M.Tech. Programme

in

POWER SYSTEMS

SYLLABUS

FOR

CREDIT BASED CURRICULUM

(Applicable for 2008 batch onwards)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPPALLI

The total minimum credits required for completing the M.Tech. Programme in Power Systems is 62

SEMESTER – I

CODE	COURSE OF STUDY	L	T	P	C
MA603	Optimization Techniques	3	0	0	3
EE601	Advanced Power System Analysis	3	0	0	3
EE603	Power Conversion Techniques	3	0	0	3
EE605	Power System Stability	3	0	0	3
	Elective I	3	0	0	3
	Elective II	3	0	0	3
	Total	18	0	0	18

SEMESTER - II

CODE	COURSE OF STUDY	L	T	P	C
EE602	Power System Operation and Control	3	0	0	3
EE604	High Voltage DC Transmission	3	0	0	3
EE606	Flexible AC Transmission Systems	3	0	0	3
	Elective III	3	0	0	3
	Elective IV	3	0	0	3
	Elective V	3	0	0	3
EE608	Power System Simulation Lab	0	0	3	2
	Total	18	0	3	20

SEMESTER III

CODE	COURSE OF STUDY	L	T	P	C
EE647	Project Work	0	0	24	12

SEMESTER IV

CODE	COURSE OF STUDY	L	T	P	C
EE648	Project Work	0	0	24	12

For the elective courses, a student may take a maximum of two courses from other Post Graduate programs.

ELECTIVES

CODE	COURSE OF STUDY	L	T	P	C
Group I elective subjects recommended for 1st semester					
EE 653	Industrial Control Electronics	3	0	0	3
EE655	System Theory	3	0	0	3
EE615G	Analysis and design of Artificial Neural Networks	3	0	0	3
EE627	Digital Signal Processing & Applications	3	0	0	3
EC661	Digital System Design	3	0	0	3
	Any one course from other department				
Group II elective subjects recommended for 2nd semester					
EE654	Power Electronic Drives	3	0	0	3
EE626	Digital Controllers in Power Electronics Applications	3	0	0	3
EE616G	Computer Networking	3	0	0	3
EE618	Electrical Distribution Systems	3	0	0	3
EE624	Fuzzy Systems	3	0	0	3
IC662	Design of Intelligent Controllers	3	0	0	3
IC668	VLSI Architecture and Design Methodologies	3	0	0	3
	Any one course from other department				

G-Global Elective

LIST OF RESERVE ELECTIVES

From year to year, the departmental electives listed under group 1 & group 2 elective subjects may be replaced by suitable courses from the following list depending upon the interest of the majority of the students.

CODE	COURSE OF STUDY	L	T	P	C
EE 614	Transient over voltages in Power Systems	3	0	0	3
EE619	Stochastic Models and Applications	3	0	0	3
EE620	Renewable Power Generation Sources	3	0	0	3
EE621	Power System Planning and Reliability	3	0	0	3
EE622	Advanced Power System Protection	3	0	0	3
EE623	Modeling and Analysis of Electrical Machines	3	0	0	3
EE625	Power Quality	3	0	0	3
EE656	Microcontrollers Applications in Power Converters	3	0	0	3

MA603 - OPTIMIZATION TECHNIQUES

Linear programming –formulation-Graphical and simplex methods-Big-M method-Two phase method-Dual simplex method-Primal Dual problems.

Unconstrained one dimensional optimization techniques -Necessary and sufficient conditions –Unrestricted search methods-Fibonacci and golden section method-Quadratic Interpolation methods, cubic interpolation and direct root methods.

Unconstrained n dimensional optimization techniques – direct search methods – Random search –pattern search and Rosen brooch's hill claiming method-Descent methods-Steepest descent, conjugate gradient, quasi -Newton method.

Constrained optimization Techniques- Necessary and sufficient conditions – Equality and inequality constraints-Kuhn-Tucker conditions-Gradient projection method-cutting plane method- penalty function method .

Dynamic programming- principle of optimality- recursive equation approach-application to shortest route, cargo-loading, allocation and production schedule problems.

1. *Rao,S.S.,'Optimization :Theory and Application' Wiley Eastern Press, 2nd edition 1984.*
2. *Taha,H.A., Operations Research –An Introduction,Prentice Hall of India,2003.*
3. *Fox, R.L., 'Optimization methods for Engineering Design', Addition Welsey, 1971.*

EE601 - ADVANCED POWER SYSTEM ANALYSIS

Load Flow - Network modeling – Conditioning of Y Matrix – Load flow-Newton Raphson method- Decoupled – Fast decoupled Load flow -three-phase load flow.

