University of Asia Pacific

Master of Science in Electrical and Electronic Engineering Program

Revised Curriculum

1. Overview

Department of Electrical & Electronic Engineering (EEE) of University of Asia Pacific (UAP) proposes to offer the post graduate program, namely Master of Science in Electrical & Electronic Engineering, abbreviated as **M.Sc. in EEE** to meet the increasing demand of higher studies in Electrical, Electronics and related fields. The curriculum has been designed with a view to enhance the academic and professional career to meet the contemporary challenges in the field of Electrical and Electronic Engineering. The following sections describe the structure of the program.

2. Program and Semester Duration

The minimum duration of the M. Sc. in EEE program shall normally be three semesters. A candidate for the Master's degree must complete all the requirements for the degree within **five** academic years from the date of the first admission in the respective program. The academic year is divided into two semesters, i,e, Spring and Fall, each containing 18 weeks. The breakdown of these semesters is as follows:

Classes	14 weeks
Mid Semester Examination	1 week
Preparatory Leave	1 week
Semester Final Examination	2 weeks
	Total 18 weeks

Commencement of Spring and Fall semesters are as follows:

Semester	**Duration**
Spring	April to September
Fall	October to March

3. Eligibility for Admission

A candidate must fulfill all of the following requirements for admission in the M. Sc. in EEE. program:

1. A bachelor degree in Electrical/ Electrical & Electronic/ Electronic & Communication/ Electronic & Telecommunication Engineering/ Computer Science and Engineering or equivalent from a recognized institute/university at home or abroad.
2. A CGPA of at least 2.5 on a scale of 4.0 or equivalent in bachelor program.
3. No third class/division in any public examinations (SSC/HSC/ Dakhil/ Fazil) and its equivalent examination.
4. Must clear all the prerequisite courses suggested by the Board of Postgraduate Studies (BPGS).

4. Enrollment

There are two categories of students, namely, full-time students and part-time students. A student enrolled as a full time will normally take a minimum of 9 credit hours and a maximum of 12 credit hours in any semester. For part time enrollment, maximum 9 credit hours in any semester will be allowed. Thesis registration can only be done after completion of minimum 12 credit hours in theory courses.

5. Formation of Board of Post Graduate Studies

There shall be a Board of post graduate studies (**BPGS**) in the Department of Electrical and Electronic Engineering. The Board of post graduate studies would be constituted as follows:

Chair	Head of the department of EEE
Member	All Faculty members of EEE Department of the rank of Assistant Professor or above and having a Master's degree or higher in EEE discipline.
Two members	External

6. Evaluation Policy

The total performance of a student in a given course is based on class assessment (assignments, class participation, projects and seminar presentation), a mid-semester examination and a semester final examination. The percentile distribution of marks for a theoretical course is as follows:

Class Assessment	30%
Mid Semester Examination	20%
Final Examination	50%
Total	100%

Thesis work will be done under the supervision of a faculty member assigned by the EEE department. A thesis must be of 18 (eighteen) credit hours for **M.Sc. in EEE**. Evaluation of a thesis will be done by a thesis evaluation committee constituted as follows:

Chair	Thesis supervisor
At least One Member	From the department
One Member	External
Ex-officio Member	Head of EEE Department

On the basis of the presentation and the thesis work done, the committee may award either "S" (Satisfactory) grade or "I" (incomplete) grade to the student.

7. Grading System

Numerical Grade	Letter Grade	Grade Point
80% and above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00
Incomplete Work	I	---
Satisfactory	S	---
Withdrawn	W	---

Courses in which the student gets **F** grades shall not be counted towards credit hour requirements and for the calculation of Grade Point Average (GPA).

Grade **I** is given only when a student is unable to sit for the examination of a course at the end of the semester because of circumstances beyond his control. She/he must apply to the Head of the Department within one week after the examination to get an I grade in that course. If it is not completed within the next two semesters, the **I** becomes **F** grade.

Grade **S** (Satisfactory) is used only as final grades for thesis. If however, thesis performance is found unsatisfactory, an **I** (incomplete) grade shall be given.

Grade **W** means officially withdrawn from a course. A student must withdraw officially from a course within two working weeks of the commencement of the semester or else his grade in that course shall be

recorded as **F** unless she/he is eligible to get a grade of **I**.

8. Thesis Requirement

A thesis must be of 18 (eighteen) credit hours for M.Sc. in EEE. The thesis should demonstrate the student's ability to identify and solve an acceptable problem in the area of Electrical & Electronic Engineering and to reflect the work in a document of acceptable literary quality. The appropriateness of the topic is determined by the BPGS. At the conclusion of the thesis work and report preparation, the student must prepare for the presentation of the thesis.

9. Eligibility of Faculty Member Conducting the Course or Thesis

A faculty member in the rank of Assistant Professor or above , who would be chosen to conduct courses in M. Sc. in EEE program or to supervise the thesis of the graduate program must have at least one postgraduate degree in the relevant field.

10. Degree Requirements

M.Sc. in EEE:

1. Completion of minimum 36 (thirty-six) credit hours including 18 (eighteen) credit hours thesis work.
2. Completion of at least 3 (three) courses from his/her group of interest and at least 1 (one**)** course from interdisciplinary courses.
3. Obtaining a minimum CGPA of **2.75** out of 4.0.

11. Course Numbering

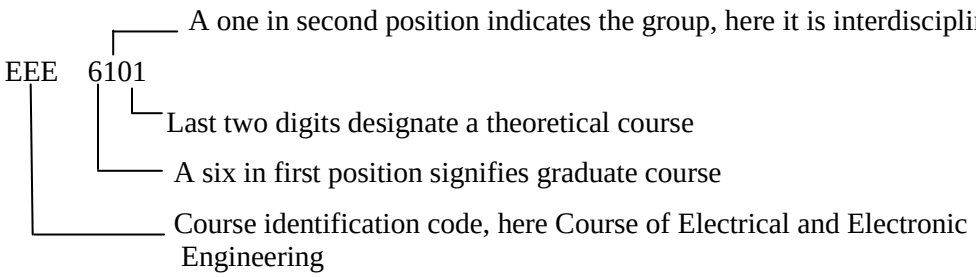
The type of the course and a four-digit course number identifies each course offered by the department of EEE. These numbers indicate course level, as follows:

Course Numbers	Level
6000~6499	Graduate Courses

The first digit will correspond to the graduate level. The second digit will be reserved for specific group. The third and fourth digits will be reserved for course numbering. For thesis, the course number has 0 as the second digit.

