DEPARTMENT OF ELECTRICAL ENGINEERING

Course Book for

M.Tech. in Integrated Power Systems

Visvesvaraya National Institute of Technology

2014

Brief about M.tech. programs:

The main Objectives: of IPS-PG program are

1. To develop specified manpower for electrical power and energy industry.
2. To enhance analytical skills so as to enable to solve complex industrial problems.
3. To augment the student's capacity in pursuing research in emerging areas of power systems.
4. To improve student's perspective towards environmental issues by sensitizing and building the awareness of green technologies.
5. To inculcate the culture of research oriented projects with state of art facility laboratories in power systems.

Department of Electrical Engineering offers M.TECH. program in Integrated Power Systems & M.TECH. program in Power Electronics & Drives. These are four semester programs, where in students has to complete certain number of credits as indicated in Table 1. Each subject (or course) has certain number of credits. There are two type of subjects: Core and Elective. Core courses are compulsory and some courses from electives are to be taken to complete the required credits.

Departmental core (DC)		**Departmental Electives (DE)**	
Category	Credit	Category	Credit
Departmental core (DC)	70	Departmental Electives (DE)	34
Grand Total (DC+DE)			104

The number of credits attached to a subject depends on number of classes in a week. For example, a subject with 3-0-2 (L-T-P) means it has 3 Lecture, 0 Tutorial and 2 Practical hours in a week. This subject will have eight credits (3x2 + 0x1 + 2x1 = 8). If a student is declared pass in a subject, then he/she gets the credits associated with that subject. Depending on marks scored in a subject, student is given a Grade. Each grade has got certain grade points as follows:

Grades	AA	AB	BB	BC	CC	CD	DD	FF
Grade Points	10	09	08	07	06	05	04	Fail

The performance of a student will be evaluated in terms of two indices, viz. the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point of time. SGPA & CGPA are:

$$\textbf{SGPA} = \frac{\sum_{\text{semester}}(\text{Course credits X Grade points})\text{for all courses except audit}}{\sum_{\text{semester}}(\text{Course credits })\text{for all courses except audit}}$$

$$\textbf{CGPA} = \frac{\sum_{\text{All semester}}(\text{Course credits X Grade points})\text{for all courses with pass grade except audit}}{\sum_{\text{All semester}}(\text{Course credits })\text{for all courses except audit}}$$

Students can Audit a few subjects. i.e., they can attend the classes and do home work and give exam also, but they will not get any credit for that subject. Audit subjects are for self enhancement of students.

The Cumulative Grade Point Average (CGPA) earned by the student on a scale of 10 is an indication of his/her academic standing and in the class. Where, for purpose of placement of students and/or their eligibility for competitive exams etc., a conversion of CGPA to percentage is required, a CGPA of 10 may be deemed to be 100% and accordingly the following table is used for conversion. Further, the institute does not issue certificate towards position/rank at the class or institute level.

CGPA	4.00	5.0	6.0	7.0	8.0	9.0	10.0
Percentage	40	50	60	70	80	90	100

Details about faculty members of Electrical Engineering Department

Name of Faculty Member	Designation	Qualification	Areas of Specialization
Aware M.V.	Professor & H.O.D	Ph.D.	Electrical Drives, Power Electronics, High Voltage Engineering
Ballal M.S.	Associate Professor	Ph.D.	Condition Monitoring, Incipient Fault Detection, Power Quality
Bhat S.S.	Associate Professor	Ph.D.	Power System Analysis
Bhide S.R.	Associate Professor	Ph.D.	Power System Protection, Artificial Intelligence Technique
Bhorgate V.B.	Associate Professor	Ph.D.	Power Electronics, Electrical Machine Design
Chaudhari M.A.	Associate Professor	Ph.D.	Power Quality, Power Electronics
Dhabale A.	Assistant Professor	M.TECH.	Control Systems, Electrical Drives
Junghare A.S.	Associate Professor	Ph.D.	Power Systems, Control Systems
Kale V.S.	Associate Professor	Ph.D.	Power System Protection, A.I Applications in Power Systems
Khedkar M.K.	Professor	Ph.D.	On deputation
Kulkarni P.S.	Associate Professor	Ph.D.	Power Systems Operation & Control, Renewable Energy Systems
Patne N.R.	Assistant Professor	Ph.D.	Power Systems, Power Quality
Patnaik S.P.	Associate Professor	Ph.D.	Power Electronics Converters
Ramteke M.R.	Associate Professor	Ph.D.	Power Electronics
Satputaley R.J.	Assistant Professor	M.tech.	Power Systems, Power Quality
Suryawanshi H.M.	Professor	Ph.D.	Power Electronics, Electrical Drives
Tambay S.R.	Assistant Professor	M.tech.	Power System Protection, Power System Analysis
Umre B.S.	Associate Professor	Ph.D.	Power Systems, Electrical Machines