DC power flow –Single phase and three phase -AC-DC load flow - DC system model – Sequential Solution Techniques – Extension to Multiple and Multi-terminal DC systems – DC convergence tolerance – Test System and results.

Fault Studies -Analysis of balanced and unbalanced three phase faults – fault calculations – Short circuit faults – open circuit faults.

System optimization - strategy for two generator systems – generalized strategies – effect of transmission losses - Sensitivity of the objective function- Formulation of optimal power flow-solution by Gradient method-Newton's method.

State Estimation – method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation.

1. *Grainger, J.J. and Stevenson, W.D. 'Power System Analysis' Tata McGraw hill, New Delhi, 2003.*
2. *Arrillaga, J and Arnold, C.P., 'Computer analysis of power systems' John Wiley and Sons, New York, 1997.*
3. *Pai, M.A., 'Computer Techniques in Power System Analysis', Tata McGraw hill, New Delhi, 2006.*

EE602 – POWER SYSTEM OPERATION AND CONTROL

Economic operation- Load forecasting - Unit commitment – Economic dispatch problem of thermal units – Gradient method- Newton's method –Base point and participation factor method.

Hydro-thermal co-ordination-Hydroelectric plant models –short term hydrothermal scheduling problem - gradient approach – Hydro units in series - pumped storage hydro plants-hydro-scheduling using Dynamic programming and linear programming.

Automatic generation control -Review of LFC and Economic Dispatch control (EDC) using the three modes of control viz. Flat frequency – tie-line control and tie-line bias control – AGC implementation – AGC features - static and dynamic response of controlled two area system

MVAR control - Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators

Power system security-Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding-security constrained optimal power flow-Interior point algorithm-Bus incremental costs.

1. *Allen J.Wood and Wollenberg B.F., 'Power Generation Operation and control', John Wiley & Sons, Second Edition,1996.*
2. *Kirchmayer L.K., 'Economic Control of Interconnected Systems', John Wiley & Sons, 1959.*
3. *Nagrath, I.J. and Kothari D.P., 'Modern Power System Analysis', TMH, New Delhi, 2006.*

EE603 – POWER CONVERSION TECHNIQUES

Single-Phase and Three-Phase AC to DC converters- half controlled configurations-operating domains of three phase full converters and semi-converters. Operation of 12-pulse converter.

Single phase and Three phase inverters, Voltage source and Current source inverters, multi-stepped inverters.

AC to AC voltage regulators , continuous and discrete configurations , single phase and three phase circuits , introduction to DC to DC voltage regulators –Step down and Step up configuration .

Reactive power and harmonic considerations and analysis in the context of converters and inverters.

Pulse Width Modulation Techniques in converters and inverters: Sinusoidal PWM, selected harmonic elimination, Bus clamping PWM, space vector based PWM.

1. *Ned Mohan, Undeland and Robbin, 'Power Electronics: converters, Application and design' John Wiley and sons.Inc, Newyork, 3rd edition,2002.*
2. *Rashid M.H., 'Power Electronics Circuits, Devices and Applications', Prentice Hall India, New Delhi, 3ra edition ,2004.*
3. *P.C Sen.,' Modern Power Electronics', Wheeler publishing Co, First Edition,New Delhi, 1998.*

EE604 – HIGH VOLTAGE DC TRANSMISSION

General aspects -HVAC and HVDC links –comparison – economic, technical performance reliability-limitation-properties of thyristor converter circuits -choice of best circuit for HVDC converters

Thyristor converter circuits -Analysis with overlap in converters - basic means of control-power reversal-desired features of control-actual control characteristics

Inverters- power control – commutation failure -D.C Reactors –voltage and current oscillations- Circuit breakers, over voltage protection

Characteristic and uncharacteristic harmonics-troubles due to harmonics-harmonic filters-converter charts of direct current and voltage-active and reactive power.

Interaction between ac and dc systems- converter transformers-earth electrodes -design of back to back thyristor converter system.

