homogeneous and heterogeneous transcoding, the drift problem, spatial and temporal domain transcoding.
10. Video Surveillance: Basic set-up for video surveillance, background extraction, moving object extraction and detection. IoT applications with video analytics, object identification/tracking by template matching, HoG (Histogram of Oriented Gradients), and colour Histogram.

Laboratory Exercises

1. Laboratory Exercise 1: Image and video Processing under Visual C++ environment
   The objectives of this laboratory include: (i) to display images and videos using a Library, (ii) to read and write images/videos using Visual C++ Console Application, and (iii) to modify images at any pixel location using Visual C++ Console Application.

2. Laboratory Exercise 2: MPEG-4(Part10)/H.264 Verification Model
   This exercise is to let the student familiar with the 'MPEG-4 part10 (H.264) Verification Module', such that the student can understand MPEG-4 Part 10 better, evaluate its structure and make use of the verification model to develop further algorithms for its realization. Topics of specific attention include multiple reference frame coding, quarter-pixel and variable block size motion estimation, etc

Teaching/Learning Methodology

The theories and applications of video technology will be discussed and explained in lectures. Lab sessions will be provided to strengthen students' understanding. Students will also be requested to write a report on a given topic.

Teaching/Learning Methodology	Intended Subject Learning Outcomes				
	a	b	c	d	e
Lectures	✓	✓		✓	✓
Tutorials	✓	✓		✓	✓
Self-learning/report	✓	✓	✓	✓	✓
Laboratory exercise	✓	✓	✓	✓	✓

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	e
1. Continuous assessment	50%	✓	✓	✓	✓	✓
• Assignment	12%			✓		✓
• Tests	16%	✓	✓		✓	

	• Quizzes	10%	✓	✓		✓	
	• Laboratory Sessions	12%	✓	✓	✓	✓	✓
	2. Examination	50%	✓	✓		✓	✓
	Total	100%					

Student Study Effort Expected	**Class contact:**	
	▪ Lectures/Tutorial/Laboratory	39 Hrs.
	Other student study effort:	
	▪ Self study and Assignments	66 Hrs.
	Total student study effort Tutorials	105 Hrs.

Reading List and References

<u>Indicative reading list and references</u>:

1. A.M. Tekalp, *Digital Video Processing*, Prentice-Hall, 2015.
2. Madhuri A. Joshi, *Image and Video Compression: fundamentals, techniques and applications*, CRC Press, 2015.
3. I.E.G. Richardson, *H.264 and MPEG-4 Video Compression*, John Wiley & Sons, Ltd, 2003.
4. H. Sun, X. Chen and T. Chiang, *Digital Video Transcoding for Transmission and Storage*, CRC Press, 2005.
5. C.A. Poynton, *A Technical Introduction to Digital Video*, John Wiley & Sons, Inc., 1996.
6. F. Pereira and T. Ebrahimi, *The MPEG-4 Book*, Prentice Hall PTR, 2002.
7. A. Walsh and M. Bourges-Sevenier, *MPEG-4 Jump Start*, Prentice Hall PTR, 2002.
8. Selected Reading from recent issues of IEEE Transactions on Circuits and Systems for Video Technology and IEEE Transactions on Image Processing, between years 2008 to 2016.
9. H.246 JM and HEVC HM evaluation models, 2016.

Subject Description Form

Subject Code	EIE553
Subject Title	Security in Data Communication
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The students are expected to have some basic knowledge about TCP/IP such as addressing, routing, layering. Extra materials will be provided for self-review before the commencement of the course on request for those who do not have the appropriate knowledge. Please contact the subject lecturers for details.
Objectives	This subject aims at providing senior students, practicing engineers and information system professionals, who will study network security for the first time, a solid foundation about information security in the context of data communication and networking. After attending this course, the students will master the basic principles of network and information security. They will also learn to apply these principles in various scenarios. They will be able to identify security problems in the context of data communication, apply basic principles to design and evaluate solutions to meet different security requirements in networking and particularly Internet of things applications.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** a. Identify, formulate, and describe security issues and problems in the context of data communication. b. Understand and describe the basic theories and principles in network security. c. Analyze, design, and evaluate solutions to network security problems. **(2) Attributes for all-roundedness** d. Communicate effectively. e. Think critically and creatively. f. Assimilate new technological development in related field.
Subject Synopsis/ Indicative Syllabus	1. <u>Overview of Security Challenges in Data Communication</u> An introduction to the common security issues related to data communications, with identification on unique security characteristics of Internet of Things applications such as computational and power limits, system vulnerabilities, and high data volume. 2. <u>Applied Cryptography for Data Communication</u> Cryptographic tools for security models: cryptographic hash function for integrity, symmetric and asymmetric encryption for confidentiality, digital signature for authentication. 3. <u>Security Standards and Solutions for Data Communication</u> ISO 27001/2 and similar standards such as NIST SP 800, HIPAA, Public-Key Infrastructure (X.509), IP security (IPSec); firewall, virtual private network, authentication and access control. 4. <u>Case studies of Internet of Things Security Threats and Solutions</u> With a focus on the following Internet of Things technologies: Wi-Fi, Bluetooth, Low-power wide-area network, and 5G.

Teaching/Learning Methodology

<u>Lectures and Tutorials are effective teaching methods:</u>

1. To provide an overview of the subject contents.
2. To introduce, identify and describe common security issues in data communication.
3. To introduce the common approaches and solutions for ensuring data security.
4. To use feedbacks from students for gauging their progress

<u>Assignments and Tests:</u>

1. To supplement the teaching materials.
2. To foster a deeper understanding of the concepts.
3. To test the mastery of the subject matter by the students at different stages.

<u>Case studies, lab sessions:</u>

1. To ensure deep learning and real understanding of the students.
2. To cultivate students' problem-solving skills.
3. To foster deep understanding of the subject.

Teaching/Learning Methodology	Intended Subject Learning Outcomes					
	a	b	c	d	e	f
Lecture	✓	✓	✓		✓	✓
Tutorial	✓	✓	✓	✓	✓	✓
Test/Assignment	✓	✓	✓	✓	✓	
Case study, Labs				✓	✓	✓

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	e	f
1. Assignments	10%	✓	✓	✓	✓	✓	
2. Tests	10%	✓	✓	✓	✓		
3. Laboratory demonstration and reports	15%	✓	✓	✓	✓		
4. Mini project	15%	✓	✓	✓	✓	✓	✓
5. Examination	50%	✓	✓	✓	✓	✓	
Total	100%						

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	27 Hrs.
▪ Laboratory	12 Hrs.
Other student study effort:	
▪ Lecture: further reading, doing homework/ assignment, preparing for tests, examination	36 Hrs.
▪ Writing laboratory reports	10 Hrs.
▪ Mini-project: studying, writing report, giving presentation	20 Hrs.
Total student study effort	105 Hrs.

Reading List and References	***Text Book:*** 1. Network Security Essentials: Applications and Standards (6th Edition) 6th Edition, William Stallings, Pearson, August 2016. ***General References and standards:*** 2. Network Security, André Perez, Wiley (DDA), Hoboken, N.J. : Wiley, 2014. (PolyU Library Acc. No.: TK5105.59 .P47 2014, online access available) 3. IPsec virtual private network fundamentals, James Henry Carmouche, Indianapolis, Ind.: Cisco Press, 2007. (PolyU Library Call Number: TK5105.567 .C37 2007). 4. Firewall policies and VPN configurations, Anne Henmi, technical editor; Mark Lucas, Abhishek Singh, Chris Cantrell, Rockland, Mass.: Syngress, 2006. (PolyU Library Call Number: TK5105.59 .F478 2006) 5. Abusing the Internet of Things: Blackouts, Freakouts, and Stakeouts, Nitesh Dhanjani: O'Reilly Media; 1 edition, April 2015. 6. Practical Internet of Things Security, Brian Russell, and Drew Van Duren, Packt Publishing, June 2016. 7. IoT Penetration Testing Cookbook: Identify vulnerabilities and secure your smart devices, Aaron Guzman and Aditya Gupta, Packt Publishing, November 2017. 8. Wireless Communications Security: Solutions for the Internet of Things, Jyrki T. J. Penttinen, John Wiley & Sons, 2017.