SCHEME OF EXAMINATION/INSTRUCTION-

M.TECH. (IPS)

I Semester

Code	Course	L-T-P	Credits
Core			
EEL501	Power System Analysis	3-0-0	6
EEL502	Power System Dynamics I	3-0-0	6
EEL504	Digital Protection of Power System	3-0-0	6
EEP501	Power System Analysis Lab	0-0-2	2
EEP504	Digital Protection of Power System	0-0-2	2
Elective (Any Two)			
EEL409	HVDC	3-0-0	6
EEL421	Power Quality	3-0-0	6
EEP421	Power Quality lab*	0-0-2	2
EEL410	Advanced Control theory	3-0-0	6
	Total credits	34/36	
* compulsory with EEL421			

II Semester

Code	Course	L-T-P	Credits
Core			
EEL507	Power System Dynamics II	3-0-0	6
EEL414	µP Application to PE/PS	3-0-0	6
EEL503	Power System Management	3-0-0	6
EEL411	FACTS	3-0-0	6
EEP411	FACTS lab	0-0-2	2
EEP507	Power System Dynamics Lab	0-0-2	2
Elective (Any Two)			
EEL413	Advanced Electric Drives & Control	3-0-0	6
EEL408	Advanced Power Electronics	3-0-0	6
EEP499	Power Electronics & Drives Lab*	0-0-2	2
EEP413	Advanced Electric Drives Lab*	0-0-2	2
EEL512	Distributed Generation	3-0-0	6
EEP512	Distributed Generation Lab*	0-0-2	2
	Total Credits	36	
*Compulsory with theory course			

III Semester

Code	Course	L-T-P	Credits
Core			
EED501	Project Phase-I	---	6
Elective (Any two)			
EEL505	AI Based Systems	0-0-3	6
EEL506	Special Topics in PS	0-0-3	6
EEL407	Electrical Power Distribution System	0-0-3	6
	Total Credits	18	

IV Semester

Code	Course	L-T-P	Credits
Core			
EED502	#Project Phase-II (# prerequisite: Project Phase-I)	0-0-9	18

FIRST SEMESTER

EEL501: POWER SYSTEM ANALYSIS (3-0-0- Credits-6)

Objectives:

- Getting detailed information of load flow techniques
- Learning about fault analysis, voltage stability and various errors in power system

Syllabus:

Load flow: overview of Newton–Raphson, Gauss-siedal and fast decoupled methods, convergence properties, sparcity techniques, handling Q-max violations in constant matrix, inclusion in frequency effects, AVR in load flow, handling of discrete variable in load flow.

Fault analysis: simultaneous faults, open conductors fault, generalized method of fault analysis

Security analysis; security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, multiple line outages, overload index ranking.

Power system equivalents: WARD and REI equivalents.

State estimation, sources of errors in measurement, virtual and pseudo, measurement, observability, tracking state estimation, WSL method, bad data correction.

Voltage stability: voltage collapse, pv curve, multiple power flow solution, continuation power flow, optimal multiplies based load flow, voltage collapse proximity indices.

Text Books:

1. J. J. Stevenson, "Power system analysis by Grainger", Mc Graw Hill, 1994.
2. Arther Berger, "Power System Analysis" ,Pearson Publications.
3. M.A PAI 'Power System Analysis'.

Reference Books:

1. Kusic, "Computer aided power system analysis", Prentice Hall India.
2. A. J. Wood, "Power generation, operation and control", John Wiley 1994.
3. P .M. Anderson, "Faulted power system analysis".
4. L. L. Grisby, "Power system stability and control", CRC press, 2007.
5. V.Ajjarapu, Springler, "Computational techniques for assessment of voltage stability and control," 2006.

EEL502: POWER SYSTEM DYNAMICS I (3-0-0- Credits-6)

Objectives:

- Study of system dynamics and its physical interpretation

Syllabus:

Synchronous Machines: Per unit systems, Park's Transformation (modified), Flux-linkage equations, Voltage and current equations, Formulation of State-space equations, Equivalent circuit. Sub-transient and transient inductance and Time constants, Simplified models of synchronous machines.
Small signal model, Introduction to frequency model, Excitation systems and Philips-Heffron model, PSS
Load modelling, Modelling of Induction Motors, Prime mover controllers.

Text Books:

1. Padiyar K.R.; Power System Dynamics, Stability and Control; B.S. Publications, Hyderabad 2002.
2. Kimbark, E.W.; Power system stability, Vol. I & III, John Wiley & Sons, New York 2002.

