Post graduate Courses of the Department of Electrical and Electronic Engineering, BUET

Divisions of Specialization and choice of courses at EEE Department:

Presently there are two divisions of specialization namely (1) Electrical Energy and Power Systems (EEPS) Division and (2) Communication and Electronics (C&E) Division under which a postgraduate student can specialize. In future some more divisions may be formed segregating these two divisions. Presently the PG theory courses are arranged as: Interdisciplinary group (EEE 6001 - 6002, EEE 6101 - 6102, EEE 6301 - 6302, EEE 6701 - 6703), EEPS Division (EEE 6801 - 6803, EEE 6901 - 6910), and C&E Division (EEE 6201 - 6212, EEE 6401 - 6410, EEE 6501 - 6506, EEE 6601 - 6606).

For the degree of M.Sc. Engg., a student has to take a minimum of 6 courses of which **at least three are from his /her assigned Division**, and the remaining three courses are from the Interdisciplinary group or any Division. For the degree of M. Engg., a student has to take a minimum of 10 courses of which **at least five are from his/ her Division** and the remaining five courses are from the Interdisciplinary group or any Division.

The topic of the thesis (for M.Sc. Engg. degree) / project (for M. Engg. degree) **must be related to division of the student or the interdisciplinary group**.

EEE 6000: Thesis
(for PhD: 45 Credits, for M.Sc. Engg.: 18 Credits) / Project (for M. Engg: 6 Credits)

EEE 6001: Engineering Analysis
3 Credits

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

EEE 6002: Selected Topics in Electrical and Electronic Engineering
3 Credits

Course contents to be decided by the course teacher with the approval of the Board of Postgraduate Studies (BPGS) of EEE Dept.

(NB: This course can be taken by a student only once in any program. Any student intending to enroll in the subject EEE6002 in a semester will have to declare in the 'Remarks' column of his/her Course Registration form that he/she has not taken this course previously irrespective of the topic title under EEE6002).

EEE 6101: 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 differtial difference equations. Linear differential equation with varying coefficient. Stability of nonlinear systems.

EEE 6102: 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.

EEE 6201: Information and Coding Theory
3 Credits

Definition and measure of information, information capacity. Fundamentals of error control coding: forward error correction (FEC) and automatic repeat request. Binary coding: and automatic repeat request. Binary Coding: properties of codes, construction of binary compact codes. Convolutional coding: Viterbi and sequential decoding; algebra of linear block codes; error correction and detection using block codes; transmission line codes.

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 intersymbol 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.

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.

EEE 6204: Optical Fibre Communication
3 Credits

Optical fibre: modes of propagation, transmission characteristics, waveguide analysis. Optical sources: light emitting diode (LED) and semiconductor laser diode (SLD); operational principles, characteristic curves; optical transmitter design using LED/SLD. Optical amplifiers: laser and fibre amplifier5s. Photo detectors: P-i-N and avalanche photo detectors (APDs), noise sources. Optional modulation and detection schemes. Direct and coherent detection receivers: configuration, operation, noise sources, sensitivity calculation, performance curves. Design of analog and digital receivers.

Transmission link analysis: point-to point and point-to multi-point links, system configuration, link power budget, rise time budget, line coding schemes, transmission system limitations, design of fibre-optic systems. Optical data buses, optical networks, fibre distributed data interface (FDDI) and synchronous optical network (SONET). Optional frequency division multiplexing (OFDM) and wavelength division multiplexing (WDM) transmission systems.

EEE 6205 Biomedical Signal Processing
3 Credits

Dynamic medical signals: electrocardiogram, electroencephalogram, electromyogram. Detailed analyses of electromedical 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. Medical image analysis and compression. On-line monitoring and diagnosis.

EEE 6206 Optical Networks
3 Credits

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.