Example

Course code and title: EEE 6101 Engineering Analysis



12. List of Courses

Course Code and Course Title	Credit Hours
Interdisciplinary Courses	
EEE 6101: Engineering Analysis	3.0
EEE 6102: Selected Topics in Electrical and Electronic Engineering	3.0
EEE 6103: Nonlinear System Analysis	3.0
EEE 6104: Artificial Neural Systems	3.0
EEE 6105: Power Semiconductor Circuits	3.0
EEE 6106: Design of Power Semiconductor Circuits and Drives	3.0
EEE 6107: Electric and Magnetic Properties of Materials	3.0
EEE 6108: Research Methodology	3.0
Communication Group	
EEE 6201: Information and Coding Theory	3.0
EEE 6202: Advanced Telecommunication Engineering	3.0
EEE 6203: Advanced Digital Signal Processing	3.0
EEE 6204: Biomedical Signal Processing	3.0
EEE 6205: Optical Communications and Networks	3.0
EEE 6206: Advanced Multimedia Communications	3.0
EEE 6207: Digital Communication	3.0
EEE 6208: Digital Satellite Communication	3.0
EEE 6209: Speech and Image Processing	3.0

Course Code and Course Title	Credit Hours
EEE 6210: Antennas and Propagation	3.0
EEE 6211: Wireless Communications and Networks	3.0
Electronics Group	
EEE 6301: MOS Devices	3.0
EEE 6302: Compound Semiconductor Devices	3.0
EEE 6303: VLSI Technology and Device Modeling	3.0
EEE 6304: Advanced VLSI Design	3.0
EEE 6305: Carbon Nanotechnology	3.0
EEE 6306: Nano Systems	3.0
EEE 6307: Thin film Growth and Deposition	3.0
EEE 6308: Semiconductor Characterization Technology	3.0
EEE 6309: Electronics of Solids	3.0
EEE 6310: Semiconductor Materials and Heterostructures	3.0
Power Group	
EEE 6401: Optimization of Power System Operation	3.0
EEE 6402: Computer Methods in Power System Analysis	3.0
EEE 6403: Advanced Power System Protection	3.0
EEE 6404: Power System Stability	3.0
EEE 6405: Transients in Power Systems	3.0
EEE 6406: Reliability of Modern Power System	3.0
EEE 6407: Power System Planning	3.0
EEE 6408: Advanced Power System Control	3.0
EEE 6409: Energy Conversion and Storage	3.0
EEE 6410: Modern Power System Modeling	3.0
EEE 6411: Smart Grid Operation	3.0
Thesis	
EEE 6000: Thesis (for M.Sc. in EEE)	18.0

13. Description of Courses for M. Sc. in EEE Program

EEE 6101: Engineering Analysis
3 Credits

Wavelet transform. Chaos and bifurcation theorems. Walsh function. Green's function. Finite element techniques. Fuzzy logic. Genetic algorithms.

Recommended Books:

1. Merle Potter, "Engineering Analysis", Springer.
2. Leonid P Lebedev, Michael J Cloud and Victor A Eremeyev, "Advanced Engineering Analysis", World Scientific.

EEE 6102: Selected Topics in Electrical and Electronic Engineering
3 Credits

This course will explore an area of current interest in Electrical and Electronic Engineering. The emphasis will be on thorough study of a contemporary field within EEE, and the course will be made accessible to students with an EEE background. The syllabus of the course should be approved by the BPGS before the registration start.

EEE 6103: Nonlinear System Analysis
3 Credits

Numerical methods. Graphical methods. Equations with known exact solution. Analysis of singular points. Analytical methods. Forced oscillation systems. Systems described by differential difference equations. Linear differential equation with varying coefficient. Stability of nonlinear systems.

Recommended Books:

1. Austin Blaquiere, Nonlinear System Analysis, 1st Edition, Elsevier.
2. Dongbin Lee, Christos Volos and Timothy Burg, Nonlinear Systems- Design, Analysis, Estimation and Control.

EEE 6104: Artificial Neural Systems
3 Credits

Biological nervous system : the bran and neurons . Artificial neural networks. Historical backgrounds. Hebbian associator . Perceptions : learning rule, illustration ,proof, failing Adaptive linear (ADALINE) and Multiple Adaptive linear (MADALINE) networks . Multilayer perceptions: generating internal representation Back propagation, cascade correlation and counter propagation networks. Higher order

and bidirectional associated memory .Hopfield networks: Lyapunov energy function. attraction basin. Probabilistic updates: simulated annealing, Boltzman machine. Adaptive Resonance Theory (ART) network ART1, ART2, Fuzzy ART mapping (ARTMAP) networks. Kohonen's feature map, learning vector Quantization (LVQ) networks. Applications of neural nets.

Recommended Books:

1. Artificial Intelligence A Modern Approach, Stuart J. Russell and Peter Norvig Hagen, Demuth, and Beale.
2. Neural Network Design, PWS Publishing Company, 1996. − J. T. Tou and R. C. Gonzalez.
3. Pattern Recognition Principles, Addison-Wesley. − MATLAB Neural Networks Toolbox and Image Processing Toolbox.
4. C. M. Bishop: Neural Networks for Pattern Recognition.
5. Andrew Webb: Statistical Pattern Recognition.
6. Gonzalez, Woods, and Eddins: Digital Image Processing Using MATLAB.

