SYLLABUS

POSTGRADUATE PROGRAMME

M. TECH.

SPECIALIZATION:

POWER AND CONTROL SYSTEM

DEPARTMENT OF
ELECTRICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, MANIPUR
TAKYELPAT, IMPHAL-795001
MANIPUR, INDIA

2022

POWER AND CONTROL SYSTEM (EE)

SEMESTER – I			
COURSE NO.	**COURSE NAME**	**L - T – P**	**CREDIT**
EE 501	LINEAR SYSTEMS THEORY	3-0-0	6
EE 503	MODERN CONTROL THEORY	3-0-0	6
EE 505	MODERN POWER SYSTEMS	3-0-0	6
EE 507	HVDC AND FACTS	3-0-0	6
EE 5XY	DEPARTMENT ELECTIVE - I	3-0-0	6
EE 531	POWER and CONTROL LAB	0-0-3	3
		15-0-3	**33**
SEMESTER - II			
EE 502	OPTIMAL AND ADAPTIVE CONTROL	3-0-0	6
EE 504	DIGITAL CONTROL	3-0-0	6
EE 506	ADVANCE POWER SYSTEM PROTECTION	3-0-0	6
EE 508	POWER SYSTEM TRANSIENTS	3-0-0	6
EE 5XY	DEPARTMENT ELECTIVE -II	3-0-0	6
EE 532	ADVANCED POWER AND CONTROL LAB	0-0-3	3
		15-0-3	**33**
SEMESTER – III			
EE 621	PROJECT -I	0-0-24	24
		0-0-24	**24**
SEMESTER - IV			
EE 622	PROJECT -II	0-0-24	24
		0-0-24	**24**

DEPARTMENTAL ELECTIVES

POWER AND CONTROL SYSTEM (EE) M. TECH.

DEPARTMENT ELECTIVE-I				
S. No.	**COURSE NO.**	**COURSE NAME**	**L-T-P**	**Credit**
1.	EE551	ELECTRIC VEHICLES AND CHARGING TECHNOLOGY	3-0-0	6
2.	EE553	ELECTRO MAGNETIC INTERFERENCE AND COMPATIBILITY	3-0-0	6
3.	EE555	POWER SYSTEM STABILITY AND CONTROL	3-0-0	6
4.	EE557	APPLICATIONS OF POWER CONVERTERS	3-0-0	6
5.	EE559	ADVANCED ELECTRIC DRIVES AND CONTROL	3-0-0	6
6.	EE561	DSP CONTROLLED DRIVES	3-0-0	6
7.	EE563	STATE ESTIMATION AND SECURITY ANALYSIS	3-0-0	6
8.	EE565	ALTERNATIVE SOURCES OF ELECTRIC ENERGY	3-0-0	6
9.	EE567	ADVANCED COMPUTER METHODS IN POWER SYSTEMS	3-0-0	6
10.	EE569	AI TECHNIQUES IN POWER SYSTEMS	3-0-0	6
11.	EE571	DESIGN AND TESTING OF HIGH VOLTAGE APPARATUS	3-0-0	6
12.	EE573	ADVANCED DISTRIBUTION SYSTEMS PLANNING AND AUTOMATION	3-0-0	6
13.	EE575	ECONOMIC OPERATION OF POWER SYSTEMS	3-0-0	6
14.	EE577	POWER SYSTEM RELIABILITY AND PLANNING	3-0-0	6
15.	EE579	RENEWABLE ENERGY INTEGRATION FOR EVs	3-0-0	6

DEPARTMENT ELECTIVE-II				
S. No.	**COURSE NO.**	**COURSE NAME**	**L-T-P**	**Credit**
1	EE552	POWER SYSTEM DEREGULATION	3-0-0	6
2	EE554	EHV AC & DC TRANSMISSION	3-0-0	6
3	EE556	ADVANCED SOFT COMPUTING TECHNIQUES	3-0-0	6
4	EE558	MECHATRONICS AND ITS APPLICATION	3-0-0	6
5	EE560	NONLINEAR CONTROL SYSTEMS	3-0-0	6
6	EE562	ROBOTICS AND AUTOMATION	3-0-0	6
7	EE564	MICROPROCESSOR BASED INDUSTRIAL CONTROL INSTRUMENTATION	3-0-0	6
8	EE566	RANDOM PROCESS CONTROL AND ESTIMATION	3-0-0	6
9	EE568	PARAMETER ESTIMATION & SYSTEM IDENTIFICATION	3-0-0	6
10	EE570	ARTIFICIAL NEURAL NETWORKS & FUZZY SYSTEMS	3-0-0	6
11	EE572	ADAPTIVE AND ROBUST CONTROL	3-0-0	6
12	EE574	ADVANCED PROCESS CONTROL	3-0-0	6
13	EE576	ADVANCED DIGITAL SIGNAL PROCESSING	3-0-0	6
14	EE578	IMAGE PROCESSING	3-0-0	6
15	EE580	ADVANCED ELECTRIC TRACTION AND DRIVES	3-0-0	6

EE 501 Linear Systems Theory 3-0-0 6

Essentials of linear algebra: vector spaces, subspaces, singular value decomposition; state variable modeling of linear dynamical systems; transfer function matrices; Stability theory: Lyapunov Theorems; controllability and observability; realization theory: balanced realization, Kalman canonical decomposition; linear state feedback and estimation. Introduction to linear robust control: model uncertainty, model reduction and co-prime factorization; robust stability and robust performance.

