Revised Syllabus for
Master of Science (M. Sc.) / Master of Engineering (M. Engg.)
in
Electrical and Electronic Engineering (EEE)

Introduction

Modern electronics and telecommunications are bringing a revolution in the lives of business and individuals, and play a vital role in the socio-economic development and poverty alleviation. The global economy relies increasingly on high-speed data and other digital data networks interconnecting computers and other digital devices across the world. But it is the electricity, which is the basic need to lift up these industries, and is considered as the driving force of all development activities. The objective of the degree is to produce a well-trained graduate who can use electronic / telecommunication / power system engineering tools to solve real world problems. Students would be trained in cutting-edge research so that they can contribute towards creation of new knowledge. In designing the course, the requirements of IEEE and curricula of North American and European universities and institutes have been taken into consideration.

Structure of M. Sc./ M. Engg. (EEE) Program

Master of Science (M. Sc.) / Master of Engineering (M. Engg.) in Electrical and Electronic Engineering (EEE) degree program is comprised with the following three major divisions:

1. Telecommunications
2. Electronics
3. Power Systems

Courses required for the Masters Degree (M. Sc. / M. Engg.) in Electrical and Electronic Engineering with a concentration in Telecommunications / Electronics / Power Systems consist mainly of core courses, elective courses and a thesis (for M. Sc.) / project (for M. Engg.).

For the degree of M. Sc. a student has to take a minimum of 6 courses of which at least 3 are from his /her assigned division, and remaining 3 are from the other two divisions with at least one from each. For the degree of M. Engg. a student has to take a minimum of 10 courses of which at least 5 are from his/ her division and the remaining 5 are from the other two divisions with at least one from each. The topic of the thesis / project must be related to division of the student or the interdisciplinary group.

Upon admission, each student is assigned an adviser for guidance and direction in meeting the degree requirements and academic goals. A thesis/project supervisor will also be assigned for each student within the second week of the first semester. The students taking the thesis (for M. Sc. in EEE) must submit and present a research proposal to the graduate course committee for final approval.

Admission Criteria

A student intended to take admission to Master Degree (M. Sc. / M. Engg.) in Electrical and Electronic Engineering (EEE) program must have B. Sc. in Electrical & Electronic Engineering (EEE) / Electronic & Telecommunication Engineering (ETE) or equivalent degree with a minimum CGPA of 2.50 out of 4. A candidate who has completed same or equivalent course(s) may be waived from talking that (those) course(s) provided equivalence of that (those) course(s) are done by an "equivalence committee" of the university with respect to the syllabus of the university. The equivalence committee must be approved/ formed by the academic council of the university. The equivalences must be reported to the academic council.

Course Duration

The course duration should be minimum 5 semesters for a full time student. In addition to completing the course work this minimum period is necessary to meet the requirements of graduate project mentioned in EEE 598 and graduate thesis mentioned in EEE 599. A student will have to do research work, write thesis, prepare a presentation, appear in an oral examination, present his work and present his work before an examination committee, must satisfy the examiners. A full time student must register for a minimum of 9 credit hours. A part time student may register for a maximum of 6 credit hours of course in any semester.

Degree Requirements

To obtain an M. Sc. / M. Engg. degree in Electrical and Electronic Engineering (EEE), the students must complete a minimum of 36 credit hours with a minimum CGPA of 2.75 out of 4 scale. Students pursuing M. Sc. in EEE are required to take a total of 6 (3 core and 3 elective) courses of 18 credit hours along with a thesis of 18 credit hours. Students pursuing M.Engg. in EEE are required to take a total of 10 (5 core and 5 elective) courses of 30 credit hours along with a project of 6 credit hours. A student may also be required to take prerequisite and supplementary non-credit courses to improve study skills, presentation and communication skills. The breakdown of the credits for both the streams is listed bellow.

M. Sc. in Electrical and Electronic Engineering	
3 (Three) Core Courses:	9 credits
3 (Three) Elective Courses:	9 credits
Thesis:	18 credits
Total Credits:	**36 credits**

M. Engg. in Electrical and Electronic Engineering	
5 (Five) Core Courses:	15 credits
5 (Five) Elective Courses:	15 credits
Project:	6 credits
Total Credits:	**36 credits**

Credit Hours

Credit hours have been based on the number of hours of lectures that need to be delivered in a week. One-hour lecture per week throughout the semester means 1 Credit Hour. Lectures of a 3 Credit Hours course are delivered in 3 hours per week.

Grading System

The grades for the program will be indicated in the following manner:
90 - 100 = A (4.0) Excellent
85 - <90 = A- (3.7)
80 - <85 = B+ (3.3)
75 - <80 = B (3.0) Good
70 - <75 = B- (2.7)
65 - <70 = C+ (2.3)
60 - <65 = C (2.0) Fair
55 - <60 = C- (1.7)
50 - <55 = D (1.0) Poor
<50 -- -- = F (0.0) Failure

List of M. Sc. / M. Engg. (EEE) Courses

Compulsory Courses

EEE 598 Graduate Project (for M. Engg. in EEE) (6 Credits)
EEE 599 Graduate Thesis (for M. Sc. in EEE) (18 Credits)

Concentration (Core & Electives) Courses:

Telecommunications Division:

Students intending to do concentration in Telecommunications will take at least three (for M. Sc.) / five (for M. Engg.) core courses from the following list of courses and will take at least three (for M. Sc.) / five (for M. Engg.) elective courses from multiple course areas outside the area of Telecommunications with at least one from each division:

EEE 501 Stochastic Processes (3 Credits)
EEE 502 Advanced Digital Communications (3 Credits)
EEE 503 Optical Fiber Communications (3 Credits)
EEE 504 Cellular Mobile Communications (3 Credits)
EEE 505 Wireless Communications
EEE 506 Advanced Digital Signal Processing (3 Credits)
EEE 507 Image and Video Signal Processing
EEE 508 Advanced Computer Networks (3 Credits)
EEE 509 Network Planning, Management and Administration (3 Credits)
EEE 510 Network Programming (3 Credits)
EEE 511 Cryptography and Network Security (3 Credits)
EEE 512 Telecommunication Transmission & Switching Systems (3 Credits)
EEE 513 RF and Microwave Engineering (3 Credits)
EEE 514 Antennas and Propagation (3 Credits)
EEE 515 Information and Coding Theory (3 Credits)
EEE 516 Cloud Computing (3 Credits)

Electronics Division:

Students intending to do concentration in Electronics will take at least three (for M. Sc.) / five (for M. Engg.) core courses from the following list of courses and will take at least three (for M. Sc.) / five (for M. Engg.) elective courses from multiple course areas outside the area of Electronics with at least one from each division:

EEE 506 Advanced Digital Signal Processing (3 Credits)
EEE 507 Image and Video Signal Processing
EEE 531 Image and Speech Recognition (3 Credits)
EEE 532 Image and Video Compression (3 Credits)
EEE 533 Advanced VLSI Design and Testing (3 Credits)
EEE 534 Advanced Microelectronics (3 Credits)
EEE 535 Embedded Systems and Real Time Interfacing (3 Credits)
EEE 536 Advanced Semiconductor Devices (3 Credits)
EEE 537 Power Semiconductor Circuits and Drives (3 Credits)
EEE 538 Advanced CMOS Technology (3 Credits)
EEE 539 Application Specific Integrated Circuit Design (3 Credits)
EEE 540 Nanoelectronics Technology (3 Credits)
EEE 541 Biomedical Electronics (3 Credits)
EEE 542 Artificial Intelegence & Neural Networks (3 Credits)

Power Systems Division:

Students intending to do concentration in Power Systems will take at least three (for M. Sc.) / five (for M. Engg.) core courses from the following list of courses and will take at least three (for M. Sc.) / five (for M. Engg.) elective courses from multiple course areas outside the area of Power Systems with at least one from each:

EEE 561	Energy Conversion Engineering (3 Credits)
EEE 562	Power System Planning (3 Credits)
EEE 563	Optimization of Power System Operation(3 Credits)
EEE 564	Power System Reliability (3 Credits)
EEE 565	Power System Modeling (3 Credits)
EEE 566	Transients in Power Systems (3 Credits)
EEE 567	Advanced Power System Stability (3 Credits)
EEE 568	Advanced Power System Control (3 Credits)
EEE 569	Protection of Power Systems (3 Credits)
EEE 570	Advanced Machine Design (3 Credits)
EEE 571	Generalized Machine Theory (3 Credits)
EEE 572	Modern Control Theory (3 Credits)
EEE 573	Renewable Energy Technologies (3 Credits)

Details of Course Descriptions

Compulsory Courses:

EEE 598 Graduate Project (for M. Engg. in EEE) (6 Credits)

In addition to successful completion of course works, a student must undertake a research project work on M. Engg. in Electrical and Electronic Engineering topic under the guidance of a supervisor in partial fulfilling of the requirements of a degree. The student is required to prepare and submit the report within the time specified. The student submitting a project shall be required to appear at an oral examination through a presentation before an examination committee on a date or dates fixed by the chair of the department and must satisfy the examiners that he/she shows evidence of satisfactory knowledge related to the theory and technique used in his/her project work, and is capable of applying the project to solve the real life problems. The oral examination and submitted report will be graded and a student must get at least a B grade, which is the passing grade for this course.