EEE 6105: Power Semiconductor Circuits
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, Fourier analysis of static converter waveforms, HD, THD, pf, ZVS and ZCS of static converters. Multilevel inverters. Hysteresis current of AC drives.

Recommended Books:

3. Muhammad H. Rashid, "Power Electronics Circuits, Devices and Applications", Prentice Hall, 3rd Edition.
4. Abraham I. Pressman, "Switching Power Supply Design", McGraw-Hill, 2nd Edition.
5. Bimol K Bose, "Modern Power Electronics and AC Drives"

EEE 6106: Design of Power Semiconductor Circuits and Drives
3 Credits

Design of SCR communication circuits, base and gate drive circuits of static switching devices, snubber circuits, switching losses and heat sink. Input/output filter design of static power converters. Design of protection circuits for static power converters. Scalar and vector control of AC machines using static power converters. Design of Microcontroller-based switching circuits for static power converters.

Recommended Books:

1. Muhammad H. Rashid, "Power Electronics Circuits, Devices and Applications", Prentice Hall, 3rd Edition.
2. Abraham I. Pressman, "Switching Power Supply Design", McGraw-Hill, 2nd Edition.

EEE 6107: Electric and Magnetic Properties of Materials
3 Credits

Electric Properties: Polarization, electrical conductivity and dielectric losses. Pyroelectric phenomena, piezoelectric effect and electrostriction. Domain structure and peculiarities electric properties of ferroelectrics and anti-ferroelectrics. Structure and properties of some ferroelectrics and anti-ferroelectrics. Phase transition in ferroelectrics, fundamentals of spontaneous polarization theory.

Magnetic Properties: Disordered magnetics, ordered magnetics. Domain structure of ferromagnetic crystals and magnetization processes. Anisotropy of ferroelectric crystals. Structure of some magnetically ordered crystals and reorientation transition. Piezomagnetic and magnetoelectric effect.

Recommended Books:

1. Philippe Robert, "Electrical and Magnetic Properties of Materials", Artech House Publishers, 1988.
2. RE Hummel, " Electronic Properties of Materials", Springer, 2011.

EEE 6108: Research Methodology
3 Credits

Introduction to research- Overview, role of research and research process; Research philosophies and research theory building; Research expertise- Understanding, report writing, critical thinking, research communication, teamwork and real time efficiency; Research problems and hypotheses; Research Design- Experimental/non Experimental/field/survey; Project management; Methods of data collection; Attitude measurement and scaling; Introduction to sampling techniques and statistical tools; Processing and analysis of data; Environmental, social and ethical issues in conducting research; Getting published and author's profile

Recommended Books:

1. Kirsty Williamson Graeme Johanso (2017). Research Methods, 2nd Edition. Chandos Publishing, Elsevier.
2. Betz, Frederick (2011). Managing Science- Methodology and Organization of research, 1st Edition, Springer-Verlag New York Publisher, Springer.
3. Chawla, Deepak & UrbinaSondhi, Neena (2011). Research Methodology: Concepts and cases, Vikas Publishing House Pvt. Ltd. Delhi.

EEE 6201: Information and Coding Theory
3 Credits

Introduction to Information Theory, uncertainty, Information and Entropy, Source Coding theorem (Data Compaction, Huffman Coding, Lempel-Ziv Coding), Discrete Memory less Channels (DMC), Mutual Information, Channel Capacity, Channel Coding Theorem, Information Capacity Theorem; Introduction to Error-Control Coding, Linear Block Codes, Generator Matrix, Parity-Check Matrix, Syndrome, Group Theory; Introduction to Convolutional Codes, Convolutional Encoder, Usual Code of Operation, General

Rate 1/n Constraint Length K Code, Tree Representation of Convolutional Codes, Finite-State Machine Code Representation, Trellis Representation of Convolutional Codes, ML Decoding of a Convolutional Code, Viterbi Algorithm, Free Distance of a Convolutional Code.

Recommended Books:

1. Richard B. Wells, Applied Coding & Information Theory for Engineers, Prentice Hall, NJ 1999
2. Elements of Information Theory, 2nd Edition, T. M. Cover and J. A. Thomas, Wiley Interscience, 2006,
3. Digital Communications, John G. Proakis, 5th Ed., McGraw-Hill, 2007
4. Coding and Information Theory, Hamming, Richard W., 2nd Ed., Prentice-Hall Inc.,1986

EEE 6202: Advanced Telecommunication Engineering
3 Credits

Challenges in modern communications technology, baseband and broadband signal transmission, first and second Nyquist's criteria for zero inter symbol interference; robust signal compression and detection techniques, optimum receivers, design of frequency- and time domain equalizers and echo cancellers; wired and wireless channel characteristics, AWGN channels, time-varying multipath faded channels, channel modeling; advanced source and channel coding techniques, high bit rate digital modulation schemes and MODEMs; SS7 and HDLC protocols, H.323, H.26x, RTP and SCTP; modern high speed communication networks and emerging technologies, access and backbone networks, intelligent networks, NGN; advanced switching and routing principles, complex multiplexing and multiple access techniques, orthogonal signals, OFDM, DWDM; broadband wireless communication, spread spectrum techniques, CDMA2000 and WCDMA, multi-carrier systems; 3G and 3GPP mobile communications and WiMAX technology, UMTS, VoIP, IP TV, HDTV.

Recommended Books:

1. John Dunlop and D. Geoffrey Smith , "Telecommunications Engineering", 3rd Edition, CRC Press, 1994.
2. Roger L. Freeman, "Telecommunication System Engineering", Fourth Edition, Wiley, 2005.