Texts:

1. S. Lang, *Introduction to Linear Algebra*, Springer-Verlag, 2/e, 1997.
2. L. A. Zadeh and C. A. Desoer, *Linear System Theory: The State Space Approach*, Springer-Verlag, 2008.
3. C.T. Chen, *Linear System Theory and Design*, Oxford University Press, 3/e, 1999.
4. W. Rugh, *Linear System Theory*, Prentice Hall, 2/e, 1995.

EE 503 Modern Control Theory 3-0-0-6

System representation-introduction to state and state variable- transformations- state transition matrixproperties and methods of valuation - time response of linear systems - state diagrams - resolvent matrixcontrollability andobservability-state variable feedback - pole placement-stability-stability in the sense of liapunov, stability oflinear systems and non linear systems-optimal control-formulation of the optimal control problem - use ofhamiltonian method - continuous time linear state regulator matrix riccati equation-state variable feedbackdesign.

TEXTS:

1. Katsuhiko Ogata : Modern Control Engineering, 5th Edition, Prentice-Hall of India, 2010.
2. M. Gopal : Modern Control Systems Theory, 2nd Edition, New Age Intl. Pvt. Ltd., 1993.

EE 502 Modern Power Systems 3-0-0 6

Introduction to modern power system: interconnected power system, main objective in operation of power system, structure of Indian power system; Power Component static and dynamic modeling: static modeling of transmission lines, transformer, and capability curve of generator ; Power flow analysis: Gauss-Seidel, Newton-Raphson (polar and rectangular form), decoupled load flow, fast decoupled power flow, DC load flow, Distribution system power flow ; Contingency analysis: contingency ranking, DC and AC sensitivity analysis ; Power system stability: equal area criteria, rotor angle and voltage stability, energy function approach towards transient stability prediction; Power system Operation and Control: Economic load dispatch, load frequency control.

Texts :

1. J. J. Grainger and W D. Stevenson, *Power System Analysis*, Tata McGraw-Hill, 2003.
2. A. J. Wood and B. F. Wollenberg, *Power Generation Operation andControl*, John Wiley and Sons, 2ndEdition, 2005.
3. N. G. Hingorani and L. Gyugyi, *Understanding FACTS*, Wiley-IEEE Press, 1999.
4. J. Arrillaga, *High voltage direct current transmission*, IEE Power Engineering Series, 2nd Edn., 1998.
5. P. Kundur, *Power System Stability and Control*, McGraw-Hill, 1995.

EE504 HVDC and FACTS 3-0-0-6

HVDC transmission- introduction- analysis of HVDC converters - pulse number-converter bridge characteristics- converter and HVDC system control- principles of dc link control- power control- harmonics & filters - introduction- generation of harmonics- types of ac filters- power flow analysis in ac/dc systems - generalmodeling of dc links - flexible ac transmission systems(FACTS)-flow of power in an ac system-basic types of FACTS controllers- objectives, basic operating principle and control approaches.

TEXTS:

1. K.R. Padiyar: HVDC Power Transmission System, 2nd Edition, New Age Intl. Pvt. Ltd., 2012.
2. N.G. Hingorani and L.Gyugyi: Understanding FACTS: Concepts and Technology of Flexible ACTransmission Systems, Wiley India Pvt. Ltd., 2011.

EE 502 Optimal and Adaptive Control 3-0-0 6

Basic mathematical concepts, Conditions for optimality, Calculus of variations, Pontryagin's maximum principle, Hamilton Jacobi-Bellman theory, dynamic programming, structures and properties of optimal systems, various types of constraints, singular solutions, minimum time problems, optimal tracking control problem Model reference adaptive control, gain scheduling, adaptive internal model control, adaptive variable structure control, adaptive backstepping design, introduction to system identification, direct and indirect adaptive control.

Texts:

1. D. E. Kirk, Optimal Control Theory: An Introduction, Prentice-Hall, 2004.
2. B.D.O. Anderson and J.B. Moore, Optimal Control: Linear Quadratic Methods, 2007.
3. M. Krstic, P. V. Kokotovic, I. Kanellakopoulos, Nonlinear and Adaptive Control Design, John Willey andSons, 1995.
4. K. J. Astrom and B. Wittenmark, Adaptive Control, 2/e, 2008.
5. G. Feng and R. Lozano, Adaptive Control Systems, Oxford University Press, 1999..

EE 504 Digital Control 3-0-0 6

Discrete-time system representations: modeling discrete-time systems by linear difference equations and pulse transfer functions, time responses of discrete systems; discrete state-space models, stability of discrete-time systems. Finite settling-time control design: deadbeat systems, inter sample behavior, time-domain approach to ripple-free controllers, limitations and extensions of the deadbeat controller.
State-feedback design techniques: linear system properties, state feedback using Ackermann's formula, tracking of known reference inputs. Output-feedback design techniques: observer design ,
observer-based output feedback design.

