M. Tech. Programme
in

POWER ELECTRONICS

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 ELECTRONICS

SEMESTER I

CODE	COURSE OF STUDY	L	T	P	C
EE651	Power Converters	3	0	0	3
EE653	Industrial Control Electronics	3	0	0	3
EE655	System Theory	3	0	0	3
	Elective I	3	0	0	3
	Elective II	3	0	0	3
	Elective III	3	0	0	3
EE657	Power Converters Laboratory	0	0	3	2
	Total	**18**	**0**	**3**	**20**

SEMESTER II

CODE	COURSE OF STUDY	L	T	P	C
EE652	Switched Mode Power Conversion	3	0	0	3
EE654	Power Electronic Drives	3	0	0	3
EE656	Microcontroller Applications In Power Converters	3	0	0	3
	Elective IV	3	0	0	3
	Elective V	3	0	0	3
	Elective VI	3	0	0	3
	Total	**18**	**0**	**0**	**18**

SEMESTER III

CODE	COURSE OF STUDY	L	T	P	C
MA697	Project Work	0	0	24	12

SEMESTER IV

CODE	COURSE OF STUDY	L	T	P	C
EE698	Project Work	0	0	24	12

ELECTIVES

CODE	COURSE OF STUDY	L	T	P	C
MA603	Optimization Techniques	3	0	0	3
EE661	Advanced Power System Analysis	3	0	0	3
EE662	Analysis And Design Of Artificial Neural Networks	3	0	0	3
EE663	Advanced Digital System Design	3	0	0	3
EE664	Flexible AC Transmission Systems	3	0	0	3
EE665	Advanced Digital Signal Processing	3	0	0	3
EE666	Computer Networking	3	0	0	3
EE667	Fuzzy Systems	3	0	0	3
EE668	Principles Of VLSI Design	3	0	0	3
EE669	Modeling And Analysis Of Electrical Machines	3	0	0	3
EE670	Renewable Power Generation Technologies	3	0	0	3
EE671	Power Systems Operation And Control	3	0	0	3
EE672	Electrical Distribution Systems	3	0	0	3
EE673	Power System Planning And Reliability	3	0	0	3

EE674	Advanced Power System Protection	3	0	0	3
EE675	Digital Simulation Of Power Electronic Systems	3	0	0	3
EE676	PWM Converters And Applications	3	0	0	3
EE677	Transient over Voltages in Power Systems	3	0	0	3
EE678	High Voltage DC Transmission	3	0	0	3
EE679	Embedded System Design	3	0	0	3
EE680	Computer Relaying And Wide Area Measurement Systems	3	0	0	3
EE681	Advanced DSP Architecture And Programming	3	0	0	3
EE682	Power System Restructuring and Pricing	3	0	0	3
EE683	Advanced Topics in Power Electronics	3	0	0	3
EE684	Design Techniques for SMPS	3	0	0	3
EE685	Smart Grid Technologies	3	0	0	3
EE686	Electric Systems in Wind Energy	3	0	0	3
EE687	Embedded Processors and Controllers	3	0	0	3
EE688	Distributed Generation and Micro-grid	3	0	0	3
EE689	Control Design Techniques for Power Electronic Systems	3	0	0	3
EE690	Energy Auditing and Management	3	0	0	3
EE691	Electric and Hybrid Vehicles	3	0	0	3
EE692	Energy Storage Systems				

EE651 – POWER CONVERTERS

Objective:

To give a systematic approach for transient and steady state analysis of all power electronic converters with passive and active loads.

Outcome:

The student will be able to comprehensively understand and carry out transient and steady state analysis of different power converters of different types of loads and switching sequences.

Prerequisite:

Power Electronics in UG

Analysis of power semiconductor switched circuits with R, L, RL, RC loads, d.c.motor load, battery charging circuit.

Single-Phase and Three-Phase AC to DC converters- half controlled configurations- operating domains of three phase full converters and semi-converters – Reactive power considerations.

