Courses Offered in Level 4

Level-4 Term-I

Sl. No	Course Number	Course Name	Contact Hours per Week	Credit Hour
1	EEE 400	Project/Thesis	6.0	3.0
2	EEE 415	Microprocessors and Embedded Systems	3.0	3.0
3	EEE 416	Microprocessors and Embedded Systems Laboratory	3.0	1.5
4	EEE 439	Communication Systems II	3.0	3.0
5	EEE XXX	Elective I	3.0	3.0
6	EEE XXX	Elective II	3.0	3.0
7	EEE XXX	Elective II Laboratory	3.0	1.5
8	EEE XXX	Elective III	3.0	3.0
		Total	**30.0**	**21**

Level-4 Term-II

Sl. No	Course Number	Course Name	Contact Hours per Week	Credit Hour
1	EEE 400	Project/Thesis	6.0	3.0
2	EEE 414	Electrical Services Design	3.0	1.5
3	EEE XXX	Elective IV	3.0	3.0
4	EEE XXX	Elective IV Laboratory	3.0	1.5
5	EEE XXX	Elective V	3.0	3.0
6	EEE XXX	Elective VI	3.0	3.0
7	EEEXXX	Elective VI Laboratory	3.0	1.5
8	EEEXXX	Elective VII	3.0	3.0
		Total	**27.0**	**19.5**

EEE 414 Electrical Services Design

1.5 Credit Hours, 3 Contact Hours per Week

Familiarization with CAD tools for building services design. Introduction to building regulations, codes and standards: BNBC, NFPA etc. Terminology and definitions: fuses, circuit breakers, distribution boxes, cables, bus-bars and conduits. Familiarization with symbols and legends used for electrical services design. Classification of wiring. Design for illumination and lighting: lux, lumen, choice of luminaries for various applications- domestic building, office building and industry. Wattage rating of common electrical equipment.

Designing electrical distribution system for low and high rise domestic, office and academic buildings, for multipurpose buildings. Size selection of conductors and breakers, bus-bar trunking (BBT) system for various applications. Single line diagram (SLD) of a typical 11kV/0.415kV, 500kVA sub-station and a 200kVA pole-mounted transformer.

Earthing requirements, various earthing methods. Earthing and lightning protection system design.

Familiarization with indoor and underground telephone and fiber optic cables, UTP and CAT5/6 data cables. Designing routing layout and installation of intercom, PABX, telephone, public address (PA) systems, cable TV distribution, LAN and wireless data systems for a building.

Safety regulations, design of security systems including CCTV, burglar alarm.

Concept of fire prevention and its importance. Fire detection (smoke, heat etc.) and alarm system (with voice evacuation), firefighting system (sprinkler system, hose).

Installation of air-conditioning, heating, lifts and elevators.

EEE 415 Microprocessors and Embedded Systems

3 Credit Hours, 3 Contact Hours per Week

Basic components of a computer system. Simple-As-Possible (SAP) computer: SAP-1, selected concepts from SAP-2 and SAP-3 (jump, call, return, stack, push and pop). Evolution of microprocessors.

Introduction to Intel 8086 microprocessor: features, architecture, Minimum mode operation of 8086 microprocessor: system timing diagrams of read and write cycles, memory banks, design of decoders for RAM, ROM and PORT.

Introduction to Intel 8086 Assembly Language Programming: basic instructions, logic, shift and rotate instructions, addressing modes, stack management and procedures, advanced arithmetic instructions for multiplication and division, instructions for BCD and double precision numbers, introduction to 8086 programming with C language. Hardware Interfacing with Intel 8086 microprocessor: programmable peripheral interface, programmable interrupt controller, programmable timer, serial communication interface, keyboard and display interface (LED, 7 segment, dot matrix and LCD).

EEE 416 Microprocessors and Embedded Systems Laboratory

1.1 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in EEE 415. In the second part, students will design simple systems using the principles learned in EEE 415.

EEE 439 Communication Systems II

3 Credit Hours, 3 Contact Hours per Week

Baseband digital transmission, Limitations, Pulse shaping, Repeaters, Pulse equalization techniques, AWGN channel model, bit error rate of a baseband transmission system, channel capacity theorem.

Digital modulation techniques, detection and demodulation techniques, digital receivers, matched filter and correlator receiver, bit error rate calculation of a digital link, digital link design.

Error correction coding: block codes, cyclic codes, systematic and nonsystematic cyclic codes, decoding techniques.

Wireless digital communication system, wireless channel model, non-cellular and cellular communication, cellular concept, frequency reuse techniques.

Multiple access techniques: FDMA, TDMA, CDMA and SDMA. Introduction to 2G and 3G mobile communication systems.

Introduction to optical fiber communication and Satellite communication.

Local area network, OSI model, random access techniques, Aloha, slotted Aloha.

EEE 400 Thesis/Project

3 Credit Hours, 6 Contact Hours per Week Level-4, Term-I
3 Credit Hours, 6 Contact Hours per Week Level-4, Term-II

Study of practical problems in the fields of electrical and electronic engineering.

Elective Courses

Interdisciplinary

EEE 421 Control System II

3 Credit Hours, 3 Contact Hours per Week

Compensation using pole placement technique. State equations of digital systems with sample and hold, state equation of digital systems, digital simulation and approximation. Solution of discrete state equations: by z-transform, state equation and transfer function, state diagrams, state plane analysis. Stability of digital control systems. Digital simulation and digital redesign. Time domain analysis. Frequency domain analysis. Controllability and observability. Optimal linear digital regulator design. Digital state observer. Microprocessor control. Introduction to neural network and fuzzy control, adaptive control. H^{α} Control, nonlinear control. Elements of System Identification, Introduction to Multivariable control (decoupling, interaction, analysis & design), Introduction to optimal control and estimation, Case studies.