Texts:

1. B. C. Kuo, Digital Control Systems; Oxford University Press, 2/e, Indian Edition, 2007.
2. K. Ogata, Discrete Time Control Systems; Prentice Hall, 2/e, 1995.
3. M. Gopal, Digital Control and State Variable Methods; Tata Mcgraw Hill, 2/e, 2003.
4. G. F. Franklin, J. D. Powell and M. L. Workman; Digital Control of Dynamic Systems; Addison Wesley,1998, Pearson Education, Asia, 3/e, 2000.
5. K. J. Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design; Prentice Hall, 3/e,1997.

EE506 ADVANCED POWER SYSTEM PROTECTION 3-0-0-6

Static Relays- Block diagram - types of static relays- over current, differential and distance relays - DigitalProtection - Modelling of digital relays- Protection of power system and apparatus using digital protectionschemes - New developments in relaying principles.

TEXTS:

1. T.S.Madhava Rao: Power System Protection - Static Relays, 2nd Edition, TMH Publications, 2004.
2. Arun G.Phadke and James S. Thorp: Computer Relaying for Power Systems, 2nd Edition, John Wileyand Sons Inc., 2009.

EE508 POWER SYSTEM TRANSIENTS 3-0-0-6

Introduction to Power System Transients- abnormal switching transients- Electromagnetic Phenomena Under Transient Conditions- Travelling Waves on Transmission Lines- Modelling of Power Apparatus Under ransientConditions- Protection of System Against Transients.

TEXTS:

1. Allen Greenwood: Electrical Transient in Power Systems, 2nd Edition, Wiley India Pvt. Ltd., 2010.
2. Harold A Peterson: Transient in Power Systems, 1st Edition, John Wiley & Sons, 1951.
3. E. Kuffel, W.S. Zaengl and J. Kuffel, High Voltage Engineering Fundamentals, 2nd Edition, NewnesPublishers, 2011.

EE 512 Advance Power and Control Lab 0-0-3-3

Study of 3-phase inverter, Study of 3-phase rectifier, Control of buckboost converter, Position control of servo-motor, Speed control of 3- phase AC motor, Speed and position control of stepper motor, Load flow analysis with power flow control using series compensation, Control of power flow using back-to- back converter, Effectof SVC (Static Var Compensator) in controlling the bus voltage,
Synchronization of alternators.

Texts:

1. C. S. Indulkar, Laboratory Experiments in Electrical Power Engineering, Khanna Publishers, 1/e, 2003.
2. 2. G. K Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2/e, 2002.

3. O. P. Arora, Power Electronics Laboratory: Theory, Practice & Organization, Narosa Publishing House, 1/e, 2007.
4. P. Kundur, Power System Stability and Control, McGraw-Hill, 1/e, 1994.

DEPARTMENTAL ELECTIVES

EE551 ELECTRIC AND HYBRID VEHICLES 3-0-0-6

Introduction to Hybrid Electric Vehicles, Conventional Vehicles, Hybrid Electric Drive-trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor, Energy Storage Requirements in Hybrid and Electric Vehicles, Sizing the drive system, Design of a Hybrid Electric Vehicle, Energy Management Strategies.

Text books:
Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
References:
James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003. 2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

EE553 ELECTRO MAGNETIC INTERFERENCE AND COMPATIBILITY 3-0-0-6

Introduction: EMC standardization and description, measuring instruments, conducted EMI references, EMI in power electronic equipment: EMI from power semiconductors circuits. Noise suppression in relay systems: A.C. switching relays, shielded transformers, capacitor filters, EMI generation and reduction at source, influence of layout and control of parasites. EMI filter elements: Capacitors, choke coils, resistors, EMI filter circuits. EMI filter design for insertion loss: Worst case insertion loss, design method for mismatched impedance condition and EMI filters with common mode choke-coils.

TEXTS:

1. Laszlo Tihanyi: Electromagnetic Compatibility in Power Electronics, IEEE Press, 1995.
2. R. F. Ficchi: Practical Design for Electromagnetic Compatibility, Hayden Book Co., 1971.

EE555 POWER SYSTEM STABILITY AND CONTROL 3-0-0-6

Synchronous machine modelling - parks transformation- dq0 equivalent circuits- machine impedances - time constants - phasor diagrams - basic models for power system studies - action of proportional and forced action avr-dynamic stability of smib system and mmp systems-transient stability studies – stability analysis of multi machine systems, effect of exciter and governor models, computer solution and flow charts - methods to improve stability - methods to improve steady state, dynamic, transient and voltage stability.

TEXTS:

1. P.M. Anderson and A.A. Fouad: Power System Control and Stability, 2nd Edition, IEEE Computer Society Press, 2002.
2. Prabha Kundur: Power System Stability and Control, 1st Edition, TMH Publishers, 2006.
3. V.A. Venikov; Transient Process in Electrical Power Systems, 1st Edition, MIR Publications, 1977.

EE557 APPLICATIONS OF POWER CONVERTERS 3-0-0-6

Power converter topologies for Induction heating-welding-lighting, HV power supplies: X-ray-radar-space, Low voltage high current power supplies- UPS-Active Filters-Electric Vehicle-Automotive Electronics, Hybrid Electric Vehicles, Unmanned Electric Vehicles, Electric Aircraft..

TEXTS:

1. Ali Emadi, A. Nasiri, and S. B. Bekiarov: Uninterruptible Power Supplies and Active Filters, CRC Press, 2005.
2. M. Ehsani, Y. Gao, E. G. Sebastien and A. Emadi: Modern Electric, Hybrid Electric and Fuel Cell Vehicles, 1st Edition,CRC Press, 2004.
3. William Ribbens: Understanding Automotive Electronics, Newnes, 2003.
4. Research Publications in the relevant areas.

