SYLLABUS

UNDERGRADUATE PROGRAMME

B.Tech

DEPARTMENT OF

ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, MANIPUR

TAKYELPAT, IMPHAL-795001

MANIPUR, INDIA

2014

Electrical Engineering (EE)

SEMESTER - III			
COURSE NO.	**COURSE NAME**	**L - T - P**	**CREDIT**
EE201	Semiconductor Devices & Circuits	3-0-0	6
EE202	Analog Circuit	3-0-0	6
EE203	Network Analysis	3-0-0	6
MA201	Mathematics –III	3-0-0	6
HS2XX	HSS Elective II	2-0-0	4
EE233	Semiconductor Devices & Circuits Laboratory	0-0-3	3
EE235	Analog Circuits Laboratory	0-0-3	3
EE231	Network Analysis Laboratory	0-0-3	3
		15-0-9	37

SEMESTER - IV			
COURSE NO.	**COURSE NAME**	**L - T - P**	**CREDIT**
MA203	Numerical Methods	3-0-0	6
EE202	Digital Electronics and Computer Architecture	3-0-0	6
EE204	Signals & Systems	3-0-0	6
EE206	Measurement & Instrumentation	3-0-0	6
EE208	Electrical Machines –I	3-0-0	6
EE232	Digital Electronics Laboratory	0-0-3	3
EE234	Electrical Machines-I Laboratory	0-0-3	3
EE236	Measurement & Instrumentation Laboratory	0-0-3	3
		15-1-9	41

SEMESTER – V			
COURSE NO.	**COURSE NAME**	**L - T – P**	**CREDIT**
EE301	Power Electronics	3-0-0	6
EE303	Electrical Machines-II	3-0-0	6
EE305	Transmission and Distribution	3-0-0	6
EE307	Control System	3-0-0	6
EE309	Electromagnetic Field	3-0-0	6
EE331	Electrical Machines-II Laboratory	0-0-3	3
EE333	Power Electronics Laboratory	0-0-3	3
EE335	Numerical Methods Laboratory	0-0-3	3

		15-0-9	39

SEMESTER – VI			
COURSE NO.	**COURSE NAME**	**L - T – P**	**CREDIT**
EE302	Microprocessor and Applications	3-0-0	6
EE304	Power System Protection	3-0-0	6
EE306	Advance Control System	3-0-0	6
EE308	Renewable Energy Resources	3-0-0	6
EE310	Communication System	3-0-0	6
EE332	Microprocessor Laboratory	0-0-3	3
EE334	Power System Laboratory	0-0-3	3
EE336	Control System Laboratory	0-0-3	3
		15-0-9	39

SEMESTER - VII			
COURSE NO.	**COURSE NAME**	**L - T - P**	**CREDIT**
EE401	High Voltage Engineering	3-0-0	6
EE403	Power System Analysis	3-0-0	6
EE4XX	Elective-I	3-0-0	6
EE4XX	Elective-II	3-0-0	6
EE411	Renewable Energy Laboratory	0-0-3	3
EE412	Project I	0-0-6	6
		12-0-9	33

SEMESTER – VIII			
COURSE NO.	**COURSE NAME**	**L - T - P**	**CREDIT**
EE402	Power System Operation and Control	3-0-0	6
EE4XX	Elective-III	3-0-0	6
XXxxx	Open Elective	3-0-0	6
HS4xx/7xx	HSS Elective IV	3-0-0	6
EE413	Project II	0-0-8	8
		12-0-8	32

EE201 NETWORK ANALYSIS [3-0-0-6]

Network Graphs; Matrices associated with graphs; incidence, fundamental cut set and fundamental circuit matrices. Solution methods: nodal and mesh analysis. Network theorems: superposition, Thevnin and Norton's maximum power transfer, Wye-Delta transformation. Steady State sinusiodal analysis using phasors. Linear constant coefficent differential equations: time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits. 2-port network parameters: driving point and transfer functions. State equations for network

Transient analysis using transform methods, high pass, low pass, band pass, band stop, all pass filters and frequency dependent negative resistors, Applications of active networks (op-amp, BJT, FET, tunnel diode etc.)and systems, Non-linear network analysis and systems.