July 2021

Subject Description Form

Subject Code	EIE557
Subject Title	Computational Intelligence and Its Applications
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	The subject aims to introduce students to (i) fundamentals of key intelligent systems technologies including knowledge-based systems, neural networks, fuzzy systems, and evolutionary computation, and (ii) practice in integration of intelligent systems technologies for engineering applications.
Intended Learning Outcomes	Upon completion of the subject, students shall be able to a. Gain a working knowledge of knowledge-based systems, neural networks, fuzzy systems, and evolutionary computation; b. Apply intelligent systems technologies in a variety of engineering applications including IoT; c. Implement typical computational intelligence algorithms in MATLAB/Python; d. Present ideas and findings effectively; and e. Think critically and learn independently.
Subject Synopsis/ Indicative Syllabus	1. Introduction to Computational Intelligence 1.1 Intelligence machines 1.2 Computational intelligence paradigms 1.3 Data mining for IoT 2. Rule-Based Expert Systems and Fuzzy Expert Systems 2.1 Rule-based expert systems 2.2 Uncertainty management 2.3 Fuzzy sets and operations of fuzzy sets 2.4 Fuzzy rules and fuzzy inference 2.5 Fuzzy expert systems 2.6 Case study: fuzzy logic controller for washing machines 3 Artificial Neural Networks 3.1 Fundamental neurocomputing concepts: artificial neurons, activation functions, neural network architectures, learning rules 3.2 Supervised learning neural networks: multi-layer feedforward neural networks, simple recurrent neural networks, time-delay neural networks, supervised learning algorithms 3.3 Unsupervised learning neural networks: self-organizing feature maps 3.4 Radial basis function networks 3.5 Deep neural networks and learning algorithms 3.6 Case study: anomaly detection for video surveillance 4 Evolutionary computation 4.1 Chromosomes, fitness functions, and selection mechanisms 4.2 Genetic algorithms: crossover and mutation

	4.3 Genetic programming 4.4 Evolution strategies 4.5 Case study: cost-sensitive control in wireless sensor networks 5 <u>Hybrid Intelligent Systems</u> 5.1 Neural expert systems 5.2 Neuro-fuzzy systems 5.3 Evolutionary neural networks 5.4 Applications to IoT
Teaching/Learning Methodology	Lecture/case studies (leaning outcomes a and b) • fundamental principles and key concepts of the subject are delivered to students; • guidance on further readings, applications and implementation is given. The formal lectures will be accompanied by case studies of successful real-world engineering applications of intelligent systems technologies. Tutorial (learning outcomes a and b) • students will be able to clarify concepts and to have a deeper understanding of the lecture material; • problems and application examples are given and discussed. Laboratory exercises (learning outcomes a - e) Students will make use of the software tools and MATLAB/Python to develop simple computational intelligence systems.

Teaching/Learning Methodology	Intended Subject Learning Outcomes				
	a	b	c	d	e
Lectures	✓	✓			
Tutorials	✓	✓			
Laboratories	✓	✓	✓	✓	✓
Assignments	✓	✓		✓	✓

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	e
1. Test	25%	✓	✓			✓
2. Final examination	50%	✓	✓		✓	✓
3. Laboratories (including report writing)	15%	✓	✓	✓	✓	✓
4. Assignments	10%	✓	✓		✓	✓
Total	100%					

Student Study Effort Expected	Class contact:	
	▪ Lecture	26 Hrs.
	▪ Tutorial	7 Hrs.
	▪ Laboratory	6 Hrs.
	Other study efforts:	
	▪ Self-learning	48 Hrs.
	▪ Assignments, laboratory report writing	18 Hrs.
	Total student study effort	105 Hrs.
Reading List and References	1. M. Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, 3rd Edition, Pearson/Addison Wesley, 2011. 2. A.P. Engelbrecht, Computational Intelligence: An Introduction, 2nd Edition, John Wiley & Sons, 2007. 3. H.K. Lam, S.S.H. Ling, and H.T. Nguyen, Computational Intelligence and Its Applications: Evolutionary Computation, Fuzzy Logic, Neural Network and Support Vector Machine, Imperial College Press, 2011. 4. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016. 5. C.C. Aggarwal, Neural Networks and Deep Learning, 1st Edition, Springer, 2018. 6. E. Turban, J. E. Aronson, T.-P. Liang, Decision Support Systems and Intelligent Systems, 8th Ed., Pearson Prentice Hall, 2015. 7. E. Cox, The Fuzzy Systems Handbook, Boston: AP Professional, 1998. 8. S. Russell and P. Norvig. Artificial Intelligence – A Modern Approach, Prentice Hall, 2010. 9. S. Haykin, Neural Networks – A Comprehensive Foundation, Prentice Hall, 1999. 10. N. Baba and L.C. Jain, Computational Intelligence in Games, Heidelberg; New York: Physica-Verlag, 2001. 11. F.F. Soulie and P. Gallinari (Editors), Industrial Applications of Neural Networks, Singapore; River Edge, NJ: World Scientific, 1998. 12. S. Chen (editor), Evolutionary computation in economics and finance, Heidelberg; New York: Physica-Verlag, 2002. 13. R.J. Jr., Bauer, Genetic Algorithms and Investment Strategies, John Wiley & Sons, 1994. 14. H.J. Zimmermann et al (Editors), Advances in Computational Intelligence and Learning: Methods and Applications, Boston: Kluwer Academic Publishers, 2002. 15. L.C. Jain and P. de Wilde (Editors), Practical Applications of Computational Intelligence Techniques, Boston: Kluwer Academic Publishers, 2001. 16. Selected papers on computational intelligence techniques for various applications including IoT.	

Subject Description Form

Subject Code	EIE558
Subject Title	Speech Processing and Recognition
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	This subject aims to enable students to master the state-of-the-art theories and technologies behind various speech-related products and services, such as mobile phones, voice search, Internet phones, dialog systems, voice biometrics, and voice cloning. The course will cover theoretical foundations, algorithms, and practical issues of speech processing and recognition systems. The course will put emphasis on how recent advances in deep learning and deep neural networks revolutionaries these systems. After completing the subject, students will have an understanding of what the current speech technologies can offer and be able to apply speech processing techniques to industrial and commercial applications. The course is suitable for students with a background in signal processing and statistics. It is also ideal for research students working in speech processing. Prior experience in speech processing is not necessary.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. master the fundamental principles behind voice-enable products and services; b. know what the current state-of-the-art speech technologies can offer; c. apply speech processing technologies to voice-enabled products and services; d. take the limitations of current speech technologies into consideration when deploying voice-enabled services.
Subject Synopsis/ Indicative Syllabus	**Part I: Fundamental Concepts** 1. Speech Production and Modelling 1.1 Physiology of speech generation; acoustic characteristics of speech sounds 1.2 Discrete-time speech production model 2. Speech Analysis and Parameterization 2.1 Short-term Fourier analysis; spectrograms 2.2 Linear prediction; cepstrum; LPCC; MFCC **Part II: Advanced Topics and Applications** 3. Speech Enhancement 3.1 Spectral subtraction; 3.2 DNN-based approaches 4. Speech Coding 4.1 Attributes of speech coders and coding standards 4.2 Waveform coding: PCM and ADPCM 4.3 Linear predictive coding: LPC and MELP 4.4 Analysis-by-synthesis coders: CELP and MPLPC 5. Machine Learning and Deep Learning 5.1 Gaussian mixture models 5.2 Support vector machines 5.3 Deep Learning and deep neural networks 5.4 Convolutional neural networks, ResNet, and DenseNet 6. Speech Recognition 6.1 Types of speech recognition 6.2 Hidden Markov models (HMM); language models; DNN-HMM 6.3 End-to-End speech recognition: Seq2Seq and CTC 6.4 Speaker adaptation: MAP; MLLR; DNN adaptation

7. <u>Speaker Recognition</u>
   - 7.1 Types of speaker recognition
   - 7.2 Speaker modelling: GMM-UBM and GMM-SVM
   - 7.3 Speaker embedding: i-vectors; x-vectors; ResNet and DenseNet x-vectors
   - 7.4 Scoring: LDA, PLDA, and cosine distance
   - 7.5 Performance metrics: EER, minimum DCF and actual DCF

Teaching/Learning Methodology

The theories and applications of various speech technologies will be discussed and explained in lectures. Lab sessions will be provided to strengthen students' understanding on the theories and hands-on experiences. Students will also be requested to write an essay of a selected topic.

Teaching/Learning Methodology	Intended Subject Learning Outcomes			
	a	b	c	d
Lecture	✓	✓	✓	✓
Tutorial	✓			
Laboratory			✓	✓
Essay writing	✓	✓		

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. Laboratory reports	30%	✓		✓	
2. Quiz	10%	✓			
3. Essays	20%		✓		✓
4. Examination	40%	✓	✓		✓
Total	100%				

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

1. **Lab Reports**: For each lab session, students will need to understand the fundamental concepts [Outcome (a)] before they can complete the lab exercises and write a report. Because the lab sessions involve the application of speech technologies [Outcome (c)], students' ability to apply these technologies should be reflected in their reports.
2. **Quiz:** A quiz will be given to check students' understanding on the fundamental concepts.
3. **Essays:** Students will need to conduct surveys on various speech technologies, find out the limitations of these technologies [Outcome (d)], and determine what the current technologies can offer [Outcome (c)].
4. **Exam:** Students will need to answer questions about the fundamental concepts [Outcome (a)] of various speech technologies and their applications [Outcome (b)]. Limitations of current speech technologies [Outcome (d)] will also be asked in the exam.

Student Study Effort Expected

Class contact:	
▪ Lectures and tutorials	30 Hrs.
▪ Laboratory sessions	9 Hrs.
Other student study effort:	
▪ Writing essay	22 Hrs.
▪ Writing laboratory report and self learning	45 Hrs.
Total student study effort	106 Hrs.

Reading List and References

1. M.W. Mak and J.T. Chien, "*Machine Learning for Speaker Recognition*", Cambridge University Press, 2020.
2. T. Backstrom, *Speech Coding: With Code-Excited Linear Prediction*, Springer, 2017.