EEE 422 Control System II Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in EEE 421. In the second part, students will design simple systems using the principles learned in EEE 421.

EEE 425 Biomedical Signals, Instrumentation and Measurements

3 Credit Hours, 3 Contact Hours per Week

Origin and major types of biological signals: Human body: cells and physiological systems, bioelectric potential, bio-potential electrodes and amplifiers, blood pressure, flow, volume and sound, electrocardiogram, electromyogram, electroencephalogram, phonocardiogram, vector cardiogram. Interpretation of bio-signals. Noise in bio-signals.

Measurement of bio-signals: transducers, amplifiers and filters. Measurement and detection of blood pressure. Blood flow measurement: plethysmograph and electromagnetic flow meter. Measurement of respiratory volumes and flow, related devices. X-ray. Tomograph: positron emission tomography and computed tomography. Magnetic resonance imaging. Ultrasonogram. Patient monitoring system and medical telemetry. Therapeutic devices: cardiac pacemakers and defibrillators. Electrical safety in bio instrumentations and sensing.

EEE 426 Biomedical Signals, Instrumentation and Measurement Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in EEE 425. In the second part, students will design simple systems using the principles learned in EEE 425.

EEE 427 Measurement and Instrumentation

3 Credit Hours, 3 Contact Hours per Week

Introduction: Applications, functional elements of a measurement system and classification of instruments. Measurement of electrical quantities: Current and voltage, power and energy measurement. Current and potential transformer. Transducers: mechanical, electrical and optical. Measurement of non-electrical quantities: Temperature, pressure, flow, level, strain, force and torque. Basic elements of DC and AC signal conditioning: Instrumentation amplifier, noise and source of noise, noise elimination compensation, function generation and linearization, A/D and D/A converters, sample and hold circuits. Data Transmission and Telemetry: Methods of data transmission, DC/AC telemetry system and digital data transmission. Recording and display devices. Data acquisition system and microprocessor applications in instrumentation.

EEE 428 Measurement and Instrumentation Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in EEE 427. In the second part, students will design simple systems using the principles learned in EEE 427.

CSE 451 Computer Networks

3 Credit Hours, 3 Contact Hours per Week

Switching and multiplexing; ISO, TCP-IP and ATM reference models. Different Data Communication Services: Physical Layer- wired and wireless transmission media, Cellular Radio: Communication satellites; Data Link Layer: Elementary protocols, sliding window protocols. Error detection and correction, HDLC, DLL of internet, DLL of ATM; Multiple Access protocols, IEEE.802 Protocols for LANs and MANs, Switches, Hubs and Bridges; High speed LAN; Network layer: Routing, Congestion control, Internetworking, Network layer in internet: IP protocol, IP addresses, ARP; NI in ATM transport layer: transmission control protocol. UDP, ATM adaptation layer; Application layer: Network security; Email, Domain Name System; Simple Network Management Protocol; HTTP and World Wide Web.

CSE 452 Computer Networks Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in CSE 451. In the second part, students will design systems using the principles learned in CSE 451.

Communication and Signal Processing Group

EEE 331 Random Signals and Processes

3 Credit Hours, 3 Contact Hours per Week

Probability and Random variables: Sample space, set theory, probability measure, conditional probability, total probability, Bayes theorem, independence and uncorrelatedness. Expectation, Variance, moments and characteristic functions. Commonly used distribution and density functions. Central limit theorem. Transformation of a random variables: one, two and N random variables. Joint distribution, density, moments and characteristic functions. Hypothesis Testing.

Random Processes: Correlation and covariance functions. Process measurements. Gaussian, and Poisson random processes. Markov Process. Noise models. Stationarity and Ergodicity. Spectral Estimation. Correlation and power spectrum. Cross spectral densities. Response of linear systems to random inputs. Statistical Estimation Techniques (ML, MMSE, MAP).

EEE 431 Digital Signal Processing II

3 Credit Hours, 3 Contact Hours per Week

Spectral estimation of random processes: classical methods, minimum variance method, parametric methods: AR and ARMA spectral estimation, Levinson-Durbin algorithm, super resolution techniques: Pisarenko, and MUSIC.

Adaptive signal processing: Applications, e.g., equalization, interference suppression, acoustic echo cancellation. FIR and IIR adaptive filters. Recursive least squares algorithm, steepest descent and Newton algorithm, least mean-square (LMS) algorithm, convergence analysis. Variable step-size LMS algorithm.

Multirate DSP: Interpolation and decimation, single-stage and multistage implementation, design of anti-aliasing and anti-imaging filters. Polyphase representation of multirate systems. Multirate implementation of ideal LP filter, digital filter banks, narrowband filters. Perfect reconstruction filters banks. Short time Fourier transform, subband decomposition and wavelet transform, CWT, DWT, inter-scale relationship of DWT coefficients, multirate implementation. Applications of wavelet transform.