Texts:

1 Network Analysis, Van Valkenburg, PHI Pbs, 2010

2 Circuit Theory, Kuriakose-PHI Pbs, 2005

References:

1 Network Analysis, Bakshi & Bakshi, Technical Publications, 2009

2 Network Analysis and Synthesis, Wadhwa, New Age Publications, 2008

EE203 SEMICONDUCTOR DEVICE AND CIRCUITS [3-0-0-6]

Energy Bands in Silicon, intrinsic and extrinsic silicon. Carrier transport in Silicon: diffusion current, drift current, mobility and resistivity. Generation and recombination of carriers. P-n junction diode, Zener diode, tunnel diode, BJT, JFET, MOS capacitor, MOSFET, LED, p-I-n and avalanche photo diode, Basics of LASERs. Device technology: integrated circuits fabrication process, oxidation, diffusion, ion implantation, photolithography, n-tub, p-tub and twin tub CMOS process

1-D, 2-D, 3-D and 0-D nanostructures, influence of external fields on the nano-devices, quantized systems (magnetic quantization, magneto size quantization, magneto inversion layers), scattering mechanisms for bulk, 0-D, 1-D, 2-D and 3-D systems

Texts:

1 Solid State Electronic Devices by Streetman & Banerjee

References:

1 Semiconductor Devices: Jasprit Singh

2 Integrated Electronics: Millman & Halkis

3 Semiconductor Physics and Devices: Donald Neaman

4 Semiconductor Devices: Kanan Kano

5 Semiconductor Optoelectronic Devices: Pallab Bhattacharaya

EE205 ANALOG CIRCUITS [3-0-0-6]

Small signal equivalent circuits of diodes, BJTs, MOSFETs and Analog CMOS. Simple diode circuits, clipping, clamping, rectifier. Biasing and bias stability of transistor and FET amplifiers. Amplifiers: single and multi-stage, differential and operational, feedback and power. Frequency response of amplifiers. Single opamp circuits. Filters. Sinusoidal oscillators; criterion for oscillation; single transistor and opamp configurations. Function generators and wave shaping circuits, 555 Timers. Power Supplies. Network synthesis of active analog devices.

Texts:

1 Donald A. Neamen, Electronic Circuit Analysis and Design, Irwin Publications, 1996.

References:

1 Op-AMPS and Lenear Integrated Circuits- Ramakant A. Gayakwad-Prentice Hall of India.
2 Sergio Franco, 'Design with Operational Amplifiers and Analog Integrated Circuits', Tata McGraw Hill Book Company, 3rd Edn., 2002.
3 Jacob Baker R., Li H.W. & Boyce D.E., 'CMOS- Circuit Design, Layout & Simulation', PHI, 2000.
4 VLSI Technology, 2nd edition, S M Sze.
5 Semiconductor Devices & Circuits - B.P. Singh
6 Electronics Devices and Circuits - Allen Mottershead
7 Integrated Electronics - Millman & Halkias

MA201	**MATHEMATICS**	**[3-0-0-6]**

HS2XX	**HSS ELECTIVE I**	**[2-0-0-4]**

EE231	**NETWORK ANALYSIS LAB**	**[0-0-3-3]**

Pre-requisites: Nil
Syllabus: Laboratory exercises and assignments to provide additional support to EC201
Laboratory will be set in consonance with the material covered in EC201
Verification of all network theorems

EE233	**SEMICONDUCTOR DEVICE AND CIRCUITS LAB**	**[0-0-3-3]**

Pre-requisites: Nil
Syllabus: Laboratory exercises and assignments to provide additional support to EC203
Laboratory will be set in consonance with the material covered in EC203
Fabrication and characterization of thin films

EE235	**ANALOG CIRCUITS LAB**	**[0-0-3-3]**

Pre-requisites: Nil
Syllabus: Experiments using BJTs, FETs, op-amps and other integrated circuits: Multistage amplifiers, frequency response of amplifiers; waveform generators; filters.
Experimental verification of frequency dependent negative resistors.

EE202	Digital Electronics and Computer Architecture	**3**	**0**	**0**	**6**

Combinational logic analysis and design: logic minimization methods, Combinational design using MSI, LSI and PLDs, Number systems and arithmetic, Logic families, Delay, Hazards. Sequential logic design: latches and flip-flops, Setup and Hold time , Clock frequency, Finite state machine design, state minimization, state assignment, synthesis using D-FF and JK-FF, counters, shift registers, MSI devices as state machines. Introduction to computer architecture: Instruction Set Architecture, System Software; Processor Design: Data path, Control unit, Instruction types, addressing modes.

Text Books:

1. J.F.Wakerly, "*Digital Design Principles and Practices*", PH, 1999.

References:

1. D.D. Givone, "*Digital Principles and Design*', TMH, 2002.
2. M. Raffiquzzman & Rajan Chandra, "*Modern Computer Architecture*", Galgotia Publications, 1990.
3. David Patterson and John Hennessy, "*Computer Organization and Design*', Elsevier, 2007.