3. S. Watanabe and J.T. Chien, “Bayesian Speech and Language Processing”, Cambridge University Press, 2015.
4. J. Benesty, et al. *Speech Enhancement*, Academic Press, 2014.
5. Y. LeCun, Y. Bengio and G.E. Hinton, “Deep Learning”, *Nature*, vol. 521, pp. 436-444, May 2015.
6. T. Kinnunen and H. Z. Li, “An overview of text-independent speaker recognition: From features to supervectors,” *Speech Communication*, 2010.
7. J.R. Deller, J.G. Proakis, and J.H.L. Hansen, *Discrete-Time Processing of Speech Signals*, Macmillan Pub. Company, 2000.
8. L.R. Rabiner and B.H. Juang, *Fundamentals of Speech Recognition*, Prentice Hall, 1993.
9. S.Y. Kung, M.W. Mak and S.H. Lin, *Biometic Authentication: A Machine Learning Approac*h, Prentice Hall, 2005.
10. A.M. Kondoz, *Digital Speech: Coding for Low Bit Rate Communications Systems*, 2^{nd} Edition, Wiley, 2004.
11. T.E. Quatieri, *Discrete-Time Speech Signal Processing*, Prentice Hall, 2002.

July 2021

Subject Description Form

Subject Code	EIE563
Subject Title	Digital Audio Processing
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Knowledge of digital signal processing. Calculus, linear algebra and basic statistics. Some programming (preferably MATLAB)
Objectives	This course focuses on digital audio processing techniques and their applications. This syllabus is designed to fill the gap between the hardcore theory of various digital signal processing techniques and their applications in various real-world digital audio products and services. Students are expected to be able to handle digital audio processing and design, and have a deep understanding of the topics in the field after completing this course successfully.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Understand the fundamentals of audio processing and associated techniques. b. Solve practical problems with some basic audio processing techniques. c. Design simple systems for realizing some applications with some basic audio processing techniques.
Subject Synopsis/ Indicative Syllabus	1. <u>Fundamentals of DSP</u> Fourier transform; Time-frequency analysis; Multirate systems; Filter bands etc. 2. <u>Fundamentals of Digital Audio</u> Sampling; Dithering; Quantization; Dynamic Range; SNR; Technical terms in the field etc. 3. <u>Digital Audio Recording</u> Recording process; Input lowpass filtering; Sample-and-hold circuit; Oversampling; Analog-to-digital conversion; Dithering; Noise shaping; Post-processing. 4. <u>Digital Audio Compression</u> Critical bands; threshold of hearing; Amplitude masking; Temporal masking; Waveform coding; PCM, DPCM; Perceptual coding; Coding techniques: Subband coding and Transform coding; Codec examples. . 5. <u>Digital Audio Reproduction</u> Reproduction process; Model; Digital-to-audio Conversion; Sampling-and-hold circuit; Filtering; Oversampling; Noise shaping; Sigma-delta modulation; Equalization; Post-processing; Practical implementation issues. 6. <u>Digital Audio Restoration</u> Detection of Pops/Clicks/Pulses; Estimation of corrupted samples; Techniques: Prediction-error detection, LS gap filling, Bayesian approaches etc.; Background noise reduction; Short-time spectral attenuation etc. 7. <u>Case Study of System/Codecs</u> MP3; MP3-Pro; CD; DVD-Audio; AC-3; Dolby digital; SRS Surround system etc. 8. <u>Digital Audio watermarking</u> Time-domain techniques, frequency-domain techniques.

Teaching/Learning Methodology

Method	Remarks
Lectures	Fundamental principles and key concepts of the subject are delivered to students.
Tutorials	Supplementary to lectures and are conducted with smaller class size if possible; students will be able to clarify concepts and to have a deeper understanding of the lecture material; problems and application examples are given and discussed.
Laboratory sessions	Students will make use of the software MATLAB to simulate various image processing techniques and evaluate their performance.

Teaching/Learning Methodology	Intended Subject Learning Outcomes		
	a	b	c
Lectures	✓	✓	✓
Tutorials	✓	✓	✓
Laboratory sessions	✓	✓	✓

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
1. Test	20%	✓	✓	✓
2. Quiz	15%	✓	✓	✓
3. Laboratory assignments and reports	20%	✓	✓	✓
4. Examination	45%	✓	✓	✓
Total	100%			

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial (13 weeks, 3 hours per week)	39 Hrs.
Other student study effort:	
▪ Homework and self-study	66 Hrs.
Total student study effort	105 Hrs.

Reading List and References

1. K.C. Pohlmann, *Principles of Digital Audio*, 5th ed., McGraw-Hill, 2005.
2. K.C. Pohlmann, *Advanced Digital Audio*, SAMS, 1991.
3. S.J. Godsill and P.J.W. Rayner, *Digital Audio Restoration - A Statistical Model-Based Approach*, Springer-Verlag, London, 1998.
4. U. Zolzer, *Digital Audio Signal Processing*, Wiley, 1997.
5. Selected papers in IEEE Transactions and international journals.

Subject Description Form

Subject Code	EIE566
Subject Title	Wireless Communications
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	1. To introduce the fundamental issues, concepts, and design principles in cellular and wireless communications. 2. To model how various channel-fading phenomena degrades a transmitted wireless signal. 3. To introduce various wireless standards and their potential applications to Internet of things.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: Category A: Professional/academic knowledge and skills a. Understand and describe the physical-layer features of wireless communication systems and their potential applications to Internet of things. b. Understand the frequency-reuse concept in cellular communications, and to analyze its effects on interference and system capacity. c. Understand large-scale and small-scale fading-channel models, and to analyze their influence on the performance of a wireless communication system. Category B: Attributes for all-roundedness d. Communicate effectively. e. Think critically and creatively. f. Assimilate new technological development in related field.
Subject Synopsis/ Indicative Syllabus	1. Digital modulation schemes, multiplexing and multiple access schemes, duplexing Analog versus digital modulations. Phase shift keying (BPSK), frequency shift keying (FSK), amplitude shift keying (ASK), quadrature amplitude modulation (QAM). Frequency-division multiplexing (FDM) and multiple-access (FDMA), time-division multiplexing (TDM) and multiple-access (TDMA), code-division multiplexing (CDM) and multiple-access (CDMA), frequency hopping (FH) and direct sequence (DS) spreading, hybrid schemes. Simplex, half-duplex and full duplex, time division duplexing (TDD) and frequency division duplexing (FDD). 2. Cellular communication systems Cellular structure, frequency reuse, cell splitting, macrocell, microcell, picocell and femtocell. Channel assignment. Co-channel interference, adjacent-channel interference, system capacity, power control, call handoffs. 3. Macroscopic fading models for radiowave propagation Free-space radio-wave propagation. Reflection, diffraction, and scattering. Various path-loss models such as ground-reflection, log-distance, lognormal. 4. Microscopic fading models for radiowave propagation

Rician and Rayleigh fading models. Doppler frequency, delay spread, coherence bandwidth, level crossing rate. Characterization of multipath phenomena. Fading effects due to multi-path time delay spread. Fading effects due to Doppler spread.

5. Wireless standards, advanced modulation schemes, and Internet of Things (IoT)

Global Mobile Communication (GSM), 3G, 4G Long-Term Evolution (LTE), Wi-fi, Zigbee, narrow-band IoT, LoRa technology, orthogonal frequency-division multiplexing (OFDM), orthogonal frequency-division multiple access (OFDMA), single-carrier FDMA (SC-FDMA), multiple antenna operation, multiple-input multiple-output (MIMO) transceiver.

Teaching/Learning Methodology

The physical-layer characteristics of a digital communication system will be described and explained in lectures. Channel characteristics will be presented in lectures and tutorials. Performance of a digital communication system under different channel conditions will be simulated with Matlab programs. Students will also be required to study one or more wireless communication 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
Lectures / Tutorials	✓	✓	✓		✓	
Mini-project	✓			✓		✓

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	e	f
1. Assignments	30%	✓	✓	✓		✓	✓
2. Test	40%	✓	✓	✓			
3. Mini-project	30%			✓	✓		
Total	100%						

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

Assignments and tests let students review the taught materials, do further reading for deeper learning and apply the learnt materials to solving common communication system problems.

Mini-project requires the student to do further reading, search for information, keep abreast of current development, give presentations and write a report.

Student Study Effort Expected

Class contact:	
▪ Lectures/Test	33 Hrs.
▪ Presentation	6 Hrs.
Other student study effort:	
▪ Further reading, doing homework/assignment and preparing for tests	30 Hrs.

	▪ Mini-project: studying, writing a report, and preparing presentations	40 Hrs.
	Total student study effort	109 Hrs.
Reading List and References	1. A. Goldsmith, *Wireless Communications*, Cambridge University Press, 2005. 2. Andreas F. Molisch, *Wireless Communications,* Wiley – IEEE, 2nd ed., 2010. 3. A. Ghosh, J. Zhang, J. G. Andrews, and R. Muhamed, *Fundamentals of LTE*, Prentice-Hall, 2010. 4. IEEE and other publications.	