Reference Books:

1. P. M. Anderson and A. A., Fouad "Power System Control and Stability", Galgotia Publications, New Delhi, 1981.
2. J Machowski, J Bialek. and J. R W. Bumby. "Power System Dynamics and Stability", John Wiley & Sons, 1997
3. P.Kundur, "Power System Stability and Control", McGraw Hill inc., 1994.

4. ***www.IEEE xplorer***

EEL504: DIGITAL PROTECTION OF POWER SYSTEMS (3-0-0- Credits-6)

Objectives:

- Study of relays
- Mathematical approach towards protection
- Study of algorithms for numerical protection

Syllabus:

Evolution of digital relays from electromechanical relays, Performance and operational characteristics of digital protection.

Mathematical background to protection algorithms: Finite difference techniques, Interpolation formulas: forward, backward and central difference interpolation, Numerical differentiation, Curve fitting and smoothing, Least squares method, Fourier analysis, Fourier series and Fourier transform, Walsh function analysis.

Basic elements of digital protection: Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers, Conversion subsystem: the sampling theorem, signal aliasing error, sample and hold circuits, multiplexers, analog to digital conversion, Digital filtering concepts, The digital relay as a unit consisting of hardware and software.

Sinusoidal wave based algorithms: Sample and first derivative (Mann and Morrison) algorithm. Fourier and Walsh based algorithms: Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm. Walsh function based algorithm.

Least Squares based algorithms. Differential equation based algorithms.

Traveling Wave based Techniques. Digital Differential Protection of Transformers. Digital Line Differential Protection.

Recent Advances in Digital Protection of Power Systems.

Text Books:

1. A. G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009.
2. A. T. Johns and S. K. Salman , 'Digital Protection of Power Systems', IEEE Press , 1999.

Reference Books:

1. Gerhard Zeigler, "Numerical Distance Protection" ,Siemens Publicis Corporate Publishing, 2006.
2. Y. G. Paithankar, S.R. Bhide – " Fundamentals of Power System Protection", PHI, 2nd edition, 2010.
3. H.J Altuve Ferrer, E.O. Schweitzer, 'Modern Solutions for Protection of Control & Monitoring of Power Systems, 2010.
4. Emmanuel Ifeachor , B.W.Jervis, 'Digital Signal Processing A Practical Approach', Pearson 2007.

EEP504: DIGITAL PROTECTION OF POWER SYSTEMS (0-0-2- Credits- 2)

List of Experiments:

1) Familiarization with various features of MATLAB/Simulink environment.
2) Demonstrating the phenomenon of aliasing due to under-sampling.
3) Implementation of algorithms based on undistorted sinwave approximation like
    - Sample and it's derivative
    - 3-sample technique
    - 2-sample technique
    - First and second derivative technique
4) Implementation of Differential Equation Algorithm (DEA)
    - Numerical differentiation
    - Numerical integration
5) Implementation of Sachdev's Least Square Error (LSQ) Algorithm.
6) Implementation of Fourier algorithms like

- DFT
- Sliding DFT
- FFT (decimation in time and decimation in frequency)

7) Studying response of DFT to off-nominal frequency signal and it's relevance in synchrophasor applications.
8) Implementation of Goertzel's algorithm for extracting specific frequency component.
9) Implementation of digital low-pass FIR filters and plotting their frequency response.

Text Books:

1. A.T.Johns and S.K.Salman , "Digital Protection of Power Systems", Peter Peregrinus/IEE,1997.

Reference Books:

3. A.G.Phadke and J.S.Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009.
4. A.G.Phadke and J.S.Thorp, "Synchronized Phasor Measurements and Their Applications", Springer, 2008.
5. R.G.Lyons, "Understanding Digital Signal Processing", Pearson, 2002.

EEP501: POWER SYSTEM ANALYSIS (0-0-2-Credits -2)

List of Experiments:

1) Write a program to form Y bus by Inspection method.
2) Write a program for formation of Y bus by singular matrix transformation.
3) Study of load flow methods
   a) Gauss Siedal method
   b) Newton Raphson method
4) Write a program for fault analysis for
   a) LG b) LLG c) LLL
5) Write a program for security analysis using load flow & ranking of contingency.
6) Write a program for ranking of contingency using overload security analysis.
7) Study of Mi Power Software.
8) Write a program to form Z_{bus} matrix.

EEL409: HVDC (3-0-0- Credits-6)

Objectives:

- To expose the students to the state of the art HVDC technology.
- Methods to carry out modeling and analysis of HVDC system for inter-area power flow regulation.