EE204	Signals & Systems	**3**	**0**	**0**	**6**

Definitions and properties of Laplace transform, continuous time and discrete time Fourier series, continuous-time and discrete-time Fourier Transform, DFT and FFT, Z-transform. Sampling theorem. Linear Time-Invariant (LTI) Systems: definitions and properties; causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay. Signal transmission through LTI systems.

Text Books:

1. M.J Roberts, "*Fundamentals of Signals and Systems*", Tata McGraw Hill, 2007.

References:

1. A.V. Oppenheim, A.S. Willsky and H.S. Nawab, "*Signals and Systems*", Prentice Hall of India, 2006.
2. P. Lathi, "*Signal Processing and Linear Systems*", Oxford University Press, 1998.
3. R.F. Ziemer, W.H. Tranter and D.R. Fannin, "*Signals and Systems - Continuous and Discrete*", Prentice Hall of India, 1998.
4. Simon Haykin, Barry van Veen, "*Signals and Systems*", John Wiley and Sons, 1998.

EE206	Measurement & Instrumentation	**3**	**0**	**0**	**6**

Basic Measurement Techniques: Construction and principle of operation of Moving coil, Moving Iron, dynamometer, Wattmeter, Electro-static Instruments, Thermal and Rectifier type deflecting instruments, extension of instrument ranges using shunts, multipliers and instrument transformers. **Errors in Measurement**: Definition of accuracy, precision, Fidelity, speed of response, non-linearity, techniques of linearization, classification of errors. Statistical analysis. **Measurements of Resistances**: Measurement of low, medium and high resistances, Kelvins double bridge, multimeters, megger, D.C. and A.C. potentiometers. **Localization of cable faults**: Murray and Varley loop methods. *AC Bridges*: measurement of inductances, capacitance and frequency by A.C. Bridges-Maxwell, Schering, Anderson, De-Sauty, Wien. **Measurement of power & Energy**: Measurements of power in polyphase circuits, various wattmeter connections. A.C. and D.C. energy meters. *Cathode Ray Oscilloscope*: C.R.O. construction & principle of operation. **Sensors & Transducers**: piezoelectric sensors, LVDT, Stain Gauges, Actuators A/D, D/A conversion techniques; S/H and multiplexers; isolation amplifiers; Data Acquisition system. **Digital Instrumentation** – Block diagram of Instrumentation schemes, DVM, DMM, frequency counter. **Frequency domain instruments:** Wave analyzer, spectrum analyzer. **Special Purpose Instruments**: Signal generators, Q-meter.

Text Books:

1. A. Bell David, '*Electronic Instrumentation & Measurement*', Reston Publishers, 2003.

References:

1. H.S. Kalsi, "*Electronic Instrumentation*", Tata Mc-Graw Hill, 2010.
2. Sawhney A K, "A *course in Electrical & Electronic Measurements & Instruments*", Dhanpat Rai & Co, 1994.
3. Golding E.W. & Wides F.C, "*Electrical Measuring Instruments & Measurements"*, Wheeler.
4. S. K. Singh, "*Industrial Instrumentation & Control"*, Tata McGraw Hill, New Delhi, 2007.

EE208	Electrical Machines –I	**3**	**0**	**0**	**6**

D.C. Generator-Principle of Operation, Construction of D.C. Machines, E.M.F. equations, Armature reaction, Commutation, interpoles and compensating winding, Types of Generator, Characteristics of self excited generator and separately excited generators-applications. D.C. Motor- Principle of operation, back E.M.F. torque and speed equations, characteristics of D.C Motors, speed control of series and shunt motors by flux control, armature control and voltage controlled methods- applications, Swinburn's test, brake test, DC motor 3-point starters. Transformer-Construction and principle of operation, E.M.F. equations, phasor diagram, actual and approximate equivalent circuits, open and short circuit tests, voltage regulations, losses and efficiency, Sumpner's test, parallel operation and load sharing. Autotransformer, 3 phase transformer- Scott connection of transformers for phase conversion, on -load and off-load tap changers, induction regulators.

Text Books:

1. Nagrath I. J and Kothari D. P. "*Electric Machines"*, Tata McGraw Hill Publishing Company Ltd,1990.
2. P.S. Bimbhra, "*Electrical Machinery"*, Khanna Publishers, 2003.