Analysis and design of DC to DC converters- Control of DC-DC converters, Buck converters, Boost converters, Buck-Boost converters, Cuk converters

Single phase and Three phase inverters, Voltage source and Current source inverters, Voltage control and harmonic minimization in inverters.

AC to AC power conversion using voltage regulators, choppers and cyclo-converters, consideration of harmonics, introduction to Matrix converters.

References:

1. Ned Mohan, Undeland and Robbin, ‘Power Electronics: converters, Application and design’, John Wiley and sons.Inc, Newyork, 2006.
2. Rashid M.H., ‘Power Electronics-Circuits, Devices and Applications ‘, Prentice Hall India, New Delhi, 2009.
3. P.C Sen., ‘Modern Power Electronics’, Wheeler publishing Company, 1st Edition, New Delhi, 2005.

EE653 – 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.

EE655- SYSTEM THEORY

Objective:

The main objective of this course is to understand the fundamental of physical systems interms 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.

Controllability and Observability definitions and Kalman rank conditions. Detectability and Stabilizability, Kalman decomposition.

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. Various methods to check the stability of nonlinear systems.

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

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.

EE657 - POWER CONVERTERS LABORATORY

Experiments and computer simulations on:

1. **Single-phase, three-phase semi converters and full converters**
2. **DC-DC Choppers using SCRs and Self commutating devices**
3. **Single-phase and three-phase inverters using IGBTs**
4. **AC-AC voltage regulators**
5. **DC and AC drives**

EE652 - SWITCHED MODE POWER CONVERSION

Objective: Understand the concepts, basic operation, steady-state operation of efficient switched-mode power conversion techniques, including basic circuit operation and magnetics design.

Outcome: After taking this course students will be able to do the Steady-State Analysis, modelling, design of switched-mode dc-dc power converters and corresponding control techniques. Become proficient with computer skills (e.g., PSPICE and MATLAB) for the analysis and design of switched-mode power converters.

Prerequisite: Power Converters

Design constraints of reactive elements in Power Electronic Systems: Design of inductor, transformer and capacitors for power electronic applications, Input filter requirement.

Basic concepts and steady-state analysis of second and higher order Switched Mode power converters: PWM DC - DC Converters (CCM and DCM) - operating principles, constituent elements, characteristics, comparisons and selection criteria.

Dynamic Modelling and control of second and higher order switched Mode power converters: analysis of converter transfer functions, Design of feedback compensators, current programmed, frequency programmed and critical conduction mode control.

Soft-switching DC - DC Converters: zero-voltage-switching converters, zero-current-switching converters, Multi-resonant converters and Load resonant converters.

Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform, single phase and three-phase converter systems incorporating ideal rectifiers and design examples.
Non-linear phenomena in switched mode power converters: Bifurcation and Chaos.

References:

1. Robert W. Erickson and Dragan Maksimovic, 'Fundamentals of Power Electronics', Springer, 2nd Edition, 2001.
2. Marian K. Kazimierczuk, 'Pulse-width Modulated DC-DC Power Converters' John Wiley & Sons Ltd., 1st Edition, 2008.
3. Philip T Krein, 'Elements of Power Electronics', Oxford University Press, 2nd Edition, 2012.
4. Batarseh, 'Power Electronic Circuits', John Wiley, 2nd Edition, 2004.
5. H. W. Whittington, B. W. Flynn, D. E. Macpherson, 'Switched Mode Power Supplies', John Wiley & Sons Inc., 2nd Edition, 1997.

EE654 - 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.

EE656 - MICRO CONTROLLER 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.

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.

EE661 - 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.

EE662 - 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-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 – 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.

EE663 - 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.

EE664 - 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.

EE665 - 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. 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.

EE666 - 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.

EE667 - 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.

EE668 - PRINCIPLES OF VLSI DESIGN

Objective:
Enables the student to get exposure on low power electronic system design and its application.

Outcome:
The learner will be able to excel in the low power circuits which can be used for power management systems in integrated circuits.