Syllabus:

Development of HVDC Technology, DC versus AC Transmission, Selection of converter configuration.

Rectifier and Inverter operation, Digital Simulation of converters, Control of HVDC converters and Systems, Individual phase control, Equidistant firing controls, Higher level controls.

Characteristics and non-characteristics harmonics filter design.

Fault development and protection, interaction between AC-DC power systems.

Over voltages on AC/DC side, multi-terminal HVDC systems, control of MTDC systems.

Modeling of HVDC systems, per unit system, Representation for power flow solution, representation for stability studies.

Text Books:

1. J. Arrillaga, "High Voltage Direct Transmission", Peter Peregrinus Ltd. London, 1983.
2. K. R. Padiyar, "HVDC Power Transmission Systems", Wiley Eastern Ltd., 1990.

Reference Books:

1. E. W. Kimbark, "Direct Current Transmission", Vol. I, Wiley Interscience, 1971.
2. Erich Uhlmann, "Power Transmission by Direct Current", B.S. Publications, 2004.

EEL421: POWER QUALITY (3-0-0- Credits-6)

Objectives:

- To study literature of power quality.
- Effect of power quality in distribution system, mitigation of power quality problem by power electronic devices are studied.

Syllabus:

Introduction to power quality, PQ standards, terms, definitions

Voltage sag and interruptions, its sources, types, characteristics, behavior of different electric equipments, concept of area of vulnerability

Voltage swell and transient overvoltages, sources of overvoltages like capacitor switching, load switching, lightening etc. problems due to over voltages, computer tools for transient analysis

Harmonics distortions, voltage and current harmonics, THD , sources of other harmonics, its ill effects, interharmonics, harmonic filters, other PQ problems like EMI, noise, notching , flicker , DC offset.

Typical wiring and grounding problem causing poor power quality, solutions to wiring and grounding problem

Need of measuring and monitoring of PQ problems, location of monitoring equipments and frequency

Text Books:

1. Roger C. Dugan, "Electrical power system quality", Mc Graw-Hill.
2. Alexander Kusko, "Power quality in electrical systems", Mc Graw-Hill.

Reference Books:

1. Ewald Fusch, "Power quality in power system and electrical machines", Academic press.
2. H.J.Math, "Understanding power quality problems: voltage sags and interruptions", by IEEE press.

EEL410: ADVANCED COTROL THEORY (3-0-0- Credits -6)

Objectives:

- To teach determination of linear and non-linear systems' relative stability
- Study of analog and digital control techniques

Syllabus:

Review of State variable analysis, Controllability and observability.

Digital Control Systems, Models of Digital control Devices, State description of Digital processors and sampled continuous time plants, Discretisation of Digital continuous time state equations, Solution of state difference equation.

Controllability and observability tests for digital control systems, Stability of discrete time systems, Pulse transfer function and its realization, Stability improvement by state feedback, Pole-placement design and state observers

Text Books:

1. M.Gopal, "Digital Control and State Variable Methods", Tata McGraw Hill, New Delhi, 1997.

Reference Books:

1. D.E. Kirk, "Optimal Control Theory", Prentice Hall, 1970.
2. M.Gopal, "Digital Control Engineering", Wiley Eastern, 1988.

EEP421: POWER QUALITY (0-0-2- Credits-2)

List of experiments:

1. To study the effect of non linear loads on power quality.
2. To demonstrate the voltage and current distortions experimentally.
3. To reduce the current harmonics with filters.
4. To study the voltage sag due to starting of large induction motor.
5. To study the capacitor switching transients.
6. To study the effect of balanced non linear load in a three phase circuit on neutral current.
7. To study the effect of ground loop.
8. To study the effect of voltage flicker on power quality.
9. To calculate the distortion power factor.
10. Study the effect of harmonics on meter reading.
11. To study effect of voltage sag on electrical equipments.
12. To obtain the current harmonics drawn by power electronics interface using PSCAD software.

SECOND SEMESTER

EEL507: POWER SYSTEM DYNAMICS –II (3-0-0- Credits-6)

Objectives:

- Study of system dynamics and its physical interpretation

Syllabus:

Basic Concepts of Dynamic Systems and Stability Definition Small Signal Stability (Low Frequency Oscillations) of Unregulated and Regulated System, Effect of Damper, Flux Linkage Variation and AVR.

Large Signal Rotor Angle Stability, Dynamic Equivalents And Coherency, Direct Method of Stability Assessment, Stability Enhancing Techniques, Mitigation Using Power System Stabilizer, Asynchronous Operation And Resynchronization. Multi-Machine Stability.

Dynamic Analysis of Voltage Stability, Voltage Collapse.