EEE 433 Microwave Engineering

3 Credit Hours, 3 Contact Hours per Week

Transmission Lines: The Lumped-Element Circuit Model for a Transmission Line, Field Analysis of Transmission Lines, The Terminated Lossless Transmission Lines, The Smith Chart, The Quarter-Wave Transformers, Generator and Load Mismatches, Impedance Matching and Tuning, Lossy Transmission Lines. Waveguides: General Formulation, Modes of Propagation and Losses in Parallel Plate, Rectangular and Circular Waveguides. Microstrip Lines: Structures and Characteristics. Microwave Resonators: Waveguide Cavity Resonators, Microstrip Resonators. Microwave Network Analysis: Scattering Matrices and Multiport Analysis Techniques. Radiation and Antennas: Types of Antenna and Their Applications, Radiating Field Regions, Radiation Pattern- Isotropic, Directional and Omni Directional Patterns, Radiation Power Density, Radiation Intensity, Beamwidth, Directivity, Antenna Efficiency and Gain, Polarization, Vector Effective Length, Effective Aperture, Equivalent Circuit Model and Corresponding Parameters, Friis Transmission Equation, Mathematical Formalism for Far Field Analysis, Infinitesimal Dipole Antenna, Finite Length Dipole Antenna, Infinitesimal Loop Antenna, Antenna Array, N Element Linear Array, Endfire and Broadside Array- Array Factor and Directivity.

EEE 434 Microwave Engineering Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in EEE 433. In the second part, students will design simple systems using the principles learned in EEE 433.

EEE 435 Optical Communications

3 Credit Hours, 3 Contact Hours per Week

Introduction to optical communication. Guided and unguided optical communication system, Light propagation through guided medium, Optical Fibers: SMF and MMF, SI fibers and GI fibers. Fiber modes, mode theory for light propagation through fibers, single mode condition and multimode condition. Transmission impairments: fiber loss, chromatic dispersion in a fiber, polarization mode dispersion (PMD). Different types of fibers: DSF, DCF, Dispersion compensation schemes. Fiber cabling process, Fiber joints/connectors and couplers, Optical transmitter: LED and laser, Operating principles, Characteristics and driver circuits. Optical receivers: PN, PIN and APD detectors, Noise at the receiver, SNR and BER calculation, Receiver sensitivity calculation. IM/DD and Coherent communication systems. Nonlinear effects in optical fibers. Optical amplifiers, Optical modulators, Multichannel optical systems: Optical FDM, OTDM and WDM. Optical Access Network, Optical link design and Free space optical communication.

EEE 437 Wireless Communication

3 Credit Hours, 3 Contact Hours per Week

Introduction: Wireless communication systems, regulatory bodies. Radio wave propagation: Free-space and multi-path propagation, ray tracing models, empirical path loss models, large-scale and small-scale fading, power delay profile, Doppler and delay spread, coherence time and bandwidth. Statistical channel models: Time-varying channel models, narrowband and wideband fading models, baseband equivalent model, discrete-time model, space-time model, auto- and cross-correlation, PSD, envelope and power distributions, scattering function. Channel capacity: Flat-fading channels - CSI, capacity with known/partially known/unknown CSI. Frequency-selective fading channels - time-invariant channels, time-varying channels. Performance of digital modulations: Error and outage probability, inter-symbol interference, MPSK, MPAM, MQAM, CPFSK. Diversity techniques: Time diversity - repetition coding, beyond repetition coding. Antenna diversity - SC, MRC, EGC, space-time coding. Frequency diversity - fundamentals, single-carrier with ISI equalization, DSSS, OFDM. Space-time communications: Multi-antenna techniques, MIMO channel capacity and diversity gain, STBC, OSTBC, QOSTBC, SM, BLAST, smart antennas, frequency-selective MIMO channels. Broadband communications: DSSS, FHSS, spreading codes, RAKE receivers, MC-CDMA, OFDM, OFDMA, multiuser detection, LTE, WiMAX.

EEE 438 Wireless Communication Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

Laboratory experiments and design of wireless communication systems based on the syllabus of EEE 437 Wireless Communications.

EEE 441 Telecommunication Engineering

3 Credit Hours, 3 Contact Hours per Week

Introduction: Principle, evolution and telecommunication networks. National and International regulatory bodies, Telephone apparatus, telephone Exchanges, subscriber loop, supervisory tones, PSTN. Switching systems: Introduction to analog system: Strowger and Crossbar switching systems, Stored program control (SPC) systems, Digital switching systems: space division switching, time division switching, blocking probability and multistage switching, and digital memory switch. Traffic analysis: Traffic characterization, grades of service, network blocking probabilities, delay system and queuing. Integrated services digital network (ISDN): N-ISDN and B-ISDN, architecture of ISDN, B-ISDN implementation. Digital subscriber loop (DSL), Wireless local loop (WLL), FTTx, SONET/SDH, WDM Network, IP telephony and VoIP, ATM network and Next Generation Network (NGN).

EEE 443 Radar and Satellite Communications

3 Credit Hours, 3 Contact Hours per Week

Introduction to Satellite Communication, Satellite frequency bands, satellite orbits, satellite types, regulation of the spectrum and interference, propagation channel, air interfaces, link budget analysis, Digital Modulation, Error Correction Codes, Multiple Access, receiver synchronization, baseband processing, fixed and mobile applications, basics of satellite networking.

Radar equation, radar cross section, information contents in radar signals, noise and clutter, radar detectors, Doppler and MTI radar, pulse compression, CW and FM-CW radar, radar transmitter and receivers, introduction to polarimetric radar and synthetic aperture radar.

EEE 445 Multimedia Communications

3 Credit Hours, 3 Contact Hours per Week

Introduction and classification of multimedia signals, auditory and visual systems of humans, representations of text, audio and video signals, color representations of visual signals. Compression of multimedia signals for communication: sampling, orthogonal transforms and subband coding of signals. Techniques of compressions for communication: text compression using Huffman and Lempel Ziv coding, audio compression using LPC, GSM/CELP, MP3/AAC, image compression using JPEG, JPEG2000, video compression using H.363, MPEG-4. Mutlimedia communication networks and protocols: MPEG transport stream, H.221 framing, IP-based transport protocols such as UDP, TCP, RTP, DCCP, RTCP and VoIP. Quality of Services. Synchronization and signaling of multimedia communications using SS7, H.323, SIP, SDP, RTSP, Megaco. Digital television, HDTV. Multimedia content creation and management. Wireless communications of multimedia signals. Security issues of multimedia communications.

