Department of Electrical and Communication Engineering

Master of Engineering in Communication Engineering

(Proposed)

INTRODUCTION

The Department of Electrical Engineering was established to produce highly qualified professionals and technical manpower in the field of Electrical, Electronics and Communication Engineering. The Department runs degree programs, organizes and conducts short-term training programs on the topics of interest for practicing engineers, technicians as well as technical teachers of various organizations, colleges and schools. The graduating engineer of the department can work as a design engineer, technologist and maintenance engineer, as a researcher in research institutions and as a manager in firms dealing with production, service and trade in the field of Electrical, Electronics and Communication engineering at various industrial and commercial establishments.

It is imperative and indeed a demand to look ahead for the department curriculum to meet the present and future needs of the country in the field of Communication engineering and to provide educational means to meet these needs. Thus to minimize the gap between the state of the art technology and the present teaching learning process, the department has successfully brought the changes in the curriculum that supports and maintain the relevance of educational standards in the field of engineering. Thus the department proposes a Graduate Program with specialization in Communication Engineering.

Rationale of the Graduate Program

The basic rationale for all of the programs is the prevailing conditions in the country as a whole with respect to the needs for professionals in the proposed areas and the future trends that are developing in the demands for the professions. The following points provide some of the major facts and observations on which the need for developing of the postgraduate programs premised.

a) **Country's Need:** The needs of the country for engineers specialized in specific areas of Communication engineering can be met through graduate studies that are being currently proposed. The graduate program that is now proposed is an outgrowth of the experiences of the department in offering undergraduate courses over the years, and a series of discussions within the Department and with major employers/stakeholders and practicing professionals.

b) **Rapid development:** With the rapid development of ICT and communication networks in the country deeper knowledge of various branches of Communication engineering is required.

c) **Future Economy:** We feel, the country would take necessary steps to strengthen the Communication industrial sectors for its economy. To equip the students with the necessary knowledge and skills for assisting such vision and objectives of country, it would be necessary to launch P.G program in these fields.

d) **Increasing number of Graduates:** With the increasing number of graduates from the Electrical and Communication engineering department, it is becoming inevitable that many shall be seeking higher education. In addition many practicing engineers and teaching staff in the ranks of Graduate Assistants and Assistant Lecturers at the Universities both in and outside the country are seeking for admission into Graduate Programs.

e) **Limited Higher Learning Institutes:** Limited or no number of higher learning institutions offering the proposed programs in country.

f) **Research and Development:** The higher studies in these fields are essential for engineers who can engage themselves in academic and industrial sector in fields, such as research, development and engineering administration is also being felt.

IMPACT ON CONTACT HOURS FOR THE DEPARTMENT COURSES [CORE]

There is no major change of contact hours. We have already recruited three faculties in the department. One has already joined and two are about to joint in Jan. /Feb. 2019. One faculty has come back from study leaves. Some more applications have been received and we are planning to conduct interviews soon.

IMPACT ON RESOURCES

None

IMPACT ON OTHER DEPARTMENTS / PROGRAMS

None

IMPACT ON CONTACT HOURS FOR THE SERVICE COURSES

None

Program Outcome

On completion of this program, students will be able to:

1. Apply knowledge from basic engineering and other disciplines to identify, formulate and present solutions to technical problems related to Communication engineering and technology.
2. Manage new technologies in the fields of tele and wireless networks along with the concepts of that require advanced knowledge within the field.
3. Design advanced state of the art communication systems and conduct experiments, analyze and interpret data.
4. Select techniques, modern engineering tools, software and equipment necessary to evaluate and analyze the systems in tele environments.
5. Create and conduct a systematic study on significant research topic within the field at global standards.
6. Communicate professionally, develop confidence for self-education and use it for lifelong learning.

Duration of the program:

The department offers a full time Post Graduate program of four semesters spread over two academic years.

Degree Nomenclature

The degree awarded shall be Master of Engineering in Communication Engineering.

Admission Requirements

Entry is open to students with a four (4) year Bachelor of Engineering degree in Electrical/Electronic/ Instrumentation/Communication/Power/Electrical and Communication Engineering or equivalent. The rules about admission, registration, supervision and administration of postgraduate programs shall be those of the PNG University of Technology applicable to Master of Engineering programs.

Graduation Degree Requirements

In order to complete the degree requirements, each student is expected to earn credits as required by PNG University of Technology Master in Engineering programs (Subjects plus a Dissertation).

Course Credit Requirements

The program courses including thesis work contains minimum of 130 credit hours. In the second year, it is required to undertake a suitable thesis work which can be carried out in two phases in the department or industry in consultation with supervisors. During this stage, students must present their work to their respective supervisors to show the progress of their thesis work and the final completion presentation to be made to the panel constituted by Head of Department in consultation with the Principal Supervisor. One supervisor can supervise 2-3 students dissertation in 2nd year. Upon completion, students must submit final documentation to the department at stipulated time.