Frequency Stability, Automatic Generation Control, Primary and Secondary Control.

Sub-Synchronous Resonance and Counter Measures.

Text Books:

1. P.Kundur, “Power System Stability and Control”, McGraw Hill Inc, 1994.
2. J. Machowski, Bialek, Bumby, “Power System Dynamics and Stability”, John Wiley & Sons, 1997.

Reference Books:

1. K.R. Padiyar, “Power System Dynamics, Stability and Control”, B.S. Publications, Hyderabad 2002.
2. L.Leonard Grigsby (Ed.); “Power System Stability and Control”, Second edition, CRC Press, 2007.
3. V. Ajjarapu, “Computational Techniques for voltage stability assessment & control”; Springer, 2006.

EEL414: MICROCONTROLLERS AND THEIR APPLICATIONS IN POWERELECTRONICS AND POWER SYSTEMS (3-0-0-Credits-6)

Objectives:

- ***To learn architecture and instruction set of microcontroller.***
- ***To learn embedded c programming.***
- ***To study interfacing concepts and applications in area of power system and power electronics.***

Syllabus:

Introduction to Microcontrollers: Comparison of Microcontroller with Microprocessor, Criteria for choosing a microcontroller for particular application, Overview of 8051 family.

Introduction to 8051 microcontroller: Review of Architecture, Pin description, Special Function Registers, Addressing Modes, Instruction Set, Assembler directives, illustrative examples, Subroutines, parameter passing to subroutines.

Programming 8051microcontroller using Assembly Language and 'C' Language: I/O port programming, on-chip timer/counter programming, Serial port programming, Interrupt programming,

Interfacing: Interfacing of external memory chips, address allocation technique and decoding; LED, LCD and Keyboard interfacing, Interfacing data converters and sensors, RTC interfacing and programming

Introduction to PIC microcontrollers: Types, Features, Architecture and Programming of 8 bit PIC microcontroller.

Microcontroller Applications: Measurement of Various Electrical and Non-Electrical Parameters, Speed Monitoring and Control of Various Motors, Control of Firing Circuits of Power Electronics Systems, Numerical Protective Relays etc.

Text Books:

1. M.A.Mazidi, J.G.Mazidi, R.D.McKinlay, 'The 8051 Microcontroller and Embedded Systems using Assembly and C', Pearson Education2
2. Ayala, Kenneth J., 'The 8051 Microprocessor Architecture, Programming and Applications', Penram International.

Reference Books:

1. Subrata Ghoshal, '8051 Microcontroller: Internals, Instructions, Programming and Interfacing', Pearson Education.
2. A.V.Deshmukh, "Microcontrollers Theory and Applications", Tata MaGraw Hill.

EEL503: POWER SYSTEM MANAGEMENT (3-0-0- Credits -6)

Objectives:

- Indepth study of power flow in power system and co-ordination between various types of generation stations
- Study of parameters regarding active and reactive power

Syllabus:

Optimum power flow, Co-ordination of steam, hydro and nuclear power stations.
Optimum generation allocation to thermal units with and without transmission losses, emission dispatch.
Hydro-thermal co-ordination, Unit commitment.

Loss minimization by reactive power control. Active and reactive power optimization by non-linear programming method.

Text Books:

1. PSR Murthy, "Power System Operation and Control" Tata McGraw-Hill, New Delhi; 1984.
2. Nagrath and Kothari., "Power System Engineering", Tata McGraw-Hill, 2003.

Reference Books:

1. L.K. Kirchmayer., "Economic Operation of Power System; Economic Operation of Power System", Johy Wiley, New York, 1958.
2. A.J. Wood and B.F. Wollenberg, " Power Generation Operation and Control", John Wiley & Sons INC", 1984.

EEL411: FACTS (3-0-0- Credits-6)

Objectives:

- To impart the knowledge, to tackle the problem of regulatory constraints on the expansion of power transmission network by introduction of high power electronic controllers for regulation of power flow and voltages in the AC transmission network.

Syllabus:

Introduction of semiconductor devices, Steady state and dynamic problems in AC systems, Power flow.
Flexible AC transmission systems (FACTS) : Basic realities & roles, Types of facts controller, Principles of series and shunt compensation.

Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC).
Modelling and Analysis of FACTS controllers. Control strategies to improve system stability. Power Quality problems in distribution systems.

Harmonics, harmonics creating loads, modelling, Series and parallel resonances, harmonic power flow, Mitigation of harmonics, filters, passivefilters.

Active filters, shunt, series hybrid filters, voltage sags and swells, voltage flicker. Mitigation of power quality problems using power electronic conditioners. IEEE standards.29.