EEE 447 Introduction to Digital Image Processing,

3 Credit Hours, 3 Contact Hours per Week

History and background of digital image processing, image processing system and applications, visual perception, sensors for image acquisition, sampling and quantization, intensity transformation and enhancement of images in spatial domain, histogram equalization, Fuzzy techniques for image processing, 2D discrete Fourier transform, image restoration, Wiener and constraint least-square filters for images, homomorphic filters, image reconstruction from projections, multi-resolution image processing, sub-band coding and image compression.

EEE 449 Information and Coding Theory

3 Credit Hours, 3 Contact Hours per Week

Entropy and Mutual Information: Entropy, joint entropy and conditional entropy, Relative entropy and mutual information, chain rules for entropy, relative entropy and mutual information, Jensen's inequality and log-sum inequality

Differential Entropy: Differential entropy and discrete entropy, joint an conditional differential entropy, properties of differential entropy, relative entropy and mutual information

Entropy Rates of Stochastic Process: Markov Chain, Entropy rate and hidden Markov models

Source Coding: Kraft inequality, optimal codes, Huffman code and its optimality, Shannon-Fano-Elias coding, arithmetic coding

Channel Capacity: Binary symmetric channels and properties of channel capacity, channel coding theorems, joint source and channel coding theorem

Block coding and decoding, BCH, RS codes, Convolutional coding, Viterbi Decoder, Turbo codes, decoding techniques

STBC, SFBC, STFBC

Gaussian Channel: Introduction to Gaussian Channel, Band limited channel, Parallel Gaussian Channel, Gaussian Channel with feedback.

EEE 491 Introduction to Medical Imaging

3 Credit Hours, 3 Contact Hours per Week

Introduction to imaging, medical imaging modalities, Medical imaging before x-rays, Hippocratic thermography, dissection, laproscopy, X-radiography, Computed tomography (CT), evolution of CT scanner design, image reconstruction algorithms, filtered back-projection method, iterative method, low dose computed tomography, Ultrasound, Sonar and other early applications of acoustics, basic principles of ultrasound imaging, Evolution of ultrasound technology and clinical applications, Magnetic resonance imaging, Early use of nuclear magnetic resonance (NMR) spectroscopy, Principles of NMR and MRI, Evolution of magnetic resonance imaging (MRI) technology and clinical applications, development and applications of functional MRI, Introduction to Nuclear imaging.

EEE 493 Digital Filter Design

3 Credit Hours, 3 Contact Hours per Week

Application of digital filters, analog filters, linear phase FIR filters, optimal filter design, Remez exchange algorithm, multiband filters, approximately linear phase IIR filter, all pass filter, design of IIR filter using optimization methods: Newton's method, Quasi-Newton algorithms, Minimax algorithms, improved Minimax algorithms, filter design in time-frequency domain, design of special filters: Hilbert transformer, narrowband filter, fractional delay filter, Wiener filter, filter design using Kalman filter/parallel Kalman filter, Wavelet filter.

EEE 495 Speech Communication

3 Credit Hours, 3 Contact Hours per Week

Speech production and phonetics: articulatory and acoustic features; Speech analysis: formant, pitch, time and frequency domain analysis techniques, spectrogram; Speech coding: linear predictive coding, vocoders, vector quantization; Speech enhancement: spectral subtraction based techniques; Speech synthesis: formant synthesizers; Speech and speaker recognition: feature extraction and conventional recognition methods.

EEE 497 Telecommunication Networks

3 Credit Hours, 3 Contact Hours per Week

Introduction to Telecom System and Networks, Essentials of a Telecom Network. Telecommunication Switching system: TDM switching, Space division switching, Time-Space Switching, Circuit Switching and Packet Switching, Switching Fabrics. Integrated Services Digital Network (ISDN), Broadband ISDN (B - ISDN), Switching and Signaling Techniques in ISDN, Signaling System – 7 (SS - 7), ISDN Protocols and standards. Telecom Network Architectures, Network Topology: Ring, Bus, Tree, Star, Architecture of a node, Functions of a node; Routing & Switching, Principles of Routing; Hot Potato Routing, Deflection Routing, Virtual Path Routing, Shortest Path Routing etc. Access Technologies: Conflict free Multiple Access techniques: FDMA, OFDMA, TDMA, CDMA, Demand Assignment Multiple Access (DAMA), CSMA-CD, CSMA-CA. Network Protocol Stack, IP Protocol, Voice over IP (VoIP), Asynchronous Transfer Mode (ATM) technology, IP over ATM, Synchronous Optical Network (SONET) and Synchronous digital Hierarchy (SDH), IP over SONET, SONET over WDM networking Access Network Technologies: Hybrid Fiber Coax (HFC), Fiber to the X (FTTX), Ethernet Passive Optical Network (EPON), Gigabit PON (GPON). Next generation Networking (NGN), Next generation SONET/SDH, Networks and Standards, Multiple Protocol Label Switching (MPLS), MPLS over WDM.

(**Note: For total credit hour fulfillment of the degree of B. Sc. Engg (EEE), credits of either EEE 497 or EEE 499 will be counted but not both.)**

EEE 498 Telecommunication Networks Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

Laboratory experiments and designs based on the course EEE 497 Telecommunication Networks.