Course Structure

The program has four semesters. In second semester students are eligible to choose elective courses. Every student will carry out dissertation under the supervision of a Supervisor(s). The topic shall be approved by a Committee constituted by Head of Department. Every student will be required to present two seminars, first at the beginning of Dissertation (Phase-I) to present the scope of the work and to finalize the topic and second towards the end of the semester presenting the work carried out by him/her during the semester. The Dissertation Phase-1 will be continued as dissertation in 4th Semester. At the end of fourth semester the thesis work will be evaluated by two external examiners.

SUBJECTS AND SCHEDULES

Credit Structure

Credits	Semester I	Semester II	Semester III	Semester IV	Total
Core Courses	43	31			74
Elective Courses		11			11
Seminar		1			1
Thesis			22	22	44
Total	43	43	22	22	130

Course Matrix

Year I **Semester I**

Course	Course Title	CCC	L	T	Lab	Prerequisite
EE-511	Information Theory and Coding	11	2	1	0	-
EE-512	Linear algebra and Special functions	11	2	1	0	-
EE-513	Research Methodology	9	2	0	0	-
EE-514	Advanced Digital Communication	12	2	1	1	-
	Total	43	8	3	1	-

Year I **Semester II**

Code	Course Title	Credi	L	T	Lab	Prerequisite
EE-521	Statistical Signal Processing	11	2	1	0	EE -512
EE-522	Optical Communication Networks	11	2	1	0	EE-514
	Elective I	11	2	1	0	-
EE-523	Entrepreneurship for Engineers	9	2	0	0	
EE-524	Technical Seminar	1	0	0	1	-
	Total	43	8	3	1	-

Elective I

Code	Name of the subject	Prerequisite
EE-525	Nonlinear Dynamics	EE512, EE521
EE-526	Electromagnetic Interference and Compatibility in System Design	-
EE-527	Mobile Communication Networks	-
EE-528	Wireless Sensor Networks	-
EE-529	Base band algorithms on FPGA	-
EE-530	Mobile Adhoc Networks	-
EE531	Wireless Security	-

Year II **Semester I**

Course	Course Title	CCC	L	T	Lab	Prerequisite
EE-611	Thesis phase I	22	0	0	15	

Year II **Semester II**

Course	Course Title	Credit	L	T	Lab	Prerequisite
EE-611	Thesis phase II	22	0	0	15	EE-611

M.E. (COMMUNICATION ENGINEERING): SEMESTER-1

Proposed

EE-511: INFORMATION THEORY AND CODING

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: NIL

Learning Outcomes: On completion of this subject, students will be able to:

1. Design Analog communication systems to meet desired needs.
2. Examine the practical implementation issues, such as Error control coding, convolutional code.
3. Design and develop digital and analog systems.
4. Test various error correction techniques
5. Formulate convolution codes for information exchange.

Syllabus

Information theory

Concept of amount of information -units, Entropy -marginal, conditional and joint entropies -relation among entropies Mutual information, information rate, channel capacity, redundancy and efficiency of channels.

Discrete channels

Symmetric channels, Binary Symmetric Channel, Binary Erasure Channel, Cascaded channels, repetition of symbols, Binary unsymmetric channel, and Shannon theorem. Continuous channels – Capacity of band limited Gaussian channels, Shannon-Hartley theorem, Tradeoff between band width and signal to noise ratio, Capacity of a channel with infinite band width, Optimum modulation system.

Source coding

Encoding techniques, Purpose of encoding, Instantaneous codes, Construction of instantaneous codes, Kraft's inequality, Coding efficiency and redundancy, Noiseless coding theorem. Construction of basic source codes – Shannon-Fano algorithm, Huffman coding, Arithmetic coding, ZIP coding.

Error detection and correction

Parity check coding, Linear block codes, Error detecting and correcting capabilities, Generator and Parity check matrices, Standard array and Syndrome decoding, Hamming codes, Encoding and decoding of systematic and unsystematic codes. Cyclic codes – Generator polynomial, Generator and Parity check matrices, Encoding of cyclic codes, Syndrome computation and error detection, Decoding of cyclic codes, BCH codes, RS codes, Burst error correction.

Convolutional codes

Encoding- State, Tree and Trellis diagrams, Maximum likelihood decoding of convolutional codes - Viterbi algorithm, Sequential decoding -Stack algorithm. Interleaving techniques – Block and convolutional interleaving, Error Control and Signal Space Coding.