References:

1. Fitzgerald. A.E., Charles KingselyJr, Stephen D. Umans, *"Electric Machinery"*, McGraw Hill Books Company, 1992.

2. Hill Stephen, Chapman.J, *"Electric Machinery Fundamentals"*, McGraw Hill Book Co., New Delhi, 4th edition 2005.

EE301	Power Electronics	**3**	**0**	**0**	**6**

General Introduction of Power Electronics, Scope and Application, **Power Semiconductor Devices Power diodes** - power transistors - SCRs - Triac - GTO - Power MOSFETs - IGBTs- Principles of operation and characteristics, device specifications and ratings, methods of turning on SCR- gate triggering circuit, methods of turning off SCR- commutation circuits. Protection and gate drive circuits. **Control rectifiers (AC to DC converter):** Single phase converters: Principle of phase control, half wave controlled rectifier load, fully controlled bridge converter, half controlled (semi) converter, Effect of single phase full converter with source inductance, Dual converter, 3-phase half wave controlled rectifier, 3-phase fully controlled bridge converter, 3-phase semi converter. **Inverter:** Series inverter, parallel inverter, single phase bridge inverter, concept of VSI and CSI, 3-phase bridge inverter (120° and 180° conduction mode), concept of PWM inverter. **D.C. Choppers:** Principle of operation, control techniques, transient analysis of step down chopper, buck, boost & buck-boost regulator, voltage commutated chopper, current commutated chopper, load commutated chopper, jones chopper. **Cyclo converters:** Single- phase mid-point type and bridge type cyclo converter, Applications: HVDC transmission, UPS, Zero voltage switch, Zero current switch.

Text Books:

1. P.S. Bimbhra, *"Power Electronics"*, Khanna Publication, 2012.
2. M.H. Rashid, *"Power Electronics"*, Pearson Publication, 2003.

References:

1. P.C. Sen, *"Power Electronics"*, Tata McGraw-Hill, 1987.
2. V.R. Moorthi, *"Power Electronics"*, Oxford University Press, 2005.
3. M.D. Singh & K.B. Khanchandani, *"Power Electronics"*, Tata McGraw-Hill, 2007.

EE303	Electrical Machines-II	**3**	**0**	**0**	**6**

Synchronous Generator: Constructional details – Types of rotors – emf equation – Synchronous reactance – Armature reaction – Voltage regulation – EMF, MMF, ZPF and A.S.A methods – Synchronizing and parallel operation – Synchronizing torque - Change of excitation and mechanical input – Two reaction theory – Determination of direct and quadrature axis synchronous reactance using slip test – Operating characteristics - Capability curves. **Synchronous Motor**: Principle of operation – Torque equation – Operation on infinite bus bars - V-curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power developed. **Three Phase Induction Motor**: Constructional details – Types of rotors – Principle of operation – Slip – Equivalent circuit – Slip torque characteristics - Condition for maximum torque – Losses and efficiency – Load test - No load and blocked rotor tests - Circle diagram – Separation of no load losses – Double cage rotors –Induction generator – Synchronous induction motor. Single phase induction motor, single phase synchronous motor, single phase commutator motors. Special purpose Machine.

Text Books:

1. D.P. Kothari and I.J. Nagrath, *"Electric Machines"*, Tata McGraw Hill Publishing Company Ltd 2002.
2. P.S. Bhimbhra, *"Electrical Machinery"*, Khanna Publishers, 2003.

References:

1. A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, *"Electric Machinery"*, Tata McGraw Hill publishing Company Ltd, 2003.
2. J.B. Gupta, *"Theory and Performance of Electrical Machines"*, S. K. Kataria and Sons, 2002.
3. K. Murugesh Kumar, *"Electric Machines"*, Vikas Publishing House Pvt. Ltd, 2002.

EE305	Transmission and Distribution	**3**	**0**	**0**	**6**

Introduction: Structure of electric power systems – one line diagram – Two wire DC, AC single phase and three phase systems- Recent Trends in transmission systems, comparison of EHVAC and HVDC systems. **Transmission line parameters:** Resistance, inductance and capacitance of single phase transmission lines –stranded and bundled conductors – symmetrical and unsymmetrical spacing –transposition of conductors– Double circuit line Application of self and mutual GMD – Skin and Proximity effect –Corona loss. **Performance of transmission lines:** Equivalent circuits for short, medium and long lines – transmission efficiency and voltage regulation – Real and reactive power

flows in lines –power angle diagram – power circle diagrams for receiving and sending end, limiting factors for transmission line loadability– Ferranti effect. **Mechanical design of Transmission line:** Factors affecting mechanical design, line supports, sag. **Insulators and cables:** Insulators - Types, voltage distribution in insulator string and grading, improvement of string efficiency. Underground cables - Introduction-Types of cables, Capacitance of Single-core cable, Grading of cables. **Distribution System:** Types of distribution system – Radial and Ring main system. Current and voltage calculation in distributors with concentrated and distributed loads-Kelvin's law for the design of feeders and its limitations - Substation design-Types of Substation- Bus-bar Arrangement- Substation Bus Schemes-Substation Location- Substation Equipments.