Text Books:

1. N.G. Hingorani, "Understanding of FACTs", IEE press.
2. T.E.Acha, "Power Electronics Control in Electrical Systems" , New NES (Elsevier) Publication, 2006.

Reference Books:

1. G.T. Heydt, Power Quality, "Stars in a Circle Publications, Indiana, 1991.
2. T.J.E. Miller, "Static Reactive Power Compensation", John Wiley & Sons, New York, 1982.
3. Yong Hua Song, "Flexible AC transmission system (FACTS)".
4. Recent publications on IEEE Journals.

EEP411: FACTS LAB:

List of experiments:

1. Familiarization with PSCAD/EMTDC, power world simulator software.
2. Understanding of Reactive Power and Power Factor Correction in AC Circuits
3. To study the effect of real and reactive powers on bus voltages
4. To study the influence of including a tap-changer and a phase-shifter on power flow and bus voltage
5. Modelling of Thyristor Converters.
6. Modelling of Thyristor Controlled Reactors (TCR).
7. Modelling of Thyristor Controlled Series Capacitors (TCSC) .
8. Modelling of Static Shunt compensator (STATCOM).
9. Modelling of Static Synchronous Series compensator (SSSC).

EEP507: POWER SYSTEMS DYNAMICS LAB (0-0-2- Credits **-2)**

List of experiments:

1) Study of ATP, PSCAD and MATLAB (Simulink) software
2) Simulation of machine dynamics
3) Simulation of AVR, PSS models
4) Simulation of various faults in power system
5) Study of Transient over voltages
6)Simulation of Travelling waves
7) Simulation of SSR
8) Stability studies – i) Large/small signal rotor angle stability ii) voltage instability.

EEL413: ADVANCED ELECTRICAL DRIVES AND CONTROLS (3-0-0- Credits **-6)**

Objectives:

- Understand the modeling of AC/DC machines.
- Design procedure of controllers in closed loop operation.
- Various new control method to improve the performance of the motors in industrial applications.

Syllabus:

Dynamics of Electric Drives: Basic elements of an electric drives, Classification of electric drives, Stability consideration of electric drives.

Analysis of Electric Machinery: Voltage and torque equations in machines variables, theory of direct current machines, Theory of symmetrical induction machines, Theory of synchronous machines, Reference frame theory, Literalized machine equations.

Solid State Converters for Drives:Solid state converters for DC drive system, Speed control techniques, Variable frequency control of A. C. motors using inverters, Slip energy recovery and rotor resistance control of induction motor.

Control of DC/AC machines:State variable approach, Scalar / Vector control of induction motors.
Digital Control of Drives:Application of microprocessors / computers in electrical drives control, Switch reluctance motors and permanent magnet brushless dc motors.

Text Books:

1. G.K. Dubey, "Fundamentals of Electrical Drives", CRC Press, 2002.
2. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, India ,1984.
3. R.Krishnan, "Electric Motor Drives, Modelling, Analysis and Control", Prentice Hall India, 2003.

Reference Books:

1. I Bridges. & S.A. Nasar, "Electric Machine Dynamics", Macmillan Publishing Company, NY, 1986.
2. B.K Bose., "Power Electronics and AC Drives", Printice Hall, NJ, 1985.
3. R.Krishnan,"Electric Motor Drives, Modelling", Analysis and Control; Prentice Hall India, 2003.
4. P.C. Krause, "Analysis of Electrical Machinery", McGraw Hill 1987.

EEL408: ADVANCED POWER ELECTRONICS (3-0-0- Credits- **6)**

Objectives:

- To impart knowledge of recent and advanced developments in PE area.
- To study the advanced applications of PE converters.
- To introduce the topologies of energy conversion in PE.

Syllabus:

Overview of power semiconductor devices – their characteristics, ratings and protection. Analysis of multi-pulse controlled line commutated converters. DC-DC converter operations in DCM/CCM mode. Isolated/non-isolated converter topology. Multi-phase/multilevel DC-DC converter operation. DC-AC converter control and their various PWM techniques. Multi-level/Multiphase DC-AC converter operation. AC-AC converters and their operation. Design and Modeling of converters (active and passive elements) with their performance parameters.
SVCs and Power conditioners.

Text Books:

1. N.Mohan, T.M.Undeland , W.P.Robbins, "Power Electronics, Converters, Applications and Design", John Wiley & Sons, 1995.
2. M. H. Rashid, "Power Electronics, Circuit, Devices and Applications", Prentice-Hall of India, 3rd Edition 2000.

Reference Books:

1. C. W Lander, " Power Electronics", McGraw Hill, 1993.
2. Joseph Vithyathil,"Power Electronics, Principles and Applications", McGraw Hill.
3. Bin Wu, "High Power converter and AC drives" , Wiley –IEEE Press, (2006).