EEE 6203 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. Bose, T. "Digital Signal and Image Processing", Wiley, 2004.
2. S. K., "Digital Signal Processing", McGraw Hill, 2001
3. Lim, J.S. and Oppenheim, A.V., "Advanced Topics in Signal Processing", Prentice-Hall, 1988.
4. Grant, P.M. et al, "Analogue and Digital Signal Processing and Coding", Chartwell-Bratt, 1989

EEE 6204 Biomedical Signal Processing
3 Credits

Dynamic medical signals: electrocardiogram (ECG), electroencephalogram (EEG), electromyogram (EMG). Detailed analyses of electro medical signals: waveform, origin, interpretation and significance. Linear and nonlinear parametric modeling: autoregressive (AR), moving average (MA), autoregressive moving average (ARMA), bilinear models. Nonlinear nonparametric modeling: neural network, fractal and chaos based models. Software based medical signal detection and pattern recognition (Matlab, MIT-BIH, EEG-LAB). Medical image (X-Ray, CT scan, MRI) analysis and compression. Arrhythmia detection form one dimensional biological signal and MRI.

Recommended Books:

1. Biomedical Instrumentation and Measurements : Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer Prentice-Hall India
2. Biomedical Engineering: Bridging Medicine and Technology, by Mark Saltzman
3. Fundamentals of Biomedical Engineering—by G. S. Swahney

EEE 6205: Optical Communications and Networks
3 Credits

The evolution of fiber optic systems Optical fiber modes and configurations Mode Theory and waveguide equations Single-Mode and graded-index fiber structure Signal degradation in optical fibers Optical Sources Photo detectors Optical Receiver Performance and Operation Optical Measurements, Optical networking: principles and challenges; evolution of optical networks, wavelength routed network, wavelength division multiplexing (WDM) network, sub-carrier multiplexing optical networks. Enabling technologies: optical transmitter, optical fiber, optical receivers, optical amplifiers, optical switching elements, optical cross-connects (OXC), multiplexers/demultiplexers, wavelength routers, optical wavelength converters, WDM network test beds. Network architecture, IP over WDM. Broadcast optical networks: single and multiple hop networks, channel sharing and multi-casting, shared channel multicasting network- GEMNET, performance evaluation for unicast and multicast traffic, experimental WDM networks. Wavelength routed networks: virtual topology design, routing and wavelength assignment, circuit switched and packet switched approaches, performance evaluation. Reconfiguration in WDM network, network control and management, network optimization, design considerations. Multi wavelength star and ring networks. Photonic switching, optical TDM (OTDM) and optical CDMA (O-CDMA) networks, next generation optical networks.

Recommended Book:

1. Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, " Optical Networks: A Practical Perspective", 3rd Edition, Elsevier, 1998.
2. Govind P. Agrawal, “Fiber-Optic Communication Systems”, John Wiley & Sons, Third edition, 2002

EEE 6206 : Advanced Multimedia Communications
3 Credits

Review of multimedia communications; asynchronous and synchronous transmission techniques, advanced signal compression; high-speed multimedia communication networks; emerging technologies: ATM, SONET, SDH, ISDN, SMDS; wireless network for multimedia, mobile IP and mobile Adhoc networking; protocol specification, UDP, TCP/IP and OSI reference models, SS7 and HDLC protocols, FTP, H.26x, RTP, SCTP, MSCTP, ICMP: message formats and transmission; voice over IP and mobile IP protocols, IPv6/IPv4 interoperability; advanced routing mechanisms, broadcast and multicast routing; NGI and Internet 2, transcoding of Internet’s multimedia content for universal access; entertainment networks, IP applications, audio and video conferencing, Internet through mobile and WiMAX.

Recommended Books:

1. Multimedia over IP and Wireless Networks: Compression, networking, and Systems, Mihaela van der Schaar. And Philip Chou, Academic Press, 2007
2. Multimedia Communications Directions and Innovations, A volume in Communications, Networking and Multimedia, edited by JERRY D. GIBSON, Academic Press, 2001.
3. Video Processing and Communications, Yao Wang, Joern Ostermann, and Ya-Qin Zhang. Prentice Hall, 2001.
4. Compressed Video over Networks, edited by Ming-Ting Sun and Amy R. Reibman, Marcel Dekker Inc., Switzerland, 2000.

EEE 6207: Digital Communication
3 Credits

Data digitization: Sampling and quantization. Base-band and pass-band signaling. Digital modulation and demodulation techniques, Pulse shaping. Radio channels: fading, multipath propagation, shadowing. Error sources: Thermal noise, AWGN, interference and inter-symbol interference. Channel coding: Linear block codes and convolutional codes. Structure of coders and decoders. Different coding methods for different modulation technique. Receiver: Optimal detection, Matched filtering, channel equalization. Error rates and spectral efficiency. Bit error probabilities, delays and utilized bandwidth. Radio resource management: Link budgets, Strategies and some algorithms for scheduling of packet data over fading wireless channels.

Multi-user systems and multiple access: Frequency division, time division, code division and spatial division multiple access. Orthogonal frequency division multiplexing. Multiple-input multiple output: Diversity-based transmission and adaptive transmission. System architecture: cellular systems, interference management, heterogeneous wireless networks. Wireless technologies and standards: GSM, WCDMA, LTE, WLAN and digital television.

Recommended Books:

1. Digital Communications, Fundamentals & Applications, Sklar, Bernard, 2nd Edition, Prentice-Hall Inc.,2001
2. Digital Communications, Haykin, Simon, John Wiley & Sons, 1988
3. Digital Communications, 5th Ed., John G. Proakis and Masoud Salehi, McGraw Hill, 2007/2008.
4. Fundamentals of Digital Communication, U. Madhow, Cambridge University Press, 2008

EEE 6208 : Digital Satellite Communication
3 Credits

Introduction to Digital Satellite Communications; Orbital Aspects of Earth Satellites; Digital Satellite Link Design; Propagation on Satellite-Earth Paths and Its Influence on Link Design; Modulation, Multiplexing and Multiple Access Techniques in Satellite Communications; Satellite Networking ; Spacecraft and Earth Station Technology; Types of Satellite Networks; Performance and Reliability of Satellite Communications.

Recommended Books:

1. Tri T. Ha: Digital Satellite Communications, McGraw-Hill, 1990.
2. G. Maral, M. Bousquet: Satellite Communications Systems, John Willey and Sons, Fourth Edition, 2003, 757pp.
3. T. Pratt, C.W. Bostian: Satellite Communications, John Wiley and Sons, 1986.