Subject Description Form

Subject Code	EIE567
Subject Title	Wireless Power Transfer Technologies
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The student is expected to have knowledge in basic electricity, electronics, circuits, and ability to analyze problems using computer tools.
Objectives	From mobile, cable-free re-charging of portable devices, notebooks and electric vehicles to delivering power to lighting systems, wireless power transfer (WPT) technologies offer convenient power supply solutions to consumer products and large infrastructures. This course explains the fundamental principles and latest advances in WPT and illustrates key applications of this emergent technology. The key objectives are to introduce: 1. The fundamental principles of WPT for cable-free transfer of power. 2. Theories for inductive power transfer (IPT) based on the coupled inductor model and low-order circuit compensation. 3. Specific converter topologies for lighting and battery charging applications. 4. Technology trends in the adoption of WPT for key consumer applications.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** a. Understand the characteristics of power transfer through coupled inductors and the significance of leakage inductance b. Analyze and design appropriate compensation circuits and efficient power converters for WPT applications c. Understand technical requirements for applications involving solid-state loads and battery loads using WPT technologies d. Appreciate the factors affecting adoption of WPT in consumer applications including lightings, charging of smartphones and electric vehicles. **(2) Attributes for all-roundedness** e. Communicate effectively f. Think critically and creatively
Subject Synopsis/ Indicative Syllabus	**Syllabus:** 1. <u>Basic Circuit Theory</u> Review of transformers. Leakage inductance. Circuit compensation principles. Low-order compensations; series and parallel compensations. Resonance and operating frequency. Efficiency equation. 2. <u>Power Converters Fundamentals</u> DC-DC converters. AC-DC converters and inverters. PWM and soft switching principles. Basic topologies with transformers. Input, output and transfer characteristics of power converters. Incorporation of leaky transformer. Control methods.

	3. <u>Compensation Configurations</u> Types of compensation for inductor power transfer. Characteristics for various termination requirements. Design for load-independence output voltage and output current. Efficiency optimization. 4. <u>Applications</u> Circuit requirements for various loading conditions. Characteristics of LED loads, resistors and battery loads. Appropriate compensation design. Lighting systems. Battery charging profiles. Electric vehicle charging. Energy efficiency metric for charging. 5. <u>Technology Trends</u> Demand for safe power transfer and durable operation. Portable and smart devices. Mobile communication devices. IoT devices and systems. Sensors. Solid-state lighting development. Battery technologies. Electric vehicle development. Renewable source integration trends. Future trends and demand for wireless power transfer.
Teaching/Learning Methodology	This course emphasizes fundamental understanding of the principles and design procedure of wireless power transfer systems as well as the various parameters involved in the optimization of wireless power transfer systems. Selected examples will help students learn the salient aspects of the technologies and the key design constraints. Case studies of specific consumer applications will reinforce understanding of the basic principles and inspire thoughts on future applications.

Teaching/Learning Methodology	Intended Subject Learning Outcomes					
	a	b	c	d	e	f
Lecture	✓	✓	✓			
Tutorial	✓	✓			✓	✓
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	e	f
1. Assignments	30%	✓	✓	✓		✓	✓
2. Test	20%		✓	✓	✓	✓	✓
3. Project proposal, report and viva examination	10% 20% 20%		✓	✓	✓	✓	✓
Total	100%						

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

Assignments allow students to reinforce their understanding of the basic theories and design principles. Since MSc students are mostly mature technical personnel, engineers and managers, the course must be relevant to their needs. Each student has different background and career needs. Hard memorization of a fixed set of theories and facts is not useful. It is important that students are able to extract useful contents

<table>
<tr><td></td><td colspan="2">relevant to their profession, and being mature students, they know best what are relevant and useful for them. Thus, instead of taking a written exam, students are given the opportunity to define and formulate their case studies under the guidance of the instructor and to pursue a detailed study and analysis of a topic that is strongly relevant to their experience and needs. The nature of case study may range from deep technology survey, innovative system design, to detailed circuit analysis at research level, catering individual needs. The case study project requires students to do further reading, search for information, keep abreast of current development, develop a proposal for specific application, give a presentation and write a complete report.</td></tr>
<tr><td rowspan="9">Student Study Effort Required</td><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lecture/Tutorial</td><td>21 Hours</td></tr>
<tr><td>▪ Case study – presentations and discussions</td><td>15 Hours</td></tr>
<tr><td>▪ Test</td><td>3 Hours</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Lecture: further reading, doing homework/ assignment</td><td>42 Hours</td></tr>
<tr><td>▪ Tutorial/Project: design, writing a report</td><td>30 Hours</td></tr>
<tr><td>Total student study effort</td><td>111 Hours</td></tr>
<tr><td>Reading List and References</td><td colspan="2">Text books:
1. C. T. Rim and C. Mi, Wireless Power Transfer for Electric Vehicles and Mobile Devices, New York: IEEE Press-Wiley, 2017.
2. J. I. Agbinya, Wireless Power Transfer, River Publishers, 2015.

References:
1. Z. Huang, S. C. Wong, and C. K. Tse, "Design of a single-stage inductive-power-transfer converter for efficient EV battery charging," IEEE Transactions on Vehicular Technology, vol. 66, no. 7, pp. 5808-5821, July 2017.
2. L. Xu, Q. Chen, X. Ren, S. C. Wong, and C. K. Tse, "Self-oscillating resonant converter with contactless power transfer and integrated current sensing transformer," IEEE Transactions on Power Electronics, vol. 32, no. 6, pp. 4839-4851, June 2017.
3. W. Zhang, S. C. Wong, C. K. Tse, and Q. Chen, "Load-independent duality of current and voltage outputs of a series or parallel compensated inductive power transfer converter with optimized efficiency," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 3, no. 1, pp. 137-146, March 2015.
4. J. Hou, Q. Chen. X. Ren, X. Ruan, S. C. Wong, and C. K. Tse, "Precise characteristics analysis of series/series-parallel compensated contactless resonant converter," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 3, no. 1, 101-110, March 2015.
5. J. Hou, Q. Chen, S. C. Wong, C. K. Tse, and X. Ruan, "Analysis and control of series/series-parallel compensated resonant converters for contactless power transfer," IEEE Journal of Emerging and Selected Topics in Power Electronics,vol. 3, no. 1, pp. 124-136, March 2015.</td></tr>
</table>

Subject Description Form

Subject Code	EIE568
Subject Title	IoT – Tools and Applications
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The students are expected to have some basic knowledge on computer hardware and software.
Objectives	1. To provide an overview on IoT tools and applications including sensing devices, actuation, processing and communications. 2. To introduce hands-on IoT concepts including sensing, actuation, and communication through lab exercises with IoT development kits.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** a. Understand key IoT concepts on sensing devices, actuation, processing and communications b. Hands-on skills on prototyping IoT products and applications **2) Attributes for all-roundedness** c. Communicate effectively. d. Think critically and creatively. e. Assimilate new technological development in related field.
Subject Synopsis/ Indicative Syllabus	1. Introduction to Internet of Things (IoT) - Historical background of IoT - The IoT system stack: Sensors, edge computing, networking, cloud computing - How IoT could enable innovative products and services 2. Electronics for IoT - Overview of electronic signals (sampling and Nyquist theorem) - General Purpose Input/Output (GPIO) and Pulse Width Modulation (PWM) - ADC and DAC concepts - Microcontrollers and computers for IoT (e.g., Arduino, Raspberry Pi, etc.) 3. Sensors for IoT - An overview of sensors used in IoT - Sampling frequency and bandwidth requirements for different sensors - Interface common sensors and actuators to IoT development kits 4. Software and Data Analytics for IoT - Libraries of development kits and examples (e.g., Arduino) - Selection of development programming languages for different IoT services - Web server and web services (e.g., ThingsBoard, MQTT/HTTP) - Data analytics with machine learning techniques (e.g., Python, Anaconda) 5. Low Power Wide Area Networks (LPWAN) - Transmission of latency-sensitive real-time data and reliable signaling data - Protocols for exchanging information among different IoT devices - IoT communication protocols: Sigfox, LoRa, NB-IoT, etc. 6. Internet of Things Capstone - To conclude the subject with a hands-on project on IoT applications

Teaching/Learning Methodology	The theories and applications of IoT will be described and explained in lectures. Tutorial and lab sessions will be conducted to deliver hands-on skills on prototyping IoT products and applications based on IoT development kits. Finally, the subject will be concluded with a hands-on project on IoT applications. Students are requested to present their developed applications and summarize their findings through a presentation and a written report.

Teaching/Learning Methodology	Intended Subject Learning Outcomes				
	a	b	c	d	e
Lecture	✓				
Tutorial and Lab	✓	✓		✓	
Mini project	✓	✓	✓	✓	✓

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	e
1. Assignments	20%	✓		✓	✓	
2. Test/Quizzes	20%	✓		✓	✓	✓
3. Lab	20%		✓		✓	✓
4. Mini project	40%	✓	✓	✓	✓	✓
Total	100%					

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

Assignments and test/quizzes let students review the taught materials, do further reading for deeper learning and apply the learnt materials to solving problems.

Lab exercises and the mini project require students to do further reading, search for information, keep abreast of current IoT development, develop their own IoT prototypes, give a presentation and write a report.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	24 Hrs.
▪ Laboratory sessions	15 Hrs.
Other student study effort:	
▪ Lecture: further reading, doing homework /assignment	72 Hrs.
Total student study effort	111 Hrs.