EEP499: PE & DRIVES LAB (0-0-2- Credits **-2)**

PE Lab:
List of experiments:

1) To study DC circuit breaker using SCR.
2) To study phase control AC-DC converter using SCR.
3) Simulation of i) Single phase half wave rectifier.
ii) Single phase full wave fully controlled rectifier [R, R-L, R & high L].
4) To study AC Voltage regulator using triac.
5) To study single phase inverter using self controlled devices as IGBT/MOSFET(single PWM, Multiple PWM, Sinusoidal PWM).
6) To study the Three phase inverter.
7) To study DC-DC converter i) Buck converter ii) Boost converter.iii) Flyback and forward converter.

8) Simulation of following experiments using PSIM

i) AC Voltage regulator using SCR

ii) Single phase inverter using self controlled devices as IGBT/MOSFET (Single PWM, Multiple PWM, sinusoidal PWM).

iii) Three phase inverter.

iv) DC-DC converter **: -** a) Buck converter. b) Boost converter.

ELECTRICAL DRIVES LAB:

List of Experiments:

1) Time response of the separately excited dc motor
2) Three phase fully controlled converter driven DC Sep. Exc. Motor
3) DC-DC Buck converter for DC motor speed control
4) DC-DC boost converter for DC motor speed control
5) 1-phase AC Voltage controller for IM
6) 1-phase inverter operation and performance analysis
7) PID controller-Design and implementation for close loop operation of electrical drives.

EEP413: ADVANCED ELECTRICAL DRIVES LAB (0-0-2- Credits **-2)**

List of Experiments:

1) Analysis of separately excited dc motor
2) Study of speed control of dc motor using 3-phase fully controlled bridge rectifier
3) Study of phase controlled AC regulator
4) Transformation of AC induction machine variables from one reference frame to another
5) Induction motor modeling in state space form
6) Study of sinusoidal pulse width modulation (SPWM Technique)
7) Study of variable speed induction motor drive using V/F control
8) Study of current regulation SPWM FOC induction motor drive.
9) DTC control of Induction Motor drive.

EEL512: DISTRIBUTED GENERATION (3-0-0- Credits-6)

Objectives:

- ***To learn the principles of generating Heat Energy and Electrical energy from Non-conventional / Renewable Energy Sources.***

- ***To gain understanding of the working of Off-grid and Grid-connected Renewable Energy Generation Schemes.***

Syllabus:

Introduction, Distributed vs Central Station Generation, Sources of Energy such as Micro-turbines, Internal Combustion Engines, Solar Energy, Wind Energy, Combined Heat and Power, Hydro Energy, Tidal Energy, Wave Energy, Geo Thermal Energy, Bio Mass and Fuel Cells, Power Electronic Interface with the Grid, Impact of Distributed Generation on the Power System, Power Quality Disturbances, Transmission System Operation, Protection of Distributed Generators, Economics of Distributed Generation, Case Studies.

Text Books:

1. Ranjan Rakesh, Kothari D.P, Singal K.C, 'Renewable Energy Sources and Emerging Technologies', 2^{nd} Ed.

Reference Books:

1. Math H.Bollen,Fainan Hassan, 'Integration of Distributed Generation in the Power System', July 2011, Wiley –IEEE Press.
2. Loi Lei Lai, Tze Fun Chan, 'Distributed Generation: Induction and Permanent Magnet Generators', October 2007, Wiley-IEEE Press.
3. Roger A.Messenger, Jerry Ventre, 'Photovoltaic System Engineering', 3^{rd} Ed, 2010.
4. James F.Manwell, Jon G.Mc Gowan,Anthony L.Rogers, John Wiley and Sons, 2^{nd} Ed,2010.

EEP512: DISTRIBUTED GENERATION LAB (0-0-2- Credits-2)

List of experiments:

1 Single PV module I-V and P-V characteristics with radiation and temperature changing effect.

2 I-V and P-V characteristics with series and parallel combination of modules.

3 Effect of shading and Effect of tilt angle on I-V and P-V characteristics of solar module.

4 Study of Stand-alone system using Combine AC and DC load system with battery.

5 Finding MPP by varying the resistive load by varying the duty cycle of DC-DC converter.

6 Finding P_{max} with different values of perturbation (delta D) .

7 Perform the experiment with battery in the circuit.

8 Observe the output voltage waveform of inverter in auto mode.

9 Observe the RMS value and waveform of output voltage with both 180 and 120 degree control.

10 Field Visit to Solar Street Lighting System.

11 Study of Solar PV Grid-Tied system.

12 Study of Wind Energy System .

<u>THIRD SEMESTER</u>

EED501: PROJECT PHASE I (0-0-3- Credits-6)

EEL505: AI BASED SYSTEMS (3-0-0- Credits-6)

Objectives:

- To learn various theoretical aspects of four major approaches to artificial intelligence namely, Artificial Neural Network, Fuzzy Logic, Genetic Algorithm and Expert System
- To study methodologies for applying AI techniques to the problems in the fiels of electrical engineering.