EEE 599 Graduate Thesis (for M. Sc. in EEE) (18 Credits)

In addition to successful completion of course works, a student must undertake a research work on M. Sc. in Electrical and Electronic Engineering topic under the guidance of a supervisor in partial fulfilling of the requirements of a degree. The student is required to prepare and submit a thesis on his/her research within the time specified. The student submitting a thesis shall be required to appear at an oral examination through a presentation before an examination committee on a date or dates fixed by the chair of the department and must satisfy the examiners that he/she is capable of intelligently applying the results of this research to the solution of problems, of undertaking independent work, and also show evidence of satisfactory knowledge related to the theory and technique used in his/her research work. The oral examination and submitted thesis will be graded and a student must get at least a B grade, which is the passing grade for this course.

Concentration (Core & Electives) Courses:

Telecommunications Division

EEE 501 Stochastic Processes (3 Credits)

Concepts and classification of stochastic processes; special processes (binary transmission, telegraph, random walk, Wiener-Levy, Poisson); transmission of stochastic processes through systems; stochastic

integrals and ergodicity; bandlimited processes; Gaussian processes; Markov processes; Markov chains; counting processes. These topics will be treated with sufficient mathematical rigour so that students will learn various statistical concepts and their inter-relationships in the way of a connected theory.

Recommended Books:

1. Athanasios Papoulis, "Probability, Random Variables, and Stochastic Processes", Mc-Graw Hill.
2. Richard F. Bass, “Stochastic Processes”, Cambridge Series in Statistical and Probabilistic Mathematics.
3. Richard M. Feldman and Ciriaco Valdez-Flores, “Applied Probability and Stochastic Processes” Springer.
4. Roy D. Yates and David Goodman, “Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers”, John Wiley & Sons.

EEE 502 Advanced Digital Communications (3 Credits)

Gaussian Random Variables and Vectors, Random Processes and White Gaussian Noise, Complex Baseband Representation, Signal Space Concepts, Modulation, Proper Complex Random Variables and Vectors, Optimum Reception in AWGN, Optimum Receiver for Linear Memoryless Modulation and Performance, Coherent Detection of Orthogonally Modulated Signals, Noncoherent Communication, Differential Modulation and Detection, Shannon's Capacity Theorem and Spectral Efficiency of Modulation Methods, Signaling on Bandlimited Channels, Equalization, Channel capacity, Wireless Channel Modeling, Signaling Through Slow Flat Fading Channels, Error Control Coding, Analysis of coded systems; Direct sequence and frequency hopped spread spectrum systems.

Recommended Books:

1. J. G. Proakis, Digital Communications, McGraw-Hill.
2. U. Madhow, Fundamentals of Digital Communication, Cambridge University Press.
3. J. M. Wozencraft and I. M. Jacobs, Principles of Communication Engineering, Wiley.
4. T.M. Cover and J.A., "Thomas Elements of Information Theory", Wiley.
5. R.G. Gallager, Information Theory and Reliable Communicatio", Wiley.
6. MIT Open Courseware, 6.450 Digital Communication, web.mit.edu/6.450/
7. J.M. Wozencraft and I.M. Jacobs, "Principles of Communication Engineering", Wiley.

EEE 503 Optical Fiber Communications (3 Credits)

Overview of optical fiber communications, optical fibers: Geometrical-optics description, wave propagation, dispersion in single-mode fibers, dispersion induced limitations, fiber losses, nonlinear optical effects, fiber manufacturing; Optical transmitters: basic concepts, light-emitting diodes, semiconductor lasers, control of longitudinal modes, laser characteristics, transmitter design; optical receivers: basic concepts, common photodetectors, receiver design, receiver noise, receiver sensitivity, sensitivity degradation, receiver performance; Lightwave systems: system architecture, power budget and rise-time budget, long-haul systems, sources of power penalty, computer-aided design; optical amplifiers: Basic concepts, SOA, Raman amplifiers, EDFA, system applications; Dispersion management; multichannel systems: WDM lightwave systems, WDM components, system performance issues, TDM, code-division multiplexing; soliton and coherent lightwave systems, CO-OFDM; optical networks.

Recommended Books:

1. Govind P. Agrawal, Fiber-Optic Communication Systems, John Wiley & Sons, Inc.
2. Gerd Keiser, Optical Fiber Communications, McGraw-Hill.
3. John M. Senior, “Optical Fiber Communications - Principles and Practice, Prentice Hall.
4. Leonid Kazovsky, Optical Fiber Communication Systems, Artech House Publishers.
5. A. J. Rogers, Understanding Optical Fiber Communications, Artech House Publishers.

6. Clifford Headley, Govind Agrawal, Raman Amplification in Fiber Optical Communication Systems, Academic Press.
7. Le Nguyen Binh, Optical Fiber Communications Systems: Theory and Practice with MATLAB and Simulink Models; CRC Press.
8. T. Okoshi, K. Kikuchi, Coherent Optical Fiber Communications, Springer.

EEE 504 Cellular Mobile Communications (3 Credits)

Trend of mobile wireless: standard bodies, spectrum allocation, spectrum efficiency considerations; Introduction to cellular systems: basic cellular systems, performance criteria, Uniqueness of mobile radio environment, operation of cellular systems, concept of frequency reuse channels, co-channel interference reduction factor, handoff mechanism, cell splitting, different cellular systems and B3G-systems; Digital cellular systems (2G): GSM, CDMA; B2G systems: GPRS, EDGE, HSCSD, iDEN, PHS, IS-95B; 3G systems: WCDMA-UMTS (UTRA-FDD) physical layer, WCDMA-ARIB physical layer, WCDMA-TDD physical layer, UMTS network architecture, evaluation of UMTS-3GPP release 4 and beyond, cdma2000 physical layer, cdma2000 network, cdma2000 EV-DO and EV-DV, B3G systems: IEEE-based wireless standard systems; Propagation in mobile radio channels: channel models, fading; Multiple access techniques: FDMA, TDMA and Spread Spectrum Communications; DS-CDMA and FH-CDMA: modulator and demodulator structure, probability of error, jamming margin, decoding, performance in the presence of interference, PN sequence, CDMA. Multi-user detection: multiple access interference, detector performance measures - BER, asymptotic efficiency, near-far resistance; detectors including - matched filter detector, de-correlator detector ; Diversity and combining techniques: Multiple antenna systems - SISO, SIMO, MISO and MIMO systems, STBC, OSTBC, QOSTBC, spatial multiplexing (SM) schemes; Interference and management and mobility management in wireless communications, security in wireless communication systems. Multi-carrier communications: OFDM - oscillator based and FFT implementation; special issues of OFDM - cyclic prefix, timing offset, frequency offset, synchronization, peak power problem; OFDMA, MC-CDMA, WiMAX; industry standards.

Recommended Books:

1. T. S. Rappaport, Wireless Communications: Principles and Practice, Prentice Hall.
2. Jack M. Holtzman , David J. Goodman, Wireless and Mobile Communications, Springer.
3. W. C. Y. Lee, Wireless & Cellular Telecommunications, 3rd Edition, McGraw Hill.
4. Mischa Schwartz, Mobile Wireless Communications Cambridge University Press.
5. Vijoy K. Garg , Wireless Communications & Networking, Morgan Kaufman Publications.
6. Krzysztof Wesolowski, Mobile Communication Systems, John Wiley & Sons.
7. James E. Katz, Manuel Castells, Handbook of Mobile Communication Studies, MIT Press.

EEE 505 Wireless Communications (3 Credits)

Overview of cellular structure and frequency reuse; mobile radio propagation and path loss models; statistical nature of radio channels; coding and time or frequency diversity; spread spectrum CDMA techniques and 3G Systems; OFDM and Wireless LAN standards; fast and slow frequency hopping technology and Bluetooth. Systems and protocols for wireless communication networks; from cellular to wireless IP applications, multiple access protocols, advanced and current wireless networking technologies, wireless infrastructure for cellular and wireless networks, wireless network performance and capacity analysis, packet data access and protocols, QoS for wireless multimedia.

Recommended Books:

1. T. S. Rappaport, Wireless Communications: Principles and Practice, Prentice Hall.
2. Andreas F. Molisch, Wireless Communications, Wiley.
3. William Stallings, Wireless Communications & Networks, Pearson.
4. Ke-Lin Du and M. N. S. Swamy, Wireless Communication Systems: From RF Subsystems to 4G Enabling Technologies, Cambridge.
5. Vijoy K. Garg , Wireless Communications & Networking, Morgan Kaufman Publications.

6. Cotter W. Sayre, Complete Wireless Design, McGraw-Hill.

EEE 506 Advanced Digital Signal Processing (3 Credits)

Adaptive filtering: Review of the LMS and RLS algorithms, adaptive lattice-ladder filters, frequency-domain adaptive filtering methods, variable step-size adaptive filters, application of adaptive filtering, Power spectrum estimation: Review of parametric techniques for power spectrum estimation, high resolution methods, Multirate signal processing: filter banks: cosine modulated filter banks, paraunitary QMF banks, multidimensional filter banks, emerging applications of multirate signal processing.

