

M. Tech. Programme
in
POWER SYSTEMS

SYLLABUS
FOR
CREDIT BASED UNIFORM CURRICULUM
(Applicable for 2013 batch onwards)



**Department of Electrical and Electronics Engineering
National Institute of Technology, Tiruchirappalli – 15.**

Revised Curriculum for M. Tech. Power Systems

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 System Stability	3	0	0	3
	Elective I	3	0	0	3
	Elective II	3	0	0	3
	Elective III	3	0	0	3

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 IV	3	0	0	3
	Elective V	3	0	0	3
	Elective VI	3	0	0	3
EE608	Power System Simulation Lab	0	0	3	2

SEMESTER III

Code	Course of study	L	T	P	C
MA647	Project Work	0	0	24	12

SEMESTER IV

Code	Course of study	L	T	P	C
EE648	Project Work	0	0	24	12

ELECTIVES

Code	Course of study	L	T	P	C
EE 611	Power Conversion Techniques*	3	0	0	3
EE612	Industrial Control Electronics	3	0	0	3
EE613	System Theory	3	0	0	3
EE614	Analysis and Design of Artificial Neural Networks	3	0	0	3
EE615	Advanced Digital Signal Processing	3	0	0	3
EE616	Digital System Design	3	0	0	3
EE617	Power Electronic Drives	3	0	0	3
EE618	Digital Controllers in Power Electronics Applications	3	0	0	3
EE619	Computer Networking	3	0	0	3
EE620	Electrical Distribution Systems	3	0	0	3
EE621	Fuzzy Systems	3	0	0	3
EE622	Transient Over Voltages In Power Systems	3	0	0	3
EE623	Stochastic Models And Applications	3	0	0	3
EE624	Renewable Power Generation Technologies	3	0	0	3
EE625	Power System Planning And Reliability	3	0	0	3

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EE626	Advanced Power System Protection	3	0	0	3
EE627	Modeling And Analysis Of Electrical Machines	3	0	0	3
EE628	Power Quality	3	0	0	3
EE629	Microcontroller Applications in Power Converters	3	0	0	3
EE630	Power System Restructuring and Pricing	3	0	0	3
EE631	Computer Relaying And Wide Area Measurement Systems	3	0	0	3
EE632	Advanced DSP Architecture And Programming	3	0	0	3
EE633	Swarm Intelligent Techniques	3	0	0	3
EE634	Smart Grid Technologies	3	0	0	3
EE635	Electric Systems in Wind Energy	3	0	0	3
EE636	Embedded Processors and Controllers	3	0	0	3
EE637	Distributed Generation and Micro-grids	3	0	0	3
EE638	Control Design Techniques for Power Electronic Systems	3	0	0	3
EE639	Energy Auditing and Management	3	0	0	3
EE640	Electric and Hybrid Vehicles	3	0	0	3

* will be offered as an Essential Elective for the benefit of M.Tech. (Power Systems) students

MA603 - OPTIMIZATION TECHNIQUES

Objective:

To learn essential optimization techniques for applying to day to day problems.

Outcome:

After learning the techniques they can apply to engineering and other problems.

Prerequisite:

Undergraduate level mathematics

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 brock’s hill climbing 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

References:

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 Wiely, 1981.

E601 - ADVANCED POWER SYSTEM ANALYSIS

Objective:

To perform steady state analysis and fault studies for a power system of any size and also to explore the nuances of estimation of different states of a power system.

Outcome:

On completion of the course, the students will be able to investigate the state of a power system of any size and be in a position to analyze a practical system both under steady state and fault conditions. Also the students would be able to determine the operating condition of a system according to the demand without violating the technical and economic constraints.

Prerequisite:

A basic knowledge on the subjects viz., Power System analysis, Matrix manipulations, Alternating machines and network analysis

Network modeling – Single phase and three phase modeling of alternators, transformers and transmission lines, Conditioning of Y Matrix -- Incidence matrix method, Method of successive elimination, Triangular factorization

Load flow analysis - Newton Raphson method, Fast Decoupled method, AC-DC load flow – Single and three phase methods – Sequential solution techniques and extension to multiple and multi-terminal DC systems.

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

References:

1. Grainger, J.J. and Stevenson, W.D. 'Power System Analysis' Tata McGraw hill, New Delhi, 2003.
2. Hadi Saadat, 'Power System Analysis', Tata McGraw hill, New Delhi, 2002.
3. Arrillaga, J and Arnold, C.P., 'Computer analysis of power systems' John Wiley and Sons, New York, 1997.
4. Pai, M.A., 'Computer Techniques in Power System Analysis', Tata McGraw Hill, New Delhi, 2006.

EE603 - POWER SYSTEM STABILITY

Objective:

This course aims to give basic knowledge about the dynamic mechanisms behind angle and voltage stability problems in electric power systems, including physical phenomena and modeling issues.

Outcome:

At the end of this course, Students will be able to analyse and understand the electromagnetic and electromechanical phenomena taking place around the synchronous generator.

Will be able to solve the reactive power problems in power system

Prerequisite:

Numerical Methods , Electrical Machines, Power System Analysis

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 multi machine 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

References:

1. Kundur, P., 'Power System Stability and Control', McGraw-Hill International Editions, 1994.
2. Van Cutsem, T. and Vournas, C., 'Voltage Stability of Electric Power Systems', Kluwer Academic Publishers, 1998.
3. Abhijit Chakrabarti, D.P. Kothari, A.K. Mukhopadhyay and Abhinandan De, 'An Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems', PHI Learning Private Ltd., 2010.