1. *Kimbark, E.W., 'Direct current transmission-vol.1', Wiley Interscience, New York, 1971.*
2. *Arrilaga, J., 'High voltage direct current transmission', peter pereginver Ltd., London, U.K. 1998.*
3. *Padiyar, K.R., 'HVDC transmission systems', Wiley Eastern Ltd., New Delhi, 1992.*

EE605 POWER SYSTEM STABILITY

Power system stability considerations – definitions-classification of stability-rotor angle and voltage stability-synchronous machine representation –classical model-load modeling concepts-modeling of excitation systems-modeling of prime movers.

Transient stability-swing equation-equal area criterion-solution of swing equation-Numerical methods -Euler method-Runge-Kutte method-critical clearing time and angle-effect of excitation system and governors-Multimachine stability –extended equal area criterion-transient energy function approach.

Small signal stability – state space representation – eigen values- modal matrices-small signal stability of single machine infinite bus system – synchronous machine classical model representation-effect of field circuit dynamics-effect of excitation system-small signal stability of multimachine system.

Voltage stability – generation aspects - transmission system aspects – load aspects – PV curve – QV curve – PQ curve – analysis with static loads – loadability limit - sensitivity analysis-continuation power flow analysis - instability mechanisms-examples.

Methods of improving stability – transient stability enhancement – high speed fault clearing – steam turbine fast valving-high speed excitation systems- small signal stability enhancement-power system stabilizers – voltage stability enhancement – reactive power control.

1. *Kundur, P., 'Power System Stability and Control', McGraw-Hill International Editions, 1994.*
2. *Anderson, P.M. and Fouad, A.A., 'Power System Control and Stability', Galgotia Publications, New Delhi, 2003.*
3. *Van Cutsem, T. and Vournas, C., 'Voltage Stability of Electric Power Systems', Kluwer Academic Publishers, 1998.*

EE606 - FLEXIBLE AC TRANSMISSION SYSTEMS

Fundamentals of ac power transmission, transmission problems and needs, emergence of FACTS-FACTS control considerations, FACTS controllers.

Principles of shunt compensation – Variable Impedance type & switching converter type-Static Synchronous Compensator (STATCOM) configuration, characteristics and control.

Principles of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC).

Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters- power circuit configurations.

UPFC -Principles of operation and characteristics, independent active and reactive power flow control, comparison of UPFC with the controlled series compensators and phase shifters.

1. *Song, Y.H. and Allan T. Johns, 'Flexible ac transmission systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.*
2. *Hingorani ,L.Gyugyi, ' Concepts and Technology of flexible ac transmission system', IEEE Press New York, 2000 ISBN –078033 4588.*
3. *R .Mohan Mathur and Rajiv K.Varma , 'Thyristor - based FACTS controllers for Electrical transmission systems', IEEE press, Wiley Inter science , ISBN no . 0-471-20643-1,2002.*
4. *K.R.Padiyar, 'FACTS controllers for transmission and Distribution systems' New Age international Publishers 1st edition -2007.*

EE608 - POWER SYSTEM SIMULATION LABORATORY

1. **Load flow studies.**
2. **Short circuit studies.**
3. **Transient stability studies.**
4. **Simulation of IGBT inverters.**
5. **Simulation of thyristor converters.**
6. **Economic Load Dispatch with thermal power plants.**
7. **Economic Load Dispatch with Hydro thermal power plants.**
8. **Simulation of Facts controllers**
9. **Simulation of single -area and Two -area Systems.**
10. **Load forecasting and unit commitment.**

Software ETAP/ MiPOWER / MATLAB / LABVIEW will be used.

ELECTIVES

EE614 - TRANSIENT OVER VOLTAGES IN POWER SYSTEMS

Transients in electric power systems – Internal and external causes of over voltages-– Lightning strokes – Mathematical model to represent lightning,Travelling waves in transmission lines – Circuits with distributed constants – Wave equations – Reflection and refraction of travelling waves – Travelling waves at different line terminations.

Switching transients –double frequency transients – abnormal switching transients – Transients in switching a three phase reactor- three phase capacitor.

voltage distribution in transformer winding – voltage surges-transformers – generators and motors, Transient parameter values for transformers,reactors,generators and transmission lines.

Basic ideas about protection –surge diverters-surge absorbers-protection of lines and stations Modern lighting arrestors,Insulation coordination,Protection of alternators and industrial drive systems.

Generation of high AC and DC-impulse voltages,currents-measurement using sphere gaps-peak vpltmeters-potential dividers and CRO.