Prerequisite:
Digital Electronics, Electronic Circuits

MOS and Fabrication: **VLSI technology- NMOS, CMOS and BICMOS circuit fabrication. Comparison of IC technologies. Operation characteristics, design equations, models and second order effects of MOS transistors, Fabrication of resistors and capacitors. Latch up, Driver circuits.**

Hardware Description languages: **VHDL- Modeling styles –Design of simple/ complex circuits using VHDL. Overview of Verilog HDL -Design of simple circuits using Verilog HDL.**

CMOS Logic Circuits: **Implementation of logic circuits using MOS and CMOS, Pass transistor and transmission gates – Implementation of combinational and sequential circuits – memory design.**

Programmable Devices: **Simple and Complex Programmable logic devices (SPLD and CPLDs), Field Programmable Gate Arrays (FPGAs), Internal components of FPGA, Case study: A CPLD and a 10 million gates type of FPGA.**

ASIC: **Types of ASICs-Design flow-Programmable ASICs-Programmable ASIC logic cells and interconnect for Xilinx and Altera families.**

References:

1. Neil Weste, David Harris, 'CMOS VLSI Design: A Circuits and Systems Perspective', Addison-Wesley, 4th Edition,2010
2. M. J. Smith, 'Application Specific Integrated Circuits', Addison Wesley, 1997.
3. Uyemura, 'Introduction to VLSI Circuits and Systems', Wiley, 2002.
4. J. Bhaskar, 'A Verilog HDL Primer', Star Galaxy, 2nd Edition, 2000.

EE669 - 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.

EE670 - 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 Overstraeton 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

EE671 - 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 *and* 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.

EE672 - 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. Tuvar Goner, ‘Electrical Power Distribution System Engineering’, McGraw hill, 2008.
3. Sterling, M.J.H., ‘Power System Control’, Peter Peregrinus, 1986.

EE673 - 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', Gordan & Breach Scain Publishers, 1990.
3. Eodrenyi, J., 'Reliability modelling in Electric Power System' John Wiley, 1980.

EE674 - 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.

EE675- DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS

Objective:
To provide knowledge on modeling and simulation of power simulation circuits and systems.

Outcome:
The candidate will be able to simulate power electronic systems and analyze the system response.

Prerequisite:
Knowledge in Power Electronics and machines.

Review of numerical methods. Application of numerical methods to solve transients in D.C.Switched R, L, R-L, R-C and R-L-C circuits. Extension to AC circuits.

Modeling of diode in simulation. Diode with R, R-L, R-C and R-L-C load with ac supply. Modeling of SCR, TRIAC, IGBT and Power Transistors in simulation. Application of numerical methods to R, L, C circuits with power electronic switches. Simulation of gate/base drive circuits, simulation of snubber circuits.

State space modeling and simulation of linear systems. Introduction to electrical machine modeling: induction, DC, and synchronous machines, simulation of basic electric drives, stability aspects.

Simulation of single phase and three phase uncontrolled and controlled (SCR) rectifiers, converters with self commutated devices- simulation of power factor correction schemes, Simulation of converter fed dc motor drives ,Simulation of thyristor choppers with voltage, current and load commutation schemes, Simulation of chopper fed dc motor.

Simulation of single and three phase inverters with thyristors and self-commutated devices, Space vector representation, pulse-width modulation methods for voltage control, waveform control. Simulation of inverter fed induction motor drives.

References:

1. Simulink Reference Manual , Math works, USA.
2. Robert Ericson, ‘Fundamentals of Power Electronics’, Chapman & Hall, 1997.
3. Issa Batarseh, ‘Power Electronic Circuits’, John Wiley, 2004Simulink Reference Manual , Math works, USA.

EE676 - PWM CONVERTERS AND APPLICATIONS

Objective:

For students to:

- Understand the concepts and basic operation of PWM converters, including basic circuit operation and design.
- Understand the steady-state and dynamic analysis of PWM converters along with the applications like solid state drives and power quality.