EE559ADVANCED ELECTRIC DRIVES AND CONTROL 3-0-0-6

Vector Control of Induction Motor: Principles of vector control, direct vector control, derivation of indirect vector control, implementation-block diagram, estimation of flux, flux weakening operation. DTC principle, operation and control and its comparison with vector control of IM, Sensor less Vector Control of Induction Motor: Slip and speed estimation at low performance, rotor angle and flux linkage estimation at high performance, rotor speed estimation scheme, estimators using rotor slot harmonics, model reference adaptive systems, extended Kalman filter, injection of auxiliary signal on salient rotor, Control of Synchronous Motor Drives: Synchronous motor and its characteristics- Control strategies-Constant torque angle control- power factor control, constant flux control,

flux weakening operation, Load commutated inverter fed synchronous motor drive, motoring and regeneration, phasor diagrams. Sensorless control and flux observer, Control of Switched Reluctance Motor Drives: SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies-SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers, Control of BLDC Motor Drives: Principle of operation and control of BLDC and PMSM Machine, Sensing and logic switching scheme,

Texts:

1. Electric Motor Drives Modeling, Analysis & control -R. Krishnan- Pearson Education
2. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications

References:

1. Sensorless Vector Direct Torque control –Peter Vas, Oxford University Press
2. Power Electronics control of AC motors – MD Murphy & FG Turn Bull Pergman Press -1st edition-1998.
3. Fundamentals of Electrical Drives – G.K. Dubey – Narosa Publications -1995
4. Power Semiconductor drives- G.K. Dubey-Prentice hall.

EE521 DSP CONTROLLED DRIVES 3-0-0-6

Overview of TMSLF2407 DSP controller: Instruction Set, Interrupts. Clarke's and park's transformations: Implementation of Clarke's and Park's transformation, SV PWM, BLDC Motor Control System, permanent magnet synchronous machines control system, vector control of IM, field oriented control, Induction Motor Speed Control using LF2407 DSP.

TEXTS:

1. Hamid A. Toliyat: DSP Based Electromechanical Motion Control, 1st Edition, CRC Press, 2004. 2. Ned Mohan, T.M. Undeland and William P.Robbins: Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009.

EE563 STATE ESTIMATION AND SECURITY ANALYSIS 3-0-0-6

Introduction to State Estimation in Power Systems - State Estimation of Ac Networks - Types of State Estimation - An Introduction to Advanced Topics in State Estimation - Power System Security Analysis Computer Control of Power Systems.

TEXTS:

1. Allen J. Wood and B.F. Woolenberg: Power Generation, Operation and Control, 2nd Edition, Wiley India Pvt. Ltd., 2006.
2. John J. Grainger and William D Stevenson: Power System Analysis, 1st Edition, McGraw Hill ISE, 2003.
3. Special Issue on Computer Control of Power Systems, IEEE Proc. July 1974.

EE565 ALTERNATE SOURCES OF ELECTRIC ENERGY 3-0-0-6

Introduction: Renewable sources of energy, distributed Generation, renewable energy economics. Photovoltaic power plants: Solar energy, generation of electricity PV cell characteristic. Fuel cells: Fuel cells, commercial and manufacturing issues, equivalent circuit. Induction generators: Operating principle, self-excited induction generator, Speed and Voltage Control. Storage systems: Parameters, lead-acid batteries, ultra-capacitors, flywheels, superconducting magnetic storage system, pumped hydroelectric energy storage, compressed air energy storage. **TEXTS:**

1. Felix A. Farret and M. Godoy Simões: Integration of Alternative Sources of Energy, John Wiley & Sons, 2006. 2. R. Teodorescu, M. Liserre and Pedro Rodríguez: Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.

EE567 ADVANCED COMPUTER METHODS IN POWER SYSTEMS 3-0-0-6

Incidence and network matrices - introduction, graphs, incidence matrices formation - ybus by singular transformation- introduction to load flow analysis- gauss-seidel, newton-raphson and fast-decoupled methodalgorithms for formation of zbus matrix- short-circuit (sc) studies- introduction, sc calculations using zbus, zfabc, yfabc, zf012, yf012 matrices for various faults, example of sc calculations using zbus for l-l-l and lg faults-Power Flow (PF)solutions- sparsity technique - comparison of gs, nr, fdc methods- review of ac/dc load flow solutions, nr-load flow study with facts devices - PF analysis using MATLAB.

TEXTS:

1. Stagg G.Ward and El-Abiad: Computer Methods in Power System Analysis, McGraw Hill ISE, 1986.
2. Hadi Saadat : Power System Analysis, 3rd Edition, PSA Publishers, 2010.
3. J. Arrilaga and C.P. Arnold: Computer Modeling of Electric Power Systems, 1st Edition, John Wiley & Sons, N.Y., 2001.

EE569 AI TECHNIQUES IN POWER SYSTEMS 3-0-0-6

Artificial neural networks- introduction- neural network models- architectures - knowledge representation learning process-back propagation, rbf algorithms- hopfield network-fuzzy logic- introduction- fuzzy sets - membership function - fuzzy logic - fuzzy inference-defuzzification methods - genetic algorithmsintroductionen coding -fitness function-genetic operators- applications of ai techniques- load forecasting - load flow studies - economic load dispatch - load frequency control - reactive power control - speed control of dc and ac motors.