4. L.J. Ippolito: Radiowave Propagation in Satellite Communications, Van Nostrand, N.Y., 1986, 241 pp.
5. W.L. Prichard, H.G. Suyderhoud and R.A. Nelson: Satellite Communications Systems Engineering, Prentice Hall, Inc., New Jersey, 1993.
6. G.D. Gordon and W.L. Morgan: Principles of Communication Satellites, John Wiley & Sons, Inc., N.Y., 1993, 533 pp.

EEE 6209 : Speech and Image Processing
3 Credits

Overview of Applications of Vision and Image Processing, Digital Image Formats, Colour Models.

Matlab Basics- Data Types, Operators, Manipulating Matrices, File I/O, The Image Processing Toolbox, Grayscale Transforms and Filtering- Thresholding, Histogram Equalization, Linear Filtering (convolution), Noise Reduction, Nonlinear Filtering. Edge Detection- Gradients, Edge Magnitude and Direction, Finite Difference Filters, Laplacian of Gaussian Filter, Canny Edge Detector. Colour Image Processing- Colour Transformations, Colour Histogram Equalization, Colour Median Filtering, Colour Gradient and Edge Detection. Thresholding and Region Processing- Thresholding as a form of Segmentation, Basic Global Thresholding, Optimal Global Thresholding,Techniques to improve global thresholding, Region Labeling, Boundary Tracing. Segmentation- Edge Based Segmentation, Region-based Segmentation, Hybrid Methods. Segmentation Validation- Boundary-based measures of accuracy, Region-based measures of accuracy, Measuring Reproducibility. Speech production and phonetics:
speech organs, articulatory phonentics, acoustic theory of speech production, vocal tract models. Description - Boundary Descriptors, Region and Shape Descriptors, Texture Description, SIFT Features and Bags of Words. Classification- Supervised and Unsupervised Clustering, Nearest Neighbor Classifiers, Bayesian Classification, Training and Testing Methodologies.

Recommended Book:

1. Richard C. Dorf, " Circuits, Signals, and Speech and Image Processing", 1st Edition, CRC Press, 2006.

EEE 6210: Antennas and Propagation
3 Credits

Definitions, antenna as 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 . Banbiner`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. G. S. N Raju, "Antennas and Wave Propagation", Pearson Education India, 2006.
2. K.A. Bakshi, A.V. Bakshi and U.A. Bakshi, "Antennas and Wave Propagation", Technical Publications, 2009.

EEE 6211: Wireless Communications and Networks
3 Credits

Basics of Wireless Communication and Network, Wireless Propagation Modeling; Types of Digital Modulation used in Wireless Systems, Cellular Mobile Systems, Diversity Combining, Performance over Fading Channels, Multiple Access Techniques, Architectures and Communication Protocols for Wireless Networks, Sensor Networks, Wireless Local Area Networks, Ad-hoc Networks, Wireless Mesh Networks, Reliability of Wireless Networks, Next Generation Wireless Systems and Networks.

Recommended books:

1. Next-Generation Wireless Technologies: 4G and Beyond, Springer, 2013, by Naveen Chilamkurti and Sherali Zeadally
2. Next Generation Wireless Systems and Networks, Wiley, 2006, by Hsiao-Hwa Chen, Mohsen Guizani

EEE 6301: MOS Devices
3 Credits

The two terminal MOS Structure: flat-band voltage, inversion, properties of the regions of inversion and small signal capacitance. The four terminal MOS structure: charge-sheet model, strong inversion, moderate inversion and weak inversion. Threshold voltage-effects of ion implantation, short channel and narrow width. The MOS transistor in dynamic operation, small signal model for low medium and high frequencies, Charge Coupled devices (CCD).

Recommended books:

1. Yasuhisa Omura, Abhijit Mallik and Naoto Matsuo, "MOS Devices for Low Voltage and Low Energy Applications", John Wiley & Sons Singapore Pte. Ltd, 2017.
2. Dieter K. Schroder, "Advanced MOS devices", Addison-Wesley Pub. Co.
3. Norman Einspruch, "Advanced MOS Device Physics", Academic Press.

EEE 6302: Compound Semiconductor Devices
3 Credits

Introduction to GaAs device technology. 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. Opto-electronic integration of compound semiconductor devices: heterojunction

phototransistor (HPT) and light amplifying optical switch (LAOS). Low-temperature compound semiconductor electronics. Design consideration of MMICs and power MMICs using compound semiconductor devices.

Recommended Books:

1. Sandip Tiwari, "Compound Semiconductor Device Physics", Elsevier Science, 2013.
2. J.S. Yuan Juin and Jei Liou, "Semiconductor Device Physics and Simulation", Springer Science & Business Media, 2013.

EEE 6303: VLSI Technology and Device Modeling
3 Credits

VLSI Si process technology. Si crystal growth and wafer preparation . epitaxial growth on Si substrate. Oxidation of Si. Lithography, diffusion: methods and models. Ion implantation, metallization. Overview and process flow of a CMOS and a BICMOS process. VLSI si devices. Isolation techniques. Second order effects in BJT devices: base width modulation. Emitter current crowding, kirk effect . Second order effects in MOS devices: short channel effects, narrow width effects. Device scaling rules. Device models. Compact models for bipolar devices. Ebers-Moll type model. Gummel-poon type model and their implementation in SPICE. BJT model in SPICE2. Compact models for MOS transistor and their implementation in SPICE. Level 1,2 and 3 MOS model parameters in SPICE. Parameter extraction for bipolar and MOS device models. Geometry, process and temperature dependency of bipolar and MOS model parameters. Parameter optimization, statistics of parameters and statistical modeling.

Recommended Books:

1. James D. Plummer, "Silicon VLSI Technology: Fundamentals, Practice and Modeling", Pearson Education India, 2009.
2. John Y. Chen, "CMOS devices and technology for VLSI", Prentice Hall, 1990.