EEE 6207 Broadband Wireless Communications
3 Credits

Overview of broadband wireless communications, multiple access techniques – TDMA, FDMA. Spread spectrum communications – direct sequence spread spectrum (DSSS), FHSS, THSS, modulator and demodulator structure, probability of error, jamming margin, decoding, performance in the presence of interference, PN sequence, CDMA, MC-CDMA, UWB transmission. Multi-user detection: multiple access interference, detector performance measure – BER, asymptotic efficiency, near-far resistance; detectors – matched filter detector, de-correlator detector, MMSE detector, SIC, PIC, MAP and MLSE detectors. Propagation in mobile radio channels; channel models, fading – large scale and small scale fading, flat fading and frequency selective fading channel, fast fading and slow fading channel; delay spread, Doppler spread and angle spread; channel autocorrelation functions, scattering function, correlated and uncorrelated scattering (US), WSS and WSSUS model. Multiple antenna systems, capacity of SISO, SIMO, MISO and MIMO systems, ergodic capacity, outage capacity, STBC, OSTBC, QOSTBC, spatial multiplexing (SM) scheme, SM detection techniques, diversity and diversity combining techniques. Multi-carrier communications; Orthogonal FDM (OFDM), OFDM transceivers. Special issues of OFDM – cyclic prefix, timing offset, frequency offset, synchronization, peak power problem, Broadband wireless standards.

EEE 6208 Advanced Multimedia Communications
3 Credits

Review of multimedia communications; asynchronous and synchronous transmission techniques, synchronization issues and challenges, advanced signal compression, error-detection and correction methods; high-speed multimedia communication networks, switched network and enterprise networks; emerging technologies: ATM, SONET, SDH, ISDN, SMDS networks and their framing formats, bandwidth requirements; traffic characteristics, traffic scheduling, resource reservation, and QoS issues of multimedia networks; wireless network for multimedia, mobile IP and mobile Adhoc networking, network security and secured remote access; 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, watermarking and authentication for multimedia documents; NGI and Internet 2, revolutionary applications of Internet, transcoding of Internet's multimedia content for universal access; entertainment networks, IP applications, audio and video conferencing, Internet through mobile and WiMAX.

EEE 6209 Digital Image Processing
3 Credits

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.

EEE 6210 Digital Video Processing
3 Credits

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.

EEE 6211 Digital Speech Processing
3 Credits

Speech production and phonetics: speech organs, articulatory phonentics, acoustic theory of speech production, vocal tract models, speech analysis: time and frequency domain analysis, formant and pitch estimation, speech coding: linear predictive coding (LPC), vocoders, vector quantization, speech enhancement techniques, speech synthesis: formant and LPC synthesizers, effect of different speeches and languages, automatic speech and speaker recognition: feature extraction, hidden Markov models, noise robustness, measures of similarity, language and accent identification.

EEE 6212 Genomic Signal Processing
3 Credits

Fundamentals of molecular biology, genomics, and proteomics; DNA and microarray; genome sequencing; microarray technology and data pre-processing; gene feature selection; gene expression analysis; hidden Markov Model-based and time-frequency analysis of genomics and proteomic sequences, regulatory motif discovery; gene finding; gene clustering and classification; proteomic technologies, protein-protein interactions and protein function prediction, modeling and inference for genetic regulatory networks, emerging applications of genomic signal processing.

EEE 6301: 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. Hysteresis current of AC drives.

EEE 6302: 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 microcomputer controllers for static power converter switching.

EEE 6401: 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).

EEE 6402: 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.

EEE 6403: Quantum Phenomena in Nanostructures
3 Credits

Fundamentals of quantum mechanics: effective-mass Schrodinger Equation, matrix representation, Greenis function: Fundamentals of nonequilibrium statistical mechanics: scattering and relaxation. Carrier transport: density of states, current, tunneling and transmission probabilities, introduction to transport in the collective picture. Basic principles of a few effective devices: resonant tunnel diode, super lattice, quantum wire and dot.

EEE 6404: 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.

EEE 6405: 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.

EEE 6406: Testing VLSI Circuits
3 Credits

Physical defects in VLSI Circuits. Complexity and economics of testing. Fault models: Stuck-at, Stack-on, Stack-open, bridging and delay faults. Testing combinational logic circuits : terminologies , path sesicization, fanout and reconvergence, fault matrix , fault collapsing . test generation using D-algorithm, Boolean difference and other methods. Testing sequential logic circ its : problems and remedies. Testability of different types of CMOS circuits for various faults . test invalidation . Robustly testable CMOS circuits . Test generation for static and dynamic CMOS.