TEXTS:

1. S.Rajasekaran and G.A.V.Pai: Neural Networks, Fuzzy Logic and Genetic Algorithms, 1st Edition, PHI, 2009.
2. Rober J. Schalkoff, Artificial Neural Networks, 1st Edition, Tata McGraw Hill Education Pvt. Ltd., 2011.
3. G.J.Klir and T.A.Folger; Fuzzy Sets,Uncertainty and Information, 1st Edition, PHI Pvt. Ltd., 2009.
4. Bart Kosko; Neural Network and Fuzzy System, 1st Edition, Dorling Kindersley (India) Pvt. Ltd., 2007

EE571 DESIGN AND TESTING OF HIGH VOLTAGE APPARATUS 3-0-0-6

Introduction - High Voltage Overhead Lines - High Voltage Cables - High Voltage Bushings - High Voltage Power Transformers - Generation of High Voltages and Testing Techniques - High Voltage Measuring Techniques.

TEXTS:

1. H.M. Ryan: High Voltage Engineering and Testing, IET Press, 2nd Revised Edition 2001.
2. Ravindra Arora and Wolfgang Mosch: High Voltage and Electrical Insulation Engineering, IEEE Press, 2011.
3. E. Kuffel, W.S. Zaengl and J. Kuffel, High Voltage Engineering Fundamentals, Newnes Publishers, 2nd Edition 2011..

EE573 ADVANCED DISTRIBUTION SYSTEMS PLANNING AND AUTOMATION 3-0-0-6

Distribution system planning - planning and forecasting techniques, load characteristics - definitions - load forecasting - load management - tariffs-distribution transformers- types - three phase and single phase transformers - connections, dry type and self protected type transformers - regulation and efficiency-sub transmission lines and distribution sub-stations- distribution substations - bus schemes - substation location and rating - primary systems - voltage drop and power loss calculations - capacitors in distribution systems distribution system protection - distribution system automation- grounding.

TEXTS:

1. Turan Gonen : Electric Power Distribution System Engineering, 2nd Edition, BS Publications, 2007
2. Pabla A.S.: Electric Power Distribution Systems, 4th Edition, TMH, 2006

EE575 ECONOMIC OPERATION OF POWER SYSTEMS 3-0-0-6

Economic dispatch problem and methods of solutions - economic importance-generator unit characteristics - economic dispatch problem considering and neglecting transmission losses - iterative and non-iterative methods of solutions- economic dispatch using dynamic programming, economic dispatch versus unit commitment- unit commitment- constraints in thermal and hydro-units - unit commitment solution methodshydro thermal coordination - long range and short-range hydro-scheduling - dynamic programming solution to hydro-thermal scheduling - control of generation- models of power system elements - single area and multi area block diagrams - generation control with pid controllers, implementation of automatic generation control (agc) - agc features- economic dispatch by ann and ga approaches.

TEXTS:

1. Allen J. Wood and B.F. Woolenberg: Power Generation, Operation and Control, 2nd Edition, Wiley India Pvt. Ltd., 2006.
2. John J. Grainger and William D Stevenson: Power System Analysis, 1st Edition, McGraw Hill ISE, 2003.
3. PSR Murthy : Operation and Control in Power System, 2nd Edition, BS Publications, 2009.

EE577 POWER SYSTEM RELIABILITY AND PLANNING 3-0-0-6

Basic reliability concepts- reliability function- markov process- reliability models-generating capacity – basic probability methods - the generation system model, loss of load and loss of energy indices- transmission systems reliability evaluation- radial configuration - conditional probability approach, network configurations - state

selection- generation planning- comparative economic assessment of individual generation projects investigation and simulation models - probabilistic generator and load models - transmission planning deterministic contingency analysis - probabilistic transmission system - reliability analysis – distribution planning- network configuration design-consisting of schemes - security criteria configuration synthesis.

TEXTS:

1. Roy Billinton and Ronald Allan Pitam: Reliability Evaluation of Power Systems, 2nd Edition, BS Publications, 2008.
2. R.L. Sullivan: Power System Planning, 1st Edition, McGraw Hill International Book Co., 1977O. P. Arora, Power Electronics Laboratory: Theory, Practice & Organization, Narosa Publishing House, 1/e,2007.
3. P. Kundur, Power System Stability and Control, McGraw-Hill, 1/e, 1994.

EE552 POWER SYSTEM DEREGULATION 3-0-0-6

Overview of key issues in electric utilities- introduction - management of inter zonal/intra zonal congestion analysis- open access same-definitions transfer capability issues - atc - ttc - trm - cbm calculations – electricity pricing- introduction - electricity price volatility-pricing - short-time price forecasting- power system operation in competitive environment- introduction-ancillary services management- introduction - reactive power as an ancillary service - a synchronous generators as ancillary service providers.

TEXTS:

1. Kankar Bhattacharya, Math H.J. Bollen and Jaap E. Daalder: Operation of Restructured Power Systems, Springer Publishers, 2001.
2. Mohammad Shahidehpour and Muwaffaq alomoush - Restructured Electrical Power Systems, 1st Edition, Marcel Dekker, Inc, 2001.