Text Books:

1. Herbert Taub, and Donald L. Schilling, Principles of Communication Systems, Tata McGraw-Hill, 2007
2. Simon Haykin, Communication Systems, John Wiley & Sons. Pvt. Ltd, 2009

Reference(s) Books

1. Shu Lin and Daniel J. Costello, Error Control Coding Fundamentals and Applications, Prentice Hall Inc, 2004.
2. Sklar Bernard, Digital Communications Fundamentals and Applications, Person Education Asia, 2001

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1 x 3 hours)

EE-512: LINEAR ALGEBRA AND SPECIAL FUNCTIONS

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: NIL

Learning Outcomes: On completion of this subject, students will be able to:

1. Integrate under graduate fundamentals with advanced knowledge to solve complex problems.
2. Test the idea of optimization and its applications.
3. Create Eigen values and Eigen vectors from differentiable equations.
4. Combination of theoretical knowledge and independent mathematical thinking using special functions.
5. Formulate the complex mathematical model of engineering problems

Syllabus

Calculus of Variations

Introduction to variation problems - Euler's equation - Functional dependent on first and higher order derivatives - Functional dependent on functions of several independent variables - Some applications - Direct methods: Ritz methods.

Vector space

Definition and examples of linear space - Linear dependence and independence - Basis and Dimension - lnner product space - Orthogonalization process - Gram - Schmidt process Least - square problems - Applications of inner product spaces.

Eigen values and Eigen vectors

Generalized Eigen values and Eigen vectors - Characteristic equation - Diagonalization - Eigen vectors and linear transformations - Complex Eigen values - Applications to differential equations - Iterative estimates for Eigen values.

Advance matrix theory

Diagonalization of symmetric matrices - Quadratic forms - Singular values decomposition - Change of basis. Matrix norms - Jordan canonical form - Pseudo inverse - Least square approximations -QR algorithm.

Special Functions

Bessel's equation – Bessel functions – Legendre's equation – Legendre's polynomials – Rodrigues's formula – Recurrence relations – Generating functions and orthogonal property for Bessel's functions – Strum-Liouville problem – Error functions.

Text Books:

1. David C Lay, Linear Algebra and its Applications, Pearson Education Asia, New Delhi, 2012.
2. Elsgolts.L, Differential Equation and Calculus of variations, MIR Publishers, 1996.

Reference Book(s):

1. B S Grewal, Higher Engineering Mathematics, Fortieth Edition, Khanna Publications, New Delhi 2014.
2. Howard Anton, Elementary Linear Algebra, John Wiley & Sons, 2010.
3. Raisinghania. M. D, Ordinary and partial differential equations, S. Chand & Co, New Delhi, 2006.

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1 x 3 hours)

EE 513: RESEARCH METHODOLOGY

Hours per week: **[Lecture: 2, Tutorial: 0, Laboratory: 0]**

Credits: **09**

Prerequisite: NIL

Course Outcomes: After completion of this subject, the students will be able to

1. Demonstrate the concepts of engineering research and its methodologies.
2. Understand the various methods used to collect the data to research.
3. Categorize the research design into different steps.
4. Formulate appropriate research problem and conduct the experiments using systematics methods.
5. Select appropriate software and hardware tools for the research.

Syllabus:

Foundations of Research: Meaning, Objectives, Motivation, Utility, Characteristics of scientific method
Research Design: Concept and Importance in Research, Features of a good research design, Background research for experimental planning
Experiments Design: Statistical data analysis, executing engineering experiments and analyzing experimental findings,
Communication and Ethics: Oral communication of research, Written communication of research, Engineering ethics, plagiarism and information sources, Intellectual property, social impact, and financial considerations of engineering research, Laboratory safety, a laboratory notebook maintenance.
Software and hardware tools: Matlab, LabView, Arduino, etc.

Text Book(s)

1. C.R Kothari., Research Methodology: Methods and techniques, New Age Publications, New Delhi, 2009.
2. R. Panneerselvam, Research Methodology, Prentice-Hall of India, New Delhi, 2004.

Reference Book(s):

1. Alan Bryman and Emma Bell, Business Research Methods, Oxford University Press.
2. Donald Cooper and Pamela Schindler, Business Research Methods, TMGH, 9th edition

Assessment:
Continuous: 100% (Individual reporting-20%, Weekly Assignment- 30%, Case study 50%)

EE 514: ADVANCED DIGITAL COMMUNICATION

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 1]**

Credits: **12**

Prerequisite: NIL

Course Outcomes: On completion of this subject, students will be able to:

1. Design Analog communication systems to meet desired needs.
2. Evaluate fundamental communication system parameters, such as bandwidth, power, signal to noise ratio and data rate.
3. Appraise practical implementation issues, such as non-ideal filters, non-ideal sampling pulses, aliasing, and intersymbol-interference (ISI).
4. Create detection of signal vectors and Gassian noise.
5. Estimate and formulate the parameters of the problem.

Syllabus

Baseband Data Transmission

Baseband PAM –One Shot Minimum Distance Receiver –Minimum Distance Sequence Detection-M-ary signaling scheme-shaping of the transmitted signal spectrum-Noise in Baseband System - Coherent and Non coherent Technique, Orthogonal Modulation-OFDM modulation and Demodulation–Multidimensional Modulation-Modulation with Memory.