Design for testability: different techniques of enhancing testability scan design techniques, built-in self (BIST) Built-in current sensors (BICS) for IDDQ testing of CMOS circuits. Error detecting codes and self-checking circuits. Testable design of regular array architectures and PLAS: Testable design of regular array architectures and PLAS: the concept of C-testability.

EEE 6407 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.

EEE 6408 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 silicon 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.

EEE 6409: Thin film Growth and Deposition
3 Credits

Introduction to Thin Film Technology. Vacuum systems. Kinetic theory of gases. The physics and chemistry of evaporation/deposition mechanism. Physical vapor deposition and related techniques. Theories of epitaxy and nucleation, molecular beam epitaxy. Chemical vapor deposition techniques: reaction types, growth kinetics. Liquid phase epitaxy and related techniques. Theories of plasma and discharges. Sputtering (DC, RF and ECR). Solution based deposition techniques (Sol-gel), spray pyrolysis.

EEE 6410: Semiconductor Characterization Technology
3 Credits

Overview of semiconductor technology. 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.

EEE 6501: 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.

EEE 6502: Electronics of Solids
3 Credits

Crystal Structure: lattice types, basis, defects, reciprocal lattice, Miller indices.

Free Electron Theory: Drude model and Sommerfield theory.

Band Theory: Blochis theorem and crystal momentum, the nearly free electron model, band structures of Si and III-V semiconductors.

Carrier Transport: Boltzmann transpord theory, relaxation time approximation, high field transport and hot-carrier effects, Hall effect.

EEE6503 Laser Theory
3 Credits

Black body radiation and the Planck law. Stimulated and spontaneous emission, atomic and spectral line width, 3-level atomic, systems. Laser operation under steady state condition, laser output coupling and power . Q-switching and mode locking. Line broadening mechanisms: homogeneous and inhomogeneous broadening. Open resonator and Gaussion beam, stability criterion for optical resonators. Principles of operation of gas, solid state and semiconductor lasers.

EEE 6504 Semiconductor Materials and Heterostructures
3 Credits

Residual impurities in silicon wafers, zone refining. Crystal imperfections: structural, optical and electronic properties. Implantation related defects, recovery of crystal structure, solid phase epitaxial regrowth (SPE). Semiconductor alloys: Structural and electronic properties: growth techniques- molecular beam epitaxy (MBE). Chemical vapour deposition (CVD): pseudomorphic and metastable structures, tetragonal distortion. Strain relaxation. Structural and optical properties of double sided heterostructures, quantum wells and superlattices; types of band alignment. Solid state heterostructural LED and LASER . optoelectronic Functionality in silicon chip . Structural and electrical study of heterojunction bipolar transistor (HBT), heterojunction avalanche photodiode , and silicon-germanium MOSFET.

EEE 6505: Nanophotonics and Plasmonics
3 Credits

Interaction of light with material; wave equation in matter from Maxwell's equations; Dielectric properties of insulators, semiconductors and metals; Interaction of light with microstructures and nanostructures; Optical properties of metal-dielectric composites; Photonic Crystals: Electromagnetic effects in periodic media; One-, two- and three-dimensional photonic crystals; Applications of photonic crystals: omni-directional reflection , light localization, photonic crystal fibers; Surface Plasmons: Surface plasmonpolariton at single interface, multilayer system, localized surface plasmons; Excitation of surface plasmonpolariton; Prism coupling, grating coupling; Application of surface plasmons; Sub-wavelength waveguides, plasmonic photovoltaics, plasmonic bio-sensors; Metamaterials: Electric metamaterials, magnetic metamaterials, negative index metamaterials, hyperbolic metamaterials.