EE602 - POWER SYSTEM OPERATION AND CONTROL

Objective:

To understand the economics of power system operation with thermal and hydro units
To realize the requirements and methods of real and reactive power control in power system
To be familiar with the power system security issues and contingency studies

Outcome:

Upon completion of this course , students will be able to

- Develop generation dispatching schemes for thermal and hydro units
- Apply control and compensations schemes on a power system

Adopt contingency analysis and selection methods to improve system security

Prerequisite: Optimization

Techniques Advanced Power

System Analysis

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

References:

1. Robert H. Miller, James H. Malinowski, 'Power system operation', Tata McGraw-Hill, 2009
2. Allen J. Wood, Bruce F. Wollenberg, 'Power Generation, Operation and Control', Wiley India Edition, 2nd Edition, 2009.
3. Abhijit Chakrabarti & Sunita Halder, 'Power system Analysis-Operation & Control', PHI, 3rd Edition, 2010.
4. T J Miller, 'Reactive Power Control in Electric Systems', Wiley, 1982.
- 5.

EE604 - HIGH VOLTAGE DC TRANSMISSION

Objective:

To facilitate the students understand the basic concepts and recent trends in HVDC transmission as it an upcoming area of development. To enable the students decide, design and work with the concepts of HVDC transmission

Outcome:

On completion of the course the students would be skilled enough to work with the HVDC systems, being capable of analyzing the HVDC circuits and develop exquisite interest to work in the area of HVDC transmission

Prerequisite:

Basic knowledge on Circuit theory, Control Systems and Power Electronic is sufficient to undergo the course.

Introduction to HVDC transmission, Comparison between HVAC and HVDC systems - economic, technical and reliability, limitations, choice of best topology for HVDC converters, types of HVDC links - monopolar, bipolar and homopolar links, Rectifier operation of Graetz circuit with and without overlap

Inverter operation – analysis with and without overlap. Equivalent circuit model, Combined characteristics of HVDC system, basic means of control - desired features of control, power reversal

Basic controllers - Constant Ignition Angle, Constant Current and Constant Extinction Advance angle control, power control, high level controllers. Converter faults - misfire, arc through, commutation failure. D.C. Reactor design - voltage and current oscillations.

Protection issues in HVDC – DC Circuit breakers, over voltage and over current protection. Characteristic and uncharacteristic harmonics - troubles due to harmonics - harmonic filters - active and passive filters - Reactive power control of converters

Interaction between ac and dc systems. Recent trends in HVDC - VSC based HVDC – Multi-terminal HVDC systems and Hybrid HVDC systems. Back to back thyristor converter system.

References:

1. Padiyar, K.R., 'HVDC transmission systems', Wiley Eastern Ltd., 2010.
2. S.Rao, 'EHV-AC, HVDC Transmission and Distribution Engineering', Khanna Publications, 3rd Edition, 2012.
3. S.Kamakshaiah and V.Kamaraju, 'HVDC Transmission', 1st Edition, Tata McGraw Hill, 2011.
4. Kimbark, E.W., 'Direct Current Transmission-vol.1', Wiley Interscience, 1971.
5. Arrilaga, J., 'High Voltage Direct Current Transmission', 2nd Edition, Peter Peregrinver Ltd., 1998.

EE606 - FLEXIBLE AC TRANSMISSION SYSTEMS

Objective:

This course introduces the application of a variety of high power-electronic controllers for active and reactive power in transmission lines. Students are exposed to the basics, modeling aspects, control and scope for different types of FACTS controllers.

Outcome:

The students shall be able to explain the basic principles of different types of FACTS controllers and their characteristics. Also they shall be able to model different FACTS controllers, form a basis for selecting a particular controller for a given application and analyze and compare the performance of various FACTS controllers

Prerequisite:

Power System Analysis

Power Conversion techniques

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

References:

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. Mohan Mathur R. and Rajiv K.Varma , 'Thyristor - based FACTS controllers for Electrical transmission systems', IEEE press, Wiley Inter science , 2002.
4. Padiyar K.R., 'FACTS controllers for Transmission and Distribution systems' New Age International Publishers, 1st Edition, 2007.
5. Enrique Acha, Claudio R.Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho 'FACTS – Modeling and simulation in Power Networks' John Wiley & Sons, 2002.

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 used: ETAP/POWER WORLD SIMULATOR/ MI POWER/ PSIM/ MATLAB/ Lab VIEW

EE611 - POWER CONVERSION TECHNIQUES

Objective:

The aim of this course to present the concepts of typical power electronic circuits: topologies and control. Converter analysis, modeling, design and control of converters will be presented as relevant to different applications. This course also aims to apply the mathematical skills to a number of practical problems.

Outcome:

At the end of this course students will be able to explain working of various power electronic converters, derive mathematical relations, analyze and design electronics for the control of converters.

Prerequisite:

Knowledge on the power semiconductor devices, electronic circuits, circuit theory and mathematics, such as Fourier series analysis and Laplace transform and differential equations, are essential.

DC-DC converters - Buck converter, boost converter, buck - boost converter, averaged circuit modeling, input-output equations, ripple calculations, filter design

DC-AC inverters -Single phase VSI, Three phase VSI, Single phase CSI, Three phase CSI, voltage control and harmonic reduction in inverters-standard PWM techniques

AC-DC converters- Uncontrolled rectifiers, single and three phase fully controlled and semi controlled converters, continuous current conduction, discontinuous current conduction, Reactive compensation, Harmonic compensation techniques

AC-AC converters-single phase and three phase circuits employing Phase angle control, on-off control. AC choppers

Loss calculations and thermal management: Device models for loss calculations, ratings, safe operating areas, data sheets, forward conduction loss, switching losses, heat sink design, snubber design drive and protection circuits, commutation circuits, Soft switching

References:

1. Ned Mohan, Undeland and Robbin, 'Power Electronics: converters, Application and design', John Wiley and sons. Inc, 3rd Edition, 2002.
2. Rashid M.H., 'Power Electronics Circuits, Devices and Applications', Prentice Hall India, 3rd Edition ,2004.
3. Singh M.D., Khanchandani K. B., 'Power Electronics', Tata McGraw-Hill, 2nd Edition, 2008.
4. Umanand L., 'Power Electronics: Essentials & Applications', Wiley India Pvt. Ltd., 2009.

EE612 - INDUSTRIAL CONTROL ELECTRONICS

Objective:

This course gives a comprehensive coverage of various control electronics used in the industries. This combines the analog and digital concepts together with Power Electronics for the design of the controllers. Further an overview of stepper motor and servomotor with associated control circuits is given.