EEE 6304: Advanced VLSI Design
3 Credits

Trends and issues in high performance digital VLSI design : interconnect as key limiting factor, wire modeling, clock distribution of high speed system, power distribution, crosstalk and power distribution noise. High speed circuit design techniques; Low power design issues; High density and high speed memory design; SOI technology and circuits. VLSI circuits in signal processing; VLSI circuits in wireless communication. ASIC design.

Recommended Books:

1. H.B. Bakoglu, "Circuits, Interconnections and Packaging for VLSI", Addison Wesley Publishing Company.
2. Douglas A. Pucknell and Kamran Eshragian, "Basic VLSI Design", Prentice Hall, 3rd Edition.

3. Neil H. E. Weste, David Harris and Ayan Banerjee, "CMOS VLSI design", Pearson Education, 3rd edition.
4. Bosco Leung and Charles G. Sodini, "VLSI for Wireless Communication", Pearson Education.

EEE 6305: Carbon Nanotechnology
3 Credits

Nanomaterials and nanostructures: graphene, carbon nanotubes, fullerenes, molecules and organic nanostructures. Synthesis methods of nanostructures: electric arc, pulsed laser deposition, chemical vapor deposition (CVD); thermal CVD, catalytic CVD, micro wave CVD (MWCVD), plasma enhanced CVD (PECVD), spray pyrolysis. Physical and opto-electronic properties; characterization techniques.

Applications: carbon nanotube and graphene based devices, bio-sensors, bio-inspired nanostructures, molecular motors, fuel cells and solar cells.

Recommended Books:

1. Carbon Nanotubes: Properties and Applications, Edited by: Michael J. O'Connell, Ph.D.
2. Published in 2006 by CRC Press, Taylor & Francis Group, New York, USA.
3. Carbon Nanotubes: Basic Concepts and Physical Properties, S. Reich, C. Thomson and J. Maultzsch, Published in 2004 by Wiley-VCH Verlag Gmbh & Co. KGaA.
4. GRAPHENE: Carbon in Two Dimensions, MIKHAIL I. KATSNELSON, Published in 2012 by Cambridge University Press.
5. Fullerenes: Principles and Applications, Edited by: Fernando Langa & Jean-Francois Nierengarten, Published in 2007 by Royal Society of Chemistry.

EEE 6306: Nano Systems
3 Credits

Nanosystems and Devices: Introduction- nanomaterials, nanodevices, nanostructures. Nanoscale Lithography: X-ray, Electron-Beam and Ion-Beam; Soft Lithography; Scanning Probe Lithography. Advances in Device Technology: nanoscale sil icon devices, process technology, present challenges. Self Assembled Nanocrystals: self assembly, surface defects and passivation, structures, energy levels, transitions, luminescence and lasing. Nano Electro Mechanical Systems (NEMS): stress in thin films, mechanical to electrical transduction, surface engineering techniques, process flow, NEMS actuators, high aspect ratio system technology. Nano Biotechnology: scope and dimensions; detection of biological species on electrical, mechanical and optical criteria; Bio functionality on silicon; Biochip sensors and systems- structures, process technology.

Recommended books:

1. Textbook of Nanoscience and Nanotechnology, Authors: Murty, B.S., Shankar, P., Raj, B., Rath, B.B., Murday, J., Published by Springer in 2013.
2. Nanoelectromechanical Systems, Authors: Laurent Duraffourg, Julien Arcamone, Published by Wiley-ISTE in 2015.

EEE 6307: Thin film Growth and Deposition
3 Credits

Deposition by various PVD techniques such as evaporation, sputtering, ion-plating as well as chemical coating methods (CVD and ALD). Plasma technologies for thin films. Fundamental physical and chemical processes. Effect of the substrate on the film growth and techniques for surface modification. Models for nucleation and film growth. Morphology and texture and their impact on material properties. Applications of thin film materials and deposition technologies.

Recommended Books:

1. Milton Ohring, Materials Science of Thin Films, 2nd edition, Academic Press, 2002.
2. Thin Film Processes II, edited by John L. Vossen & Werner Kern, Academic Press Ltd., 1991.
3. Handbook of Thin Film Deposition, edited by Krishna Seshan, Elsevier, 2012.

EEE 6308: Semiconductor Characterization Technology
3 Credits

Overview of semiconductor technology: Thin Film Deposition. Structural characterization: X-ray diffraction (XRD), low energy electron diffraction (LEED), reflection high energy electron diffraction (RHEED), atomic force microscopy (AFM), scanning tunneling microscopy (STM), scanning electron microscopy (SEM), transmission electron microscopy (TEM), Rutherford backscattering spectroscopy (RBS), energy dispersive x-ray analysis (EDX), Auger electron spectroscopy (AES), electron energy loss spectroscopy (EELS), secondary ion mass spectroscopy (SIMS), X-ray photoelectron spectroscopy (XPS), elastic recoil detection (ERD). Electrical characterization: resistivity measurements, Hall measurement, current-voltage (I-V), capacitance-voltage (C-V), deep level transient spectroscopy (DLTS), lifetime measurements. Optical characterization: optical transmittance and reflectance spectroscopy, ellipsometry, photoluminescence (PL), Raman spectroscopy, Fourier transform infrared spectroscopy. Advanced characterization methods of thin film photovoltaic cells.

Recommended Books:

1. Dieter K. Schroder, Semiconductor Material and Device Characterization, 3rd edition, Wiley-IEEE Press, June 2015.
2. Carlo Lamberti, Characterization of Semiconductor Heterostructures And Nanostructures, Elsevier Science, 2008.
3. Sidney Perkwitz, Optical characterization of semiconductors: infrared, Raman, and photoluminescence spectroscopy, Academic Press Ltd., 1993.
4. Daniel Abou-Ras, Thomas Kirchartz, and Uwe Rau, Advanced Characterization Techniques for Thin Film Solar Cells, Wiley-VCH, 2011.