EEE 6506: Advanced Photodetection System
3 Credits

General introduction on photodetectors and photodetection systems: Performance and Figure-of-merits for photodetectors; Comparative study on different detector structures; Bandgap engineering and III-V materials; Opto-Electronic Integrated Circuits (OEIC) and receiver systems, receiver noise and other performance characteristics; Infrared Sensors; Quantum Dots; Focal Plane Arrays; Solar and Photovoltaic cells; Fabrication issues (leakage mechanisms – surface leakage, dark current, tunneling current, etc.); Optical properties relevant to detection systems, Biosensors; Nanosensors.

EEE 6601: Applied EM Theory
3 Credits

Generalized approach to field theory: introduction to reaction concept, wave propagation through isotropic, anisotropic and gyrotropic media. Scattering of EM Waves. Microwave antennas-theory and design. Advanced topics in EM theory.

EEE 6602: Microwave theory and techniques
3 Credits

Circuit theory for wave guide systems. N port circuits: impedance matrix, admittance matrix, scattering matrix and transmission matrix, their properties. Periodic structures and filters: wave analysis, impedance matching, wave and group velocities; comb lines and their analysis: introduction to filters, filter design by image parameter and insertion-loss methods; design of different type of filters.

EEE 6603: Microwave Tubes and Circuits
3 Credits

Electron guns and their design; interaction of electron beams and electromagnetic fields. Details of microwave tubes. Masers, parametric amplifiers, microwave circuits . Matrix representation of microwave component design. Analysis of waveguide discontinuations and non-reciprocal microwave circuits , selected topics.

EEE 6604: 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.

EEE 6605 Microwave Solid State Devices and Circuits
3 Credits

Introduction to N port network for lossless Junctions . Resonant circuits and different types of resonators. Modern microwave transmission lines and microwave integrated circuits (MICs); TEM, quasi TEM and non TEM type MIC lines, microstrip lines. Microwave passive devices: directional couplers, hybrid junction / magic T, Wilkinson power divider, microstrip line filters, isolators, phase shifters, attenuators. Microwave amplifiers and oscillators.

EEE 6606 Optical Waveguide Theory
3 Credits

Types of optical waveguides: optical integrated circuits and guiding structures. Basics of optical waveguide analysis: basic equations for light waves, polarization of light, reflection and refraction, wave equations. Guided and radiation modes in dielectric slab waveguides. Coupled mode theory. Analytical solution for optical waveguides: WKB method, Marcatili's method, effective index method, equivalent network method. Computer aided design of integrated optical waveguide devices. Application of photonics to microwave devices. Nonlinear optical waveguides.

EEE 6701: Nonlinear Control Systems
3 Credits

General introduction: the phase plane: method of isoclines: Linenard's method: Pelts method: common nonlinearities: transient response from phase trajectory: describing function and their applications. Relay servo mechanism. Lyapunov's method.

EEE 6702: Sampled Data Control System
3 Credits

Z Transform and modified Z transform: root-locus and frequency method of analysis of sampled data systems. Compensation, discrete and continuous method. Physical realization of discrete compensations.

EEE 6703: 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.

EEE 6801: 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. 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.

EEE 6802: Special Machines
3 Credits

Course will be broadly on current topics on electrical machines and devices. The following areas will be covered: permanent magnet machines. Hysteresis machine. Eddy current devices: homopolar machines. PAM motors and reluctance machines.

EEE 6803: Advanced Machines 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.

EEE 6901: 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 dispath of generators.

EEE 6902: 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 networks: symmetrical components and sequence impedances, balanced and unbalanced faults. Faults impedance and admittance matrices. Short circuit studies using ZBUS and ZLCOP, open circuit fault studies. Load flow studies, power flow equations. Gauss-Seidel. Newton-Raphson, decoupled and fast decoupled methods of load flow analysis. Three phase load flow.

EEE 6903: Advanced Protective Relays
3 Credits

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.

EEE 6904: 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.

EEE 6905: 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.

EEE 6906: Reliability of Power System
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.

EEE 6907: 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, 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.

EEE 6908: 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).

EEE 6909: Energy Conversion
3 Credits

Energy conversion processes; general introduction, energy sources, principles or conservation of energy balance equations. Direct electrical energy conversion: introduction: magnetohydronamic (MHD): fuel cell: thermoelectrostatic: 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.

EEE 6910: 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 super conducting 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.