Recommended Books:

1. Proakis, J.G. and Manolakis, D.G., "Digital Signal Processing", Macmillan.
2. Claude S. Lindquist, Adaptive and Digital Signal Processing With Digital Filtering Applications, Steward and Sons
3. Monson H. Hayes, Statistical Digital Signal Processing and Modeling, Wiley
4. Saeed V. Vaseghi, Advanced Signal Processing and Noise Reduction, Wiley
5. Peter M. Clarkson, Optimal and Adaptive Signal Processing, CRC-Press
6. Bose, T. "Digital Signal and Image Processing", Wiley.
7. S. K., "Digital Signal Processing", McGraw Hill.
8. Lim, J.S. and Oppenheim, A.V., "Advanced Topics in Signal Processing", Prentice-Hall.
9. Saeed V. Vaseghi, “Advanced Digital Signal Processing and Noise Reduction,” Wiley.

EEE 507 Image and Video Signal Processing (3 Credits)

Image Processing: Fundamentals of image processing: image formation, representation in pixel and transform domains, reconstruction from projections and interpolation, human visual system, stochastic models for images, enhancement and restoration techniques in spatial and frequency domains, image processing in color space, morphological filters, multi-resolution image processing, image compression techniques and standards, segmentation for edge detection and texture analysis, pattern classification, image watermarking, registration and fusion, emerging applications of image processing.

Video Processing: Formation and representation of video, spatio-temporal video sampling, motion analysis and estimation: real versus apparent motion, optical flow, block- and mesh-based methods for motion estimation and region-based stochastic motion modeling, motion segmentation and layered video representations, video filtering: motion-compensated filtering, noise reduction, signal recovery, deblurring, superresolution, mosaicing, deinterlacing and frame-rate conversion, video compression techniques and standards, content-based video indexing and retrieval, video communication: digital television, streaming over IP and wireless networks, error control and watermarking, stereo and multiview sequence processing.

Recommended Books:

1. Oge Marques, “Practical Image and Video Processing Using MATLAB,” Wiley.
2. John W. Woods, “Multidimensional Signal, Image, and Video Processing and Coding,” Academic Publishers.
3. H.R. Wu and K.R. Rao, “Digital Video Image Quality and Perceptual Coding (Signal Processing and Communications)”, Taylor & Francis.
4. Rao, K.R. and J.J. Hwang, "Techniques and Standards for Image, Video and Audio Coding", Prentice-Hal.

EEE 508 Advanced Computer Networks (3 Credits)

Overview of Internet Protocol; Application layer (HTTP, SMTP, FTP, DNS); Transport layer (UDP, TCP, congestion control) ; Network layer (routing, IP addressing, IPv6, NAT, DHCP); Link layer and LANs; Multimedia networking (streaming, RTSP, RTP, H.323); Quality-of-Service issues (IntServ, DiffServ, RSVP, MPLS); Network security (IPSec, SSL); advanced topics in unicast and multicast;

other advanced applications/topics (peer-to-peer protocols, grid computing, cloud computing, etc), mobile IP, and security.

Recommended Books:

1. James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach, Addison Wesley.
2. Larry L. Peterson and Bruce S. Davie, Computer Networks, Fifth Edition: A Systems Approach, MK (Elsevier).
3. Andrew S. Tanenbaum and David J. Wetherall, Computer Networks, Pearson.
4. Advanced Computer Networks
5. William Stallings, High-Speed Networks and Internets: Performance and Quality of Service, Pearson Education India
6. Robert P Davidson, Broadband Networks: A Manager's Guide, Wiley
7. Tanenbaum, Computer Networks, Pearson Education India
8. Comer, Computer Networks and Internets: With Internet Applications, Volume I, II &III, Pearson Education India
9. Douglus Comer, Computer Networks and Internets, Prentice Hall
10. Debra Littlejohn Shinder, Computer Networking Essentials, CISCO Press
11. Larry S Peterson & Bruce Davie, Computer Networks: A Systems Approach, Morgan Kaufmann
12. Keshav, An Engineering Approach To Computer Networking: ATM Networks, The Internet, and The Telephone Network, Pearson Education India
13. William Stallings**,** High-Speed Networks: TCP/IP and ATM Design Principles, Prentice Hall
14. Robert Wright, IP Routing Primer**,** CISCO Press

EEE 509 Network Planning, Management and Administration (3 Credits)

Technical Considerations in Network Design and Planning: Overview of the Network Design Process, Data Collection, Automated Data Generation, Traffic & Cost Generators and Tariff Data, Technical Requirements Specification, Node Selection, Placement, and Sizing, Routing Strategies, Architectures, Representation of Networks Using Graph Theory, Introduction to Network Algorithms, Automated Design and Network Management Tools, Queuing Notation, Loss and Delay in Networks, Queuing Model and Kendal Notation, Business Continuity (BC) & Disaster Recovery (DR)

Wide Area Network (WAN) & Local Area Network (LAN) Design and Planning: Management & Technical Overview of WAN&LANDesign, Centralized Network Design, System Network Architecture (SNA), Migration of SNA Networks to Open Networking Standards, Backbone Networks, IEEE LAN Standards, Ethernet LANs, Wireless LANs

Network Design and Administration: Network Design Considerations Wired Networks, 10/100 and Gigabit Ethernet Networking, FDDI & ATM Networks, Network Administration, Workgroups, Domains, User Accounts, Security, System Restoration, Uninterruptible Power Supply (UPS), Managing and Monitoring Performance, Managing Processor Time, Managing Memory Changing Visual Effects, Performance and Quality of Service (QoS)

Simple Network Management Protocol (SNMP) and RMON: Network Management Stations (NMSs) and Agents, SNMP and UDP, Managed Devices and SNMP Polling, Managed Objects and Object Instances, Management Information Bases (MIBs), Types of MIBs, Structure of Management Information (SMI) standard& Private MIBs, Thresholds, Alarms,

and Traps, SMI in SNMPv2, MIB-II SNMPv3, Remote Monitoring (RMON), RMON and Switched Networking, Expanded MIB-II Tree, RMON1 and RMON2.

Outsourcing: Outsourcing Overview, Steps in the Outsourcing Process, Major Considerations in Outsourcing, Request for Information, Request for Proposal, Vendor Evaluation

Recommended Books:

1 Steven T. Karris, Networks Design and Management, Orchard Publications.
2 Thomas A. Limoncell, Christina J. Hogan, and Strata R. Chalup, The Practice of System and Network Administration, Addision-Wesly.
3 Teresa C. Piliouras, Network Design: Management and Technical Perspectives, Auerbach Publications (A CRC Press Company).
4 Diane Teare, Catherine Paquet, Campus Network Design Fundamentals, CISCO Press.
5 Steve Wisniewski, Network Administration, Pearson Education.
6 James, D McCabe, "Network Analysis, Architecture and Design", Morgan Kaufmann publishers.
7 Mathew Liotine*, "Mission-Critical Network Planning"*, Artech House Inc.

EEE 510 Network Programming (3 Credits)

Topic includes Formal methods. Communication paradigms. Basic techniques and design patterns. Distributed object APIs. Middleware. Application level protocols. Socket programming (UDP and TCP). Sync/async and blocking/non-blocking I/O. Timers. Multiplexing. Unix kernel APIs and data structures. Extensive examples in C, C++ and Java.

Recommended Books:

1. W. Richard Stevens, Unix Network Programming, Prentice Hall.
2. W. Richard Stevens, Bill Fenner & Andrew M. Ruddof, "Unix Network Programming", Volume 1: The Sockets Networking API; 3rd. Edition, Addison-Wesley.
3. Douglas Comer, Internetworking with TCP/IP, Volume-3, Prentice Hall.
4. Douglas Comer, Internetworking with TCP/IP, Volume-1, Prentice Hall.
5. D. E. Comer, *Computer Networks and Internets*, Prentice Hall, Englewood Cliffs, NJ, USA, 2nd Edition.
6. M. J. Donahoo and K. L. Calvert, TCP/IP Sockets in C: Practical Guide for Programmers (The Practical Guides Series), Morgan Kaufmann Publishers.
7. K. L.Calvert and M. J. Donahoo, TCP/IP Sockets in Java: Practical Guide for Programmers (The Practical Guides Series), Morgan Kaufmann Publishers.
8. W. Richard Stevens, Bill Fenner & Andrew M. Ruddof, "Unix Network Programming", Volume 1: The Sockets Networking API; 3rd. Edition, Addison-Wesley.
9. Beej's Guide to Network Programming Using Internet Sockets By Brian "Beej Jorgensen" Hall

EEE 511 Cryptography and Network Security (3 Credits)

This course introduces the principles of number theory and the practice of network security and cryptographic algorithms. Topics include: Primes, random numbers, modular arithmetic and discrete logarithms. Conventional or symmetric encryption (DES, IDEA, Blowfish, Twofish, Rijndael) and public key or asymmetric encryption (RSA, Diffie-Hellman), key management, hash functions (MD5, SHA-1, RIPEMD-160, HMAC), digital signatures, certificates and authentication protocols (X.509, DSS, Kerberos), electronic mail security (PGP, S/MIME), web security and protocols for secure electronic commerce (IPSec, SSL, TLS, SET).