1. *Allen Greenwood, 'Electrical transients in power systems', Wiley Interscience, 1991.*
2. *Bewley, L.W., 'Travelling waves and transmission systems', Dover publications, New York, 1963.*
3. *Gallaghar, P.J. and Pearmain, A.J., 'High voltage measurement, Testing and Design', John Wiley and sons, New York, 2001.*

EE615^{G} – ANALYSIS AND DESIGN OF ARTIFICIAL NEURAL NETWORKS

Pattern classification –Learning and generalisation-structure of neural networks – ADA line and Mada line-perceptrons.

Linear separability – Back propagation – XOR function-Backpropagation algorithm-Hopfied and Hamming networks- Kohensen's network-Boltzmenn machine-in and out star network – Art 1 and Art 2 nets.

Neuro adaptive control applications-ART architecture – Comparision layer – Recognition layer – ART classification process – ART implementation – Examples.

Character recognition networks, Neural network control application, connectionist expert systems for medical diagnosis, Self organizing maps.

Applications of neural algorithms and systems -Character recognition networks, Neural network control application, connectionist expert systems for medical diagnosis.

1. *Martin T. Hogan , Howard B.Demuth. M,'Neural network design'4th edition, 1996*
2. *Zureda, J.M.,'Introduction to Artificial Neural Systems', Jaico publishing house, Bombay, 1994.*
3. *Zimmermann, H.J.,' Fuzzy set theory and its applications', Allied publishers limited,Madras, 2000.*

EE616G – COMPUTER NETWORKING

Computer Network – Hardware and Software, OSI and TCP reference Model, Transmission media, Wireless transmission, public switched telephone network - Structure, multiplexing and switching.

Data link layer - design issues, Data link protocols. Medium access sub layer - channel allocations, Multiple Access protocols, IEEE protocols.

Network layer - Design issues, routing algorithms, congestion control algorithms, QoS, Transport layer- Design issues, Connection management .

Application layer – DNs, Electronic mail, World Wide Web, multimedia, Cryptography,

Internet transport protocols - TCP and UDP

1. James F. Kurose and Keith W. Ross, 'Computer Networking', 2nd Edition, Pearson Education, 2003.
2. Tanenbaum, A.S., 'Computer Networks', 4th Edition, Prentice Hall of India, 2003.
3. Stallings, W., 'Data and Computer Communication',PHI,8th edition, 2006.

EE618- ELECTRICAL DISTRIBUTION SYSTEMS

Industrial and commercial distribution systems – Energy losses in distribution system – system ground for safety and protection – comparison of O/H lines and under ground cable system .Network model – power flow, short circuit and loss calculations.

Distribution system, reliability analysis – reliability concepts – Markov model – distribution network reliability – reliability performance-

Distribution system expansion -planning – load characteristics – load forecasting – design concepts – optimal location of sub station – design of radial lines – solution technique.

Voltage control – Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems –loss reduction and voltage improvement.

System protection – requirement – fuses and section analyzers-over current. Under voltage and under frequency protection – coordination of protective device.

1. *Pabla, A.S., 'Electrical Power Distribution System', 5th edition,Tata McGraw hill, 2004.*
2. *Tuvar Goner, 'Electrical Power Distribution System Engineering', McGraw hill, 1986.*
3. *Sterling, M.I.H., 'Power System Control', Peter Peergisus, 1979.*

EE619- STOCHASTIC MODELS AND APPLICATIONS

Probability Spaces- Discrete probability distributions, Continuous probability densities, Conditional probability, distribution and densities. Distribution functions, Multiple random variables and joint distributions.

Expectations, moments, Characteristic functions and moments generating functions, sequence of random variables and Convergence Concepts.

Law of large numbers – Discrete and continuous random variables; Central limit theorem – Bernoulli trials, Discrete and continuous independent trials.

Stochastic processes-Markov chains – Transient analysis, Computation of equilibrium probabilities, Stationary distribution and Transient distribution of markov chains.

Poisson processes – Exponential distribution and applications; Birth-death processes and applications.

1. *Hole, P.G., Port, S.C., and Stone,C.J.,' Introduction to Probability Theory', Indian Edition Universal Book Stall, New Delhi,1998.*
2. *Hole,P.G., Port, S.C., and Stone,C.J.,' Introduction to Stochastic Process', Indian Edition Universal Book Stall, New Delhi,2008.*

EE620 - RENEWABLE POWER GENERATION SOURCES

Basic characteristics of sunlight – solar energy resource – photovoltaic cell-characteristics – equivalent circuit – photo voltaic for battery charging.