EE554 EHV AC & DC TRANSMISSION 3-0-0-6

General aspects and converter circuits - HVAC and HVDC links – comparison, reliability, choice of best circuit for HVDC converters- transformer connection. Bridge converters - analysis and control – power reversal- desired features of control - actual control characteristics Misoperation of converters and protection - Converter disturbance - bypass action in bridges - commutation failure - basics of protection - DC reactors - voltage and current oscillations - circuit breakers – over voltage protection. Harmonics, filters and converter charts- Characteristics and uncharacteristic harmonics - troubles due to harmonics - harmonic filters - converter charts of direct current and voltage - active and reactive power. Design of EHV lines based on steady state limits and transient over voltages - design of extra HV cable transmission - XLPE cables - gas insulated cables – corona.

TEXTS:

1. Rakesh Das Begamudre : Extra High Voltage AC Transmission Engineering, 4th Edition, New Age International Publishers, 2011.
2. Timothy.J.E. Miller: Reactive Power Control in Electric Systems, Wiley India Pvt. Ltd., 2010.
3. Turan Gonen: Electric Power Transmission System Engineering Analysis and Design, 2nd Edition, BS Publications, 2009.

EE556 ADVANCED SOFT COMPUTING TECHNIQUES 3-0-0-6

Basics of Fuzzy Sets: Fuzzy Relations – Fuzzy logic and approximate reasoning – Design Methodology of Fuzzy Control Systems – Basic structure and operation of fuzzy logic control systems. Concepts of Artificial Neural Networks: Basic Models and Learning rules of ANN's. Single layer perceptron networks – Feedback networks – Supervised and unsupervised learning approaches – Neural Networks in Control Systems. Basics of Genetic Algorithms: Evolution of Genetic Algorithm Applications. Integration of Fuzzy and Neural Systems: Neural Realization of Basic fuzzy logic operations – Neural Network based fuzzy logic inference – Neural Network based Fuzzy Modelling – Types of Neural Fuzzy Controllers. Fuzzy logic based Neural Network Models: Fuzzy Neurons – Type I, Type II, Type III – Fuzzification of Neural Network Models – Fuzzy Perceptron and Fuzzy classification with back propagation network Neural Networks with fuzzy training – Fuzzy Neural clustering.

TEXTS:

1. Jyh Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, *Neuro-Fuzzy and Soft Computing: AComputational Approach to Learning and Machine*, Prentice Hall. 1997
2. Chin –Teng Lin and C.S. George Lee, *Neural Fuzzy Systems" – A neuro fuzzy synergism toIntelligent systems*, Prentice Hall International. 1996
3. Yanqing Zhang and Abraham Kandel, *Compensatory Genetic Fuzzy Neural Networks andTheir Applications*, World Scientific. 1998.
4. T. J. Ross, *Fuzzy Logic with Engineering Applications*, McGraw-Hill, Inc. 1995.

EE558 MECHATRONICS AND ITS APPLICATION 3-0-0-6

Introduction to Mechatronics – Overview of Mechatronic products and their functioning. Survey of Mechatronical components, selection and assembly for precision – engineering applications. Study of electromechanical actuators and transducers. Load analysis and actuator selection for typical cases such as computer peripherals. Study of electronic controllers and drives for mechanical products. Rules for mechanical and electrical systems. Design assignments and practical case studies.

TEXTS:

1. Trylinsky.W. *Fine Mechanics and Precision instruments,* Pergemom Press. 1971
2. Kuo.B.C. *Motors D.D and Control Systems*, SRL Publishing Company. 1979
3. Kuo. B.C. *Step motors and Control Systems*, SRL Publishing Company. 1979

EE560 NONLINEAR CONTROL SYSTEMS 3-0-0-6

Nonlinear system behaviour, concepts of phase plane analysis, singular points, constructing phase portraits, phase plane analysis of non linear systems, existence of limit cycles, concepts of stability, describing function analysis – assumptions and definitions, describing functions of common nonlinearities. Lyapunov direct method, positive definite functions and lyapunov functions, invariant set theorems, lyapunov analysis of linear time invariant systems, the variable gradient method, performance analysis, control design based on Lyapunov's direct method, Lyapunov analysis of non autonomous systems, existence of Lyapunov functions. Feedback linearization and the canonical form, Input – state linearization, input – output linearization of SISO and MIMO systems. Sliding surfaces, continuous approximations of switching control laws, modeling performance trade offs, VSSC – examples.

TEXTS:

1. R. Marino and P. Tomei *Nonlinear control design - Geometric, Adaptive and Robust*, Prentice Hall,1995
2. J.J.E.Slotine and W.Li *Applied Nonlinear control*, Prentice Hall, 1998
3. Alberto Isidori *Non linear Control systems*, Springer Verlag, , 1999
4. Gibson J. E., "Non linear Automatic Control", McGraw Hill-1963.
5. J. C. Hsu and A. U. Mayer, "Modern Control Principles and Applications", McGraw Hill, 1968.
6. H. K. Khalil, "Non Linear Systems", 3rd Edition, Prentice Hall Intl. Inc.2001.
7. D. P. Atherton, "Non linear Control Engineering", Chapman and Hall,1982.