Recommended Books:

1. William Stallings, “Cryptography and Network Security”, Pearson Education, India.
2. M Delfs and H Knebl, “Introduction to Cryptography: Principles and Applications, Springer.
3. N Koblitz, “A Course in Number Theory and Cryptography, Springer.
4. John E. Canavan, “ The Fundamentals of Network Security," Artech House.
5. Jon C. Graff, " Cryptography and E-Commerce: A Wiley Tech Brief," Wiley.
6. Jan Killmeyer Tudor, " Information Security Architecture: An Integrated Approach to Security in the Organization," CRC Press.
7. Merike Kaeo, "Designing Network Security," Cisco Press.
8. Jalal Feghhi, Peter Williams, Jalil Feghhi, " Digital Certificates: Applied Internet Security," Addison-Wesley.
9. Thomas D. Tarman, Edward L. Witzke, "Implementing Security for ATM Networks," Artech House.
10. Christopher King, Ertem Osmanoglu, Curtis Dalton, " Security Architecture: Design, Deployment and Operations," McGraw-Hill.

EEE 512 Telecommunication Transmission & Switching Systems (3 Credits)

Introduction to telecommunication transmission technologies; Integrated Services Digital Network (ISDN) principles, systems and transport technology; Plesiochronous Digital Hierarchy (PDH) principles, systems & transport technology; Synchronous Digital Hierarchy (SDH) principles, systems & transport technology; SONET principles, systems & transport technology; ATM principles, systems & transport technology; Introduction to access network transport technologies; PONS, DSL, HFC last mile solutions; Introduction to Satellite transmission networks, Space environment, Link analysis, Satellite Access, Earth stations, Satellite services

Switching Systems: Introduction to switching systems, telecommunication standards, digital switching systems: basic concept, space division switching, time division switching, TST & multi-stage switching and their GOS; computer controlled switching systems: basic concept, call processing, hardware configuration, switching system software organization, popular digital switching systems, electronic exchanges in Bangladesh; signaling techniques: in channel signaling and common channel signaling, SS7, signaling networks; Telecommunication traffic engineering: traffic design requirements, modeling of traffic, loss systems, delay system, combined loss and delay systems; Overview of packet and circuit switching, Packet transmission on LAN & WAN, Packet switching in broadband networks, ATM switching, IP switching.

Recommended Books:

1. Richard A. Thompson, Telephone Switching Systems, Artech House Publishers.
2. T. Viswanathan, Telecommunication Switching Systems and Networks, Prentice-Hall.
3. Thomas M. Chen, Stephen S. Liu, ATM Switching Systems, Artech House Publishers.
4. Syed Riffat Ali, Digital Switching Systems: System Reliability and Analysis, McGraw-Hill Professional Publishing.
5. J. Gordon Pearce, Telecommunications Switching, Springer.
6. J. E. Flood, "Telecommunications Switching, Traffic and Networks", Prentice Hall.
7. Iakovos Venieris and Heirich Hussman, "Intelligent Broadband Networks", John Wiley and Sons Ltd.
8. Uyless Black, "Architectures for Digital Signalling Networks", Prentice Hall.
9. John Bellamy, "Digital Telephony", Wiley.
10. S. V. Kartalopolons, "Understanding SONET/SDH and ATM : Communication Networks for the Next Millennium", IEEE Press.

EEE 513 RF and Microwave Engineering (3 Credits)

Introduction to Radio Wave and Electromagnetic Spectrum; Maxwell’s Equations, RF & Microwave Systems, RF and Microwave Generators: semiconductor devices such as diodes, BJTs, FETs, and vacuum tube devices such as magnetron, klystron, gyrotron, TWT; Plane wave equations and their solutions; Transmission line theory: waveguide, coax, microstrip, stripline; Smith chart; Microwave circuit theory: S-parameters, ABCD matrices, equivalent circuits, and signal flow graphs; Passive

Microwave devices: Waveguide junctions, Power dividers, Directional couplers, Microwave tuners, Phase shifters, Filters; Passive microwave circuits and components: matching networks and microwave resonators; Active Microwave devices: Receiver, Detectors, Mixers, Filters, PIN diode switches, Transistor amplifiers, and Oscillators; RF and Microwave antenna & propagation; Some applications of RF and Microwaves: terrestrial and satellite communications, wireless communications, radar, remote sensing.

Recommended Books:

1. David M. Pozar, Microwave Engineering, John Wiley & Sons, Inc.
2. Robert E Collin, Foundations of Microwave Engineering, IEEE Press.
3. Joseph F. White, High Frequency Techniques: An Introduction to RF and Microwave Engineering, Wiley-IEEE Press.
4. Devendra K. Misra, Radio-Frequency and Microwave Communication Circuits: Analysis and Design, Wiley-Interscience.

EEE 514 Antenna and Propagation (3 Credits)

Definitions, antenna as an aperture: arrays of point sources : review of dipoles, loop and thin linear antennas . Helical antenna, biconical and spheroidal antennas . internal-equation methods, current distribution : Self and mutual impedances: arrays: design and synthesis. Reflector type antennas. Babinet`s principle and complementary antennas. Application of reaction concept and vocational principles in antennas and propagation. Frequency independent antennas. Scattering and diffraction. Selected topics in microwave antennas. Antenna measurements. Application of broadcasting, microwave links, satellite communication and radio astronomy.

Recommended Books:

1. Simon Saunders, Alejandro Aragón-Zavala, Antennas and Propagation for Wireless Communication Systems, Wiley.
2. William Gosling; Radio Antennas and Propagation: Radio Engineering Fundamentals, Newness.
3. Daniel M. Dobkin, RF Engineering for Wireless Networks: Hardware, Antennas, and Propagation, Newness.
4. Rodney Vaughan, J. Bach Andersen, Channels, Propagation and Antennas for Mobile Communications; Institution of Engineering and Technology.

EEE 515 Information and Coding Theory (3 Credits)

Information Sources and Sources Coding: Logarithmic measure for information, self and average information. Entropy, information rate, discrete sources, extensions of a discrete source, Shannon's source coding theorem. Markov source. Joint and conditional entropy. Source coding theorem and algorithms. Kraft inequality, Huffman code, prefix code, Lempel-Ziv code, rate distortion theory. Scalar and vector quantization, waveform coding; Channel Capacity and Coding: Discrete channels, a priori and a posterior entropies, equivocation, mutual information, noiseless channel, deterministic channel, channel capacity, Shannon's channel coding theorem, bandwidth-S/N trade-off. Channel capacity theorem. Continuous information source, maximum relative entropy; Linear Block and Cyclic Error-Correction Coding: Model of digital communication system employing coding. Algebraic coding theory. Definition of terms: redundancy, code efficiency, systematic codes, Hamming distance, Hamming weight, Hamming bound. Types of codes: parity check codes, Hamming codes, BCH codes, maximum-length or pseudo-random codes, Reed-Solomon codes, concatenated codes. Linear block codes, generator and parity check matrix, syndrome decoding. Cyclic codes, generation and detection. Coding for reliable communication, coding gain, bandwidth expansion ratio. Comparison of coded and uncoded systems; Convolutional Codes: Burst error detecting and correcting codes. Convolutional codes, time domain and frequency domain approaches. Code tree, Trellis and state diagram. Decoding of convolutional codes, Veterbi's algorithm, sequential decoding. Transfer function and distance properties of convolutional codes. Bound on the bit error rate. Coding gain; Applications of Coding: Coding for bandwidth constrained channels: combined

coding and modulation, Trellis coded modulation (TCM), decoding of TCM codes. Coding for white Gaussian noise channel. Coding for compound-error channels, coding for error control in data storage.

Recommended Books:

1. Norman Abramson, Information Theory and Coding, McGraw-Hill Education.
2. Steven Roman, Coding and Information Theory, Springer.
3. Solomon W. Golomb, Robert E. Peile and Robert A. Scholtz, Basic Concepts in Information Theory and Coding: The Adventures of Secret Agent, Springer.
4. Steven Roman, Introduction to Coding and Information Theory, Springer.
5. R. J. McEliece, The Theory of Information and Coding, Cambridge University Press.
6. Richard B. Wells, Applied Coding and Information Theory for Engineers, Prentice Hall.
7. Raymond W. Yeung, Information Theory and Network Coding, Springer.
8. Roberto Togneri, Christopher J.S deSilva, Fundamentals of Information Theory and Coding Design, Chapman and Hall/CRC.

EEE 516 Cloud Computing (3 credits)

The course will present the state of the art in cloud computing technologies and applications. The course will explore potential research directions, as well as the technologies that will facilitate the creation of a global marketplace for cloud computing services that support scientific, industrial, business, and consumer applications. Topics will include**:** telecommunications needs; architectural models for cloud computing; cloud computing platforms and services; security, privacy, and trust management; resource allocation and quality of service; cloud economics and business models; pricing and risk management; interoperability and internetworking; legal issues; and novel applications. Course projects will expose students to different tools and technologies used to build and utilize clouds and the related security, privacy and trust management issues.