Syllabus:

Introduction:-Brief history of artificial intelligence, comparison with deterministic methods Aims objectives of artificial intelligence and current state of the art.

Fuzzy logic: Introduction to concepts, fuzzy reasoning, defuzzification, adaptive fuzzy systems

Expert systems: Introduction to knowledge based systems Structure and definitions Knowledge acquisition Inference engine, forward and backward chaining

Artificial Neural networks: Basic concepts, back-propagation, multi-layer networks, introduction to various paradigms, learning in neural networks

Evolutionary Computing (Genetic algorithms): Basic concepts

Applications of AI to power systems like alarm processing, condition monitoring, protective relaying etc.

Text Books:

1. M.T. Hagan, H.B.Demuth, M. Beale, " Neural Network Design", Cengage Learning.
2. S.Rajasekaran, G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", Prentice Hall of India.
3. Kevin Warwick, " Arthur Ekwue and Raj Aggarwal.; "Artificial Intelligence Techniques in Power Systems", The Institution of Electrical Engineers , London, 1989.

Reference Books

1. T.S. Dillon and M.A Laughtonm; "Expert system applications in power systems", Prentice Hall International, 1992.
2. Jacek M. Zurada, " Introduction to artificial neural Systems," Jaico Pub.House, 2003.
3. DanW. Patterson, "Introduction to artificial intelligence & Expert System", Prentice Hall of India, 2004.
4. Bart Kosko , " Neural networks and Fuzzy Systems", Prentice Hall of India, 1990.

EEL506: SPECIAL TOPICS IN POWER SYSTEM (3-0-0- Credits **-6)**

Objectives:

- To acquaint the students with current research topics in field of power system

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Syllabus:

Understanding Power quality, types of power quality disturbances, power quality indices, causes and effects of power quality disturbances

Radio interference, supply standards, elimination / suppression of harmonics, classical solutions and their drawbacks, passive input filters, high power factor pre regulator, switching control circuit, transformer connections.

Electromagnetic compatibility, constant frequency control, constant tolerance band control, variable tolerance band control, continuous current control

Need and conditions for deregulation introduction of market structure, market architecture, spot market, forward market and settlements. Review of concepts: marginal cost of generation, least cost operation, incremental cost of generation, old vs. new power system operation

Transmission network and market power, power wheeling transactions, and marginal costing, transmission costing, congestion management methods, market splitting, counter trading, effect of congestion LMPs-country practices.

Text Books:

1. R.C. Duggan, "Power Quality", Mc Graw Hill.
2. A.J. Arrillga , "Power Systems Harmonics".
3. S.Kirschen and G.Strbac, "Fundamentals of Power System Economic".

Reference Books:

1. S Stoft, "Power Systems Economics: Designing markets for Electricity".

www.ieeexplorer.org

EEL407: ELECTRIC POWER DISTRIBUTION SYSTEM (3-0-0- Credits -6)

Objectives:

- Learning about power management
- Study of automation- SCADA

Syllabus:

Load and Energy Forecasting: Distribution of power, Management, Power loads, Load forecasting, Power system loading, Technological forecasting. Need Based Energy Management (NBEM) – Objectives:, Advantages, Distribution Management System (D.M.S.)

Distribution Automation: Definition, Restoration / Reconfiguration of distribution network Different methods and constraints. Interconnection of Distribution, Control & Communication Systems.

SCADA: Introduction, Block diagram, SCADA applied to distribution automation. Common Functions of SCADA, Advantages of Distribution Automation through SCADA.

Calculation of optimum number of switches, capacitors, Optimum Switching Device Placement in Radial. Distribution Systems. Sectionalizing Switches – Types, Benefits. Bellman's Optimality Principle, Remote Terminal Units.

Maintenance of automated distribution systems, Difficulties in implementing distribution automation in actual practice, Urban/Rural Distribution, Energy Management.

Text Books:

1. A.S. Pabla, "Electric Power Distribution (Fourth Edition)", Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2000.
2. M.K. Khedkar, " Learning Material for Electrical Power Distribution", 2004.

Reference Books: www.IEEE xplorer

FOURTH SEMESTER

EED502: PROJECT PHASE II (0-0-9- Credits-18)