Wind source – wind statistics - energy in the wind – aerodynamics - rotor types – forces developed by blades-Aerodynamic models – braking systems – tower - control and monitoring system – power performance

Wind driven induction generators -power circle diagram -steady state performance – modeling-integration issues –impact on central generation-transmission and distribution systems – wind farm electrical design.

Wind-diesel systems-fuel savings-permanent magnet alternators – modeling – steady state equivalent circuit-self-excited induction generators – integrated wind-solar systems.

Micro-hydel electric systems – power potential – scheme layout – generation efficiency and turbine part flow-isolated and parallel operation of generators – geothermal-tidal and OTEC systems.

1. *John F.Walker & Jenkins. N , 'Wind energy Technology ' , John Wiley and sons, chichester , U.K ,1997.*
2. *Van Overstraeton and Mertens R.P., 'Physics, Technology and use of Photovoltaics', Adam Hilger, Bristol,1996.*
3. *Freries LL , ' Wind Energy Conversion Systems', Prentice Hall, U.K., 1990*

EE621 – POWER SYSTEM PLANNING AND RELIABILITY

Objectives of planning – Long and short term planning .Load forecasting – characteristics of loads – methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting – annual and monthly peak demand forecasting.

Reliability concepts – exponential distributions – meantime to failure – series and parallel system – MARKOV process – recursive technique.Generator system reliability analysis – probability models for generators unit and loads – reliability analysis of isolated and interconnected system – generator system cost analysis – corporate model – energy transfer and off peak loading.

Transmission system reliability model analysis –average interruption rate-LOLP method-frequency and duration method.
Two plant single load system-two plant two load system-load forecasting uncertainly interconnections benefits.

Introduction to system modes of failure – the loss of load approach – frequency & duration approach – spare value assessment – multiple bridge equivalents.

1. *Sullivan, R.L., 'Power System Planning', Heber Hill, 1987.*

2. *Roy Billington, 'Power System Reliability Evaluation', Gordan & Breach Scain Publishers, 1990.*
3. *Eodrenyi, J., 'Reliability modelling in Electric Power System' John Wiley, 1980.*

EE622- ADVANCED POWER SYSTEM PROTECTION

General philosophy of protection-Characteristic function of protective relays-basic relay elements and relay terminology-basic construction of static relays-non-critical switching circuits.

Protective relays –protection of generators – Transformer protection – magnetizing inrush current – Application and connection of transformer differential relays – transformer over current protection.

Bus protection, Techniques applicable for line protection –long EHV line protection Backup remote local and Breaker failure

Placement of reactors in power system- Transformer tap changing –Protection of boosters-capacitors in an interconnected power system.

Digital signal processing –digital filtering in protection relays- numeric protection –testing Digital filtering in protection relays – digital data transmission– relay hardware – relay algorithms.Concepts of modern coordinated control system.

1. *Lewis Blackburn, J., 'Protective Relaying – Principles and Applications', Marcel Dekkar, INC, New York, 2006.*
2. *The Electricity Training Association, 'Power System Protection Vol1-4', The IEE, U.K., 1995.*
3. *Stanley, H.Horowitz (ED), 'Protective relaying for power systems II', IEEE Press, 1992.*

EE623-MODELING AND ANALYSIS OF ELECTRICAL MACHINES

Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system.

Basic Concepts of Rotating Machines-Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine.

Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form; Application of reference frame theory to three phase symmetrical

induction and synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames

Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters, Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.

Special Machines - Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self controlled operation; Analysis of Switch Reluctance Motors.

1. *Charles Kingsley,Jr., A.E. Fitzgerald, Stephen D.Umans, 'Electric Machinery', Tata Mcgraw Hill,6ht Edition, 2003.*
2. *R. Krishnan, 'Electric Motor & Drives: Modeling, Analysis and Control', Prentice Hall of India, 2001.*
3. *Miller, T.J.E,. 'Brushless permanent magnet and reluctance motor drives', Clarendon Press, Oxford, 1989.*

EE624 - FUZZY SYSTEMS

Different faces of imprecision – inexactness, Ambiguity, Undecidability, Fuzziness and certainty, Probability and fuzzy logic, Intelligent systems.

Fuzzy sets and crisp sets - Intersections of Fuzzy sets, Union of Fuzzy sets, the complement of Fuzzy sets

Fuzzy reasoning - Linguistic variables, Fuzzy propositions, Fuzzy compositional rules of inference- Methods of decompositions, defuzzification

Methodology of fuzzy design - Direct & Indirect methods with single and multiple experts, Adaptive fuzzy control, Rule base design using dynamic response.