Recommended Books:

1. John Rhoton, Cloud Computing Architected: Implementation Handbook for Enterprises, Recursive Press.
2. Barrie Sosinsky, Cloud Computing Bible, Wiley.
3. Vic (J.R.) Winkler, Securing the Cloud: Cloud Computer Security Techniques and Tactics, Syngress.

Electronics Division:

EEE 506 Advanced Digital Signal Processing (3 Credits)

Signal Modeling: Pade & Prony Matching, Solution of Autocorrelation Normal Equations, Burg's Algorithm, Linear Prediction, Wiener and Kalman Filtering. Spectral Estimation: non-parametric (periodogram, Welsh and Blackman-Tukey modifications), parametric (AR, MA and ARMA). Two Dimensional Signal Processing: 2D z-transform, 2-D DFT and DCT, 2-D filters, image processing. Multirate Signal Processing: decimation & interpolation, polyphase filters, QMF filter banks Signal Coding: waveform coding, predictive coding, transform coding, MPEG1/2/4 audio and speech coding.

Recommended Books:

1. Bose, T. "Digital Signal and Image Processing", Wiley.
2. S. K., "Digital Signal Processing", McGraw Hill.
3. Lim, J.S. and Oppenheim, A.V., "Advanced Topics in Signal Processing", Prentice-Hall.
4. Grant, P.M. et al, Analogue and Digital Signal Processing and Coding", Chartwell-Bratt.
5. Proakis, J.G. and Manolakis, D.G., "Digital Signal Processing", Macmillan.
6. Jayant, N.S., and Noll, P., "Digital Coding of Waveforms", Prentice-Hall.
7. Lim, J.S., "Two Dimensional Signal and Image Processing", Prentice-Hall.

EEE 507 Image & Video Signal Processing (3 Credits)

Multi-dimensional signals and systems; Characteristics of image and video signals; visual perception; multi-dimensional sampling and transforms; image and video enhancement and restoration; image and video compression; coding standards; delivery of visual contents over networks. Digital Image Fundamentals; Image Enhancement in Spatial Domain: Gray Level Transformation, Histogram Processing, Spatial Filters; Image Transforms: Fourier Transform and their properties, Fast Fourier Transform, Other Transforms; Image Enhancement in Frequency Domain; Color Image Processing; Image Warping and Restoration; Image Compression; Image Segmentation: edge detection, Hough transform, region based segmentation; segmentation for edge detection and texture analysis, pattern classification, image watermarking, registration and fusion, emerging applications of image processing. Morphological operators; Representation and Description; Features based matching and Bayes classification; Introduction to some computer vision techniques: Imaging geometry, shape from shading, optical flow; Laboratory exercises will emphasize development and evaluation of image processing methods.

Recommended Books:

1. A. K. Jain, Fundamentals of Digital Image Processing, Pearson.
2. Oge Marques, “Practical Image and Video Processing Using MATLAB,” Wiley.
3. John W. Woods, “Multidimensional Signal, Image, and Video Processing and Coding,”Academic Publishers.
4. H.R. Wu and K.R. Rao, “Digital Video Image Quality and Perceptual Coding (Signal Processing and Communications)”, Taylor & Francis.
5. Rao, K.R. and J.J. Hwang, "Techniques and Standards for Image, Video and Audio Coding", Prentice-Hall.

EEE 531 Image and Speech Recognition (3 Credits)

Introduction, Image & Speech signal: production, perception and characterization, Signal processing and analysis; Pattern comparison techniques: distortion measures, spectral-distortion measures, time alignment and normalization; Recognition system design and implementation: source-coding, template training, performance analysis; Connected word models, two level DP, level building algorithm, one-pass algorithm; Continuos speech recognition: subword units, statistical modeling, context-depending units; Task oriented models.

Recommended Books:

1. Lawrence Rabiner and Biing-Hwang Juang, "Fundamentals of Speech Recognition (Prentice Hall Signal Processing Series)", Prentice Hall PTR.
2. Frederick Jelinek ,"Statistical Methods for Speech Recognition", MIT Press.

EEE 532 Image and Video Compression (3 Credits)

The challenge of digital audiovisual compression: data volume, error visibility, streaming, real-time, compatibility. An overview of existing audiovisual compression standards (e.g. JPEG, H.261, H.263, MPEG-1, MPEG-2, MPEG-4). Visual coding theory and approaches: transform-based coding; hybrid coding; basic codec structure, intra/inter frames, macroblock structure, configuration of coding tools; advanced and unrestricted motion estimation, context-based arithmetic coding, overlapped-block motion estimation. JPEG: DCT coding, coefficient quantisation and Huffman coding. MPEG-1: I-,B- and P-pictures, user defined quantisation matrix. MPEG-2: Compatibility, scalability, interlaced tools, profiles and levels. MPEG-4: VOs and VOPS, layered codec structure, VOP bounding, alpha plane encoding (shape coding), half-pixel resolution motion estimation, advanced and unrestricted mode, padding/shape-adaptive DCT, scalability, error robustness, profiles. Future developments in audiovisual compression and related issues: (e.g. MPEG-7, visual object segmentation, video analysis). Non-normative coding techniques (e.g. fractal coding, region-based, wavelets).

Recommended Books:

1. Puri,A. and Chen,T., "MPEG-4/ITU-T standards, Multimedia Systems, Standards, and Networks", Marcel Dekker.
2. Rao, K.R. and J.J. Hwang, "Techniques and Standards for Image, Video and Audio Coding", Prentice-Hall.
3. Furht, B. J. Greenberg and R. Westwater, "Motion Estimation Algorithms for Video Compression", Kluwer Academic Publishers.
4. R. Westwater and B. Furht, "Real-time Video Compression: Techniques and Algorithms", Kluwer Academic Publishers.

EEE 533 Advanced VLSI Design and Testing (3 Credits)

Introduction to VLSI Technology: IC Technology and IC Era (SSI, MSI, VLSI etc.); MOS as related VLSI technologies (NMOS, PMOS, CMOS, BiCMOS) MOS transistors (enhancement and depletion modes); NMOS and CMOS fabrication; Comparison of technologies between CMOS, Bipolar and GaAS, Basic Inverter; NAND, NOR logic; Physics of MOS transistors: Fluid model, Electrical characteristics, Operation of MOS transistor as a switch and an amplifier, MOS inverters**;** VLSI Design: MOS Fabrication steps, stick diagrams, design rules and layout, MOS circuits, Registers, Counters and Memory realizations, Hierarchical view of VLSI System Design, Behavioral description, High level Synthesis Scheduling, allocation and data path synthesis, Logic synthesis multilevel minimization, PLA reduction, regular structure circuits, Synthesis of FSM-ASM chart representation and realization , Layout synthesis, Placement and routing, Testing of VLSI, Testing of stuck-at faults, Testing of PLAs, RAM, Boundary scan technique; Memory, registers and system timing**:** Shift register, 3-transistor dynamic RAM cell, 1-transistor dynamic memory cell, a pseudo static RAM/register cell, J-K flip flop, D flip flop, array of memory cells; System Design Methodologies and Tools**:** Actual industrial or academic design flows for full custom, semicustom (standard cell, Gate array) and E-CAD use; Design trade-off methods, Commercial tools for VLSI design (including rapid prototyping); Design techniques for testability and test issues.

Recommended Books:

1. V.N. Yarmolik, I.V. Kachan, Self-Testing VLSI Design, Elsevier Science.
2. Elizabeth Rudnick, Genetic Algorithms for VLSI Design, Layout and Test Automation, Prentice Hall.
3. Laung-Terng Wang , Cheng-Wen Wu, Xiaoqing Wen, VLSI Test Principles and Architectures: Design for Testability, Morgan Kaufmann.
4. Frank F. Tsui, LSI/VLSI Testability Design, Mcgraw-Hill .
5. R. Massara, Design and Test Techniques for VLSI and WSI Circuits, Institution of Electrical Engineers.

EEE 534 Advanced Microelectronics (3 Credits)

Introduction: Discrete & Integrated Circuit, TTL, MOS & CMOS IC; Process Technology: Clean environment, Wafer preparation, oxidation, diffusion, Ion implantation, plasma etching & deposition, lithography, Metallization contact & interconnects, bipolar & CMOS processing;

Basic Devices: BJT models, Ebers-Moll & Gummel-Poon models, C-V behavior of an ideal MOS System, Capacitance of the MOS system, MOS capacitors and charge-coupled devices, Long channel and short channel MOSFETS, CMOS design, CMOS Latch-up; MOS Inverters: Definition & properties, MOS & CMOS inverter; Analogue Circuits: Differential amplifies, Comparators, Integrators, Filters, DAC & ADC Circuits, Cascade amplifiers, design of two-state & cascade op-amplifier; BI CMOS Circuit Technique: BI CMOS Device & Technology – basic analog sub-circuit.

Recommended Books:

1. Richard Jaeger, Travis Blalock, Microelectronic Circuit Design, McGraw-Hill.
2. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, Oxford University Press.
3. Andrew Leven, Telecommunication Circuits and Technology, Newnes.
4. Behzad Razavi, Fundamentals of Microelectronics, Wiley.