Band-limited channels

Pulse shape design for channels with ISI: Nyquist pulse, Partial response signaling (duobinary and modified duobinary pulses), demodulation; Channel Models: Fading Dispersive channel, Time and Frequency Selective, Rayleigh channel, karhunen- Loeve Expansion; Diversity Technique: Space, polarization, path, angle, Time and frequency, Diversity Combining Technique

Equalization

Optimal Zero-Forcing Equalization- Generalized Equalization Methods- Fractionally Spaced Equalizer – Transversal Filter Equalizer –ISI and Channel Capacity –Constrained –complexity Equalizers – Adaptive Linear Equalizer – Adaptive DFE.

Detection

Detection of a Single Real-Valued Symbol- Detection of a Signal Vector –Known Signals in Gausian Noise –ML Sequence Detection with the Viterbi Algorithm – A Posteriori Probability Detection with BCJR- Symbol Error Probability for MLSD – incoherent Detection –Shot Noise Signal with known Intensity. Hypothesis Testing and the MAP Criterion, Bayes Criterion, Minimax Criterion, Neyman- Pearson Criterion, Sequential Detection.

Fundamentals of Estimation Theory

Formulation of the General Parameter Estimation Problem, Relationship between Detection and Estimation Theory, Types of Estimation Problems, Properties of Estimators, Bayes Estimation, Minmax Estimation, Maximum-Likelihood Estimation, Comparison of Estimator Parameters.

Text Books

1. John G. Proakis, Digital Communications, McGraw –Hill International Edition, 2009.
2. John R. Barry, Edward Lee and David G. Messerschmitt, Digital Communication, Springer, 2008.

Reference Book(s)

1. Bernard C. Levy, Principles of Signal Detection and Parameter Estimation, Springer, 2008.
2. Simon Haykin, Communication Systems, PHI, 2008.

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1 x 3 hours)

SEMESTER-2

EE 521: STATISTICAL SIGNAL PROCESSING

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: EE512

Learning Outcomes: On completion of this subject, students will be able to:

1. Design and implement decimator and interpolator.
2. Construct multi rate filter bank and acquires knowledge of how a multi rate system work.
3. Understand different spectral estimation techniques and linear prediction.
4. Design LMS and RLS adaptive filters for signal enhancement, channel equalization**.**
5. Estimate of spectra from finite duration observations of a signal.

Syllabus

Multirate signal Processing

Introduction-Sampling and Signal Reconstruction-Sampling rate conversion – Decimation by an integer factor – interpolation by an integer factor –Sampling rate conversion by a rational factor – poly-phase FIR structures – FIR structures with time varying coefficients - Sampling rate conversion by a rational factor- Multistage design of decimator and interpolator.

Multirate FIR Filter Design

Design of FIR filters for sampling rate conversion –Applications of Interpolation and decimation in signal processing –Filter bank implementation –Two channel filter banks-QMF filter banks –Perfect Reconstruction Filter banks – tree structured filter banks - DFT filter Banks – M-channel filter banks- octave filter banks

Linear Estimation and Prediction

Linear prediction- Forward and backward predictions, Solutions of the Normal equations- Levinson- Durbin algorithms. Least mean squared error criterion -Wiener filter for filtering and prediction, FIR Wiener filter and Wiener IIR filters, Discrete Kalman filter.

Adaptive Filters

FIR Adaptive filters - Newton's steepest descent method – Adaptive filters based on steepest descent method - LMS Adaptive algorithm – other LMS based adaptive filters- RLS Adaptive filters - Exponentially weighted RLS - Sliding window RLS – Simplified IIR LMS Adaptive filter.

Power Spectral Estimation

Estimation of spectra from finite duration observations of a signal –The Periodogram-Use of DFT in Power spectral Estimation –Non-Parametric methods for Power spectrum Estimation – Bartlett. Welch and Blackman–Tukey methods –Comparison of performance of Non – Parametric power spectrum Estimation methods –Parametric Methods - Relationship between auto correlation and model parameters, Yule-Walker equations, solutions using Durbin's algorithm, AR, MA, ARMA model based spectral estimation.

Text Books

1. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing, Pearson Education, 2006
2. Monson H. Hayes, Statistical Digital Signal Processing and Modeling, John Wiley and Sons, Inc., 2008

Reference Book(s)

1. John G. Proakis, Algorithms for Statistical Signal Processing, Pearson Education, 2002.
2. P.P.Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education, 2008.
3. Sophoncles J. Orfanidis, Optimum Signal Processing, McGraw Hill, 2007.

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1x3 hours)

EE 522: OPTICAL COMMUNICATION NETWORKS

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: EE514

Learning Outcomes: On completion of this subject, students will be able to:

1. Understand of various loss mechanisms and Non-Linear effects in optical communication.
2. Apply knowledge of optical components and WDM network elements.
3. Discus about Optical access network architectures
4. Compare layered architecture of, IP and MPLS over SONET network.
5. Measure Photonic packet switching, impediments involved and available techniques like switching, buffering, multiplexing and synchronization.