Text Books:

1. C.L.Wadhwa, *"Electrical Power System"*', New Age International Pvt. Ltd., 2007.
2. J Nagrath and D P Kothari, *"Power System Engineering"*, Tata McGraw Hill

References:

1. J Nagrath and D P Kothari, *"Power System Engineering"*, Tata McGraw Hill
2. B R Gupta, *"Power System Analysis and Design"*, Wheelers Publishers
3. Ashfaq Hussain, *"Electrical Power Systems"*, CBS publishers and distributor.
4. S.N. Singh, *"Electric Power Generation, Transmission and Distribution"*, Prentice Hall of India Pvt. Ltd, New Delhi, 2002.

EE307	Control System	**3**	**0**	**0**	**6**

Introduction- feedback and its effects-linearization Mathematical Modelling of Physical Systems- Block diagram Concept and use of Transfer function. Signal Flow Graphs Mason's gain formula. Time Domain Analysis of Control Systems - BIBO and absolute stability, Routh-Hurwitz Criterion. P, PI and PID controllers, State Variable Analysis of Linear Dynamic Systems- controllability and observability Root Locus Techniques- zero and pole. Frequency Domain Analysis of Control Systems- polar plots, Nyquist stability criterion, Bode plots, application M&N circles, Nichols charts Design of Compensators.

Text Books:

1. I .J. Nagrath, M. Gopal, "*Control Systems Engineerin*g", New Age International Publishers, 2008.
2. K. Ogata, *"Modern Control Engineering"*, Prentice Hall, 2010.

References:

1. Samarjit Ghosh, "*Control System: Theory & Applications"*, Pearson Education, 2007.
2. B. C. Kuo, Farid Golnaraghi, *"Automatic Control Systems"*, John Wiley and Sons, 2003
3. D. Roy Choudhury, *"Modern Control Engineering"*, Prentice Hall, 2005.

EE309	Electromagnetic Field	**3**	**0**	**0**	**6**

Vector algebra, Cartesian, Cylindrical and Spherical co-ordinate system. Transformation of variables from Cartesian to cylindrical and spherical coordinate system. Coulomb's law, Electric field intensity, Field of 'n' point charges, Field of line and sheet of charge. Electric flux density, Gauss's law and it's applications. Divergence and Divergence theorem. Definition of potential difference and potential, Potential of point charge and system of charges. Potential gradient, Energy density in electrostatic field. Poisson's and Laplace's equations. Current and current density, Continuity of current. Biot-Savart and Amperes circuital laws and their applications, Curl, Stoke's theorem. Magnetic flux density, Scalar and Vector magnetic potential. Maxwell's equations in steady electric and magnetic fields. Force on moving charge and differential current element, Force and torque on a closed circuit. Time varying fields and Maxwell's equations. Uniform plane waves, wave motion in free space, perfect dielectric, lossy dielectric and good conductor, skin effect. Poynting vector and power considerations. Reflection of uniform plane waves, Standing ratio.

Text Books:

1. William H.Hayt Jr. and John A. Buck, *"Engineering Electromagnetics"*, Tata McGraw-Hill, 2011.
2. K. K. Shah, *"Introduction to Electromagnetic's"*, Dhanpat Rai, 2006.
3. Mathew N. O. Sadiku, *"Elements of Electromagnetics"*, Oxford University Press, 2007.
4. Ashutosh Pramanik, *"Electromagnetism – Theory and Applicatio*ns", Prentice-Hall, 2008.

References:

1. Joseph. A. Edminister, *"Theory and Problems of Electromagnetics"*, Schaum Series, Tata McGraw Hill, 1993.
2. Kraus and Fleish, *"Electromagnetics with Applications"*, McGraw Hill International Editions, 1999.

EE302	Microprocessor and Applications	**3**	**0**	**0**	**6**

Microprocessors: Introduction to 8085; architecture; 8085 addressing modes; instruction sets; assembly language programming; timing diagram; interrupts; interrupt service routine; stack and subroutine; counters and time delays. Interfacing the 8085 - memory interfacing- I/O interfacing- types of IO data transfer; interfacing matrix keyboard; seven segments display-interfacing DAC and ADCs. Programmable peripheral devices 8255 - interfacing ADC and printer to 8085 through 8255; 8254 programmable interval timers- timing diagrams; Design of a real time clock using 8254; DMA controller 8237; Universal synchronous asynchronous receiver transmitter (USART) 8251; programmable interrupt controller 8259.