Reading List and References

1. R. Buyya, A. V. Dastjerdi, *Internet of Things: Principles and Paradigms*, Cambridge, MA, 2016.

Others:

2. IEEE Transactions and other journals.

Subject Description Form

Subject Code	EIE569
Subject Title	Sensor Networks
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The students are expected to have some basic knowledge about circuits and IP networks.
Objectives	1. To introduce the fundamental issues, concepts, and design criteria in sensor networks. 2. To understand the key concepts towards the integration of sensor networks and Internet of Things (IoT). 3. To understand hardware, communication stack, and middleware technologies utilized in sensor networks for IoT. 4. To investigate the applications of sensor networks for IoT in smart cities.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** a. Understand sensing/actuation methods, communication stack, middleware technologies and applications of current and emerging sensor networks for IoT. **(2) Attributes for all-roundedness** b. Communicate effectively. c. Think critically and creatively. d. Assimilate new technological development in related fields.
Subject Synopsis/ Indicative Syllabus	1. Sensing and actuation 1.1. Sensors and actuators 1.2. Sensing data acquisition 1.3. Actuator controls 1.4. Sensors/actuators interfaces, standards, and protocols 2. Communication networks 2.1. Optical fiber and wireless communication fundamentals 2.2. Energy and communication models 2.3. Topologies 2.4. Routing 2.5. Scheduling 2.6. Transceivers interfaces, standards, and protocols 3. Middleware technologies 3.1. Detection and coverage 3.2. Localization and tracking 3.3. Data compression and fusion 3.4. Compressive sensing 4. Applications 4.1. Smart grid systems

	4.2. Sensing as a service (SaaS) 4.3. Mobile sensor networks (MSNs) 4.4. Vehicular ad hoc networks (VANETs)

Teaching/Learning Methodology

This course aims to provide students with a theoretical understanding of sensor networks, in particular about their design criteria and limitations when applying in IoT applications. The course is taking a bottom-up approach, which begins with sensing, processing, and communication hardware, followed by data aggregation/dissemination topologies and performance-aware middleware, and finally concluded with real-life IoT applications. It will explain the unique characteristics of sensor networks from conventional optical fiber networks and Ad-Hoc mobile networks, and further elaborate the new challenges introduced by IoT systems. Throughout the course, students will be presented with various algorithms/protocols/standards in sensor networks/IoT, together with the rationales behind their designs. Upon completion, students will be able to design, implement, and evaluate their own hardware, algorithms, middleware, and applications for sensor networks in IoT.

Teaching/Learning Methodology	Intended Subject Learning Outcomes			
	a	b	c	d
Lecture	✓			
Tutorial	✓		✓	
Presentation / 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. Midterm test	10%	✓	✓	✓	✓
2. Assignments	10%	✓	✓	✓	✓
3. Case study	10%	✓	✓	✓	✓
2. Final examination	70%	✓	✓	✓	✓
Total	100%				

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

Assignments let students review the taught materials, do further reading for deeper learning and apply the learnt materials to solve problems in sensor networks for IoT.

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

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	33 Hrs.
▪ Case study – presentations and discussions	6 Hrs.
Other student study effort:	
▪ Self-reading, doing homework/assignment	72 Hrs.

	Total student study effort	111 Hrs.
Reading List and References	1. Pethuru Raj and Anupama C. Raman, *The Internet of Things: Enabling Technologies, Platforms, and Use Cases*, CRC Press, 2017 2. Arshdeep Bahga and Vijay Madisetti, *Internet of Things: A Hands-on Approach*, VPT, 2014 3. Fawzi Behmann and Wu Kwok, *Collaborative Internet of Things (C-IoT): For Future Smart Connected Life and Business*, John Wiley and Sons, 2015 4. G.P. Agrawal, *Fiber-optic communication systems*, Wiley, 2010 5. Shizhuo Yin, Paul B. Ruffin, Francis T.S. Yu, *Fiber Optic Sensors*, CRC Press, 2008 6. Holger Karl, Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley and Sons, 2005	

July 2021

Subject Description Form

Subject Code	EIE570
Subject Title	Deep Learning with Photonics
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	N/A
Objectives	1. To introduce the fundamental concepts, and design principles in deep learning and optoelectronic devices. 2. To introduce the state-of-the-art modelling methods in deep learning and photonic devices. Rebuild photonic neural networks with the frontier papers of the scientific community.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: <u>Category A: Professional/academic knowledge and skills</u> a. Understand and describe the physical-layer features of neural network structures. b. Understand the fundamental concepts/laws in photonics devices. c. Understand why the combination of the two disciplines will have great potentials for next generation information technology. <u>Category B: Attributes for all-roundedness</u> d. Communicate effectively. e. Think critically and creatively. f. Assimilate new technological development in related field.
Subject Synopsis/ Indicative Syllabus	1. Primer on Deep Learning (DL) 1-1 The overview and organization of the course 1-2 Matrix and Linear regression 1-3 Gradient descent 1-4 The cost function 1-5 Supervised Learning & Unsupervised Learning <u>Exercise1</u>: Install the DL environments <u>Exercise2</u>: Demonstration of file & matrix operation 2. Implementation of the neural network 2-1 Introduction of TensorFlow (TF) 2-2 Neural Networks Part 1: Setting up the Architecture 2-3 Neural Networks Part 2: Setting up the Data and the Loss pre-processing 2-4 Neural Networks Part 3: Learning and Evaluation 2-5 Neural Networks Part 4: Minimal Neural Network Case Study <u>Exercise3</u>: Install and Build the TF network <u>Exercise4</u>: Demonstrate handwriting number recognition 3. Primer on photonic devices 3-1 Fundamental optical laws

3-2 Diffractive grating and lens

3-3 Mach-Zhender Interferometer (MZI) array matrix

3-4 MicroRing Resonator (MRR) array matrix

3-5 Nonlinear devices

<u>Exercise5</u>: Simulation of the diffractive grating and lens

<u>Exercise6</u>: Simulation of MZI and MRR

4. Case study I: Inverse design for photonic devices

4-1 Inverse design principles

4-2 Direct Binary Search (DPS) method

4-3 Adjoined method

4-4 The forward & backward simulation

4-5 The prediction of optical waveguide modal information

<u>Exercise7</u>: Inverse design the beam splitter with DBS method

<u>Exercise8</u>: Inverse design the beam splitter with adjoin method

<u>Exercise9</u>: Demonstration of inverse design for optical waveguide design

5. Case study II: All-optical Diffractive Deep Neural Networks (D2NN)

5-1 The diffraction formula

5-2 The diffractive neural network configuration

5-3 The forward & backward propagation

5-4 The cost function

5-5 The training & validation procedure

<u>Exercise10</u>: Build the D2NN with TF

<u>Exercise11</u>: Demonstration of D2NN for handwriting number recognition

Teaching/Learning Methodology

The physical-layer characteristics of all-optical deep neural networks will be described and explained in lectures. Advantages of photonic computation will be presented in lectures. Modelling of photonic deep learning systems will be conducted during the class through the exercises. Students will also be required to study one photonic deep learning systems, share their findings with other classmates through presentations.

Teaching/Learning Methodology	Intended Subject Learning Outcomes					
	a	b	c	d	e	f
Lectures	✓	✓	✓		✓	
Exercises	✓	✓	✓	✓	✓	✓
Case study and presentation	✓	✓	✓	✓	✓	✓

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	e	f
1. Assignments	20%	✓	✓			✓	
2. Exercises	30%	✓	✓	✓	✓	✓	✓
3. Mini projects	20%	✓	✓	✓		✓	
4. Tests	30%	✓	✓	✓		✓	✓
Total	100%						

	Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes: **Assignments:** let students review the taught materials, do further reading for deeper learning and understand better of the taught knowledge. Students may find these reading useful and will practice the obtained knowledge in the associated exercises and mini projects. **Exercises:** Exercises are designated based on projects to evaluate whether the students are proficient in the taught knowledge to solve the practical problem. Students need to bring a laptop to the classroom and may conduct literature research on the topics. Mutual discussions are encouraged in order to summarize the findings in a presentation. **Mini projects:** Students will need to finish the given mini projects during the class. Students can share their ideas and views about photonic neural networks through discussions. **Tests:** Tests will evaluate student's understanding and usage of deep learning with photonics.	
Student Study Effort Expected	Class contact:	
	▪ Lectures/Tutorials	26 Hrs.
	▪ Case study and report	13 Hrs.
	Other student study effort:	
	▪ Further reading, doing homework/assignment and preparing for the subject.	66 Hrs.
	Total student study effort	105 Hrs.
Reading List and References	1. Prucnal, P. , Shastri, B. (2017) Neuromorphic Photonics. CRC Press, https://doi.org/10.1201/9781315370590. 2. Yao, K., Unni, R. & Zheng, Y. (2019). Intelligent nanophotonics: merging photonics and artificial intelligence at the nanoscale. Nanophotonics, 8(3), pp. 339-366. Retrieved 21 Mar. 2020, from doi:10.1515/nanoph-2018-0183 3. Ferreira de Lima, T., Shastri, B., Tait, A., et al. (2017). Progress in neuromorphic photonics. Nanophotonics, 6(3), pp. 577-599. Retrieved 21 Mar. 2020, from doi:10.1515/nanoph-2016-013 4. Molesky, S., Lin, Z., Piggott, A.Y. et al. Inverse design in nanophotonics. Nature Photonics 12, 659–670 (2018). https://doi.org/10.1038/s41566-018-0246-9	

<u>**Subject Description Form**</u>

Subject Code	EIE571
Subject Title	Photonic System Analysis
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	N/A
Objectives	1. Understand the principles and techniques of photonic device and system analysis, simulation and modeling 2. Learn to obtain optical characteristics of photonic devices and systems through computer simulation.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: <u>Category A: Professional/academic knowledge and skills</u> a. Understand how to analyze and design photonic devices and systems through modeling and simulation. b. Learn to use simulation methods to build up the database for the design of photonic devices and systems. <u>Category B: Attributes for all-roundedness</u> c. Communicate effectively. d. Think critically and creatively. e. Assimilate new technological development in the related field.
Subject Synopsis/ Indicative Syllabus	**1. Fundamental concepts** 1-1. Basic concepts of optics 1-2. Polarization 1-3. Size versus light wavelength 1-4. Common photonic system analysis techniques **2. Photonic simulation** 2-1. Simulation parameters 2-2. Create 2D/3D model of photonic simulation 2-3. Material import for photonic simulation 2-4. Boundary conditions **3. Meshing techniques** 3-1. Mesh types 3-2. Boundary layer meshing 3-3. Automatic re-meshing **4. Simulation solver and result verification** 4-1. Visualization of simulated results 4-2. Analysis of simulation data **5. Case study: simulation of photonic device**

Teaching/Learning Methodology	Analysis, simulation and modeling of photonic devices and systems will be described and demonstrated in this subject. Students will be guided through laboratory exercises related to the materials taught in each session. The laboratory exercises should be finished during the class. Students will be given the opportunity to study some design examples in the field and share their findings with other classmates through presentations and reports. Students are requested to design a mini project of photonic devices by using the photonic simulation method.