EEE 6309: Electronics of Solids
3 Credits

Band-structure and doping of semiconductors. Drift-Diffusion Equations; Density of states; Fermi function; Law of Mass Action. PN Junctions: Derivation of I-V characteristics. PN Junctions: Capacitance; Breakdown; Non-idealities. Bipolar Junction Transistor (BJT): Operation principles. BJT: Derivation of I-V characteristics. BJT: Ebers-Moll model; Nonidealities. MOSFET: Derivation of I-V characteristics. MOSFET: Structure; Threshold Voltage; Enhancement- & Depletion-mode. Microwave

devices. Transistors for Digital Logic: TTL, ECL, CMOS. Optoelectronic & Photonic Devices: Direct Vs Indirect Band-gap devices. LEDs; Semiconductor Lasers; Photovoltaic Cells. Principles and key technologies involved in microfabrication of integrated circuits. Microfabrication of: MOSFETs; CMOS; BJTs.

Recommended Books:

1. Walter R. Beam, "Electronics of Solids", McGraw-Hill; First Edition Edition.
2. Ben Streetman and Sanjay Banerjee, "Solid State Electronic Devices", 5th Edition, Prentice Hall, 1999.

EEE 6310: Semiconductor Materials and Heterostructures
3 Credits

Semiconductor: Basics of semiconductor, types of semiconductors, Crystal imperfections, Impurities in Si wafer, alloys, Structural and electronic properties, Epitaxial growth techniques (Molecular beam epitaxy (MBE) and Chemical vapor deposition (CVD)), Band structure, Density of carriers in intrinsic and doped compound semiconductors. Hetero-Junctions: Band alignment, band offset, Anderson's rule, single and double sided hetero-junctions, quantum well and quantization effects, lattice mismatch and strain and common hetero-structure material systems. Hetero-Junction diode: Band bending, carrier transport and I-V characteristics. Hetero-junction field effect transistor: Structure and principle of operation, band structure, carrier transport and I-V characteristics. Heterostructure bipolar transistor (HBT): Structural and electrical study and band diagram of a graded alloy base HBT.

Recommended Books:

1. Jasprit Singh, Electronic and Optoelectronic Properties of Semiconductor Structures, Cambridge University press, Cambridge University Press, 2003, 1st edition.
2. Donald A Neamen, Dhrubes Biswas, Semiconductor Physics And Devices, 4th edition, Mcgraw Higher Ed, 2012.
3. Carlo Lamberti, Characterization of Semiconductor Heterostructures And Nanostructures, Elsevier Science, 2008.
4. Simon M. Sze Gary S. May, Fundamentals Of Semiconductor Fabrication, Wiley, 2012.
5. Jasprit Singh, Physics of Semiconductors and Their Heterostructures (McGraw Hill 1993).

EEE 6401: Optimization of Power System Operation
3 Credits

General principles of optimization, its application to power system planning, design and operation. Modeling of generating units - thermal units, combined-cycle units, hydro units, pumped-storage units, photovoltaic, wind. Economic operation of power system-economic operation of thermal plants, combined thermal and hydroelectric plants. Economic dispatch, security-constrained economic dispatch. Economic operation of interconnected areas. Unit commitment. Optimum power flow (OPF). Fuel budgeting and planning, hydrothermal coordination. Reactive power optimization.

Recommended books:
1. Allen J. Wood, Bruce F Wollenberg, Power generation, operation and control
2. Jizhong Zhu, "Optimization of Power System Operation", 2nd Edition, Wiley-IEEE press, 2015.
3. Soliman, Soliman, Abdel-Hady, Mantawy and Abdel-Aal Hassan, "Modern Optimization Techniques with Applications in Electric Power Systems", Springer, 2012.

EEE 6402: Computer Methods in Power System Analysis
3 Credits

General review of network theory, matrix analysis and computer modeling. Incidance matrices, primitive networks and formation of impedance and admittance network matrices. Algorithms for formation of network matrices. Three phase load flow. AC-DC Load flow. Short Circuit Studies using bus impedance matrix and loop impedance matrix, open circuit fault studies; sequence bus impedance matrices for unsymmetrical faults. Eigenvalue analysis. Load forecasting and state estimation: estimation of average, periodic, stochastic components of load, application in power system.

Recommended Books:
1. W.D. Stevenson Jr., Elements of Power System Analysis, 4th ed., Mcgraw –Hill.
2. I.J. Nagrath and D.P. Kothari, Modern Power System Analysis, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
3. Hadi Saadat, Power System Analysis, the McGraw-Hill Publishing Co. Ltd., New Delhi.
4. J. Duncan Glover, Power System Analysis and Design, 6th Edition
5. Computer Techniques in Power System Analysis- Pai, M. A- TMH, 2nd edition, 2006.
6. V.K. Mehta, S. Chand and Co., Principles of Power Systems, 2nd ed.

EEE 6403: Advanced Power System Protection
3 Credits

Review of characteristics of over current, directional, differential, distance and pilot relays. Busbar protection using conventional relays. Transformers protection scheme based on over-current and differential relays. Distance relays protection schemes for transmission networks. Protection of rotating machines. Protection of FACTS devices. Effects of transients on relay operation. Relaying based on frequency dynamics. HVDC protection: AC side, DC side, reverse power, torsional interaction, protection of generators near converters. Protection system for renewable sources.

Recommended books:
1. Protective Relaying: Principles and Applications By J. Lewis Blackburn and Thomas J. Domin.
2. The Art and Science of Protective Relaying by C. Russell Mason.
3. Power System Protection by P.M. Anderson.

EEE 6404: Power System Stability
3 Credits

Principles of angular, voltage and frequency stability. Dynamic models of synchronous machines, excitation system, turbines, governors, loads. Modeling of single machine-infinite bus system. Mathematical modeling of multi machine system. Dynamic and transient stability analysis of single machine and multi-machine systems. Nonlinear system stability- Lyapunov's method. State space concepts and dynamic system representation. Eigen vectors in dynamic system analysis. Coherency.