EEE 499 Wireless and Mobile Networks

3 Credit Hours, 3 Contact Hours per Week

Overview of wireless networks, different generations of wireless networks. Wireless Transmission techniques: baseband transmission, Carrier modulated band pass transmission, Ultra wideband (UWB) transmission, wireless modems, Spread Spectrum techniques; direct system (DS) and Frequency Hopping (FH) Spread Spectrum Systems. Wireless Network topologies, Cellular networks, Cellular fundamentals, carrier to co channel interference ratio (C/CCI), Capacity expansion techniques. Access Techniques: FDMA, TDMA, CDMA, narrowband and wideband Access technologies, OFDMA, Hybrid multiple Access techniques: FDMA-TDMA, OFDMA-TDMA, MC-CDMA; Spectral Efficiency and Capacity of wireless networks. Diversity in Mobile networks: MIMO Wireless Networks, Space, Time and Frequency coding techniques. Switching technologies: Circuit switching, packet switching, Protocol Stack, Random Access Technology and Wireless LANs, Aloha, Slotted Aloha, CSMA-CA and W-LAN Protocols, Routing in Wireless Networks, Optimal Routing and Scheduling, Single-hop and Multi-hop Networks. Quality of Service (QoS) in Wireless Networks, Traffic Management, Wireless Adhoc Networks, Wireless Sensor Networks. Cellular Network standards: GSM, IS-95, UMTS, CDMA-2000, W-CDMA, 3G and future generation.

(**Note: For total credit hour fulfillment of the degree of B. Sc. Engg (EEE), credits of either EEE 497 or EEE 499 will be counted but not both.)**

Electronics Group

EEE 351 Analog Integrated Circuits

3 Credit Hours, 3 Contact Hours per Week

Analog IC Design: Bipolar, MOS and BiCMOS IC technology and its impact, eggshell analogy, application areas and the future of analog IC design.

Review of transistors: Large and small signal models, compact models for Bipolar, FET, and BiCMOS. Amplifiers with passive and active loads, cascode stages.

Multiple current sources/sinks using Bipolar and FET technologies. Current mirrors: Basic, cascode and active current mirrors; influence of channel modulation, mismatched transistors and error in aspect ratios. Wilson current mirror.

Constant current or voltage references: Supply voltage and temperature independent biasing, band-gap references; constant-Gm biasing. Widlar band-gap voltage reference.

Differential pairs: Differential vs. single-ended operations of simple amplifiers, differential and common mode voltages, common mode rejection ratio (CMRR), input common mode range (ICMR), transfer characteristics, small signal analysis, and frequency response of differential pairs.

High-gain amplifiers: Design and analysis of operational amplifiers (Op Amps) using BJTs and FETs, hierarchy in analog integrated circuits for an Op-Amps, internal structure of IC Op-Amps, high-performance Op-Amps.

Switch capacitor circuits: Equivalent resistance of a switched capacitor, unity gain buffers, charge amplifiers and integrators. Sampling switches: Charge injection, clock feed-through, charge feed-through; quantized model and remedy of charge injection. Switched capacitor filters. Origin of internally developed noises in ICs; shot, thermal, flicker, burst and avalanche noises in a device. Representation of noises in circuits, noises in single stage and differential amplifiers, noise bandwidth.

EEE 451 Processing and Fabrication Technology

3 Credit Hours, 3 Contact Hours per Week

Substrate materials: Crystal growth and wafer preparation, epitaxial growth technique, molecular beam epitaxy, chemical vapor phase epitaxy and chemical vapor deposition (CVD).

Doping techniques: Diffusion and ion implantation. Growth and deposition of dielectric layers: Thermal oxidation, CVD, plasma CVD, sputtering and silicon-nitride growth.

Introduction to Semiconductor Characterization Tools.

Etching: Wet chemical etching, silicon and GaAs etching, anisotropic etching, selective etching, dry physical etching, ion beam etching, sputtering etching and reactive ion etching. Cleaning: Surface cleaning, organic cleaning and RCA cleaning. Lithography: Photo-reactive materials, pattern generation, pattern transfer and metalization. Steps of lithography. Non-optical lithography.

Discrete device fabrication: Diode, transistor, resistor and capacitor. Integrated circuit fabrication: Isolation - pn junction isolation, mesa isolation and oxide isolation. BJT based microcircuits, p-channel and n-channel MOSFETs, complimentary MOSFETs and silicon on insulator devices. Testing, bonding and packaging.

EEE 453 VLSI Circuits and Design I

3 Credit Hours, 3 Contact Hours per Week

IC trends, technology and design approaches. MOS device: structure, operation, threshold voltage and characteristics.

Ratioed circuits: NMOS inverter with resistive and transistor load, Pseudo NMOS inverter.

Ratioless circuits: CMOS inverters: operation, transfer characteristics, design for equal rise and fall time, propagation delay, rise time, fall time and power consumption estimation. NMOS pass transistor and CMOS pass gate circuits. Buffer chain design to drive large capacitive load.

Integrated circuit fabrication technology: photolithography, CMOS process flow, design rules. Estimation of resistance and capacitance from layout. Layout matching. Stick diagram and area estimation from stick diagram. Reliability issues: Latch-up, electromigartion.

Basic logic gates in CMOS. Synthesis of arbitrary combinational logic in CMOS, pseudo-NMOS, dynamic CMOS, clocked CMOS and CMOS domino logic. Structured design: Parity generator, bus arbitration logic, multiplexers based design, programmable logic array (PLA) design. Clocked sequential circuit design: two phase clocking, dynamic shift register. CMOS latches and flip flops.

Subsystem design: 4-bit arithmetic processor: bus architectures, shifter, design of a general purpose ALU.