Teaching/Learning Methodology	Intended Subject Learning Outcomes				
	a	b	c	d	e
Lectures	✓	✓		✓	✓
Laboratory exercises	✓	✓		✓	✓
Case study/report	✓	✓	✓	✓	✓
Mini project	✓	✓	✓	✓	✓

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	e
1. Assignments	20%	✓	✓		✓	✓
2. Laboratory exercises	40%	✓	✓		✓	✓
3. Mini project	10%	✓	✓	✓	✓	✓
4. Tests	30%	✓	✓			
Total	100%					

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

Assignments: Students will need to review the taught materials and some of the photonics simulation design examples, give a presentation, and write a report. Students can learn more in-depth and understand the current developments of photonics simulation.

Laboratory exercises: For each session, students will need to complete the lab exercises and write a report. Through the lab exercises, students can practice and be proficient in the operating of photonic simulation.

Mini project: Students have to design a photonic device project by photonic simulation, give a presentation, and write a report.

Tests: Students will need to answer questions about the fundamentals and technologies of photonic system analysis.

Student Study Effort Expected		
	Class contact:	
	▪ Lectures/Tutorial	26Hrs.
	▪ Laboratory exercises	13Hrs.
	Other student study effort:	

	▪ Assignments and mini project	66 Hrs.
	Total student study effort	105 Hrs.
Reading List and References	1. Layla S. Mayboudi, Geometry Creation and Import With COMSOL Multiphysics (Multiphysics Modeling Series), 2019. 2. Slawomir Sujecki, *Photonics Modelling and Design*, 2014. 3. Merhzad Tabatabaian, *COMSOL5 for Engineers,* 2015. 4. Sophocles Orfanidis, *Electromagnetic Waves and Antennas*, 2016. 5. Levent Sevgi, *Electromagnetic Modeling and Simulation*, 2014.	

July 2021

Subject Description Form

Subject Code	EIE572
Subject Title	Information Photonics
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	N/A
Objectives	1. To learn the fundamental principle of information photonics. 2. To understand processes to control and manipulate the photonic information. 3. To know the working principle and applications of the modern information photonics devices and systems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: Category A: Professional/academic knowledge and skills a. Learn the fundamental principles of information photonics. b. Understand the knowledge about practical information photonic components and systems, and an overview of applications of information photonics. Category B: Attributes for all-roundedness c. Communicate effectively. d. Think critically and creatively. e. Assimilate new technological development in related field.
Subject Synopsis/ Indicative Syllabus	1. Information Communication. 2. Introduction to Photonics. 3. Vision, Visual Perception, and Computer vision. 4. Photonic Sources and Detectors for Information Processing. 5. Photonic Devices for Modulation, Storage and Display. 6. Photonics in Transform Domain Information Processing. 7. Low-Level Photonic Information Processing. 8. Photonics in Networking and Communication. 9. Photonic Computing. 10. Photonic Pattern Recognition and Intelligent Processing. 11. Nanophotonic Information System. 12. Quantum Information Processing.
Teaching/Learning Methodology	This subject aims to provide students with fundamental and practical understanding of information photonics. The concepts and principles of information photonics will be described and explained in this subject. The information photonic components and systems will be introduced and the engineering working principle of them will be explained. Students will be required to study some application cases about the advanced information photonics, and 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
Lecture	✓	✓		✓	✓
Tutorial	✓	✓	✓	✓	✓
Presentation / 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	e
1. Homeworks/Assignments	30%	✓	✓		✓	✓
2. Midterm test	20%	✓	✓			
3. Case study and presentation	20%	✓	✓	✓	✓	✓
4. Final examination	30%	✓	✓		✓	✓
Total	100%					

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

Homework, tests and case study let students review the taught materials, do further reading for deeper learning and apply the learnt materials to solve the problems in Information Photonics.

Case study requires the student to do further reading, search for information, keep abreast of current developments in Information Photonics, give a presentation and write a report.

Final examination requires students to answer questions about the fundamentals and technologies of information photonics.

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	33Hrs.
▪ Case study – presentations and discussions	6 Hrs.
Other student study effort:	
▪ Homework/assignment and further case study, presentation preparation.	66 Hrs.
Total student study effort	105 Hrs.

Reading List and References

1. Bahaa E.A. Saleh, Fundamentals of Photonics, 3rd (2019).
2. Asit Kumar Datta and Soumika Munshi, Information Photonics: Fundamentals, Technologies, and Applications (2017).
3. Georg A Reider, Photonics An Introduction (2016).
4. Craig Hoffman, Encyclopedia of Optical and Photonic Engineering (2014).
5. Clifford R. Pollock and Michal Lipson, Integrated Photonics (2003).

Subject Description Form

Subject Code	EIE573
Subject Title	Mobile Edge Computing
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Students are expected to have some basic knowledge in wireless communication and mobile computing. Extra materials will be provided for self-learning for those who do not have the appropriate knowledge. Please contact the subject lecturer for details.
Objectives	1. To introduce fundamental concepts and design principles of mobile edge computing (MEC), as well as supporting technologies. 2. To introduce MEC hardware platforms and standardization. 3. To introduce applications that are enabled by MEC.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: <u>Category A: Professional/academic knowledge and skills</u> a. To understand the basic architecture and benefits of MEC. b. To understand computation offloading, joint communication and computation resource management for MEC. c. To understand standardization and use scenarios of MEC. <u>Category B: Attributes for all-roundedness</u> d. Communicate effectively. e. Think critically and creatively. f. Assimilate new technological development in related field.
Subject Synopsis/ Indicative Syllabus	1. <u>MEC Basics</u>: Key features of MEC; Mobile Cloud Computing vs. MEC; Advantages of MEC; Market and ecosystem of MEC. 2. <u>Wireless Communication for MEC</u>: Wireless channel models; Cellular network structure; multiuser communication systems; basics of 5G networks. 3. <u>Computation Basics for MEC</u>: Mobile computing; Computation task models; Virtual machine; CPU/GPU computing platforms. 4. <u>Computation Offloading</u>: Different offloading modes; single-user offloading, multi-user offloading. 5. <u>Communication and Computation Resource Management</u>: Joint radio and computation resource allocation; MEC server scheduling; Multiuser cooperative edge computing. 6. <u>MEC hardware platform, standardization</u>: MEC network architecture; Standardization of MEC in 5G; Security and privacy issues in MEC. 7. <u>MEC application scenarios</u>: Video stream analysis, Internet of Things; AR/VR; Internet of Vehicles; edge AI.

Teaching/Learning Methodology	The basic features and architecture of MEC will be described and explained in lectures. Supporting techniques, including computation offloading, communication and computation resource management, will be presented in lectures and tutorials. The standardization and use scenarios of MEC will be introduced in lectures. Students will also be required to study one technical problem or application case of MEC, 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
Lectures / Tutorials	✓	✓	✓		✓	
Mini-Project				✓		✓

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	e	f
1. Assignments	30%	✓	✓	✓		✓	✓
2. Test	40%	✓	✓	✓			
3. Mini-project	30%				✓		✓
Total	100%						

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

Assignments and test let students review the taught materials, do further reading for deeper learning and apply the learnt materials to solving practical problems in MEC systems.

Mini-project requires the student to do further reading, search for information, keep abreast of current development, give presentations and write a report.

Student Study Effort Expected

Class contact:	
▪ Lectures/Tutorials	36 Hrs.
▪ Test	3 Hrs.
Other student study effort:	
▪ Self-study	66 Hrs.
Total student study effort	105 Hrs.

Reading List and References

1. *Multi-Access Edge Computing in Action*, by Dario Sabella, Alex Reznik, Rui Frazao, CRC Press, 2019, ISBN: 978-0367173944.
2. *Edge Computing: A Primer*, by Jie Cao, Quan Zhang, Weisong Shi, SpringerBriefs in Computer Science, 2018, ISBN 978-3-030-02082-8.
3. Y. Mao, C. You, J. Zhang, K. Huang, and K. B. Letaief, "A survey on mobile edge computing: The communication perspective," *IEEE Commun. Surveys Tuts.*, vol. 19, no. 4, pp. 2322-2358, 4th Quart. 2017.
4. W. Shi, J. Cao, Q. Zhang, Y. Li, and L. Xu, "Edge computing: Vision and challenges," *IEEE Internet Things J.*, vol. 3, no. 5, pp. 637–646, Oct. 2016.
5. Z. Zhou, X. Chen, E. Li, L. Zeng, K. Luo, and J. Zhang, "Edge intelligence: Paving the last mile of artificial intelligence with edge computing," *Proc. IEEE*, vol. 107, no.