Outcome:

The students will be able to design and analyze analog controllers for UPS, Switching regulators and inverters. Further they will be able to design opto-electronic controllers for various applications. They will have complete knowledge about signal conditioning circuits and industrial applications of stepper motor and servomotor.

Prerequisite:

Fundamental knowledge about analog, digital and Power electronic circuits.

Review of switching regulators and switch mode power supplies, Uninterrupted power supplies- off-line and on-line topologies-Analysis of UPS topologies, solid state circuit breakers, solid-state tap-changing of transformer

Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID controllers, derivative overrun, integral windup, cascaded control, Feed forward control, Digital control schemes, control algorithms, programmable logic controllers

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 , electronic circuits for photo-electric switches-output signals for photo-electric controls; Applications of opto-isolation, interrupter modules and photo sensors; Fibre-optics; Bar code equipment, application of barcode in industry.

Stepper motors – types, operation, control and applications; servo motors- types, operation, control and applications – servo motor controllers – servo amplifiers – linear motor applications-selection of servo motor.

References:

1. Michael Jacob, 'Industrial Control Electronics – Applications and Design', Prentice Hall, 1995.
2. Thomas E. Kissell, 'Industrial Electronics', Prentice Hall India, 2003
3. James Maas, 'Industrial Electronics', Prentice Hall, 1995.
4. M.D. Singh and K. B. Khanchandani, 'Power Electronics', Tata McGraw-Hill, 2nd Edition, New Delhi, 2008.

EE613 - SYSTEM THEORY

Objective:

The main objective of this course is to understand the fundamental of physical systems in terms of its linear and nonlinear models. Exploit the properties of linear systems such as controllability and observability.

Outcome:

Better understanding of state feedback control design. Stability analysis of nonlinear systems and its behavior.

Prerequisite:

Basic control, Linear algebra

Introduction to state space modeling, modeling of physical systems. Solution to vector differential equations and state transition matrix.

Stability analysis of linear systems. Controllability and Observability definitions and Kalman rank conditions. Detectability and Stabilizability, Kalman decomposition.

State feedback controller design using pole placement. Observer design using Kalman filter algorithm. LQR and LQG controller design.

Introduction to nonlinear systems. Phase plane analysis of nonlinear system using linear approximation. Limit cycle and periodic solutions. Singular points (equilibrium points) and qualitative behavior near singular points.

Stability of nonlinear systems. Lyapunov direct and indirect methods. Input-to-state stability and relative stability.

References:

1. Ogata, K., 'Modern Control Engineering', Prentice Hall of India, 2010.
2. C.T. Chen, 'Linear Systems Theory and Design' Oxford University Press, 3rd Edition, 1999.
3. M. Vidyasagar, 'Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey 07632.
4. Hassan K. Khalil, 'Nonlinear Systems', Pearson Educational International Inc. Upper Saddle River, 3rd Edition.

EE614 - ANALYSIS AND DESIGN OF ARTIFICIAL NEURAL NETWORKS

Objective:

To apply artificial neural networks in various electrical and electronics engineering applications.

Outcome:

The students acquire the skills required to innovate and build, smart and intelligent applications in electrical and electronics engineering.

Prerequisite:

Introduction to Electrical and Electronics Engineering, Basic mathematics and Probability.

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

Linear separability – Back propagation – XOR function-Back propagation algorithm-Hopfield and Hamming networks- Kohensen’s network-Boltzmann machine-in and out star network – Art 1 and Art 2 nets

Neuro adaptive control applications-ART architecture – Comparison 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

References:

1. Martin T. Hagan , Howard B.Demuth, M, and Mark H. Beale ‘Neural network design’, Vikas Publishing House, 2003.
2. Zurada, J.M., ‘Introduction to Artificial Neural Systems’, Jaico publishing house, Bombay, 1992.
3. Zimmermann, H.J., ‘Fuzzy set theory and its applications’, Allied publishers limited, Madras, 2001.

EE615 - ADVANCED DIGITAL SIGNAL PROCESSING

Objective:

Review and understanding of discrete-time systems and signals, Discrete-Time Fourier Transform and its properties, the Fast Fourier Transform, design of Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters, implementation of digital filters

Outcome:

Upon finishing the course, students are expected to accomplish the following objectives:

- Understand the basic operations of sampling and quantization processes including quantization noise;
- Perform discrete-time Fourier Transform and digital Fourier Transform;
- Understand and perform Z-Transform;
- Design different kinds of digital filters in software;

Analyze and design DSP systems.

Prerequisite:

Linear Systems Fundamentals, Signals and Systems, Circuit Theory, Mathematics

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 – Introduction to STFT WT

References:

1. John G. Prokis and Dimitris G. Hanolakis, 'Digital Signal Processing, Principles, Algorithms & Applications' 4th Edition, Pearson Education, 2006.
2. Ludemann L. C., 'Fundamentals of Digital Signal Processing', Harper and Row publications, 2009.
3. Antoniou A., 'Digital Filters – Analysis and Design', Tata Mc-Graw Hill, 2001.
4. Oppenheim and Schaffer, 'Discrete time Signal processing', Pearson Education, 2007.

EE616 - ADVANCED DIGITAL SYSTEM DESIGN

Objective:

To impart the knowledge on the advanced topics of Digital systems, design aspects and testing of the circuits.

Outcome:

The learner understands various digital circuits and techniques and will help to design excellent digital controllers which can be deployed in practical applications.

Prerequisite:

Digital Electronics

Review of sequential circuits - Mealy & Moore Models - Analysis & Synthesis of Synchronous sequential circuits

Digital system design Hierachy - ASM charts - Hardware description language - Control logic Design Reduction of state tables - State Assignments.