Memory elements design: System timing consideration, three transistor and one transistor dynamic memory cell. Pseudo-static RAM/register cell. 4 transistor dynamic and 6 transistor static CMOS memory cell. 4x4 bit register array and 16 bit static CMOS memory array.

Finite State Machine design: Design of Moore Type and Mealy type FSM using Verilog.

Testing VLSI circuits.

EEE 454 VLSI Circuits and Design I Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in EEE 453. In the second part, students will design simple systems using the principles learned in EEE 453.

EEE 455 Compound Semiconductor Devices

3 Credit Hours, 3 Contact Hours per Week

Reviews of Compound semiconductor: Zinc-blend crystal structures, growth techniques, alloys, band gap, basic opto-electronic properties, density of carriers in intrinsic and doped compound semiconductors.

Introduction to Physics of Hetero-Junctions: Band alignment, band offset, Anderson's rule, single and double sided hetero-junctions, quantum wells and quantization effects, lattice mismatch and strain and common hetero-structure material systems.

Hetero-Junction diode: Band banding, carrier transport and I-V characteristics. Hetero-junction field effect transistor: Structure and principle, band structure, carrier transport and I-V characteristics. Nonideal effects, frequency response, high electron mobility transistor.

Hetero-structure bipolar transistor (HBT): Structure and operating principle, quasi-static analysis, extended Gummel-Poon model, Ebers-Moll model, secondary effects and band diagram of a graded alloy base HBT.

Resonant Tunneling diodes: physics and operation. Resonant Tunneling Transistors: device physics, operation and characteristics.

EEE 457 VLSI Circuits and Design II

3 Credit Hours, 3 Contact Hours per Week

Scaling of MOS transistor and interconnect: RC delay modeling, repeaters and cascaded drives. Advanced CMOS nanometer process flow and enhancement of CMOS process, technology related CAD issues and manufacturing issues, design margin and PVT corners.

Circuit characterization: delay estimation and transistor sizing for minimum delay, crosstalk and noise analysis. High speed digital circuit design techniques, circuit families. Architecture for high speed design: Carry select, carry skip, carry look ahead and tree adders. Modified Booth algorithm, Wallace tree multiplication.

Sequential circuit design: sequencing methods, maximum and minimum delay constrains, clock skew. Design of latches and flip-flops, clock Generation and synchronization, High-speed clock generation and distribution.

ASIC Cell based design, standard cell place and route design, timing directed placement design, mixed signal design. Interchange formats: LEF, DEF, SDF, DSPF, SPEF, ALF PDEF,CIF and GDS2. Floor planning, power distribution and I/O design.

Algorithm and architecture for digital processors in verilog, system verilog and system-C : building block for signal processors, digital filters and signal processors, pipelined architecture.

Architecture for arithmetic processors: addition, subtraction, multiplication and division. Complete design of a simple RISC processor. Post-synthesis design validation: timing verification, fault simulation and testing, design for test.High speed and low power memory circuit design: advanced topics in DRAM and SRAM.

EEE 458 VLSI Circuits and Design II Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in EEE 457. In the second part, students will design simple systems using the principles learned in EEE 457.

EEE 459 Optoelectronics

3 Credit Hours, 3 Contact Hours per Week

Optical properties in semiconductor: Direct and indirect band-gap materials, basic transitions in semiconductors, radiative and non-radiative recombination, optical absorption, photo-generated excess carriers, minority carrier life time, luminescence and quantum efficiency in radiation.

Properties of light: Particle and wave nature of light, polarization, interference, diffraction and blackbody radiation.

Light emitting diode (LED): Principles, materials for visible and infrared LED, internal and external efficiency, loss mechanism, structure and coupling to optical fibers. Double-Hetero-structure (DH) LEDs, Characteristics, Surface and Edge emitting LEDs.

Stimulated emission and light amplification: Spontaneous and stimulated emission, Einstein relations, population inversion, absorption of radiation, optical feedback and threshold conditions.

Semiconductor Lasers: Population inversion in degenerate semiconductors, laser cavity, operating wavelength, threshold current density, power output, elementary laser diode characteristics, hetero-junction lasers, optical and electrical confinement. single frequency solid state lasers-distributed Bragg reflector (DBR), distributed feedback (DFB) laser.

Introduction to quantum well lasers. Introduction to quantum well lasers, Vertical Cavity Surface Emitting Lasers (VCSELs), optical laser amplifiers.

Photo-detectors: Photoconductors, junction photo-detectors, PIN detectors, avalanche photodiodes, hetero-junction photodiodes, Schottky photo-diodes and phototransistors. Noise in photo-detectors. PIN and APD. Photo-detector design issues. Solar cells: Solar energy and spectrum, silicon and Schottkey solar cells. Modulation of light: Phase and amplitude modulation, electro-optic effect, acousto-optic effect and magneto-optic devices. Introduction to integrated optics.

EEE 460 Optoelectronics Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

Laboratory based on EEE 459

EEE 461 Semiconductor and Nano Device

3 Credit Hours, 3 Contact Hours per Week

Lattice vibration: Simple harmonic model, dispersion relation, acoustic and optical phonons. Free electron model: Electrical conductivity. Band structure: Isotropic and anisotropic crystals, band diagrams and effective masses of different semiconductors and alloys. Scattering theory: Perturbation theory, Fermi-Golden rule for static and oscillating potentials, scattering rates for impurity and phonons, inter-band and inter-sub-band optical absorption, mobility. Quantum mechanical model of carrier transport: Tunneling transport, current and conductance, resonant tunneling, resonant tunneling diodes, super-lattices and mini-bands. Introduction to inter sub-band transition devices.