Text Books:

1. R. S. Gaonkar, "*Microprocessor Architecture, Programming and Applications with the 8085*", Penram International Publishing (India), 2000.
2. A.K. Roy & K.M. Bhurchandi, "*Advanced Microprocessor and Peripherals (Architecture, Programming & Interfacing"*, Tata McGraw-Hill Publication,

References:

1. D. V. Hall, "*Microprocessors and Interfacing: programming and hardware"*, Tata McGraw-Hill, 1995.

Ghosh & Sridhar, "*Introduction to Microprocessor for Scientists & Engineers"*, Prentice Hall of India Pvt. Ltd,

EE304	Power System Protection	**3**	**0**	**0**	**6**

Introduction to protection scheme: Need for Protective systems - Nature and causes of Faults -Types of faults - Effect of faults - fault statistics - Evolution of protective relays - Zones of protection - Primary and Back -up Protection - Essential qualities of Protection -Classification of Protective schemes -Automatic reclosing - current transformer for Protection - potential transformer - basic relay terminology. **Relays:** General considerations - sensing of faults - construction of electro-magnetic attraction and induction types relays - Buchholz and negative sequence relay -concept of reset, pick up, inverse time and definite time characteristics, over current, over voltage, directional, differential and distance relays on R-X diagram - Static Relays: Introduction, advantage and limitation of static relays, static over current, directional, distance and differential relays. Electronic relays - static relays functional circuits: comparators, level detectors, logic and training circuits, microprocessor and computer based protection schemes. **Protection:** Types & detection of faults and their effects, alternator protection scheme - Power transformer protection , generator-transformer unit protection scheme, bus bar protection - Transmission line protection, Pilot relaying schemes, power line carrier protection. **Switchgear:** Theory of current interruption- energy balance and recovery rate theory, arc quenching, recovery and restriking voltages - Types of circuit breakers - Rating selection and testing of circuit breakers/operating mechanisms - LT switchgear, HRC fuses, types construction and applications.

Text Books:

1. Badriram & Vishwakarma, "*Power System Protection*", Tata McGraw-Hill Education, 2011.
2. Paithankar Y. G., S. R. Bhide., "*Fundamentals of power system protection*", PHI Learning Pvt. Ltd., 2004.

References:

1. Ravindra Nath.B, and Chandar.M, "*Power systems protection and switchgear*", New age international (P) Ltd. 2005.
2. Rao Sunil.S, "*Switchgear and protection"*. Khanna Publishers, 1999.
3. Paithankar.Y.G," *Transmission Network Protection: Theory and Practice*", Marcel Deicker, Inc.1998.

EE306	Advance Control System	**3**	**0**	**0**	**6**

Introduction, concept of state, state variables and state Model, state modeling of linear systems, linearization of state equations. State space representation using physical variables, phase variables & canonical variables. Derivation of transfer function from state model, diazotization, Eigen values, Eigen vectors, generalized Eigen vectors. Solution of state equation: state transition matrix and its properties, computation using Laplace Transformation, power series method, Cayley-Hamilton method, concept of controllability & observability, methods of determining the same. Frequency response design: Design of lag, lead, lag-lead and PID controllers, the Nyquist criterion, analysis and design, relative stability and the Bode diagram, closed-loop response, sensitivity, time delays; Root locus design: construction of root loci, phase-lead and phase-lag design, PID controller design; Modern design: controllability and observability, state feedback with integral control, reduced order observer. Digital controllers: Use of z-transform for closed loop transient response, stability analysis using bilinear transform and Jury method, deadbeat control, Digital control design using state feedback.

Text Books:

1. M. Gopal, "*Digital Control and State Variable Methods*", Tata McGraw Hill, 2003.
2. M. Gopal, "*Control Systems*", Tata McGraw Hill, 2008.

References:

1. G. F. Franklin, J. D. Powel and A. E. Emami-Naeini, "Feedback *Control of Dynamic Systems*", Prentice Hall Inc. 2002.
2. K. J. Astrom and T. Hagglund, "*Advanced PID Control*", ISA, Research Triangle Park, NC 27709, 2005.