Analysis and synthesis of Asynchronous sequential circuits - critical and non - critical races - Essential Hazard

Combinational and sequential circuit design with PLD's - Introduction to CPLD's & FPGA's

Fault classes and models – Stuck at faults, Bridging faults - Transition and Intermittent faults. Fault Diagnosis of combination circuits by conventional methods - Path sensitization technique - Boolean different method and Kohavi algorithm

References:

1. Donald D. Givone, 'Digital principles and design', Tata McGraw-Hill, 2003.
2. Morris Mano, 'Digital Design', Prentice Hall India, 3rd Edition, 2007.
3. Samuel C. Lee, 'Digital circuits and logic design', Prentice Hall India, 1984.
4. N. N. Biswas, 'Logic Design Theory', Prentice Hall India, 1993.
5. Zvi Kohavi, 'Switching and Finite Automata Theory', Tata McGraw-Hill, 3rd Edition, 2010.

EE617 - POWER ELECTRONIC DRIVES

Objective:

To introduce basic concepts of load and drive interaction, speed control concepts of ac and dc drives, speed reversal, regenerative braking aspects, design methodology.

Outcome:

The student will be able to analyse, simulate and evaluate performance of variable speed drives.

Prerequisite:

A course in Power Electronics and electrical machines.

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. Braking and speed reversal of DC motor drives using choppers, multiphase choppers. PV fed DC drives.

Conventional methods of induction motor speed control. Solid state controllers for Stator voltage 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. Introduction to design aspects of machines.

References:

1. P.C Sen, 'Thyristor DC Drives', John Wiley and Sons, New York, 1991.
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) Pvt. Ltd., New Delhi, 2003.

EE618 - DIGITAL CONTROLLERS IN POWER ELECTRONICS APPLICATIONS

Objective:

To enrich the learner with digital controller concepts and its application in the field of Power Electronic Systems

Outcome:

The learner will be able to design digital controllers for the versatile control of Power electronic circuits.

Prerequisite:

Digital Electronics, Digital Signal Processing, Computer Architecture.

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

References:

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.

EE619 - COMPUTER NETWORKING

Objective:

This course provides an introduction to the computer networking fundamentals, design issues, functions and protocols of the network architecture.

Outcome:

The students will have an idea of Networking, network types, protocols and web services.

Prerequisite:

Data Structures and Communication Systems.

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

References:

1. James F. Kurose and Keith W. Ross, 'Computer Networking', Pearson Education, 2nd Edition, 2003.
2. Tanenbaum, A.S., 'Computer Networks', Prentice Hall of India, 4th Edition, 2003.
3. Stallings W., 'Data and Computer Communication', Prentice Hall of India, 5th Edition, 2000.

EE620 - ELECTRICAL DISTRIBUTION SYSTEMS

Objective:

To explain the principles of design and operation of electric distribution feeders and other components

To make the students to understand the distribution system expansion planning and reliability analysis procedures

Outcome:

Students will be able to do loss calculation in distribution lines, select the protective components, planning and reliability analysis

Prerequisite:

Transmission and Distribution of Electrical Energy

Power System Analysis

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 substation – 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.

References:

1. Pabla, A.S., 'Electrical Power Distribution System', 5th edition, Tata McGraw hill, 2011.
2. Tuvargoner, 'Electrical Power Distribution System Engineering', McGraw hill, 2008.
3. Sterling, M.J.H., 'Power System Control', Peter Peregrinus, 1986.

EE621 - FUZZY SYSTEMS

Objective:

This course is designed to expose students to fuzzy methods of analyzing problems which involve incomplete or vague criteria rather than crisp values. The course investigates requirements analysis, logical design, and technical design of components for fuzzy systems development.

Outcome:

The student will be able to take up fuzzy systems approach to solve applications in engineering.

Prerequisite:

Control 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.

References:

1. Zimmermann H. J., 'Fuzzy set theory and its applications', Allied publishers limited, Madras, 4th Edition, 2001.
2. Klir G. J. and Folger T., 'Fuzzy sets, uncertainty and information', Prentice Hall of India , New Delhi, 1991.
3. EarlCox, 'The Fuzzy Systems Handbook', AP professional Cambridge, 1999.

EE622 - TRANSIENT OVER VOLTAGES IN POWER SYSTEMS

Objective:

To make the students familiar with the theoretical basis for various forms of over voltages such as lightning strokes, surges, switching transients etc., and to introduce some of the protection measures against such over voltages are described. Also to depict the necessity and methods for generating impulse voltages and currents.

Outcome:

The students will be able to understand the basis for mathematical modeling of various over voltages, and analyse different situations. They will be aware of the preliminary design aspects of protection equipment needed and impulse voltage and current generators.

Prerequisite:

EE 601 Advanced Power System Analysis

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 lightning arrestors - Insulation coordination - Protection of alternators and industrial drive systems

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

References:

1. Allen Greenwood, 'Electrical transients in power systems', Wiley Interscience, 1991.
2. Bewley, L.V., 'Travelling waves on Transmission systems', Dover publications, New York, 1963.
3. Gallagher, P.J. and Pearman, A.J., 'High voltage measurement, Testing and Design', John Wiley and sons, New York, 2001.

EE623- STOCHASTIC MODELS AND APPLICATIONS

Objective: This course is designed to expose students to stochastic models, process and applications.

Outcome: The student will be able to take up probability and stochastic model approach to solve applications in engineering.

Prerequisite: Control systems, System theory, Mathematics

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 trial

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

References:

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.