EEE 463 Introduction to Nanotechnology and Nanoelectronics

3 Credit Hours, 3 Contact Hours per Week

Why Nanotechnology: importance, size scales, quantum size effects, revolutionary applications, potentials. Nanotools: scanning tunneling microscope, atomic force microscope, electron microscope, measurement techniques based on fluorescence, other techniques. Basics of Fabrication: fabrication and processing industry, wafer manufacturing, deposition techniques: evaporation, sputtering, chemical vapor deposition, epitaxy; Wet and dry etching techniques; photolithography, electron beam lithography, stamp technology. Bottom-up processes: chemical and organic synthesis techniques, self-assembly, other techniques. Nanoelectronics: overview of quantum mechanics, Schrodinger equation, particle in a box. Band theory of solids. Importance of nanoelectronics, Moore’s law, ITRS roadmap. Tunneling devices: quantum tunneling, resonant tunneling diodes. Single electron transistor: Coulomb blockade. Quantum confinement: wires and dots, carbon nanotubes, graphenes. Brief introductions on Molecular electronics and nanobiology.

Power Group

EEE 371 Power System II

3 Credit Hours, 3 Contact Hours per Week

Definition and classification of stability, two axis model of synchronous machine, loading capability, rotor angle stability - swing equation, power-angle equation, synchronizing power coefficients, equal area criterion, multi-machine stability studies, step-by-step solution of the swing curve, factors affecting transient stability. Frequency and voltage stability.

Economic Operation within and among plants, transmission-loss equation, dispatch with losses.

Flexible AC transmission system (FACTS) - **i**ntroduction, **s**hunt compensation (SVC, STATCOM), series compensation (SSSC, TCSC, TCSR, TCPST), series-shunt compensation (UPFC).

Power quality- voltage sag and swell, surges, harmonics, flicker, grounding problems; IEEE/IEC standards, mitigation techniques.

EEE 372 Power System II Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments and do simulations to verify practically the theories and concepts learned in EEE 371. In the second part, students will design simple systems using the principles learned in EEE 371.

EEE 471 Energy Conversion III

3 Credit Hours, 3 Contact Hours per Week

Basic principles of energy conversion: electromagnetic, electrostatic, thermoelectric, electrochemical, and electromechanical.

Acyclic machines: generators, conduction pump and induction pump.

Nonconventional energy conversion: solar-photovoltaic, solar-thermal, wind, geothermal, wave and tidal energy, MHD (Magneto Hydrodynamic) systems.

Motors and drives: series universal motor, permanent magnet DC motor, brushless DC motor (BLDC), stepper motor, reluctance motor, switched reluctance motor, hysteresis motor, repulsion motor, permanent magnet synchronous motor, linear induction motor, electro static motor.□

EEE 473 Renewable Energy

3 Credit Hours, 3 Contact Hours per Week

Renewable energy sources: Solar, wind, mini-hydro, geothermal, biomass, wave and tides.

Solar Photovoltaic: Characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, sun tracking systems, Maximum Power Point Tracking (MPPT): chopper, inverter. Sizing the PV panel and battery pack in stand-alone PV applications. Modern solar energy applications (residential, electric vehicle, naval, and space). Solar power plants connected to grid.

Solar thermal: principles of concentration, solar tower, parabolic dish, receiver, storage, steam turbine and generator.

Wind turbines: Wind turbine types and their comparison, power limitation, Betz's law; Control mechanism: pitch, yaw, speed. Couplings between the turbine and the electric generator, Wind turbine generator - DC, synchronous, self excited induction generator and doubly fed induction generator. Grid interconnection: active and reactive power control.

Biomass and biogas electricity generation.

EEE 475 Power Plant Engineering

3 Credit Hours, 3 Contact Hours per Week

Load forecasting. Load curve: demand factor, diversity factor, load duration curve, energy load curve, load factor, capacity factor, utilization factor. Thermal power station: heat rate, incremental heat rate, efficiency, capacity scheduling, load division. Principles of power plants: steam, gas, diesel, combined cycle, hydro and nuclear. Captive power plant and cogeneration. Power plant auxiliaries and instrumentation. Power evacuation and switchyard. Selection of location: technical, economical and environmental factors. Generation scheduling.

EEE 477 Power System Protection

3 Credit Hours, 3 Contact Hours per Week

Electric arcs, arc extinction mechanism, transient recovery voltage. Circuit Breakers: operating mechanisms, construction and operation of Miniature Circuit Breaker (MCB), Molded Case Circuit Breaker (MCCB), Air Circuit Breaker (ACB), Air Blast Circuit Breaker (ABCB), Vacuum Circuit Breaker (VCB), Oil Circuit Breaker (OCB), Minimum Oil Circuit Breaker (MOCB) and Sulfur Hexafluoride (SF6) circuit breaker. High Rupturing Capacity (HRC) Fuse, Drop Out Fuse (DOF), Load Break Switches, Contactors. Bus bar layout, isolators, earthing switch; lightning arresters, CT, PT: wound type and CCVT (Capacitor Coupled Voltage Transformer), MOCT (Magneto Optical Current Transducer).

Fundamental of protective relaying. Classical relays (electromagnetic attraction type, induction type); numerical relays. Inverse Definite Minimum Time (IDMT) relays, directional relays, differential and percentage differential relays, distance relays, pilot relays (wire pilot, carrier).

Protection of generators, motors, transformers, transmission lines, HVDC system and feeders.

EEE 478 Power System Protection Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in EEE 477. In the second part, students will design simple systems using the principles learned in EEE 477.