EE308	Renewable Energy Resources	**3**	**0**	**0**	**6**

Introduction-Fossil fuel based systems, Impact of fossil fuel based systems, Non conventional energy - seasonal variations and availability. Renewable energy - sources and features, Hybrid energy systems, Distributed energy systems and dispersed generation (DG), Other sources of energy- Solar energy, Wind energy system, Wave energy, Energy from biomass, Energy from OTEC, Geothermal energy system, The Sun -The Solar constant, Solar radiation spectrum, Solar radiation measurement, Solar radiation at earth's surface, Solar radiation data, radiation geometry, empirical relations predicting availability of solar radiation, radiation on horizontal and tilted surface, Flat plate collectors, Basic energy balance equation and its principle, concentrating collectors, It's classification and working principle, Application of solar thermal technologies-Heating, cooling, Drying, Distillation, Power generation, Solar PV system, it's principle and application, Wind Energy – Introduction, Basic principle of wind energy conversion, wind data and energy estimation, site selection, basic component of wind energy conversion system, wind turbines and their analysis, wind-electrical generation. Stand-alone and grid connected wind-electrical power system, various applications of wind energy.

Text books

1. Rai.G.D, "*Non-conventional resources of energy*", Khanna publishers, Fourth edition, 2010.
2. Khan.B.H, "*Non-Conventional Energy Resources*", The McGraw Hills, Second edition, 2009.
3. S.P. Sukhatme, "Solar energy: Principles of Thermal storage", Tata McGraw Hill.

References:

1. Godfrey Boyl, "*Renewable Energy: Power sustainable future*", Oxford University Press, Third edition, 2012.
2. Rao.S. & Parulekar, "*Energy Technology*", Khanna publishers, Fourth edition, 2005.

EE310	Communication System	**3**	**0**	**0**	**6**

Analog Communication :Introduction to communication systems, signals and spectra, electromagnetic spectrum and its usage, communication channels and propagation characteristics, amplitude modulation and demodulation - spectra, circuits and systems, frequency modulation/demodulation, frequency division multiplexing, radio transmitters and receivers, sampling theory, pulse modulation and demodulation - spectra, circuits & systems, circuit noise, performance of analogue communication systems in AWGN and fading channels. Digital Communication: Introduction to digital signals and systems, spectra and bandwidth. A-D conversion and quantization. PCM, Log-PCM , DPCM, ADPCM, DM, ADM, and LPC for speech signals, time division multiplexing, digital hierarchy and standards, baseband transmission, data regenerators and clock recovery, inter-symbol interference, equalizers, digital modulation and demodulation - binary and M-ary ASK, FSK, GMSK, PSK, DPSK and their spectra, circuits and systems, carrier recovery, performance of digital modulation systems, elements of information theory and coding.

Text books

1. S. Haykin, "Communication Systems", 3rd edition, John Wiley, 1994
2. H. Taub and D. Schilling, "Principles of Communication Systems", 3rd edition, Tata McGraw Hill

References:

1. W. Stallings, "Data and Computer Communications", 6th edition, Pearson education Asia (IPE), 2000
2. F. Halshall, "Data Communications, Computer networks and Open Systems", 4th edition, Pearson Education Asia (IPE), 1996
3 B.A. Forouzan, "Data Communications and Networking", 3rd edition, Tata McGraw Hill, 2003
4 D. Bertrekas and R. Gallagar, Data Networks, 2nd edition, Prentice Hall (EEE), 1992

EE401	High Voltage Engineering	**3**	**0**	**0**	**6**

Breakdown Phenomenon: Breakdown in gases - Mechanism of breakdown in gases, breakdown theory. Breakdown in liquids - suspended solid particle mechanism, Cavitation and bubble mechanism, Stressed Oil volume mechanism, etc. Breakdown in solids - Intrinsic breakdown, Electromechanical breakdown, breakdown of solid dielectrics in practice, Chemical and Electrochemical deterioration and breakdown, breakdown due to treeing and tracking, breakdown due to internal discharges. Overvoltage Phenomenon, Protection & Insulation Coordination Natural causes for overvoltage - lightning phenomenon, over voltage due to switching surges and due to arching ground. Line design based on lightning. Basic idea about protection against overvoltage - lightning arresters, surge absorbers, Ground wire, grounding practices etc. BIL, SIL of the equipments, V-T curve, Concepts of Insulation coordination. Generation of High AC & DC voltageHigh AC voltage generation - Testing transformer and its cascaded connections. Single phase resonant circuits. High DC voltage generation - Single stage and Multi stage voltage multiplier circuits.Impulse Voltage and Current generation.Measurement of High Voltage and Current
High Voltage Testing.