5. Donald Neamen, Microelectronics Circuit Analysis and Design, McGraw-Hill.
6. Mervyn Jack, Impact of Microelectronics Technology, Edinburgh University Press.

EEE 535 Embedded Systems and Real Time Interfacing (3 Credits)

Introduction: Embedded Systems, Hardware and Software parts of Embedded Systems; Processor and Memory Organization: Structural units in a processor and Processor Selection, Memory Devices and Selection, Direct Memory Access, Interfacing Processor, Memories & I/O Devices; Devices, Device Drivers, Buses: I/O Devices, Timer and Counting Devices, Device Drivers – Parallel and Serial Devices. Timing Devices, Bus Architectures – I^2C. CAN, ISA, PC1, BDLC, Bluetooth; Interrupts: Device Drivers and Interrupt Servicing, Interrupt Servicing Mechanism, Context and Periods of Context Switching, Latency, Introduction to R705; Processor Architecture: Processor Core Architecture, MC9S12C32 Features, Block Diagrams, Programming Models, Pinouts and Signals, System Clock, Register Blocks and Memory Mapping, Modes of Operation; Addressing and Interrupts: Addressing Modes and Assembly Language Programming, Resets and Interrupts, Watch Dog Timer, COP, Key-wakeup interrupts; I/O Ports: Parallel I/O Ports, Internal and External Resource Mapping Control, (PIM + MMC + MEBI Modules), HC12 Peripherals – I: Parallel I/O, Timer – Overflow, Output Compare, Input Capture, Pulse Accumulator, PWM, HC12 Peripherals – II: Serial I/O, SP1, SC1, Analog to Digital Converters, CAN; System Design: Parallel Port and Memory Interfacing. Expanded Mode of Operation, System Design Examples.

Recommended Books:

1. Jonathan W. Valvano, Embedded Microcomputer Systems: Real Time Interfacing, CL-Engineering.
2. Qing Li, Caroline Yao, Real-Time Concepts for Embedded Systems, CMP; 1st Edition.
3. Jonathan W. Valvano, Embedded Microcomputer Systems: Real Time Interfacing, CL-Engineering.
4. Insup Lee, Joseph Y-T. Leung , Sang H. Son, Handbook of Real-Time and Embedded Systems, Chapman and Hall-CRC.
5. Robert Oshana, DSP Software Development Techniques for Embedded and Real-Time Systems, Newnes.

EEE 536 Advanced Semiconductor Devices (3 Credits)

Review of basic semiconductor physics and III-V materials. GaAs metal-semiconductor field effect transistor (GaAs MESFET): introduction, structure, equivalent circuits, current saturation, effect of source and drain resistances, gate resistance and application of GaAs MESFET. High electron mobility transistor (HEMT): practical HEMT structure, energy band line-up, equivalent circuit, HEMT noise, pseudomorphic HEMT and applications. Fundamentals of quantum mechanics. Quantum devices: resonant tunneling diodes, quantum dots and wires. Nanotechnology: nanowires, carbon nanotubes, bio-inspired nanostructures, nano motors etc., future directions in nanotechnology.

Recommended Books:

1. William Liu, "Fundamentals of III-V Devices: HBTs, MESFETs, and HFETs/HEMTs", Wiley.
2. C.Y. Chang and Francis Kai, "GaAs High-Speed Devices", Wiley.
3. Berger, Lev I., "Semiconductor Materials", CRC Press.

EEE 537 Power Semiconductor Circuits and Drives (3 Credits)

Static switching devices, characteristics of SCR, BJT, MOSFET, IGBT, SIT, GTO, MCT. Classifications of static power converters and their application. Control circuits for static power converters. Pulse width modulation; PWM control of static power converters. Switch mode DC to DC converters, resonant converters, Cycloinverters, Hybrid resonant dc-dc converters. Fourier analysis of static converter waveforms, HD, THD, pf, ZVS and ZCS of static converters. Hysteresis current of AC drives. Input/output filter design of static power converters. Design of protection circuits for static power converters. Design of microcomputer controllers for static power converter switching., Inverters for induction heating, resonant dc link inverters, dc-dc converters with different commutation

schemes, PWM inverters, Switching dc power supplies power conditioners and uninterruptible power supplies. Motor Load dynamics. starting, Braking and speed control of DC and AC motors. DC drives; converter and chopper control. AC drives; Operation of induction and synchronous motors from voltage and current inverters. Transfer function and stability analysis Slip power recovery. Pump drives using AC line controller and self-controlled synchronous motor drives. Case study of Industrial drives.

Recommended Books:

1. Muhammad H. Rashid, "Power Electronics Circuits, Devices and Applications", Prentice Hall.
2. Abraham I. Pressman, "Switching Power Supply Design", McGraw-Hill.

EEE 538 Advanced CMOS Technology (3 Credits)

CMOS Technology Overview: Evolution and recent advances in silicon electronics, Moore's Law and the ITRS, State-of- the-Art CMOS technology. Overview on CMOS Fabrication Processes: Overview of basic silicon processing steps, photolithography, isolation technique, threshold voltage adjustment, design rules and layout, technology for nanoscale fabrication. Nanoscale MOSFETs. MOSFET figures of merit: on- and off current, CVI metric, gate delay, power-delay product. Nanometer bulk MOSFETs: doping profiles, high-k dielectrics, gate stack design. Non-classical MOSFET structures: transport enhanced MOSFETs (strained Si and SiGe, Ge), SOI MOSFETs, multiple gate MOSFETs (lateral double-gate MOSFET, FinFET, Tri-gate MOSFET). Problems and challenges of nanoscale MOSFETs: shallow source/drain junctions, doping fluctuations (in the channel, in the source/drain regions), decreasing current drive capability, the limits of scaling (physical and process constraints). RF CMOS Devices and Circuits. Figures of merit of RF transistors, small-signal and low-noise RF MOSFETs, power RF MOSFETs. Challenges of Giga-Scale Integration. Reliability and yield, interconnects and delay, power dissipation and thermal issues, economics issues, active devices beyond CMOS, Si optoelectronic components.

Recommended Books:

1. N Weste and K Eshraghian, "Principles of CMOS VLSI Design A System Perspective", Addison-Wesley.
2. A Brown, "VLSI Circuits and Systems in Silicon", McGraw-Hill.
3. L A Glasser and D W Dobberpuhl, "The Design and Analysis of VLSI Circuits", Addison Wesley.
4. F. Schwierz, H. Wong, and J. J. Liou, "Nanometer CMOS", World Scientific.

EEE 539 Application of Specific Integrated Circuit Design (3 Credits)

IC components - their characterization and design. Analysis and design of basic logic circuits. Linear ICs. Large Scale Integration. Computer simulation of ICs and layout design. High Voltage ICs. GaAs MESFET and GaAs ICs. Failure, reliability and yield of ICs. Fault modeling and testing. Linear IC applications, Combinational and sequential circuits; Available IC gates and flip-flops. Design of Combinatorial circuits using Karnaugh map; Counters and Shift registers; Active filters using OP Amps; Precision wave shaping circuits; Switching circuits using OP Amps, TTL and CMOS gates.
Types of ASICs- Standard cell, gate array, programmable logic devices. ASIC library design, library cell, gate array and standard cell design. Programmable ASIC logic cell and programmable I/O cell design. Programmable ASIC interconnects. Logic synthesis and simulation of ASIC using Hardware Description Language. Floor-planning, placement and routing of ASIC. ASIC testing: Boundary scan test, faults, fault simulation, automatic test pattern generation, built-in self test.

Books Recommended:

1. Michael John Sebastian Smith, "Application Specific Integrated Circuits", Pearson Education.

2. Michael D. Ciletti, "Advanced Digital Design with the Verilog HDL", Prentice Hall of India Pvt. Ltd..

EEE 540 Nanoelectronics Technology (3 Credits)

Introduction to Physics of the Solid State: Crystal structure and lattice vibrations; energy bands, reciprocal space, effective masses, Fermi surfaces, localised particles e.g. donors, traps, excitons. Methods of Measuring Properties: Crystallography - particle size determination and surface structure; microscopy; spectroscopy. Properties of Individual Nanoparticles: Metal nanoclusters, semiconducting nanoparticles, rare gas and molecular clusters, synthesis methods. Carbon Nanostructures: Carbon molecules, carbon clusters - C60 and fulllerenes; carbon nanotubes; applications of carbon nanotubes. Bulk Nanostructured Materials: Solid disordered nanostructures - synthesis and properties; nanostructured crystals - zeolites, photonic crystals. Nanostructured Ferromagnetism: Ferromagnetism; dynamics of nanomagnets, giant and colossal magnetoresistance; ferrofluids. Optical and Vibrational Spectroscopy: Excitons; infrared surface spectroscopy; Raman spectroscopy; Brillouin spectroscopy; Luminescence - photoluminescence, surface states, thermoluminescence. Quantum Wells, Wires and Dots: Preparation; size and dimensionality effects; excitons; single-electron tunnelling; applications - IR detectors, quantum dot lasers; superconductivity. Self-Assembly and Catalysis: process of self-assembly; catalysis. Organic Compounds and Polymers: Forming and characterizing polymers; nanocrystals; conductive polymers; supramolecular structures - dendritic molecules, micelles. Biological Materials: Biological building blocks - polypeptide nanowires and protein nanoparticles; nucleic acids - DNA, genetic code and protein synthesis. Nano Machines and Devices: Microelectromechanical systems (MEMS); nanoelectromechanical systems (NEMS); molecular and supramolecular switches.