Outcome:

After taking this course students will be able to recognize and use the following concepts and ideas:

1. Steady-State and transient modelling and analysis of power converters with various PWM techniques.

Analysis and Design of Control Loops for PWM power converters along with the applications like solid state drives and power quality.

Prerequisite:

Power Converters

AC/DC and DC/AC power conversion, overview of applications of voltage source converters, pulse modulation techniques for bridge converters.

Bus clamping PWM, space vector based PWM, advanced PWM techniques, practical devices in converter; calculation of switching and conduction losses.

Compensation for dead time and DC voltage regulation; dynamic model of a PWM converter, multilevel converters; constant V/F induction motor drives.

Estimation of current ripple and torque ripple in inverter fed drives; line – side converters with power factor compensation.

Active power filtering, reactive power compensation; harmonic current compensation.

References:

1. Mohan, Undeland and Robbins,' Power Electronics; Converters, Applications and Design',John Wiley and Sons, 1989.
2. Erickson R W,' Fundamentals of Power Electronics', Chapman and Hall, 1997.
3. Vithyathil J,'Power Electronics: Principles and Applications ', McGraw Hill, 1995

EE677 - TRANSIENT OVER VOLTAGES IN POWER SYSTEMS

Objective:

To make the students familiar with the theoretical basis for various forms of over voltages such as lighting 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 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 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. Gallaghar, P.J. and Pearman, A.J., 'High voltage measurement, Testing and Design', John Wiley and sons, New York, 2001.

EE678 - 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 Pereginver Ltd., 1998.

EE679 - EMBEDDED SYSTEM DESIGN

Objective:
To enable the learner to understand the concepts of embedded processors with its application.

Outcome:
The student learns the basic concepts of both software and hardware required for an embedded system and will be able to apply in practical systems.

Prerequisite:
Digital Systems, Microprocessors/ Microcontrollers.

Embedded System Architectures – ARM processor and SHARC processor - architectural design - memory organization - data operation - bus configurations. System on-chip, scalable bus architectures, Design example: Alarm clock, hybrid architectures.

Sensor and Actuator I/O – ADC, DAC, timers, Servos, Relays, stepper motors, H-Bridge, CODECs, FPGA, ASIC, diagnostic port.

Real time operating systems (RTOS) – real time kernel – OS tasks – task states – task scheduling – interrupt processing – clocking communication and synchronization – control blocks – memory requirements and control – kernel services.

Embedded Networks - Distributed Embedded Architecture – Hardware and Software Architectures, Networks for embedded systems– I2C, CAN Bus, Ethernet, Internet, Network–Based design– Communication Analysis, system performance Analysis, Hardware platform design, Allocation and scheduling, Design Example: Elevator Controller.

System Design – Specification, Requirements and Architectural design of PBX systems, Set-top box, Personal digital Assistants.

References:

1. Wayne Wolf, 'Computers as Components: Principles of Embedded Computing System Design', Morgan Kaufman Publishers, 3rd Edition, 2012.
2. C.M. Krishna, Kang G. Shin, 'Real time systems', McGraw Hill, 2010.
3. Gajski D. D., Vahid F., Narayan S., 'Specification and Design of Embedded Systems', Prentice Hall, 2007.
4. Herma K., Real Time Systems: Design for Distributed Embedded Applications, Kluwer Academic, 2nd Edition, 2011.
5. William Hohl, 'ARM Assembly Language, Fundamentals and Techniques', CRC Press, 2009.

EE680 - 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

EE681 - 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 - Liner 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.

EE682 - 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 bussiness 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.

EE683 - ADVANCED TOPICS IN POWER ELECTRONICS

Objective:
To give an introduction to the recent developments of power electronics from components, topology, control techniques to thermal & EMC. This course drives on the application requirements of power electronics. This is a higher level of subject that will help to work in demanding areas of power electronics.

Outcome:
The student will have introduction to recent trends in power electronics that application demands. They will get a wide knowledge on the advanced topics to choose their area of future interest.