Text Books:

1. High Voltage Engineering , 'C. L. Wadhwa ',New Age International Pub. (P) Limited, New Delhi.
2. High Voltage Engineering, 'M.S Naidu & V Kamaraju' , Tata Mc Graw Hill Publishing company, New Delhi,

References:

1. High Voltage Engineering Fundamentals, ' E. Kuffel & W. S. Zaengl' , Butterworth-Heinemann, 2000

EE403	Power System Analysis	**3**	**0**	**0**	**6**

Power system overview: Power scenario in India, Power system components, Representation. Single line diagram, per unit quantities, p.u. impedance diagram, Network graph, Bus incidence matrix, Primitive parameters, Bus admittance matrix using singular method, Formation of bus admittance matrix of large power network, Representation of off nominal transformer. **Power flow analysis:** Bus classification, Formulation of Power Flow problems, Power flow solution using Gauss Seidel method, Handling of Voltage controlled buses, Power Flow Solution by Newton Raphson method, Fast Decoupled Power Flow Solution. S**ymmetrical fault and Unsymmetrical Faults:** Symmetrical short circuit on Synchronous Machine, Bus Impedance matrix building algorithm, Symmetrical fault analysis through bus impedance matrix, Symmetrical components, Sequence impedance, Sequence networks, Analysis of unsymmetrical fault at generator terminals, Use of bus impedance matrix for analyzing unsymmetrical fault occurring at any point in a power system**. POWER SYSTEM STABILITY:** Introduction to stability studies, Swing equation, Swing curve, Equal area criterion, Critical clearing angle and time, Modified Euler's method, Fourth order Runge-Kutta method, Multi-machine transient stability.

Text Books:

1. John.J.Grainger, William D. Stevenson, "*Power System Analysis*", Tata Mc Graw Hill Publishing company, New Delhi, 2003.
2. Nagarath I.J. and Kothari D.P. "*Modern Power System Analysis*", Fourth Edition, Tata Mc Graw Hill Publishing Company, New Delhi, 2011.

References:

1. Hadi Sadat, "*Power System Analysis"*, Tata Mc Graw Hill Publishing company, New Delhi, 2002.
2. Pai M.A. "*Computer Techniques in Power System Analysis*", Tata Mc Graw Hill Publishing Company, New Delhi, 2003.
3. Abhijit Chakrabarti and Sunita Halder, "*Power System Analysis Operation and Control*", PHI Learning Private Limited, New Delhi, 2011.
4. Arthur R and Vijay Vittal, "*Power Systems Analysis*", Dorling Kinderley (India) Private Limited, New Delhi, 2012.

EE402	Power System Operation and Control	**3**	**1**	**0**	**8**

Introduction: Basic concepts of operation and control of power system - necessity of voltage and frequency regulation in power systems-real power-frequency and reactive power- voltage control loops-system load variation, load curves and basic concepts of load dispatching, load forecasting, unit commitment, load shedding and islanding.

Real power frequency control: Plant and system level control - basics of speed governing mechanisms and modeling-speed load characteristics-regulation of two generators in parallel-Concept of control area-LFC of single area system-static and dynamic analysis of uncontrolled and controlled cases- integration of economic dispatch controller with LFC-LFC of two area system-tie line modeling-block diagram representation of two area system-static and dynamic analysis-state variable model. **Reactive power voltage control:** Basics of reactive power control- Excitation system requirement-elements of excitation system-static and dynamic analysis-stability compensation-generation and absorption of reactive power-methods of voltage control-control by tap changing transformer-shunt and series compensation, phase angle compensation. **Economic operation of power system:** Statement of economic dispatch problem-incremental cost curve-input and output characteristics of thermal and hydro plants-system constraints-hydrothermal. Scheduling of long and short terms-optimal operation of thermal units without and with transmission losses using penalty factor, incremental transmission loss, and transmission loss formula (no derivation)-base point and participation factors-Statement of unit commitment-constraints in unit commitment-solution methods using priority list and dynamic programming. **Computer control of power systems:** Concept of energy control centre and functions-need of computer control of power systems-system monitoring, data acquisition and controls-System hardware configurations-SCADA.

Text Books:

1. Olle.I.Elgerd, "*Electric energy systems theory-An introduction*", Tata McGraw Hill publishing Ltd, New Delhi, 2008.
2. Prabha Kundur, "*Power system stability and control*", Tata McGraw Hill publishing Ltd, New Delhi, 5th reprint, 2008.

References:

1. Allen J.Wood, Bruce F.Wollenberg, "*Power Generation*", *Operation and Control*", 2nd Edition, John Wiley and sons, 1996.
2. I.J.Nagrath and D.P.Kothari, "*Power System Engineering*", 2nd Edition, Tata McGraw Hill publishing Ltd, New Delhi, 2008.
3. S.Sivanagaraju, G.Sreenivasan, "*Power System Operation and Control*", Pearson Education, 2010.