Recommended Books:

1. Waser. R. (ed), "Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices", Wiley-VCH, Weinheim
2. K. Vaitheki and R. Tamijetchelvy, A State Variables Analysis for Emerging Nanoelectronic Devices, Springer
3. Rainer Waser (Editor), Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley-VCH
4. Mircea Dragoman, Daniela Dragoman, Nanoelectronics: principles and devices, Artech House

EEE 541 Biomedical Electronics (3 Credits)

The need to study biological instrumentation; biological amplifiers and their interfacing with electrodes for activity monitoring solid state transducers for pressure flow, temperature and other physiological parameters and related instrumentation for long-term use. Low power consuming circuits especially for implantable pace makers; drift problem and its compensation, telemetry of biological signals. Digital signal processing and imagery-construction suitable for scanning, for example, CAT, PET, NMR and ultrasonics with a special reference to instrumentation principles.

Recommended Books:

1. Robert B. Northrop, Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation, CRC Press.
2. Yehya H. Ghallab and Wael Badawy, Lab-On-A-Chip: Techniques, Circuits, and Biomedical Applications, Artech House.
3. Eugene N. Bruce, Biomedical Signal Processing and Signal Modeling, Wiley.

EEE 542 Artificial Neural Networks (3 Credits)

Introduction & Motivation; Biological Neural Networks and simple models; The Artificial Neuron Model; Hopfield Nets; Energy Functions and Optimization; Perceptrons & Threshold Logic machines;

Multilayer Networks-their variants and Applications; Capacity of Mutilayer Networks; Backpropagation; Recurrent Nets; Tree Structured Networks; Unsupervised Learning; Hebbian Learning, Principal Component Analysis; Competitive Learning, Feature Mapping, Self Organizing Maps, Adaptive Resonance Theory. Hardware Realization of ANNs. Recent Trends and Future Directions.

Recommended Books:

1. Colin R. Tosh and Graeme D. Ruxton, Modelling Perception with Artificial Neural Networks, Cambridge
2. Dan W. Patterson, Artificial Neural Networks, Prentice Hall.
3. B Yegnanaryana, Artificial Neural Networks, Prentice Hall.

Power Systems Division:

EEE 561 Energy Conversion Engineering (3 Credits)

Energy conversion processes; general introduction, energy sources, principles or conservation of energy balance equations. Direct electrical energy conversion: introduction: magneto-hydrodynamic (MHD): fuel cell: thermo-electrostatic: Ferro-electric: photo-electric: photovoltaic, electrostatic and piezoelectric energy conversions: characteristics including efficiency, power densities, terminal properties and limitations. Electromechanical energy conversion: general introduction of electrical to mechanical, mechanical to electrical and electrical to electrical conversions. Bulk energy conversion devices. General formulations of equations; co-ordinate transformation and terminal characteristics.

Recommended Books:

1. D. Yogi Goswami, Frank Kreith, Energy Conversion, CRC Press.
2. Horacio Perez-Blanco, The Dynamics of Energy: Supply, Conversion, and Utilization, CRC Press.
3. Reiner Decher, Direct Energy Conversion: Fundamentals of Electric Power Production, Oxford University Press, USA.
4. Ewald F. Fuchs, Mohammad A.S. Masoum, Power Conversion of Renewable Energy Systems, Springer.
5. Martin A. Green, Third Generation Photovoltaics: Advanced Solar Energy Conversion, Springer.
6. Michael E. McCormick, Ocean Wave Energy Conversion, Dover Publications.
7. Liang-Shih Fan, Chemical Looping Systems for Fossil Energy Conversions, Wiley-AIChE.
8. Siegfried Heier, Rachel Waddington, Grid Integration of Wind Energy Conversion Systems, Wiley.
9. Alireza Khaligh, Omer C. Onar, Energy Harvesting: Solar, Wind, and Ocean Energy Conversion Systems, CRC Press.
10. Mathew Sathyajith, Geeta Susan Philip, Advances in Wind Energy Conversion Technology, Springer.

EEE 562 Power System Planning (3 Credits)

Basic objectives of power system planning. Generation expansion planning process. Electrical demand forecasting; current demand forecasting approaches. Generation planning; economic analysis, expected energy generation, expected fuel cost. Both-Baleriux, cummutant and segmentation methods. Probabilistic simulation of hydro and energy limited units. Expected energy production cost of interconnected systems. Economic aspects of interconnection. Different aspects of load management; effects of load Management on reliability and on production cost. Joint ownership of generation.

Recommended Books:

1. X.F. Wang , James McDonald, Wang Xifan, X.F., Wang, Modern Power System Planning, McGraw-Hill Publishing.
2. Robert L. Sullivan, Power System Planning, McGraw-Hill Inc.
3. Power System Engineering: Planning, Design, and Operation of Power Systems and Equipment, Wiley-VCH.
4. Friedrich Kiessling, Peter Nefzger, Joao Felix Nolasco, Ulf Kaintzyk, Overhead Power Lines: Planning, Design, Construction, Springer.
5. Barry Hyman, R. Charles Peterson, Electric Power Systems Planning: A Pacific Northwest Perspective, Univ of Washington Press.

EEE 563 Optimization of Power System Operation(3 Credits)

General principles of optimization, its application to power system planning, design and operation. Probability analysis of bulk power security and outage data. Economic operation of power system-economic operation of thermal plants, combined thermal and hydro-electric plants. Theory of economic operation of interconnected areas. Development and application of transmission loss formulae for economic operation of power systems. Method of optimum scheduling and dispatch of generators.

Recommended Books:

1. Allen J. Wood and Bruce F. Wollenberg, "Power Generation, Operation, and Control", Wiley-Interscience; 2nd edition, 1996.
2. Jizhong Zhu, Optimization of Power System Operation, Wiley-IEEE Press.
3. James A. Momoh, Electric Power System Applications of Optimization, CRC Press.
4. Kwang Y. Lee, Mohamed A. El-Sharkawi, Modern Heuristic Optimization Techniques: Theory and Applications to Power Systems, Wiley-IEEE Press.
5. Edgardo D. Castronuovo, Optimization Advances in Electric Power Systems, Nova Science Publishers.

EEE 564 Power System Reliability (3 Credits)

Review of basic probability theory. Basic reliability concepts. Markovian model of generation unit. Development of load models. Probabilistic simulation of generating systems. Reliability indices. Recursive, segmentation and cummulant method to obtain loss of load probability (LOLP). Modeling of forecast uncertainty. Reliability evaluation of energy limited systems. Different techniques of evaluating reliability, reliability indices of interconnected systems. Composite transmission and generating system reliability.

Recommended Books:

1. R. Billinton, Power System Reliability Evaluation, Routledge.
2. R.N. Allan, Billinton, Reliability Evaluation of Power Systems, Springer.
3. Ali Chowdhury, Don Koval, Power Distribution System Reliability: Practical Methods and Applications, Wiley-IEEE Press.
4. David Elmakias, New Computational Methods in Power System Reliability, Springer.
5. William H. Smith, P.E.,"Electric Power System Reliability", Powersmiths International, 2007.
6. Roy Billington, Robert J. Ringlee, Allen J. Wood, Power-System Reliability Calculations, MIT Press.
7. Balbir S. Dhillon, Power System Reliability, Safety and Management, Ann Arbor Science Publishers.
8. Billinton, W. Li, Reliability Assessment of Electrical Power Systems Using Monte Carlo Methods, Springer.
9. George Anders, Alfredo Vaccaro, Innovations in Power Systems Reliability, Springer.

EEE 565 Power System Modeling (3 Credits)

Overview of power electronic applications at utility and demand sides; sources of harmonics; utility devices and consumer loads. Various models for nonlinear and dynamic loads. High voltage direct current (HVDC) transmission system modeling. AC-DC load flow studies. Modeling of flexible AC transmission systems (FACTS): conventional thyristor controlled reactors and phase shifters, voltage source inverter (VSI) based static condenser (STATCON) and unified power flow controller (UPFC). Transient stability and sub-synchronous resonance (SSR) studies incorporating super conducting magnetic energy storage (SMES) model. Modeling of utility interfaced photovoltaic and wind energy sources. Power quality, cyclic and non-cyclic voltage flicker, total harmonic distortion (THD) analysis, remedial measures and harmonic load flow studies.