Fuzzy logic applications to engineering, Fuzzy decision making, Neuro-Fuzzy systems, Fuzzy Genetic Algorithms.

1. *Zimmermann, H.J., 'Fuzzy set theory and its applications', Allied publishers limited, Madras, 2001.*
2. *Klir, G.J., and Folger. T., 'Fuzzy sets, uncertainty and information', PHI, New Delhi,1997.*
3. *EarlCox,'The Fuzzy Systems Handbook', AP professional Cambridge,1998. MA 02139, 1994.*

EE625 POWER QUALITY

Electric power quality phenomena- IEC and IEEE definitions - power quality disturbances-voltage fluctuations-transients-unbalance-waveform distortion-power frequency variations.

Voltage variations, Voltage sags and short interruptions – flicker-longer duration variations - sources – range and impact on sensitive circuits-standards – solutions and mitigations – equipment and techniques.

Transients – origin and classifications – capacitor switching transient – lightning-load switching – impact on users – protection – mitigation.

Harmonics – sources – definitions & standards – impacts - calculation and simulation – harmonic power flow - mitigation and control techniques – filtering – passive and active.

Power Quality conditioners – shunt and series compensators-DStatcom-Dynamic voltage restorer-unified power quality conditioners-case studies.

1 *Heydt, G.T., 'Electric Power Quality', Stars in a Circle Publications, Indiana,2nd edition 1994.*
2 *Bollen, M.H.J., 'Understanding Power Quality Problems: Voltage sags and interruptions', IEEE Press, New York, 2000.*
3 *Arrillaga, J, Watson, N.R., Chen, S., 'Power System Quality Assessment', Wiley, New York, 2000.*

EE626 DIGITAL CONTROLLERS IN POWER ELECTRONICS APPLICATIONS

Introduction to the C2xx DSP core and code generation, The components of the C2xx DSP core, Mapping external devices to the C2xx core , peripherals and Peripheral Interface , System configuration registers , Memory , Types of Physical Memory , memory Addressing Modes , Assembly Programming using C2xx DSP, Instruction Set, Software Tools.

Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers .Introduction to Interrupts , Interrupt Hierarchy , Interrupt Control Registers , Initializing and Servicing Interrupts in Software .

ADC Overview , Operation of the ADC in the DSP , Overview of the Event manager (EV) , Event Manager Interrupts , General Purpose (GP) Timers , Compare Units, Capture Units And Quadrature Enclosed Pulse (QEP) Circuitry , General Event Manager Information

Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA – Types of FPGA , Xilinx XC3000 series , Configurable logic Blocks (CLB), Input/Output Block (IOB) – Programmable Interconnect Point (PIP) – Xilinx 4000 series – HDL programming – overview of Spartan 3E and Virtex II pro FPGA boards- case study.

Controlled Rectifier , Switched Mode Power Converters , PWM Inverters , DC motor control , Induction Motor Control

1. *Hamid.A.Toliyat and Steven G.Campbell " DSP Based Electro Mechanical Motion Control " CRC Press New York , 2004*
2. *XC 3000 series datasheets (version 3.1). Xilinx,Inc.,USA, 1998*
3. *XC 4000 series datasheets (version 1.6). Xilinx,Inc.,USA, 1999*
4. *Wayne Wolf," FPGA based system design ", Prentice hall, 2004*

EE627 DIGITAL SIGNAL PROCESSING & APPLICATIONS

Review of Discrete – Time Signal & System representation in Z – Transform domain – Inverse Z – Transform – Properties – System characterization in Z – domain -- Equivalence between Fourier Transform and the Z-Transform of a Discrete signal.

Sampling in Fourier domain - Discrete Fourier Transform and its properties – Linear filtering using DFT – Resolution of DFT - FFT Algorithm – Radix-2 FFT Algorithm - DIT & DIF Structures - Higher Radix schemes.

Classification of filter design - Design of IIR filters – Bilinear transformation technique – Impulse invariance method – Step invariance method.

FIR filter design – Fourier series method - Window function technique - Finite Word Length Effects.

Introduction to Multirate Signal Processing - Decimation - Interpolation - Case Studies on Speech Coding, Transform Coding – DSP based measurement system.