	8, pp. 1738–1762, Aug. 2019. 6. J. Zhang and K. B. Letaief, "Mobile edge intelligence and computing for the Internet of Vehicles," *Proc. IEEE*, vol. 108, no. 2, pp. 246–261, Feb. 2020.

Subject Description Form

Subject Code	EIE575
Subject Title	Vehicular Communications and Inter-Networking Technologies
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The students are expected to have some basic knowledge about wireless communications, computer networks and mobile ad-hoc networks. 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	This subject will introduce students with the emerging technologies, standards and applications in vehicular communication systems. The students will study the design considerations and challenges of vehicle-to-infrastructure and vehicle-to-vehicle communications. Theories such as vehicular mobility modeling, and vehicular technologies and standards from the physical to network layers will be introduced in the course. Examples of emerging applications of vehicular communications in Intelligent Transportation Systems will also be studied and discussed.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** a. Understand and describe the basic theories and principles, technologies, standards, and system architecture of vehicular ad-hoc networks (VANET) or inter-vehicle communication networks. b. Analyze, design, and evaluate vehicular communication platforms for various kinds of safety and infotainment applications. **(2) Attributes for all-roundedness** c. Communicate effectively. d. Think critically and creatively. e. Assimilate new technological development in related fields.
Subject Synopsis/ Indicative Syllabus	1. <u>Introduction</u> Basic principles and challenges, past and ongoing VANET activities 2. <u>Cooperative Vehicular Safety Applications</u> Enabling technologies, cooperative system architecture, safety applications 3. <u>Vehicular Mobility Modeling</u> Random models, flow and traffic models, behavioral models, trace and survey-based models, joint transport and communication simulations 4. <u>Physical Layer Considerations for Vehicular Communications</u> Signal propagation, Doppler spread and its impact on OFDM systems 5. <u>MAC Layer of Vehicular Communication Networks</u> Proposed MAC approaches and standards, IEEE 802.11p 6. <u>VANET Routing protocols</u> Opportunistic packet forwarding, topology-based routing, geographic routing 7. <u>Emerging VANET Applications</u> Limitations, example applications, communication paradigms, message coding and composition, data aggregation 8. <u>Standards and Regulations</u> Regulations and Standards, DSRC Protocol Stack, Cellular V2X

Teaching/Learning Methodology	The theories and applications of VANET will be described and explained in lectures. Techniques and parameters for evaluating various vehicular communication platforms will be presented in tutorials. Students are requested to review latest research papers on VANET and study in detail some selected vehicular communication platforms and their potential applications. Finally, share their findings with other classmates through two presentations and write a report to summarize their findings.

Teaching/Learning Methodology	Intended Subject Learning Outcomes				
	a	b	c	d	e
Lectures	✓	✓			
Tutorials	✓	✓	✓		
Assignments	✓	✓	✓	✓	✓
Mini project/Presentations	✓	✓	✓	✓	✓

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	e
1. Paper Review	10%	✓	✓	✓	✓	✓
2. Survey Report	15%	✓	✓	✓	✓	✓
3. Test/Quizzes	20%	✓	✓	✓		
4. Lab	5%	✓	✓	✓	✓	
5. Mini project	50%	✓	✓	✓	✓	✓
Total	100%					

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

Paper review, survey report, test/quizzes, and lab exercises let students review the taught materials, do further reading for deeper learning and apply the learnt materials to solving common vehicular communication network problems.

The mini project requires the student to do further reading, search for information, keep abreast of current development, give presentations and prepare written report.

Student Study Effort Required

Class contact:	
▪ Lecture/Tutorial/Lab	33 Hrs.
▪ Presentation	6 Hrs.
Other student study effort:	
▪ Lecture: further reading, doing homework/ assignment	30 Hrs.
▪ Mini-project: studying, writing a report, preparing two presentations	40 Hrs.
Total student study effort	109 Hrs.

Reading List and References

Text book:

1. H. Hartenstein and K. P. Laberteaux, *VANET: Vehicular Applications and Inter-Networking Technologies*, Wiley, 2010.

Reference books:

1. P. H.-J. Chong, I. W.-H. Ho, *Vehicular Networks: Applications, Performance*

	Analysis and Challenges, Nova Science Publishers, 2019. 2. C. Sommer, F. Dressler, *Vehicular Networking*, Cambridge University Press, 2015. 3. M. Emmelmann, B. Bochow and C. C. Kellum, *Vehicular Networking: Automotive Applications and Beyond*, Wiley, 2010. 4. M. Watfa, *Advances in Vehicular Ad-Hoc Networks: Development and Challenges*, Information Science Reference, 2010. 5. H. Moustafa, Y. Zhang, *Vehicular Networks: Techniques, Standards, and Applications*, CRC Press, 2009. Others: 1. IEEE Transactions and other journals.

July 2021

Subject Description Form

Subject Code	EIE577
Subject Title	Optoelectronic Devices
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	The aim of this course is to introduce to the students to the fundamentals of semiconductor optoelectronic devices. These include pn junctions, light emitting diodes (LEDs) and solar cells. These devices have found important commercial applications. Upon completion of the subject, the students will be able to understand: 1. wave mechanics; 2. principles of semiconductor materials; 3. operating principles of PN junctions; 4. operating principles of LEDs; and 5. principles of semiconductor solar cells.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. understand the principles of semiconductor materials including some basic ideas of quantum mechanics; b. understand the operating principles of semiconductor optoelectronic devices; c. fabricate semiconductor devices.
Subject Synopsis/ Indicative Syllabus	1. <u>Elements of Wave Mechanics</u> The Bohr atom. Wave-particle duality. General Formulation. Particle in a 1-D box. 2. <u>Basic Energy Band Theory</u> The Bloch theorem. Kronig-Penny model. Energy bands and Brillouin zones. Particle motion and effective mass. E-*k* diagrams. Band gap energy 3. <u>Semiconductor fundamentals</u> Basics of electrical and optical properties of semiconductor materials. P-N junctions. 4. <u>Semiconductor LEDS</u> Operation principles of LEDs. Human vision, photometry and colorimetry. White solid-state lamps – phosphor conversion versus multichip LEDs, Display fundamentals. 5. <u>Solar Cells</u> Operation principles of solar cells. Silicon-based solar cells, compound semiconductor based solar cells.

Teaching/Learning Methodology	The basic principles of semiconductor, quantum mechanics, and the operating principles of semiconductor optoelectronic devices will be discussed and explained in lectures. Lab sessions will be organized for students to experience the fabrication processes for a basic pn junction photovoltaic cell. Students will write an essay of a topic selected by the student himself/herself. At the end of the semester each student has to give a 15 to 20-minute presentation on his/her selected topic.

Teaching/Learning Methodology	Intended Subject Learning Outcomes		
	a	b	c
Lectures	✓	✓	
Laboratory		✓	✓
Term paper	✓	✓	

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
1. Homework & Quizzes	20%	✓	✓	
2. Laboratory	20%		✓	✓
3. Mid-term test	30%	✓	✓	
4. Term paper and presentation	30%	✓	✓	
Total	100%			

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

1. **Laboratory**: Students will learn the semiconductor devices fabrication process in the laboratory sessions. The laboratory reports will reflect their understanding of the processes. [Outcomes (b) and (c)]
2. **Term Paper and Presentation:** Students will need to conduct literature research on different optoelectronic devices, investigate the operating principles of the devices and to summarize the findings in a paper. [Outcomes (a) and (b)]
3. **Homework & Quizzes:** The homework and quizzes will cover the fundamental quantum mechanics, physics of semiconductor materials and devices. [Outcomes (a) and (b)]
4. **Mid-term test:** The mid-terms will mainly cover the fundamental quantum mechanics, physics of semiconductor materials and devices principles. [Outcomes (a) and (b)]

Student Study Effort Expected

Class contact:	
▪ Lecture	26 Hrs.
▪ Tutorial	4 Hrs.
▪ Laboratory	9 Hrs.
Other student study effort:	
▪ Self-study	39 Hrs.
▪ Laboratory reports	10 Hrs.
▪ Term paper	20 Hrs.
Total student study effort	108 Hrs.

Reading List and References	1. Advanced Semiconductor Fundamentals, 2nd Edition. Robert F. Pierret, Prentice Hall, 2003. 2. Semiconductor Devices – Physics and Technology. 3rd Edition. S.M. Sze & M.K. Lee. John Wiley & Sons, Inc. 2012. 3. The Physics of Solar Cells. J. Nelson. Imperial College Press. 2003 4. Physics of Semiconductor Devices, S.M. Sze, Kwok K. Ng, 3rd Edition. John Wiley & Sons, Inc. 2007 5. Fundamentals of solid-state lighting: LEDs, OLEDs, and their applications in illumination and displays. Vinod Kumar Khanna. CRC Press 2014

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.
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. <u>Basis of digital communication</u>
   - 1.1 Ways to measure information and Huffman code
   - 1.2 A brief introduction to Shannon capacity
   - 1.3 Geometric representation of signals
2. <u>Uncoded communication systems</u>
   - 2.1 Decoding strategies at the receiver
   - 2.2 Error probability analysis
   - 2.3 Digital modulation principles
3. <u>Coded communication systems</u>
   - 3.1 Introduction of codes
   - 3.2 Decoding strategies at the receiver
   - 3.3 Error probability analysis
   - 3.4 Convolutional codes
4. <u>Case study 1: Broadband communication in 5G</u>
   - 4.1 Massive MIMO (multiple-input multiple-output)
   - 4.2 Cloud RAN (radio access network)
5. <u>Case study 2: IoT in 5G</u>
   - 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 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/Tutorials	✓	✓	✓	✓	✓		✓		✓
Mini-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
Assignments	30%	✓	✓	✓	✓	✓		✓		
Tests	40%	✓	✓	✓	✓	✓		✓		
Mini-project	30%	✓					✓	✓	✓	✓
Total	100%									

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

	Assignments and tests let students review the taught materials, do further reading for deeper learning and apply the learnt materials to modern communication systems.. Mini-project requires the students to do further reading, search for information, keep abreast of current development, give presentations and write a report.	
Student Study Effort Expected	Class contact:	
	▪ Lecture/Tutorial/Tests	33 Hrs.
	▪ Presentation	6 Hrs.
	Other student study effort:	
	▪ Lecture: further reading, doing homework/ Assignment	30 Hrs.
	▪ Mini-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.	