Recommended Books:

1. Alexandre Nassif, Harmonics in Power Systems: Modeling, Measurement and Mitigation of Power System Harmonics, VDM Verlag.
2. Jay T. Pukrushpan, Anna G. Stefanopoulou, Huei Peng, Control of Fuel Cell Power Systems: Principles, Modeling, Analysis and Feedback Design, Springer.
3. Giuseppe Fusco, Mario Russo, Adaptive Voltage Control in Power Systems: Modeling, Design and Applications, Springer.
4. J. Watton, Fluid Power Systems: Modeling, Simulation, Analog and Microcomputer Control, Prentice Hall.
5. Federico Milano, Power System Modeling and Scripting, Springer.
6. J. Endrenyi, Reliability Modeling in Electric Power Systems, John Wiley & Sons.
7. Prabha Kundur, "Power System Stability and Control", McGraw-Hill Professional Publishing.
8. D P Kothari and I J Nagrath, "Modern Power System Analysis", Tata McGraw-Hill.
9. A.P. Meliopoulos, "Power System Modeling Control and Operation".

EEE 566 Transients in Power Systems (3 Credits)

Transients in simple electric and magnetically linked circuits, fundamentals: impacts of switching on rotating machinery. Parallel operation of interconnected networks; distribution of power impacts. Interaction of Governor?s in power systems. Overvoltage during power system faults. Systems voltage recovery characteristics. Effect of arc restriking on recovery voltage. Switching surges and overvoltage caused by sudden loss of load and by open conductor.

Recommended Books:

1. Allan Greenwood, Electrical Transients in Power Systems, Wiley-Interscience.
2. Lou van der Sluis, Transients in Power Systems, Wiley.
3. N. R. Watson, Power Systems Electromagnetic Transients Simulation, Institution of Engineering and Technology.
4. Juan A. Martinez-Velasco, Power System Transients: Parameter Determination, CRC Press.
5. M. Pavella, P. G. Murthy, Transient Stability of Power Systems: Theory and Practice, Wiley.
6. R. R. Sakis Meliopoulos, Power System Grounding and Transients, Marcel Dekker, Inc.
7. Harold A. Peterson, Transients in Power Systems, Dover Publications.

EEE 567 Advanced Power System Stability (3 Credits)

Principles of angular and voltage stability. Methods of multi machine transient stability: direct methods and time domain simulation. Equal area criterion. Extended equal area criterion, transient energy function (TEF) methods. Nonlinear system stability- Lyapunov's method. State space concepts and dynamic system representation. Eigen vectors in dynamic system analysis. Detailed modeling, simplifications, salient synchronous machines and induction machines modeling. Turbine governor, generator excitation systems and their representation in stability models. Power system stabilizers. On line identification and improvement of stability through on line control.

Recommended Books:

1. Prabha Kundur, "Power System Stability and Control", McGraw-Hill Professional Publishing.
2. Power System Dynamics: Stability and Control, Jan Machowski, Janusz Bialek, Dr Jim Bumby, Wiley

EEE 568 Advanced Power System Control (3 Credits)

Overview of requirements and constraints, real time operation and monitoring in power system; supervisory control and data acquisition (SCADA). Energy management system (EMS); on-line application functions; state estimation, short term load forecasting, unit commitment, automatic generation control (AGC), load frequency control (LFC) and security control. Open architecture EMS, on-line algorithm's speed enhancement: sparsity exploitation, fast decoupling, model/system decomposition, parallel processing-hierarchical computer and array processor configuration, application of expert system, pattern recognition, artificial neural network (ANN), fuzzy logic and genetic algorithms. EMS in the context of deregulation of utilities and independent system operator (ISO).

1. S. Sivanagaraju, Power System Operation and Control, Pearson Education India
2. Ramana N.V., Power System Operation & Control, Pearson Education India

EEE 569 Protection of Power Systems (3 Credits)

Advanced protective relaying, Basic protection schemes, relay terminology, relay as comparators, static relays, Application of solid state devices, differential relaying systems, distance relaying schemes, protection of multiterminal lines, new types of relaying criteria, special problems. Review of characteristics of over current, directional, differential, distance and pilot relays. Principles of relay design. Effects of transients on relay operation. Harmonic relaying. Static and digital relays. Applications of static and digital relaying in various protection schemes.

Recommended Books:

1. J. Lewis Blackburn and Thomas J. Domin, "Protective Relaying: Principles and Applications", CRC Press.
2. L. G. Hewitson, Mark Brown, Ramesh Balakrishnan, Practical Power System Protection, Newnes
3. Yeshwant G. Paithankar, S. R. Bhide, Fundamentals of Power System Protection, PHI Learning
4. Singh, Switchgear and Power System Protection, PHI Learning Pvt. Ltd
5. Badri Ram, D. N. Vishwakarma, Power System Protection and Switchgear, Tata McGraw-Hill Education
6. B. Ravindranath, M. Chander, Power System Protection and Switchgear, New Age International
7. Singh, Digital Power System Protection, PHI Learning Pvt. Ltd

EEE 570 Advanced Machine Design (3 Credits)

General treatment of Electrical Machine Design. Review of standard procedures in design of DC machines. AC machines, transformers and special machines. Optimization and synthesis of design procedures. Applications of material balance and critical path principles in electrical design. Design economics and safety factors. Applications of computers in modern designs including the operation of the machine in the nonlinear ranges: Magnetic flux-plots and heat transfer process etc. Mechanical design of electrical machinery and relation between machanical and electrical machine design.

Recommended Books:

1. Hamrock, Jacobson and Schmid, "Fundamentals of Machine Elements", McGraw-Hill.

EEE 571 Generalized Machine Theory (3 Credits)

Introduction to generalized machine theory. Kron's primitive machine: moving to fixed-axis transformation; Park's transformation: three-phase to d-q transformation: variable co-efficient transformation: other transformations. DC machine, induction machine and synchronous machine representation, Equivalent circuits and fault analysis. Matrix and tensor analysis of machines. Three phase synchronous and induction machines: two-phase servo motor: single phase induction motor. Smooth-air gap two-phase synchronous machine. Two-phase induction machine. The n-m winding symmetrical machine. Diagonalization by charge of variable. Symmetrical three-phase machine and special limiting cases.

Recommended Books:

1. Denis O'Kelly and S. Simmons, "Introduction to Generalized Electrical Machine Theory", McGraw-Hill Education.
8. H. Blent Ertan, "Modern Electrical Drives", Springer.

EEE 572 Modern Control Theory (3 Credits)

State space description of dynamic systems: relationship between state equations and transfer function: continuous and discrete time linear system analysis and design using state transition method. Controllability and observability. State feedback and output feedback. Pole assignment using state feedback and output feedback. H control. Optimal control-dynamic programming. Pontryagin's minimum principle. Separation theorem. Stochastic control. Adaptive control. Robust control. Discrete control. Multivariable control.

Recommended Books:

1. William L. Brogan, "Modern Control Theory", Prentice Hall.

EEE 573 Renewable Energy Technologies (3 Credits)

Wind Energy: Wind Energy Resources, Wind Turbine Systems, Wind Turbine Generation Systems Modeling for Integration in Power Systems, Technologies and Methods Used in Wind Resource Assessment, Economic Analysis of Wind Systems, Line Side Converters in Wind Power Applications, Wake Effects from Wind Turbines on Overhead Lines; Solar Energy Systems: Solar Energy Calculations, Photovoltaic Systems, Solar Thermal Electric Power Plants, Maximum Power Point Tracking Charge Controllers, Non-Grid Solar Thermal Technologies, Solar Tunnel Dryer; Bio Fuels**:** Biomass as a Source of Energy, Forest Biomass Production, Bioethanol, Biodiesel; Ocean and Small; Hydro Energy Systems: Technologies and Methods Used in Marine Energy and Farm System Model ,Operational Challenges of Low Power Hydro Plants, Frequency Control in Isolated Small Hydro Power Plant; Simulation Tools, Distributed Generation and Grid Integration: Simulation Tools for Feasibility Studies of Renewable Energy Sources, Distributed Generation, DG Allocation in Primary Distribution Systems Considering Loss Reduction , Renewable-Based Generation Integration in Electricity Markets with Virtual Power Producers; Induction Generators, Power Quality, Power Electronics and Energy Planning for Renewable Energy Systems: Modern Power Electronic Technology for the Integration of Renewable Energy Sources , Analysis of Induction Generators for Renewable Energy Applications , Control of Doubly Fed Induction Generators Under Balanced and Unbalanced Voltage Conditions, Power Quality Instrumentation and Measurement in a Distributed and Renewable Environment , Energy Resource Allocation in Energy Planning.

Books Recommended:

1. Ewald F. Fuchs, Mohammad A.S. Masoum, Power Conversion of Renewable Energy Systems, Springer.

2. Volker Quaschning, Understanding Renewable Energy Systems, Earthscan Publications Ltd.
3. D. Pimentel, Biofuels, Solar and Wind as Renewable Energy Systems: Benefits and Risks, Springer.
4. Leon Freris, David Infield, Renewable Energy in Power Systems, Wiley.
5. Boaz Moselle, Jorge Padilla, Richard Schmalensee, Harnessing Renewable Energy in Electric Power Systems, RFF Press.
6. Ali Keyhani, Mohammad N. Marwali, Min Dai, Integration of Green and Renewable Energy in Electric Power Systems, Wiley.
7. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, Wiley-IEEE Press.
8. Godfrey Boyle, Bob Everett, Janet Ramage, Energy Systems and Sustainability, Oxford University Press, USA.
9. Henrik Lund, Renewable Energy Systems: The Choice and Modeling of 100% Renewable Solutions, Academic Press.