Syllabus:

Optical Signal propagation and System Components

Propagation in optical fibers – Loss & bandwidth windows, Intermodal dispersion, Optical fiber as waveguide, Chromatic dispersion, , Non-Linear effects; Solitons; Optical Network Components– Couplers, Isolators &Circulators, Multiplexers & Filters, Optical Amplifiers, Switches, Wavelength Converters.

Client layers of Optical Layer

SONET / SDH-Multiplexing, CAT & LCAS, SONET/SDH Layers, SONET Frame structure, Elements of SONET/SDH infrastructure, Optical Transport Network- Hierarchy, Frame structure multiplexing, Generic Framing Procedure, Ethernet-Framing structure, switches, IP over WDM- routing and forwarding, QoS, MPLS-Labels and forwarding, QoS, signaling and routing,. Carrier transport, resilient packet ring, storage area networks.

WDM Network Elements and Design

WDM Network elements - Optical line terminals, Optical line amplifiers, Optical Add/drop multiplexers-Architectures, Reconfigurable OADMs,, Optical cross connects, All optical OXC configurations. WDM Network Design – Cost Trade-Offs: A detailed ring network example, LTD and RWA problems, dimensioning Wavelength routing networks, Stastical dimensioning Models, Maximum load dimensioning models

Packet switching and Access networks

Photonic Packet Switching – OTDM, Multiplexing and De-multiplexing, Synchronization, Header processing, Buffering, Burst switching, OTDM Access Networks – Network Architecture Overview, Enhanced HFC, FTTC, PON – Evolution.

Network Design and Management

Transmission System Engineering – System model, Power penalty - transmitter, receiver, Optical amplifiers, crosstalk, dispersion; Wavelength stabilization ; Overall design considerations; Control and Management – Network management functions, Optical layer services and interfacing, Layers within optical layer, Multivendor interoperability, Performance and fault management, Configuration Management.

Text Books

1. Rajiv Ramaswami and Kumar Sivarajan, Optical Networks: A Practical Perspective, Morgan Kaufmann, 2010.
2. Vivek Alwayn, Optical Network Design and Implementation, Pearson Education, 2006.

Reference Book(s)

1. Biswanath Mukherjee, Optical Communication Networks, Tata McGraw Hill, 2004.
2. P.E. Green, Jr., Fiber Optic Networks, Prentice Hall, NJ, 2005.

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1x3 hours)

EE 523: ENTREPRENEURSHIP FOR ENGINEERS:

Hours per week: **[Lecture: 2, Tutorial: 0, Laboratory: 0]**

Credits: **9**

Prerequisite: NIL

Learning Outcome: On completion of this subject, students will be able to:

1. Create a full business plan, a virtual company website.
2. Compare and organize several product presentations.
3. Compete in both the end-of-semester competitions in campus and off campus.
4. Present and discuss critical importance of entrepreneurship to world's economy (employment, technology advancement, societal development, etc.).
5. Enable students to hear from, and interact with, entrepreneurs from various sectors of economy like software, telephony, energy, light, water, social networks and enterprises, entrepreneurship and finance.

Syllabus:

The course focuses on business sectors that derive from disciplines and areas of study. Engineering Entrepreneurship is a full-immersion, multidisciplinary, engineering experience holistically designed to integrate the skills and knowledge of the students in a more in-depth exposure to new product and business development to the engineering profession. The subject covers: Entrepreneurial engineer's readiness in 21st century, innovation, money, work, time, human behavior, ethics, organization and leadership, and assessment of technology opportunities.

Text Book:

1. David Goldberg, The Entrepreneurial Engineer. Wiley, USA, 2006.

Assessment:

Continuous: 100% (Individual reporting-20%, Weekly Assignment- 30%, Case study 50%)

EE 524: TECHNICAL SEMINER

Hours per week: **[Lecture: 0, Tutorial: 0, Presentation: 1]**

Credits: **1**

Prerequisite: NIL

Every student will be required to present a seminar on a topic approved by the Department except on his/her dissertation. The committee constituted by the Head of Department will evaluate the presentation and will award the grades accordingly.

ELECTIVES

EE 525: NONLINEAR DYNAMICS

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: EE512, EE514

Learning Outcomes: On completion of this subject, students will be able to:

1. Demonstrate the ability to design and analyze nonlinear systems.
2. Develop algorithms for controlling nonlinear systems.
3. Test Chaos in the nonlinear systems.
4. Design various applications of nonlinear systems.
5. Formulate control algorithms for nonlinear systems.

Syllabus

The implications of nonlinearity, dynamics and chaos

The role of dimensionality, One-dimensional systems, one dimensional ows: visualizing the solution space; stability and xed points; linear stability analysis; existence and uniqueness. Applications and numerical methods, Bifurcations: saddle-node, trans-critical and pitchfork, Flows on the circle: uniform and nonuniform oscillators. The case of the over-damped pendulum. Applications.