EE562 ROBOTICS AND AUTOMATION 3-0-0-6

Definition and origin of robotics – different types of robotics – various generations of robots – degrees of freedom – Asimov's laws of robotics – dynamic stabilization of robots. Hydraulic, pneumatic and electric drives – determination of HP of motor and gearing ratio – variable speed arrangements – path determination – micro machines in robotics – machine vision – ranging – laser – acoustic – magnetic, fiber optic and tactile sensors. Construction of manipulators – manipulator dynamics and force control – electronic and pneumatic manipulator control circuits – end effectors – U various types of grippers – design considerations. Solution of inverse kinematics problem – multiple solution Jacobian work envelop – hill climbing techniques – robot programming.

TEXTS:

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G *Industrial Robotics*, McGraw-Hill Singapore. 1996
2. Ghosh *Control in Robotics and Automation: Sensor Based Integ*ration, Allied Publishers, Chennai.1998
3. Deb.S.R)- *Robotics technology and flexible Automation*, John Wiley, USA. 1992
4. Asfahl C.R.)- *Robots and manufacturing Automation*, John Wiley, USA. 1992
5. Klafter R.D., Chimielewski T.A., Negin M *Robotic Engineering – An integrated approach*,Prentice Hall of India, New Delhi. 1994

EE564 Microprocessor based industrial control instrumentation 3-0-0-6

Minis, micros, classification by hardware features and software facilities, performance evaluation techniques. Organization, instruction set, characteristics for process control, inputs/output arrangements, addressing techniques, memory systems. Review of availability of process control language, application packages, operating system for real time process control. Specification, environment, hardware and software requirements. Maintenance, procurement procedures, cost / performance / availability ratios. Development systems for micros, software tools, logic analyzer, cross assemblers and compilers, simulators, emulators, in-house vs. turn – key trade off.

TEXTS:

1. Intel Series of Microprocessor: Berry B. Bery
2. Microprocessor Principles and Application
3. Microprocessors with application in Process Control: S. I. Ahson

EEE566 RANDOM PROCESS CONTROL AND ESTIMATION 3-0-0-6

Theory of measurements, introduction to probability and random variable. Random process and their characteristics. Correlation functions: autocorrelation, cross correlation. Estimation of parameters in presence of noise. ML and MAP estimates. Cramer-Rao bounds. Linear estimation and non-linear estimation. Waveform estimation. Weiner's theory of optimization. Application of Weiner's theory in compensator design for feedback control system. Gauss Markov model for vector random process. Kalman Filtering and Prediction for discrete and continuous time system. Minimum variance control Array processing. Multidimensional measurement problems. System identification sinusoidal testing, pulse testing, correlation testing.

TEXTS:

1. Detection, Estimation & modulation theory: H. L. Vantrees.
2. Analytical Design of linear feedback control Newton G.C., Jr., L.A. Gould and J.F. Kaiser.

EE568 PARAMETER ESTIMATION & SYSTEM IDENTIFICATION 3-0-0-6

Models and model classification, the identification problem, some field of application. Classification methods of identification of impulse response and transfer function models, model learning techniques, linear least square estimator, properties of generalised and weighted least squares and instrumental variable method. On-line identification using recursive least squares, minimum variance algorithm, stochastic approximation method and minimum linkeihood method. Simultaneous state and parameter estimation extended kalman filter, two – stage identification methods. Non-linar identification, quasi-linearisation, invariant imbedding, numerical identification methods.

TEXTS*:*

1. Analytical Design of Linear Feedback Control: Newton G. C., Jr. L.A. Gould & J. F. Kaiser
2. Modern Control Theory: Dorf
3. Elements of Engineering Probability

EE570 ARTIFICIAL NEURAL NETWORKS & FUZZY SYSTEMS 3-0-0-6

Models of a neuron, various activation functions: Threshold function, piecewise – linear function, Stochastic model of a neuron, feedback. Single layer feed forward network, multiplayer feed forward network, recurrent network, knowledge representation. Memory Based Learning Hebbian Learning, Competitive Learning, Boltzmann Learning, Learning with a teacher, learning without a teacher, adaptation, single layer perceptions, multi-layer perceptions. Membership function, rule generation, fuzzy concept, fuzzification, defuzzification, time dependent fuzzy logic, temporary fuzzy logic, fuzzy artificial neural network, neuro fuzzy control, fuzzy neural nets, application.

TEXTS:

1. Neural Networks: Simon Haykin
2. Artificial Intelligence: Eleine Rich, Kevin Knight
3. Understanding Neural Networks and fuzzy logic: Stamatios V. Kartalopoulos.
4. Neural Intelligent System: Hungenahally Jain.

EE572 Adaptive and Robust Control 3-0-0-6

Introduction, dynamic systems, models, system identification procedure. Simulation and Prediction. Nonparametric time and frequency domain methods. Linear dynamic system Identification: Overview, excitation signals, general model structure, time series models, models with output feedback, models without output feedback. Convergence and consistency. Parameter estimation methods, minimizing prediction errors, linear regressions and Least squares method, Instrumental – variable method, prediction error method. Recursive algorithms. Closedloop Identification. Adaptive Control: Close loop and open loop adaptive control. Self-tuning controller. Auto tuning for PID controllers: Relay feedback, pattern recognition, correlation technique. Adaptive Smith predictor control: Auto-tuning and self-tuning Smith predictor. Adaptive advanced control: Pole placement control, minimum variance control, generalized predictive control. Robust control. Definition and problem statement, the H(n) norm, H∞ norm, frequency domain formulation, state space formulation robust stabilization H2 optimal control, H∞ control.