EEE 479 Power System Reliability

3 Credit Hours, 3 Contact Hours per Week

Review of probability concepts. Probability distribution: Binomial, Poisson, and Normal. Reliability concepts: Failure rate, outage, mean time to failure, series and parallel systems and redundancy. Markov process. Probabilistic generation and load models. Reliability indices: Loss of load probability and loss of energy probability. Frequency and duration. Reliability evaluation techniques of single area system. Interconnected system: tie line and evaluation of reliability indices.

EEE 481 Power System Operation and Control

3 Credit Hours, 3 Contact Hours per Week

Overview: vertically integrated vs. deregulated power system. Real-time operation: SCADA; EMS (energy management system); various data acquisition devices - RTU, IED, PMU, DFDR, WAMPAC (wide area monitoring, protection and control).

Application functions: state estimation; short term load forecasting; unit commitment (UC); economic dispatch (ED); optimal power flow (OPF). Frequency control: generation and turbine governors, droop, frequency sensitivity of loads, ACE (area control error), AGC (Automatic Generation Control) and coordination with UC and ED; frequency collapse and emergency load shed.

Power system security: static and dynamic; security constrained OPF.

Electricity market operation: GenCos, ISO, DisCos, bidding, spot market, social welfare, market clearing price (MCP), locational marginal price (LMP), bilateral contracts and forward market, hedging.

Demand side control: DMS (distribution management system), DSM (demand side management), smart grid concept.

EEE 483 High Voltage Engineering

3 Credit Hours, 3 Contact Hours per Week

High voltage DC generation: rectifier circuits, ripple minimization, voltage multipliers, Van-de-Graaf and electrostatic generators; applications.

High voltage AC generation: Tesla coils, cascaded transformers and resonance transformers. Impulse voltage generation: Shapes, mathematical analysis, codes and standards, single and multi-stage impulse generators, tripping and control of impulse generators.

Breakdown in gas, liquid and solid dielectric materials, applications of gas and solid dielectrics in transformer. Corona.

High voltage measurements and testing: IEC and IEEE standards, sphere gap, electrostatic voltmeter, potential divider, Schering bridge, Megaohm meter, HV current and voltage transducers: contact and noncontact.

Over-voltage phenomenon and insulation coordination. Lightning and switching surges, basic insulation level (EV, EHV and UHV systems), surge diverters and arresters.

EEE 484 High Voltage Engineering Laboratory

1.5 Credit Hours, 3 Contact Hours per Week

This course consists of two parts. In the first part, students will perform experiments to verify practically the theories and concepts learned in EEE 483. In the second part, students will design simple systems using the principles learned in EEE 483.

EEE 485 Power Transmission and Distribution

3 Credit Hours, 3 Contact Hours per Week

Transmission line parameters: Inductance - inductance due to internal flux, flux linkages between points external to an isolated conductor, flux linkages of one conductor in a group, single-phase two-wire line, composite-conductor lines, three-phase lines with equilateral/ unsymmetrical spacing, double circuits, bundled conductors;

Capacitance - electric field of a long straight conductor, potential difference between points due to a charge, capacitance of a two-wire line, capacitance of three-phase line with equilateral/ unsymmetrical spacing, effect of Earth on transmission line capacitance, bundled conductor, parallel-circuit three-phase lines.

Sag of overhead lines, Types of insulators and electrical stress analysis.

Underground cables: Types and construction; oil filled, gas insulated and XLPE cables; electrical characteristics - electrical stress, capacitance, charging current, insulation resistance, dielectric power factor and dielectric loss, skin effect, proximity effect; identification of fault location.

HVDC transmission: Comparison of AC and DC transmission, HVDC transmission system components, monopolar and bipolar HVDC transmission, power converters: CSC (Current source converter) and VSC (Voltage source converter), operation and control of HVDC transmission link.

Substations: Substation equipment, bus bar arrangements, substation earthing, neutral grounding, substation automation, GIS substation.

Distribution systems: Primary and secondary distribution - radial, ring main, and interconnected system, distribution losses and feeder reconfiguration.

EEE 487 Nuclear Power Engineering

3 Credit Hours, 3 Contact Hours per Week

Basic concepts: nuclear energy, atoms and nuclei, radioactivity, nuclear processes, fission, fusion. Nuclear systems: particle accelerator, isotope separators, neutron chain reaction, reactor types, power generation. Layout of nuclear power plant (NPP). Nuclear power plant reactors : pressurized water reactor, boiling water reactor, CANDU reactor, gas cooled reactor, liquid metal cooled reactor, breeder reactor. Auxiliaries, instrumentation and control. Grid interconnection issues: effects of frequency and voltage changes on NPP operation. Advanced and next generation nuclear plants; very high temperature reactors. Biological effects, reactor safety and security; Three Mile island case; Chernobyl case; Fukushima case. Fuel cycle; radioactive waste disposal.

EEE 489 Smart Grid

3 Credit Hours, 3 Contact Hours per Week

Smart grid: two way communication; distributed energy resources (DERs) - DG (distributed generation) and ES (energy storage); high power density batteries, EV (electric vehicles) and PHEV (plug-in hybrid electric vehicles); smart sensors, meters and appliances at demand side.
Data communication channels; protocols; TCP/IP; IEEE 802 series wireless LANs: bluetooth, Zigbee, WiMax; wired LANs- Ethernet, PSTN, PLC (Power Line Carrier); cyber security.
Smart meters and AMI (advanced metering infrastructure): construction; standards for information exchange- Modbus, DNP3 and IEC61850; interfacing with HAN, NAN, WAN.
Power electronic interfaces between grid and DERs.
Demand side integration (DSI): DSM; real time pricing; ancillary markets; DR (demand response) for load shaping, frequency and voltage control, energy efficiency.
Microgrids, self healing and restoration.