EE624 - RENEWABLE POWER GENERATION TECHNOLOGIES

Objective:

This course makes the student

- to aware of various forms of renewable energy
- to understand in detail the wind energy conversion system and photovoltaic conversion system

Outcome:

Students will have the knowledge

- to choose the appropriate renewable energy as an alternate for conventional power in any application

to design PV systems, wind turbine generator systems and hybrid systems for any application

Prerequisite:

Basic Electronics and Machines, Power Electronics

Sun and Earth-Basic Characteristics of solar radiation-angle of sunrays on solar collector-Photovoltaic cell-characteristics-equivalent circuit-Photovoltaic modules and arrays

PV Systems-Design of PV systems-Standalone system with DC and AC loads with and without battery storage-Grid connected PV systems-Maximum Power Point Tracking

Wind energy – energy in the wind – aerodynamics - rotor types – forces developed by blades - Aerodynamic models – braking systems – tower - control and monitoring system - design considerations-power curve - power speed characteristics-choice of electrical generators

Wind turbine generator systems-fixed speed induction generator-performance analysis-semi variable speed induction generator-variable speed induction generators with full and partial rated power converter topologies -isolated systems-self excited induction generator-permanent magnet alternator -performance analysis

Hybrid energy systems-wind-diesel system-wind-PV system-micro hydro-PV system-biomass-PV-diesel system-geothermal-tidal and OTEC systems

References:

1. Chetan Singh Solanki, 'Solar Photovoltaics-Fundamentals, Technologies and Applications', PHI Learning Pvt. Ltd., New Delhi, 2011
2. Van Overstraeten and Mertens R.P., 'Physics, Technology and use of Photovoltaics', Adam Hilger, Bristol,1996.
3. John F.Walker & Jenkins. N , 'Wind energy Technology', John Wiley and sons, Chichester, UK, 1997.
4. Freries LL ,'Wind Energy Conversion Systems', Prentice Hall, U.K., 1990

EE625 - POWER SYSTEM PLANNING AND RELIABILITY

Objective:

To acquire skills in planning and building reliable power system.

Outcome:

The scope of employability in power utilities will increase. The management skills required in the field of power system engineering is enhanced.

Prerequisite:

Power system analysis, Power system transmission and distribution, Matrices, Probability and Calculus.

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

References:

1. Sullivan, R.L., 'Power System Planning', Heber Hill, 1987.
2. Roy Billington, 'Power System Reliability Evaluation', Gordon & Breach Scain Publishers, 1990.
3. Eodrenyi, J., 'Reliability modelling in Electric Power System' John Wiley, 1980.

EE626 - ADVANCED POWER SYSTEM PROTECTION

Objective:

To facilitate the students understand the basic concepts and recent trends in power system protection. To enable the students design and work with the concepts of digital and numerical relaying.

Outcome:

On completion of the course the students would be skilled enough to work with various type of relaying schemes used for different apparatus protection.

Prerequisite:

Basic knowledge on short circuit analysis, digital system and signal processing.

General philosophy of protection - Classification and Characteristic function of various protective relays-basic relay elements and relay terminology - Development of relaying scheme

Digital Protection of power system apparatus – protection of generators – Transformer protection – magnetizing inrush current – Application and connection of transformer differential relays – transformer over current protection

Bus bar protection - line protection - distance protection–long EHV line protection - Power line carrier protection

Reactor protection – 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

References:

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., 2005.
3. C. Russeil Mason, 'The art and Science of Protective Relaying', GE Publishers, 1962.
4. A. T. Johns and S. K. Salman, 'Digital Protection for Power Systems', Peter Peregrinus Ltd., 1997.
5. Arun G Padkye and James S Thorp, 'Computer Relaying for Power Systems', John Wiley publications, 2nd Edition, 2009.

EE627 - MODELING AND ANALYSIS OF ELECTRICAL MACHINES

Objective:

To give a systematic approach for modeling and analysis of all rotating machines under both transient and steady state conditions.

Outcome:

The students will be able to model all types of rotation machines including special machines. They will have complete knowledge about electromagnetic energy conversion and application of reference frame theories for modeling of machines.

Prerequisite:

Electromagnetic field theory, Vector algebra and fundamentals of all electrical rotating 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.

References:

1. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D. Umans, 'Electric Machinery', Tata Mcgraw Hill, 5th Edition, 1992.
2. R. Krishnan, 'Electric Motor & Drives: Modeling, Analysis and Control', Prentice Hall of India, 2nd Edition, 2001.
3. Miller, T.J.E., 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, 1st Edition, 1989.

EE628 - POWER QUALITY

Objective:

Understand the various power quality phenomenon, their origin and monitoring and mitigation methods. Understand the effects of various power quality phenomenon in various equipment.

Outcome:

Students of this module shall possess the necessary skills to understand and handle power quality related problems. This involves identifying the cause or source of the problem and assessing the severity of each problem with respect to the vulnerability of the affected devices. Students expected to be conversant with power quality terminologies, and ready to tackle power quality related challenges.

Prerequisite:

Power Systems, Signals and Systems.

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

References:

1. Heydt, G.T., 'Electric Power Quality', Stars in a Circle Publications, Indiana, 2nd edition 1996.
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.

EE629 - MICROCONTROLLER APPLICATIONS IN POWER CONVERTERS

Objective:

Study the internal structure and operation of PIC 16F876 microcontroller and 8051 microcontroller; assembly language program for the generation of firing and control signals employing these microcontrollers.

Outcome:

Upon completion of this course, students will develop the microcontroller based control schemes for various power electronic circuits.

Prerequisite:

Knowledge on any digital controller and power electronics may be desirable.

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 organization – 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.

References:

1. PIC16F87X Datasheet 28/40 – pin 8 bit CMOS flash Microcontrollers, Microchip technology Inc., 2001. and MPLAB IDE Quick start guide, Microchip technology Inc., 2007.
2. John B. Peatman, 'Design with PIC Microcontrollers', Prentice Hall, 2003.
3. Myke Predko, 'Programming and customizing the PIC Microcontroller', Tata McGraw-Hill, 3rd Edition, 2008.
4. M.A. Mazidi, J.G. Mazidi and R.D. McKinlay, 'The 8051 microcontroller and embedded systems', Prentice Hall India, 2nd Edition, New Delhi, 2007.

EE630 - POWER SYSTEM RESTRUCTURING AND PRICING

Objective:

To understand the electricity power business and technical issues in a restructured power system in both Indian and world scenario.

Outcome:

- Availability of jobs in power companies at managerial level in distribution, transmission and generation sector.
- To become an entrepreneur or can become a consultant in power system business and operation.

Prerequisite:

Power system Analysis, Power system Transmission and distribution.