Texts:

1. Ljung .L, System Identification: Theory for the user, Prentice Hall, Englewood Cliffs.
2. Astrom .K, Adaptive Control, Second Edition, Pearson Education Asia Pte Ltd.
3. Chang C. Hong, Tong H. Lee and Weng K. Ho, Adaptive Control, ISA press, Research Triangle Park.
4. Nelles. O, Nonlinear System Identification, Springer Verlag, Berlin.

EE574 Advanced Process Control 3-0-0-6

Review of basics of Process Control, Control objective and benefits, Elements of Process dynamics, interacting and non-interacting systems, Process degrees of freedom, Piping and instrumentation drawings. Fundamental of control valves, Types of control valves, control valves characteristics, control valves sizing and selection, Cavitations and Flashing problems in control valves. Feedback control configuration, feed-forward control configuration, Cascade control configuration, Ratio control configuration, Spilt range control configuration, Internal Model controller (IMC), other types of control configuration, Statistical Process Control (SPC) concept, Design procedure. Effect of two position controller, effect of proportional controller mode, effect of Integral controller mode, effect of derivative controller mode, effect of composite (PID) controller mode, controller tuning methods, process reaction curve method, Quarter-amplitude criterion (Cohencoon corrections), ZieglerNichols tuning method. Electronic implementation of controller modes, introduction to operational amplifiers, introduction to pneumatic elements, implementation of pneumatic controller modes, hydraulic implementation of controller modes Case study: Design of Fuzzy-Logic and Neural Network based controllers.

Texts:

1. Thomas E. Marlin 'Process Control: Designing Processes and Control Systems for Dynamic Performance', McGraw-Hill International Edition.
2. Jose A. Romagnoli, Ahmet Palazoglu, 'Introduction to process Control' CRC Taylor and Francis group.
3. B.G. Liptak, 'Handbook of Instrumentation- Process Control', Tata McGraw Hill.
4. Les A. Kane, 'Handbook of Advanced Process Control Systems and Instrumentation' Springer.
5. P Sai Krishna " Process Control Engineering", I. K Internationals Pvt. Ltd.

EE576 ADVANCED DIGITAL SIGNAL PROCESSING 3-0-0-6

Signals and Systems - Sampling, Discrete-time signals, aliasing, impulse response, LTI systems, convolution, difference equations. Fourier Analysis and Z-Transform- DTFT, properties, applications, Definition of ztransform, properties, inverse z-transform, System function, systems with linear phase, all pass filters, minimum phase systems. Discrete Fourier and Fast Fourier Transforms- Radix-2 FFT algorithms, decimation in time, decimation in frequency. Implementation of Discrete-Time Systems - Direct, cascade and parallel structures for FIR systems and IIR systems.

TEXTS:

1. Salivahanan, Vallavaraj, Gnanapriya, Digital Signal Processing, Tata McGraw Hill - 2009.
2. Proakis and Manolakis, Digital Signal Processing Principles, Algorithms and Applications - PHI - 2003.

EE578 IMAGE PROCESSING 3-0-0-6

Digital Image Representation, Fundamental Steps in Image Processing, Arithmetic and Logic Operations, Edge Linking, Boundary Detection, Thresholding, Region Growing, Region Splitting, Chain Codes, Polygonal Approximations, Signatures, Skeleton, Boundary Descriptors, Shape Numbers, Fourier descriptors, Moments, Topological Descriptors, Image Analysis, Pattern and Pattern Classes, Minimum Distance Classifier, Baye's Classifier, Neural Network Training, Structural methods.

TEXTS:

1. RC Gonzalez and RE Woods, Digital Image Processing, Pearson Education, 2000.
2. B. Chanda, D. Dutta Majumder, Digital Image Processing and Analysis, PHI, 2000.
3. A.K. Jain, Fundamentals of Digital Image Processing, PHI, New Delhi, 2001.

EE580 Advanced Electric Traction and Drives 3-0-0-6

Requirements, AC and DC drives, modern trends in drives technology, Characteristics of DC, Induction and Synchronous motor drives, (starting, running, speed control, braking), size and rating of motors (short time, intermittent, continuous), Mechanical considerations (enclosure, bearing transmission of drive, through chain, pulley and gears noise), Control for drive systems, Control of D.C, Induction, and Synchronous motor drives. Control Techniques for electric drives, Block diagram representation, transfer functions, transient response, frequency response and stability, compensating techniques, Electric Traction: System of electric traction Mechanics of Train Movement: Speed- time, distance- time and simplified speed-time curves, Attractive effort for acceleration and propulsion, Traction Motors: Review of characteristics of different types of DC and AC motors used traction and their suitability, Rating and heating of electric drives, power loss.

Texts:

1. V.Subrahmanyam, "Electric Drives" , TMH publication
2. M.H.Rashid , "Power Electronics" , P.H.I. Edition

References:

1. G.K.Dubey, "Electric Drive", Norasa Pub. House ND
2. Austin Hughes, "Electrical motors and drives, Fundamental, Types and Application" Newnes publication
3. S.K.Pillai , "A First Course on Electrical Drives",2nd Edition, John Wiley & Sons