1. *Ludemann L. C., "Fundamentals of Digital Signal Processing", Harper and Row publications, 1997..*
2. *Antoniou A., "Digital Filters – Analysis and Design", Tata Mc-Graw Hill, 1999..*
3. *Oppenheim and Schaffer, 'Discrete time Signal processing', PHI, 1999.*
4. *P.P. Vaidhyanathan, " Multirate systems and filter banks", PHI, 1993.*

EE653 – INDUSTRIAL CONTROL ELECTRONICS

Review of switching regulators and switch mode power supplies-Uninterrupted power supplies- solid state circuit breakers – programmable logic controllers

Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID controllers, Feed forward control

Signal conditioners-Instrumentation amplifiers – voltage to current, current to voltage, voltage to frequency, frequency to voltage converters ; Isolation circuits – cabling; magnetic and electro static shielding and grounding.

Opto-Electronic devices and control , Applications of opto isolation, interrupter modules and photo sensors – Fibre optics – Bar code equipment, application of barcode in industry.

Stepper motors and servo motors- control and applications. Servo motors – servo motor controllers – servo amplifiers – selection of servo motor – applications of servo motors.

1. *Michael Jacob, 'Industrial Control Electronics – Applications and Design', Prentice Hall, 1988.*
2. *Thomas, E. Kissel, ' Industrial Electronics'PHI, 2003*
3. *James Maas, 'Industrial Electronics', Prentice Hall, 1995.*

EE654 - POWER ELECTRONIC DRIVES

Basic power electronic drive system, components. Different types of loads, shaft-load coupling systems. Stability of power electronic drive.

Conventional methods of D.C.motor speed control, single phase and three phase converter fed D.C motor drive. Power factor improvement techniques, Four quadrant operation.

Chopper fed drives, input filter design. Step -up chopper for photovoltaic systems. Braking and speed reversal of DC motor drives using choppers, multiphase choppers.

Conventional methods of induction motor speed control.Solid state controllers for Stator voltag control, soft starting of induction motors, Rotor side speed control of wound rotor induction motors. Voltage source and Current source inverter fed induction motor drives.

Speed control of synchronous motors, field oriented control, load commutated inverter drives, switched reluctance motors and permanent magnet motor drives.

1. *P.C Sen 'Thyristor DC Drives', John wiely and sons, New York, 2001.*
2. *R.Krishnan, 'Electric Motor Drives – Modeling, Analysis and Control', Prentice-Hall of India Pvt Ltd., New Delhi, 2003.*
3. *Bimal K.Bose, 'Modern Power Electronics and AC Drives', Pearson Education (Singapore) Pte. Ltd., New Delhi, 2003.*

EE655 – SYSTEM THEORY

State space modeling of physical systems –determining of STM – controllability and observability of time invariant linear system

Different techniques of linearising non-linear systems – Describing functions for various types of non-linearities – describing function analysis of non linear control systems

Method of constructing phase – trajectories- phase plane analysis of linear and non-linear systems – Bang-bang system

Different methods of constructing Liapunov functions for linear and non-linear continuous systems – stability analysis

Pole placement technique by state feedback for linear SISO time, invariant system – Theory of high-gain feedback-advantages – Pole placement technique along with high-gain feedback control.

1. *Gopal, M., 'Modern Control Systems Theory', Wiley Eastern Ltd., 1993.*
2. *Ogata, K., 'Modern Control Engineering', Prentice Hall of India, 4th edition , 2003.*
3. *Kuo, B.C., 'Automatic Control Systems', Prentice Hall of India, 1999.*

EE656–MICRO CONTROLLERS APPLICATIONS IN POWER CONVERTERS

Use of microcontrollers for pulse generation in power converters – Overview of Zero-Crossing Detectors – typical firing/gate-drive circuits – firing/gate pulses for typical single-phase and three phase power converters - PIC16F876 Micro-controller – device overview - pin diagrams.

PIC16F876 micro-controller memory organisation – Special Function Registers – I/O ports – Timers – Capture/Compare/PWM modules (CCP).

Analog to Digital Converter module - Instruction set – Instruction description - Introduction to PIC microcontroller programming – Oscillator selection – reset – interrupts - watch dog timer.

Introduction to MPLAB IDE and PICSTART plus - Device Programming using MPLAB and PICSTART plus- generation of firing/gating pulses for typical power converters.

8051 microcontroller - architecture – addressing modes – I/O ports – instruction sets – simple assembly language programming.

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