Subject Description Form

Subject Code	EIE580
Subject Title	Radio Frequency and Microwave Integrated Circuits for Communication System Applications
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Nil
Objectives	To study and understand the operating principles and design schemes of radio frequency and microwave integrated circuits for communication system applications.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. Establish and develop the overall knowledge of RF and microwave integrated circuits and devices for wireless communication applications b. Model and analyze the performances of communication circuits and subsystems with practical design parameters c. Design and evaluate the building blocks of communication systems such as wireless transmitter and receiver.
Subject Synopsis/ Indicative Syllabus	1. <u>Overview of Communication Systems and Review of Transmission Line Theory</u> Wireless and radiofrequency systems, communication techniques, receiver and transmitter architectures, waveguides and transmission lines, Smith chart, S-parameters, passive (linear) components, and active (non-linear) circuits. 2. <u>Passive and Linear Components</u> Lumped-element and transmission line elements, impedance transformers, impedance matching techniques, directional couplers, resonators, low-pass, bandpass, bandstop and high-pass filters, diplexers and multiplexers, circulators and isolators. 3. <u>Active and Nonlinear Circuits</u> Diodes and transistors, thermal noise and noise figure, nonlinear and intermodulation distortions, IP3, nonlinear analysis, dynamic range, two- and three-terminal devices, oscillators and frequency synthesizer, low-noise amplifier (LNA), power amplifier (PA), single-ended and balanced mixers 4. <u>Wireless Communication Front-End Subsystems</u> Antenna, modulators, demodulators, communication devices, radar techniques, radiofrequency identification (RFID) techniques, low-noise system design, power amplifier design, linearization techniques, and system simulation.

Teaching/Learning Methodology	Through the lectures and tutorials, students can develop basic knowledge of RF and microwave integrated circuits as well as techniques for analyzing the performance of communication circuits. Through the mini-project, student can apply the basic knowledge and analytical technique to design and evaluate the building blocks of communication systems.

Teaching/Learning Methodology	Intended Subject Learning Outcomes		
	a	b	c
Lectures	✓	✓	
Tutorials	✓	✓	
Laboratory sessions	✓	✓	✓

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
1. Continuous assessment				
Mid-semester test	15%	✓	✓	✓
End-of-semester test	15%	✓	✓	✓
Laboratory work on simulation package	10%		✓	✓
Laboratory work on RF passive circuits	10%		✓	✓
Laboratory work on RF mixers	10%		✓	✓
2. Examination	40%	✓	✓	✓
Total	100%			

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

The basic knowledge and modeling of RF and microwave integrated circuits can be assessed through examination, test and laboratory exercises.

The design and evaluation techniques for RF and microwave integrated circuited can be assessed through the laboratory exercises.

Student Study Effort Expected	Class contact:	
	▪ Lecture	18 Hrs.
	▪ Tutorial	9 Hrs.
	▪ Laboratory session	12 Hrs.
	Other student study effort:	
	▪ Self-study	66 Hrs.
	Total student study effort	105 Hrs.
Reading List and References	1. Bogdanov, G and Ludwig, R.*RF Circuit Design: Theory & Applications*, 2nd edition, Pearson Education Inc., Upper Saddle River, NJ, USA, 2009. ISBN : 978-0-13 135505-7 2. Bowick, C.*RF Circuit Design,* 2nd edition, Newnes, , Burlington, MA, USA, 2008. ISBN : 978-0-7506-8518-4 3. Yip, P.*"High Frequency Circuit Design and Measurements"* Chapman and Hall, London, UK, 1990. ISBN : 0-412-34160-3 4. Pozer, D."*Microwave Engineering*" 2nd edition, John Wiley & Sons, New York, USA, 1998. ISBN : 0-471-17096-8 5. Liao, S. Y. "*Microwave Circuit Analysis and Amplifier Design*", 3rd Edition, Prentice Hall, New Jersey, 1987. ISBN : 0-135-81786-2	

July 2021

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. Introduction 1.1 Elements of a typical digital communication system 1.2 Types of channel 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. Linear Block Codes 2.1 Parity checks 2.2 Systematic codes and generator matrices 2.3 Parity-check matrix, parity-check equations and graphical representation 3. Convolutional Codes 3.1 Encoder Constraint length, memory, generator matrix, state diagram, code tree and trellis 4. Decoder 4.1 Maximum-likelihood (ML) decoding, maximum a posteriori (MAP) decoding 4.2 Hard decision decoder and soft decision decoder 5. Turbo Codes 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	25%	✓	✓	✓	
2. Test	25%	✓	✓		
3. Simulation	20%	✓	✓	✓	
4. Case study	30%	✓	✓		✓
Total	100%				

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

Assignments and test 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, give a presentation and write a report.

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, writing a report, 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/	

Subject Description Form

Subject Code	EIE589
Subject Title	Wireless Data Network
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The students are expected to have some basic knowledge about IP networks.
Objectives	1. To introduce the fundamental issues, concepts, and design principles in wireless data networks and systems. 2. To understand the key concepts towards 4G and 5G Wireless and the convergence of cellular network and the Internet 3. To introduce Low-Power Wide-Area Networks for Internet of Things (IoT) 4. To understand software defined network and network function virtualization.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** a. Understand network topology, layered architecture and protocols of current and emerging wireless data network systems and their standards. **(2) Attributes for all-roundedness** b. Communicate effectively. c. Think critically and creatively. d. Assimilate new technological development in related field.
Subject Synopsis/ Indicative Syllabus	1. Internet standards 1.1. IETF work on IPv6 and transition from IPv4 to IPv6 1.2. IPv6 prefix allocation, DNSSEC 1.3. Internet mobility 1.4. IPv6 security 2. Cellular Networks: 4G towards 5G Wireless 2.1. Overview of cellular networks standards 2.2. Radio Access Network: key concepts in 3GPP Long Term Evolution (LTE) 2.3. Core Network: 3GPP Evolved Packet Core (EPC) 2.4. Connection and session management 2.5. 5G Wireless 3. Low-Power Wide-Area Networks for IoT 3.1. Overview of long range communications at a low bit rate among things 3.2. Protocols in non-licensed band: LoRa, Sigfox 3.3. 3GPP Protocols in licensed band: LTE-M, EC-GSM, NB-IoT 4. Software defined network and Network virtualization 4.1. Distributed versus centralized routing control 4.2. Software defined network 4.3. Virtualization in information technology and networking 4.4. Service function chaining

Teaching/Learning Methodology

Internet and Wireless networks are taught with emphasis on fundamental understanding of the architecture, components, and protocols. The fundamentals of Internet are taught with IPv6 protocols defined in Internet Engineering Task Force (IETF). The latest developments towards 5G Wireless standards are explained. New concepts of software defined network and network function virtualization will be presented together with emerging cellular network designs and standards. These examples will help students not only to learn the theoretical material but also to understand the practical issues. The students will be able to understand the challenges associated with the latest generations of wireless networks and get an insight into new techniques under development.

Teaching/Learning Methodology	Intended Subject Learning Outcomes			
	a	b	c	d
Lecture	✓			
Tutorial	✓		✓	
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. Midterm test	40%	✓	✓	✓	✓
2. Final examination	60%	✓	✓	✓	✓
Total	100%				

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

Assignments let students review the taught materials, do further reading for deeper learning and apply the learnt materials to solving circuit design problems.

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

Student Study Effort Expected

Class contact:	
▪ Lecture/Tutorial	33 Hrs.
▪ Case study – presentations and discussions	6 Hrs.
Other student study effort:	
▪ Lecture: further reading, doing homework /assignment	72 Hrs.
Total student study effort	111 Hrs.

Reading List and References

1. "5G System Design", Wan Lei, Anthony C.K. Soong, Liu Jianghua, Wu Yong, Brian Classon, Weimin Xiao, David Mazzarese, Zhao Yang, Tony Saboorian, Springer, 2020
2. "5G Mobile Communications", Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen, Springer, 2017
3. "Wireless Communications: Principles, Theory and Methodology," Keith Q.T. Zhang, Wiley, 2016
4. "Data Communications and Networking", Behrouz A. Forouzan, McGraw-Hill,

	2013 5. 3GPP standards: http://www.3gpp.org 6. IETF rfc in IPv6 and transition from IPv4 to IPv6: http://tools.ietf.org/html/rfcxxxx