Introduction – Market Models – Entities – Key issues in regulated and deregulated power markets; Market equilibrium- Market clearing price- Electricity markets around the world.

Operational and planning activities of a Genco - Electricity Pricing and Forecasting -Price Based Unit Commitment Design - Security Constrained Unit Commitment design. - Ancillary Services for Restructuring- Automatic Generation Control (AGC).

Introduction-Components of restructured system-Transmission pricing in Open-access system-Open transmission system operation; Congestion management in Open-access transmission systems- FACTS in congestion management - Open-access Coordination Strategies; Power Wheeling-Transmission Cost Allocation Methods

Open Access Distribution - Changes in Distribution Operations- The Development of Competition – Maintaining Distribution Planning

Power Market Development – Electricity Act, 2003 - Key issues and solution; Developing power exchanges suited to the Indian market - Challenges and synergies in the use of IT in power- Competition- Indian power market- Indian energy exchange- Indian power exchange-Infrastructure model for power exchanges- Congestion Management-Day Ahead Market-Online power trading.

References:

1. Loi Lei Lai, 'Power System Restructuring and Deregulation', John Wiley & Sons Ltd., 2001.
2. Mohammad Shahidehpour, Hatim Yamin, 'Market operations in Electric power systems', John Wiley & son ltd., 2002.
3. Lorrin Philipson, H. Lee Willis, 'Understanding Electric Utilities and Deregulation' Taylor & Francis, 2006.
4. Mohammad Shahidehpour, Muwaffaq Alomoush, 'Restructured Electrical Power Systems', Marcel Dekker, Inc., 2001.

EE631 - COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS

Objective:

The goal of this course is to understand the operating principles of a computer relays and wide area measurement systems. Learning about main classification of relay types, wide area measurement systems and their behavior, mathematical background for understanding relaying algorithms and also examining line relaying algorithms and protection of power system components. It will be discussed about several hardware related question-such as the computer hierarchy in the substation, subsystems of a computer relay and analog to digital converters as and system relaying and control.

Outcome:

Upon finishing the course, students are expected to accomplish the following objectives:

- Demonstrate knowledge of fundamental aspects of the theories, principles and practice of computer relaying;
- Define and understand the concept of Wide area measurement systems;

Understand and design wide are measurement systems application in Smart grid

Prerequisite:

Digital Signal Processing, Power system protection, Power system analysis

Historical background - Expected benefits - computer relay architecture - Analog to digital converters - Anti-aliasing filters - Substation computer hierarchy - Fourier series Exponential fourier series - Sine and cosine fourier series – Phasor

Walsh functions - Fourier transforms - discrete fourier transform - Random processes - Filtering of random processes - Kalman filtering - Digital filters - Windows and windowing, - Linear phase Approximation - filter synthesis – Wavelets - Elements of artificial intelligence

Introduction - Phasor representation of sinusoids - Fourier series and Fourier transform and DFT Phasor representation - Phasor Estimation of Nominal Frequency Signals - Formulas for updating phasors - Nonrecursive updates - Recursive updates - Frequency Estimation

A generic PMU - The global positioning system - Hierarchy for phasor measurement systems, - Functional requirements of PMUs and PDCs - Transient Response of Phasor Measurement Units-of instrument transformers, filters, during electromagnetic transients - Transient response during power swings

State Estimation - History, Operator's load flow - weighted least square least square, -Linear weighted least squares - Nonlinear weighted least squares - Static state estimation - State estimation with Phasors measurements - linear state estimation - Adaptive protection - Differential and distance protection of transmission lines - Adaptive protection - Adaptive out-of-step protection

References:

1. A.G. Phadke, J.S. Thorp, 'Computer Relaying for Power Systems', John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009
2. A.G. Phadke, J.S. Thorp, 'Synchronized Phasor Measurements and Their Applications', Springer Publications, 2008

EE632 - ADVANCED DSP ARCHITECTURE AND PROGRAMMING

Objective:

Exposure to the Digital signal processor architecture and its insights for the better usage of the architecture for power applications.

Outcome:

The student will be able to extensively use the processor for power and control applications.

Prerequisite:

Digital Systems, Digital Signal processing

Introduction to DSP - Example of DSP system A to D signal conversion - DSP Support tools, - code composer studio - compiler, assembler and linker - input and output with the DSK

Introduction TMS321 C6x architecture - functional units - fetch and execute packets - pipe lining – registers - Linear and circular addressing modes

Instruction set assembly directives, liner assembly - ASM statement within C – timers – interrupts - multi channel buffering serial ports - direct memory access - memory consideration - fixed and floating points format - code improvement and constraints - Fast Fourier Transform – Introduction - DIT FFT algorithm with Radix 2 - DIF FFT algorithm with Radix 2 - inverse fast Fourier transform - fast convolution, programming example using C language

Design of FIR filter - FIR lattice structure - FIR implementation using Fourier series - windows function - programming examples using C language - Real Time IIR Filtering - Design of IIR filter - IIR lattice structure - impulse invariance - bilinear transformation programming examples using C language

Introduction to DSP/BIOS - RTDX using MATLAB provide interface between PC and DSK - RTDX using Lab VIEW - interface between PC and DSK

References:

1. Digital signal processing and applications C6713 and C6416 DSK by Rulph Chassaing, Wiely publication.
2. Real-Time digital signal processing based on the TMS320C6000 by Nasser Kehtarnavaz, ELSEVIER publication
3. DSP applications using C and the TMS320c6x DSK by Rulph Chassaing, Wiely publication.

EE633 – SWARM INTELLIGENT TECHNIQUES

Objective:

To cater the knowledge of swarm intelligent techniques like genetic algorithm, particle swarm optimization, artificial bee colony algorithms, artificial immune systems, firefly algorithms, cuckoo search algorithms etc. and their applications in electrical engineering.

Outcome:

The student will be able to extensively use the various swarm intelligent techniques for engineering applications.