Prerequisite:
Power Electronics course in UG with knowledge on Basics of semiconductor switches, Basics of converter topology (AC-DC,AC-AC & DC-DC), basic control techniques of Power Electronic Equipment, Basics of reactive elements, storage and high frequency magnetic, Basics of EMC & any power simulation environment.

Introduction to switches - Advanced Silicon devices - Silicon HV thyristors, MCT, BRT & EST. SiC devices - diodes, thyristors, JFETs & IGBTs. Gallium nitrate devices - Diodes, MoSFETs.

Advance converter topologies for PEE - Interleaved converters, Z-Source converters, Multi level converters (Cascaded H-Bridge, Diode clamped, NPC, Flying capacitor) Multi pulse PWM current source converters, Advanced drive control schemes.

Advances in reactive elements - Advanced magnetic material, technology and design (Powder ferrite, Amorphous, Planar designs) Advance capacitive designs (Multilayer chip capacitors, double layers for storage, Aluminum electrolytic)

Advance storage systems - Developments in battery systems, Ultra capacitors, Fly wheel energy storage, Hybrid storage systems for EV/HEV, Power management in hybrid systems, Energy storage in renewables.

Thermal engineering with EMI/EMC techniques - Advanced thermal solutions (fan cooled, liquid cooled, heat pipes, hybrid techniques) EMC techniques (Conducted, Radiated emissions & Susceptibility), System design for EMC

References:

1. Andrzej M Trzynadlowski, ‘Introduction to Modern Power Electronics, John Wiley and sons. Inc, New York, 1998
2. R D MiddleBrook & Slobodan CUK, 'Advances in Switched Mode Power Conversion', Vol I, II, & III, Tesla Co (optimum power conversion)
3. B. Jayant Balinga, 'Advanced High Voltage Power Device Concepts', Springer New York 2011. ISBN 978-1-4614-0268-8
4. BIN Wu, ' High Power Converters and AC Drives', IEEE press Wiley Interscience, a John wiley & sons Inc publication 2006
5. Wurth Electronics, 'Trilogy of Magnetics, Design guide for EMI filter design in SMPS & RF circuits', 4th extended and revised edition.

EE684 - DESIGN TECHNIQUES FOR SMPS

Objective:

To give a practical step by step approach for design and assembly of Power Supplies and apply the necessary recent technology to comply the standards and certification requirements.

Outcome:

1. An ability to design a system or component, or process to meet the stated practical specifications and standards
2. An ability to use modern engineering techniques, skills, and tools to implement and organize system design and engineering under stated conditions

Prerequisite:

Power Electronics course in UG with knowledge on Basics of semiconductors, Basics of Power supplies- LPS & SMPS, Basic topologies in SMPC, Control of power semiconductors, Basics of high frequency magnetic, Basics of EMC & any power simulation environment.

Introduction of Available Sources & demanding loads: Sources - AC mains, Lab supplies, Batteries, Solar Cells Loads - Requirements of load, battery as load, Selection of Topology : Step-Up / Step-Down, Multiple outputs, Continuous & discontinuous modes of operation, Isolated converters, Various configurations of Converters, Selection of Components: Selection of Resistors, Chokes, Capacitors, Diodes, MoSFETs & IGBTs, Connectors, Design of Magnetics Fundamentals & ideal conditions, design of High frequency chokes & transformers, Selection of wire gauge, sealing of magnetics

Guide to Instrumentation: Basics of measurements using DMM, Oscilloscope, Electronic loads, etc Design of Magnetics Fundamentals & ideal conditions, design of High frequency chokes & transformers, Selection of wire gauge, sealing of magnetics Design of Feedback circuits Basic control requirements, Current & voltage mode control fundamentals & system stability conditions Design of Control and Monitoring circuits Practical Control circuitry & Monitoring circuitry requirements