Two dimensional systems

Beyond linear systems, Phase portraits; topological consequences; fixed points and linearization. Conservative versus dissipative systems, Reversible systems, the important case of the pendulum, Limits cycles in non-conservative systems. Closed orbits in conservative systems. Poincare-Bendixson Theorem. Existence of limit cycles, Back to bifurcations: Hopf bifurcations. Global bifurcations of cycles. Poincare maps.

Chaos

Lorentz system of equations. Symbolic dynamics illustrated for this system. Introduction to strange attractors, One dimensional maps. The logistic map. Fixed points, cobwebbing and crises. Lyapunov exponents. Universality and renormalization, Planar maps. The standard and Henon maps. Local versus global chaos. More on attractors. Self-similarity, fractals, Meet the Cantor set. Generalized dimensions.

Control algorithms

Adaptive control, back stepping and sliding mode controls and its applications in synchronization.

Text books:

1. Hassan K. Khalil, Nonlinear Systems, 3rd Edition Prentice Hall, 2002.
2. Kemin Zho and Jonn Doyle, Essentials of Robust Control, Prentice Hall, 1998.

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1 x 3 hours)

EE 526: ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: NIL

Learning Outcomes: On completion of this subject, students will be able to:

1. Demonstrate electromagnetic concepts and its measuring parameters.
2. Compare EMI coupling of various types.
3. Design and architecture of Micro machined Antennas.
4. Model Mems phase shifters and its applications.
5. Design PCBs for various applications.

Syllabus

EMI Environment

EMI/EMC concepts and definitions, Sources of EMI, conducted and radiated EMI, Transient EMI, Time domain Vs Frequency domain EMI, Units of measurement parameters, Emission and immunity concepts, ESD.

EMI Coupling Principles

Conducted, Radiated and Transient Coupling, Common Impedance Ground Coupling, Radiated Common Mode and Ground Loop Coupling, Radiated Differential Mode Coupling, Near Field Cable to Cable Coupling, Power Mains and Power Supply coupling.

EMI/EMC Standards and Measurements

Civilian standards - FCC, CISPR, IEC, EN, Military standards - MIL STD 461D/462, EMI Test Instruments /Systems, EMI Shielded Chamber, Open Area Test Site, TEM Cell, Sensors/Injectors/Couplers, Test beds for ESD and EFT, Military Test Method and Procedures.

EMI Control Techniques

Shielding, Filtering, Grounding, Bonding, Isolation Transformer, Transient Suppressors, Cable Routing, Signal Control, Component Selection and Mounting.

EMC Design of PCBs

PCB Traces Cross Talk, Impedance Control, Power Distribution Decoupling, Zoning, Motherboard Designs and Propagation Delay Performance Models.

Text Books:

1. C.R. Paul, Introduction to Electromagnetic Compatibility, John Wiley and Sons, Inc, 2005.
2. Henry W.Ott, Noise Reduction Techniques in Electronic System, John Wiley and Sons, 2008

Reference Book(s)

1. Bernhard Keiser, Principles of Electromagnetic Compatibility, Artech house, 1986.
2. V.P.Kodali., Engineering EMC Principles, Measurements and Technologies, IEEE Press, 1996.

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1x3 hours)

EE 527: MOBILE COMMUNICATION NETWORKS

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: NIL

Learning Outcomes: On completion of this subject, students will be able to:

1. Inspect the concepts of Cellular and Mobile Radio propagation.
2. Manage modulation and demodulation used in communication.
3. Rate multiple access techniques to solve communication problems.
4. Outline organization of Cellular networks and appreciate differences with fixed networks.
5. Infer on evolution of cellular networks and evaluate 2G and 3G networks.

Syllabus

Cellular Concepts and System Design Fundamentals

Evolution of mobile communications, mobile radio systems- Examples, trends in cellular radio and personal communications. Cellular Concepts: Frequency reuse, Channel assignment, Hand off strategies, Interference and system capacity, tracking and grade of service.

Mobile Radio Propagation

Free space propagation model, reflection, diffraction, scattering, Outdoor Propagation models, Indoor propagation models, Small scale Multipath propagation, Small scale Multipath measurements, parameters of Mobile multipath channels, fading and its types.

Modulation and Multiple Access Techniques

Minimum Shift Keying (MSK), Gaussian MSK, Orthogonal Frequency Division Multiplexing, Multiple Access Techniques: TDMA, FDMA, CDMA, SDMA.