Prerequisite:

Basic Electrical and Electronics, Engineering mathematics

Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing; Classification of meta-heuristic techniques- single solution based and population based algorithms – exploitation and exploration in population based algorithms; Properties of Swarm intelligent Systems; Application domain-discrete and continuous problems- single objective and multi-objective problems .

Evolutionary programs-genetic algorithms, genetic programming and evolutionary programming; Genetic Algorithm versus Conventional Optimization Techniques; Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators; Optimization problems using GA-discrete and continuous- single objective and multi-objective problems; Procedures in evolutionary programming.

Biological ant colony system - artificial ants and assumptions; Stigmergic communications; Pheromone updating- local-global; Pheromone evaporation; Pseudo-probabilistic decision making. Travelling salesman problem- ant System-ant quantity- ant density- ant cycle-ant colony system. ACO models-touring ant colony system-max min ant system-concept of elistic ants –continuous and discrete ACO; Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions-PSO topologies-swarm types-control parameters-constriction coefficient; ACO and PSO applications in electrical engineering applications.

Task partitioning in honey bees-balancing foragers and receivers; artificial bee colony (ABC) algorithms-binary ABC and continuous ABC algorithms; Bacterial foraging techniques-taxes-elimination-dispersals-bacteria motility and swarming; Biological immune systems and artificial immune systems-affinity measures- representations; Basic immune models and algorithms-bone marrow models-negative selection algorithms-clonal selection algorithms-somatic hyper mutation-immune network models- applications in electrical engineering.

Differential search algorithms, harmony Search algorithms, cuckoo search algorithms, firefly algorithms, gravitational search Algorithms, Hybrid swarm intelligent systems; Applications in electrical engineering.

References:

1. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, 'Swarm Intelligence-From natural to Artificial Systems', Oxford university Press, 1999
2. David Goldberg, 'Genetic Algorithms in Search, Optimization and Machine Learning', Pearson Education, 2007.
3. James Kennedy and Russel E Eberheart, 'Swarm Intelligence', The Morgan Kaufmann Series in Evolutionary Computation, 2001
4. Castro, LeandroNunes, Timmis and Jonathan, 'Artificial Immune Systems- A new computational approach', Springer publications, 2002
5. N P Padhy, 'Artificial Intelligence and Intelligent Systems', Oxford University Press, 2005.
6. IEEE Transaction research papers

EE634 - SMART GRID TECHNOLOGIES

Objective:

To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.

To get familiarized with the power quality management issues in Smart Grid.

To get familiarized with the high performance computing for Smart Grid applications

Outcome:

After undergoing the course, the students would get acquainted with the smart technologies, smart meters and power quality issues in smart grids.

Prerequisite:

Distribution systems and Measuring instruments.

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

References:

1. Stuart Borlase 'Smart Grid: Infrastructure, Technology and Solutions', CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012.
3. Vehbi C. Güngör, Dilan Sahin, Taskin Kocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, 'Smart Grid Technologies: Communication Technologies and Standards' IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang 'Smart Grid – The New and Improved Power Grid: A Survey', IEEE Transaction on Smart Grids.

EE635 - ELECTRICAL SYSTEMS IN WIND ENERGY

Objective:

To introduce the various electrical generators and appropriate power electronic controllers employed in wind energy systems. To teach the students the steady-state analysis and operation of different existing configurations of electrical systems in wind energy and also the recent developments taking place in this field.

Outcome:

Students shall be able to explain the principles of operation of typical electrical systems in wind energy and predetermine their performance. They should also be able to design and implement the electrical systems and their closed loop control for specific applications.

Prerequisite:

Electrical machines and power electronics.

Principle of operation – steady-state analysis-characteristics of GCIGs- operation of GCIGs with different power electronic configurations.

Process of self-excitation – steady-state equivalent circuit of SEIG and its analysis - performance equations - widening the operating speed-range of SEIGs by changing the stator winding connection with suitable solid state switching schemes - power electronic controllers used in standalone systems.

Need for single-phase operation –typical configurations for the single-phase operation of three-phase GCIGs and SEIGs –stead state equivalent circuit and analysis using symmetrical components.

Different operating modes- steady-state equivalent circuit- performance analysis- DFIG for standalone applications- operation of DFIGs with different power electronic configurations for standalone and grid-connected operation.

Operation of PMSGs- steady-state analysis- performance characteristics- operation of PMSGs with different power electronic configurations for standalone and grid-connected operation.

References:

1. Marcelo Godoy Simões and Felix A. Farret, 'Renewable Energy Systems: Design and Analysis with Induction Generators', CRC Press, ISBN 0849320313, 2004.
2. Ion Boldea, 'Variable speed Generators', CRC Press, ISBN 0849357152, 2006.
3. S.N. Bhadra, D.Kastha and S.Banerje, 'Wind Electrical Systems', Oxford University Press, 2005.
4. Siegfried Heier, Rachel Waddington, 'Grid Integration of Wind Energy Conversion Systems, 2nd Edition', Wiley, June 2006, ISBN: 978-0-470-86899-7.
5. Frerries LL, 'Wind Energy Conversion Systems', Prentice Hall, U.K., 1990.

EE636 - EMBEDDED PROCESSORS AND CONTROLLERS

Objective:

To enrich the learner with processor and controller design concepts with special concentration on system-on-chip and system-on-programmable chip.

Outcome:

The student will excel in the system design and testing with embedded processors & controllers suited for varied applications.

Prerequisite:

Digital Electronics, Microprocessors & Microcontrollers, Computer Architecture.

MSP 430 Microcontroller – Functional block diagram – memory – Interrupts and Resets – Input/ Output units – Instruction set – Addressing modes – Constant generator and Emulated Instructions.

MSP 430 Timers – on-chip data conversion systems – ADC and DAC – on-chip communication peripherals – SPI, I²C, UART – Programming concepts.

ARM7TDMI – architecture overview - processor modes – data types – Registers – program status registers – Simple programs.

Introduction to Design of Systems on a chip – Core architectures for Digital media and compilation techniques – Microsystems technology and applications – Hardware/ software co-design concepts.