Evaluations and Thermal management Performance evaluations of SMPS & thermal loss calculations and cooling options & packaging of converter EMI control requirements Overview of EMC, differentiating signal and noise, Layout concepts Low & High frequency filtering requirements, Optimal filter design Worst case analysis Introduction to datasheet reading, operation tuned to datasheet, typical worst case analysis

Standards governing the power supplies IEC standards for Electrical & Environmental testing, certification standards, Ingress protection standards Recent trend in Power supplies Recent advancements in components, Recent advancements in topologies, Digital control of power supplies, Power Integration & its Low power applications

Analysis and Simulation using PSIM : BUCK, BOOST & BUCK BOOST, Typical discrete power factor corrector circuit

References:

1. Ned Mohan ,Undeland and Robbins, 'Power Electronics Converters, Applications and Design', 2nd Edition, John Wiley&sons ,1995.
2. Abraham I Pressman, Keith Billings, Taylor Morey, 'Switching Power Supply Design', 3rd Edition, McGraw-Hill 2009.
3. L. Umanand and S R Bhat, 'Design of Magnetic Components for Switched Mode Power Converters', Wiley Eastern Limited.
4. International Standard, IEC 60571 Edition 2.1 2006-12.

EE685 - 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. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012.
3. Vehbi C. Güngör, DilanSahin, TaskinKocak, 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.

EE686 - ELECTRIC 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 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. Freries LL , 'Wind Energy Conversion Systems', Prentice Hall, U.K., 1990.

EE687 - EMBEDDED PROCESSORS AND CONTROLLERS

Objective:

To enrich the leaner with process 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 and controllers suited for varied applications.

Prerequisite:

Digital Electronics, Microcontroller and microprocessor, 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, I^2C, 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. 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.

EE688 - 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.

EE689 - 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

EE690 - 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.

EE691 – 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
3. Bimal Bose, 'Power electronics and motor drives', Elsevier, 2006
4. Ion Boldea and S.A Nasar, 'Electric drives', CRC Press, 2005

EE692 - ENERGY STORAGE SYSTEMS

Objective:
To emphasize basic physics, chemistry, and engineering issues of energy storage devices, such as batteries, thermoelectric convertors, fuel cells, supercapacitors.

Outcome:
Upon completion of this course , students will be able to apply energy storage schemes in electrical systems

Prerequisite:
Fundamental Chemistry and Material Science

Prospect for both traditional and renewable energy sources - detailed analysis of Indian energy market and future need through 2020 - energy, economic growth and the environment, implications of the Kyoto Protocol, and structural change in the electricity supply industry

Batteries - performance, charging and discharging, storage density, energy density, and safety issues, classical batteries - Lead Acid, Nickel-Cadmium, Zinc Manganese dioxide, and modern batteries -Zinc-Air, Nickel Hydride, Lithium Battery.

Thermoelectric - electron conductor and phonon glass, classical thermoelectric materials (i) four-probe resistivity measurement, Seebeck coefficient measurement, and thermal conductivity measurement.

Supercapacitors - types of electrodes and some electrolytes, Electrode materials - high surface area activated carbons, metal oxide, and conducting polymers, Electrolyte - aqueous or organic, disadvantages and advantages of supercapacitors - compared to battery systems, applications - transport vehicles, private vehicles, and consumer electronics - energy density, power density, price, and market.

Fuel cells - direct energy conversion - maximum intrinsic efficiency of an electrochemical converter, physical interpretation - carnot efficiency factor in electrochemical energy convertors, types of fuel cells - hydrogen oxygen cells, hydrogen air cell, alkaline fuel cell, and phosphoric fuel cell.

References:

1. Tetsuya Osaka, Madhav Datta, ‘Energy Storage Systems in Electronics’, Gordon and Breach Science Publishers, 2000.
2. R. M. Dell, D.A.J. Rand, ‘Understanding Batteries’, RSC Publications, 2001.
3. James Larminie, Andrew Dick, ‘Fuel Cell System Explained’, J. Wiley, 2003.
4. D.M. Rowe, ‘Thermoelectrics Handbook: Macro to Nano’, CRC Press, 2006.