2G and 2.5G Networks

Evolution of Cellular networks – AMPS, DECT and TETRA. GSM - GSM Network Architecture, Air Interface, Channel Organization, Protocols and signaling, Authentication and security, Routing of a call to Mobile Subscriber, Handover in GSM 2.5G-GPRS Network Architecture, Mobility Management, Location Management and Roaming

3G Networks and Beyond

UMTS Network Architecture, UMTS Interfaces, Channels, FDD and TDD, Time Slots, UMTS Network protocol architecture and transport network, Mobility Management, UMTS Handover. Concepts of Wi-Fi and WiMAX, Spectrum allocation for 3G, Wi-Fi, WiMAX, 4G and beyond

Improving Coverage and capacity in Cellular systems, Statistical models for multipath fading channels, Spectral Efficiency of different Wireless Access Technologies, Role of IP in GPRS and UMTS, Concepts of 5G, Cognitive Radio

Text Books:

1. Blake, Wireless Communication Technology, Thomson Delmar, 2003.
2. Saha Misra, Wireless Communications and Networks: 3G and Beyond, McGraw Hill Education, 2013.
3. R. T.S. Rappaport and B. Viswanath, Fundamentals of wireless communication, Cambridge Press 2009.

Reference Book(s)

1. Andera Goldsmith, Wireless Communications, Cambridge University Press,2005
2. T.G. Palanivelu, R. Nakkeeran, Wireless and Mobile Communication, PHI, 2009.

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1x3 hours)

EE 528: WIRELESS SENSOR NETWORKS

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: NIL

Learning Outcomes: On completion of this subject, students will be able to:

1. Apply basics of wireless sensor networks to solve network problems.
2. Create applications in enabling technologies.
3. Examine the architecture and elements of wireless sensor networks.
4. Evolution MAC protocols for wireless sensor networks.
5. Select tools and platforms needed to establish sensor networks.

Syllabus

Overview of wireless sensor networks

Challenges for Wireless Sensor Networks-Characteristics requirements-required mechanisms, Difference between mobile ad-hoc and sensor networks, Applications of sensor networks- Enabling Technologies for Wireless Sensor Networks.

Architectures

Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes , Operating Systems and Execution Environments, Network Architecture - Sensor Network Scenarios,Optimization Goals and Figures of Merit, Gateway Concepts.

Networking of sensors

Physical Layer and Transceiver Design Considerations, MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts - S-MAC , Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy- Efficient Routing, Geographic Routing.

Infrastructure establishment

Topology Control – Motivation and Clustering, Time Synchronization - LTS, RBS, Localization and Positioning – Possible approaches, single hop localization.

Sensor network platforms and tools

Operating Systems for Wireless Sensor Networks, Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms, Node-level Simulators, State-centric programming.

Text Books:

1. Bhaskar Krishnamachari, Networking Wireless Sensors, Cambridge Press, 2005.
2. Feng Zhao and Leonidas J. Guibas, Wireless Sensor Networks - An Information Processing Approach, Elsevier, 2007.
3. Holger Karl and Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley, 2005.

Reference Book(s)

1. Kazem Sohraby, Daniel Minoli and Taieb Znati, "Wireless Sensor Networks-Technology, Protocols And Applications, John Wiley, 2007.
2. Mohammad Ilyas and Imad Mahgaob, Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems, CRC Press, 2005.
3. Wayne Tomasi, Introduction to Data Communication and Networking, Pearson Education, 2007.

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1x3 hours)

EE 529: BASEBAND ALGORITHMS ON FPGA

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: NIL

Learning Outcomes: On completion of this subject, students will be able to:

1. Identify various construction blocks and operation of FPGA.
2. Implement arithmetic units and digital filters on FPGA.
3. Create FIR and IIR filter structures.
4. Design and implementation of Fourier transform and various baseband communication blocks.
5. Develop new algorithms based on FPGA.

Syllabus

FPGA Technology
Basics of FPGA, Gate array, Comparison of ASIC and FPGA, Introduction to FPGA Design flow, Programming languages, programming technology

Basic Building Blocks
Number representation, Binary adders, Binary dividers, Floating point arithmetic, MAC &SOP unit

Digital filter implementation
FIR filter, Theory and Structure, Filter design, Constant coefficient, FIR Design IIR filter, IIR theory, Coefficient computation and Implementation details, Fast IIR filter

Fourier Transform
DFT algorithms, Goertzel algorithm, Hartley transform, Winograd DFT, blustein chirp-z transform, Rader algorithm, FFT algorithms, Cooley-tukey, Good Thomas, Winograd FFT

Communication Blocks
Computation of Special Functions Using CORDIC, Error codes, Linear block code, Convolution codes, Modulation and Demodulation, Adaptive filters, LMS, RLS, Decimator and Interpolator, High Decimation Rate Filters.

Text Books:

1. Keshab K. Parhi, ”VLSI Digital Signal Processing Systems, Design and implementation”, Wiley, Inter Science, 1999
2. Uwe.Meyer Basese, “Digital Signal processing with Field Programmable Gate Arrays”, Springer, Third Edition, May 2007

Reference Book(s)

1. John G. Proakis, ”Digital Communications”, Fourth Ed. McGraw Hill International Edition, 2000
2. Michael John Sebastian Smith, ”Applications Specific Integrated Circuits”, Pearson Education, 2000

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1x3 hours)

EE 530: MOBILE ADHOC NETWORKS

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: NIL

Learning Outcomes: On completion of this subject, students will be able to:

1. Identify various challenges and vulnerabilities in MANET.
2. Revise cyber-attacks and threads in mobile networks.
3. Setup and recognize architectures, designing MAC, TCP, IP and security protocols.
4. Analyze the solutions for covering the security principles of adhoc networks.
5. Apply in-depth knowledge of wireless communications principles, systems, and networks to the solution of wireless engineering problems.