Multi-core System-on-Chip (McSoC) design – Application specific McSoC design – QueueCore Architecture – Synthesis and evaluation results – Reconfigurable multi-core architectures.

References:

1. John H. Davies, 'MSP 430 Microcontroller Basics', Elsevier Ltd., 2008.
2. William Hohl, 'ARM Assembly Language, Fundamentals and Techniques', CRC Press, 2009.
3. Abderazek Ben Abdallah, 'Multi-core systems on-Chip: Practical software and Hardware design', Atlantis press, 2010.
4. Ricardo Reis, Marcelo Lubaszewski, Jochen A.G. Jess, 'Design of Systems on a chip: Design and Test', Springer, 2006.

EE637 - DISTRIBUTED GENERATION AND MICRO-GRIDS

Objective:

To understand the planning and operational issues related to Distributed Generation and Micro-grids.

Outcome:

On completion of the course, the students will be able to design a micro-grid taking into consideration the planning and operational issues of the Distributed Generators to be connected in the system.

Prerequisite:

The students are preferred to have a basic knowledge in Power System Analysis and Distribution Systems

Need for Distributed generation, renewable sources in distributed generation, current scenario in Distributed Generation, Planning of DGs – Siting and sizing of DGs – optimal placement of DG sources in distribution systems.

Grid integration of DGs – Different types of interfaces - Inverter based DGs and rotating machine based interfaces - Aggregation of multiple DG units. Energy storage elements: Batteries, ultra-capacitors, flywheels.

Technical impacts of DGs – Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying – Impact of DGs upon transient and dynamic stability of existing distribution systems.

Economic and control aspects of DGs –Market facts, issues and challenges - Limitations of DGs. Voltage control techniques, Reactive power control, Harmonics, Power quality issues. Reliability of DG based systems – Steady-state and Dynamic analysis

Introduction to micro-grids – Types of micro-grids – autonomous and non-autonomous grids – Sizing of micro-grids- modeling & analysis- Micro-grids with multiple DGs – Micro-grids with power electronic interfacing units. Transients in micro-grids - Protection of micro-grids – Case studies.

References:

1. H. Lee Willis, Walter G. Scott ,'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.
2. M.Godoy Simoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.
3. Robert Lasseter, Paolo Piagi, ' Micro-grid: A Conceptual Solution', PESC 2004, June 2004.
4. F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.
5. Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson 'Facility Microgrids', Subcontract report, May 2005, General Electric Global Research Center, Niskayuna, New York.

EE638 – CONTROL DESIGN TECHNIQUES FOR POWER ELECTRONIC SYSTEMS

Objective : The main objective of this course is to study the application of modern control theory to power electronic converters and drives

Outcome : The main outcome from this course is the modern controller design techniques for power converters

Prerequisite : Classical Control, Systems Theory, Power Converters

Review of basic control theory – control design techniques such as P, PI, PID and lead lag compensator design. Review of state space control design approach – state feedback controller and observer design

Control of DC-DC converters. State space modeling of Buck, Buck-Boost, Cuk, Sepic, Zeta Converters. Equilibrium analysis and closed loop voltage regulations using state feedback controllers and sliding mode controllers.

Control of rectifiers. State space modeling of single phase and three phase rectifiers. State feedback controllers and observer design for output voltage regulation for nonlinear loads. Analysis of continuous and discontinuous mode of operation.

Modelling of Brushless DC motors and its speed regulations – State space model, sensorless speed control of BLDC motor and Sliding mode control design for BLDC motor. Modelling and control of switched reluctance motor.

Modeling of multi input DC-DC converters and its application to renewable energy. Output voltage regulation of Multi input DC-DC converter using state feedback controllers.

References.

1. Sira -Ramirez, R. Silva Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer, 2006
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, 'Sliding mode control of switching Power Converters', CRC Press, 2011
3. Bimal Bose, 'Power electronics and motor drives', Elsevier, 2006
4. Ion Boldea and S.A Nasar, 'Electric drives', CRC Press, 2005

EE639 – ENERGY AUDITING AND MANAGEMENT

Objective:

To emphasize the energy management on various electrical equipments and metering

To illustrate the energy management in lighting systems and cogeneration

To study the concepts behind the economic analysis and load management

Outcome:

Upon completion of this course , students will be able to

- Apply energy management schemes in electrical systems
- Perform economic analysis and load management

Prerequisite:

Electrical Machines, Transmission and Distribution of Electrical Energy, utilization of electrical energy

Basics of Energy – Need for energy management – energy accounting- energy monitoring, targeting and reporting-energy audit process

Energy management for electric motors – Transformer and reactors-capacitors and synchronous machines, energy management by cogeneration –forms of cogeneration – feasibility of cogeneration – electrical interconnection

Energy management in lighting systems – task and the working space - light sources – ballasts – lighting controls – optimizing lighting energy – power factor and effect of harmonics, lighting and energy standards

Metering for energy management – units of measure - utility meters – demand meters – paralleling of current transformers – instrument transformer burdens – multitasking solid state meters, metering location vs requirements, metering techniques and practical examples

Economic analysis – economic models- time value of money - utility rate structures – cost of electricity – loss evaluation, load management – demand control techniques – utility monitoring and control system – HVAC and energy management – economic justification

References:

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, 'Guide to Energy Management', 5th Edition, The Fairmont Press, Inc., 2006
2. Amit K. Tyagi, 'Handbook on Energy Audits and Management', The Energy and Resources Institute, 2003
3. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.

EE640 – ELECTRIC AND HYBRID VEHICLES

Objective : This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles.

Outcome : The main outcome from this course is deeper understanding of various aspects of hybrid and electric drive train such as their configuration, types of electric machines that can be used, energy storage devices, etc

Prerequisite : Power Conversion Techniques, Electrical Machines

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Basic concepts of electric traction, introduction to various electric drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.

References.

1. Sira -Ramirez, R. Silva Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer, 2006
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, 'Sliding mode control of switching Power Converters', CRC Press, 2011
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4. Ion Boldea and S.A Nasar, 'Electric drives', CRC Press, 2005