Power system stabilizer. Direct method of transient stability analysis: Transient energy function approach. Voltage stability, P-V curves, Q-V curves, sensitivity and continuation method.

Recommended Books:

1. Prabha Kundur, "Power System Stability and Control", McGraw-Hill Publishing Company, NY.
2. W.D. Stevenson Jr., Elements of Power System Analysis, 4th ed., Mcgraw –Hill.
3. J. Duncan Glover, Power System Analysis and Design, 6th Edition.
4. Hadi Saadat, Power System Analysis, the McGraw-Hill Publishing Co. Ltd., New Delhi.
5. I.J. Nagrath and D.P. Kothari, Modern Power System Analysis, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

EEE 6405: Transients in Power Systems
3 Credits

Lumped and distributed Parameters – Wave Equation – Reflection, Refraction, behavior of travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion. Interaction of Governor's in power systems. Lightning over voltages: interaction between lightning and power system ground wire voltage and voltage across insulator; switching overvoltage: Short line or kilometric fault, energizing transients - closing and re-closing of lines, methods of control; temporary over voltages: line dropping, load rejection; voltage induced by fault; very fast transient overvoltage (VFTO). Insulation coordination; surge protection. Applications of EMTP.

Recommended Books:

1. I.J. Nagrath and D.P. Kothari, Modern Power System Analysis, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. W.D. Stevenson Jr., Elements of Power System Analysis, 4th ed., Mcgraw –Hill.
3. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991.
4. Hadi Saadat, Power System Analysis, the McGraw-Hill Publishing Co. Ltd., New Delhi.
5. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

EEE 6406: Reliability of Modern Power System
3 Credits

Review of probability theories. Basic reliability concepts. Network methods. Markovian model of generation unit. Development of load models. State space method. Probabilistic simulation of generating systems. Loss of load method, loss of energy method, frequency and duration method. Modeling of forecast uncertainty. Monte Carlo simulation. Reliability of energy limited systems. Reliability of interconnected systems. Composite transmission and generating system reliability. Reliability analysis of substation (fault-tree and event-tree methods).

Recommended Books:

1. "Reliability Evaluation of Engineering Systems"- Roy Billinton, Ronald. N. Allan, 2nd Edition,

1992.
2. "Reliability Evaluation of Power Systems" - Roy Billinton, Ronald. N. Allan
3. "Reliability modeling in electrical power system"- J. Endrenyi, John Wiley & Sons.
4. "Concepts in Reliability Engineering"- L S Srinath, East West Press Ltd, 2nd edition.
5. "Monte Carlo Methods", Hammersley J.M., Handscomb D.C., John Wiley and Sons, NY, 1964.

EEE 6407: Power System Planning
3 Credits

Basic objectives of power system planning. Generation expansion planning process. Electrical load forecasting; current load forecasting approaches. Short and long term generation planning, frequency control. Economic analysis, expected energy generation, expected fuel cost. Booth-Baleriux, cummulant 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. Power Generation, Operation, and Control by Allen J. Wood, Bruce F. Wollenberg
2. Power System Planning by Robert L. Sullivan

EEE 6408: 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). Systems for substation automation based on IEC 61850, and also automation of generation plants, and distribution systems. 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). Integration of renewable Energy in the power system.

Recommended books:
1. Power System Stability and Control by Prabha Kundur.

EEE 6409: Energy Conversion and Storage
3 Credits

Forms of energy - Electric, magnetic, chemical, thermal, kinetic, etc. Details of Energy sources and classes , Energy conversion - methods, efficiency, limitations and energy balance equations; Direct electrical energy conversion- Magnetohydrodynamic (MHD), Thermoelectrostatic, Ferro-electric, Photo-electric, Electrostatic and Piezoelectric energy conversions and their characteristics including efficiency, power densities, terminal properties and limitations. Mechanism of energy storage- Batteries, supercapacitors, thermal energy, mechanical energy, embodied energy, etc.

Recommended Books:

1. Sarma M S, "Electric Machines, Steady-state Theory and Dynamic Performance", Second Edition, West Publishing Company, 1994.
2. Sorensen, B. (2007). Renewable Energy Conversion, Transmission, and Storage. Academic Press. Yasar, D. (2012). Energy: Production, Conversion, Storage, Conservation, and Coupling. Springer, UK.

EEE 6410: Modern 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 superconducting magnetic energy storage (SMES) model. Modeling of utility interfaced photovoltaic and wind energy sources. Power quality, cyclic and noncyclic voltage flicker, total harmonic distortion (THD) analysis, remedial measures and harmonic load flow studies.

Recommended books:

1. I.J. Nagrath and D.P. Kothari, Modern Power System Analysis, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. W.D. Stevenson Jr., Elements of Power System Analysis, 4th ed., Mcgraw –Hill.
3. J. Duncan Glover, Power System Analysis and Design, 6th Edition
4. Hadi Saadat, Power System Analysis, the McGraw-Hill Publishing Co. Ltd., New Delhi.
5. "Power System Stability and Control"- Prabha Kundur. McGraw-Hill Publishing Company, NY

EEE 6411: Smart Grid Operation
3 Credits

Distributed energy resources, two way communications and demand response. Energy storage devices and systems. Grid connected PV generator control, micro/mini-hydros and wind turbines. Vehicle to grid system: multi-agent charging of plug-in hybrid electric vehicles, frequency regulation, reserve and

reactive power support. Fault current limiters. Feeder reconfiguration. D-STATCOM for voltage compensation and load balancing. Demand response for blackout prevention.

Recommended Books:

1. James A. Momoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley-IEEE Press; 1 edition.
2. Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed and Efficient Energy", Academic Press; 1 edition.

EEE 6000: Thesis (for M. Sc. in EEE)
18 Credits

A student must undertake a research work on Electrical and Electronic Engineering topic under the guidance of a supervisor. The student is required to prepare and submit the thesis within the time specified.