Syllabus

Wireless LAN, PAN, WAN and MAN

Characteristics of wireless channel - Fundamentals of WLANs - IEEE 802.11 standard - HIPERLAN– WLL - Wireless ATM - IEEE 802.16 standard – HIPERACCESS- Adhoc Wireless Internet.

MAC and Routing Protocols

MAC: Design issues - Goals and classification - Contention–based MAC protocols: MACAW, DPRMA, DPSMA.MAC protocols using directional antenna- Routing protocols: AODV, DSR, ZRP, LAR,CHGSR,FSR and power-aware routing protocols.

Transport Layer and Security Protocols

Transport layer Protocol: Design issues - Goals and classification - TCP over AdHoc wireless Networks – Security - Security requirements - Issues and challenges in security provisioning - Network security attacks - Security routing.

Energy Management

Need - Classification of battery management schemes - Transmission power management schemes - System power management schemes. Wireless Sensor Networks: Architecture - Data dissemination - Date gathering - MAC protocols - Location discovery - Quality of a sensor network.

Performance Analysis

ABR beaconing - Performance parameters - Route-discovery time - End-to-end delay performance - Communication throughput performance - Packet loss performance - Route reconfiguration/repair time - TCP/IP based applications.

Text Books

1. C. K. Toh, AdHoc Mobile Wireless Networks: Protocols and Systems, Prentice Hall, 2008.
2. C. Siva Ram Murthy and B.S.Manoj, AdHoc Wireless Networks: Architectures and protocols, Prentice Hall, 2007
3. Charles E. Perkins, AdHoc Networking, Addison – Wesley, 2008

Reference Book(s)

1. Mohammad Ilyas, The Handbook of AdHoc Wireless Networks, CRC press, 2002
2. Stefano Basagni, Marco Conti, Silvia Giordano and Ivan Stojmenovic, Mobile AdHoc Networking, Wiley – IEEE press, 2004

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1x3 hours)

EE 531: WIRELESS SECURITY

Hours per week: **[Lecture: 2, Tutorial: 1, Laboratory: 0]**

Credits: **11**

Prerequisite: NIL

Learning Outcomes: On completion of this subject, students will be able to:

1. Identify the various attacks and threads of wireless Networks.
2. Setup and recognize the architectures, vulnerabilities and challenges of mobile protocols.
3. Analyze the solutions for covering the security principles of wireless networks.
4. Analyze and design security systems for wireless networks.
5. Apply in-depth knowledge of wireless communications principles, systems, and networks to the solution of wireless engineering problems.

Syllabus

Attacks on Routing Protocols
Vulnerability of MANET to attack - review of AODV and DSR - type of attack - active and passive - internal and external - behavior of malicious node - black hole, DoS, Routing table overflow, Impersonation, Energy consumption, Information Disclosure - Misuse type – Misuse goals – Security flaw in AODV -attack on AODV - wormhole and rushing attack -Performance analysis of AODV in the presence of malicious node.

Intrusion Detection in Wireless Ad Hoc Networks
Problem in current IDS techniques - requirements of IDS - classification of IDS – Network and host based - anomaly detection, misuse detection, specification based - intrusion detection in MANETs using distributed IDS and mobile agents - AODV protocol based IDS - Intrusion resistant routing algorithms - Comparison of IDS.

Mitigating Techniques for Routing Misbehavior
Watchdog, Parthrater, Packet leashes and RAP.

Secure Routing Protocols:
Self-organized network layer security in MANETs - mechanism to improve authentication and integrity in AODV using hash chain and digital signatures - on demand secure routing protocol resilent to Byzantine failures - ARIADNE, SEAD, SAR, and ARAN.

Challenges in Routing Security
Security - Challenges and solutions - Providing Robust and Ubiquitous security support - Adaptive security for multilevel Ad Hoc Network - Denial of service Attack at the MAC layer - Detection and handling of MAC layer Misbehavior.

Text Books:

1. Amitabh Mishra, Intrusion Detection in Wireless Ad Hoc Networks, IEEE Wireless Communication, February 2004.
2. C.Siva Ram Murthy and B.S.Manoj, AdHoc Wireless Networks: Architectures and Protocols, Prentice Hall PTR, 2004.
3. Ivan Stojmenović, Handbook of Wireless Networks and Mobile Computing, Wiley, 2002.

Reference Book(s)

1. Hongmei Deng, Wei Li and Dharma P. Agrawal, Routing Security in Wireless Ad Hoc Networks, IEEE Communication Magazine, Oct 2002.

Assessment:

Continuous Assessment - 50%
Final Examination - 50% (1x3 hours)