DEPARTMENT OF ELECTRICAL ENGINEERING

Revised Scheme

(To be implemented from July 2015)

and

Course Book

for

M.Tech. (Integrated Power Systems)

Visvesvaraya National Institute of Technology

2015

Brief Information about M.Tech. Program:

Objectives of MTech (Integrated Power Systems) program:

1. To develop specialized 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 the help of state of the art laboratories in power systems.

Department of Electrical Engineering offers M.Tech. program in Integrated Power Systems & M.Tech. program in Power Electronics & Drives. Both these programs are of four semester duration, wherein students have to complete specific number of credits as indicated in Table 1. Each subject (or course) has specific number of credits. There are two types of subjects: Core and Elective. All core courses are compulsory for the students and students can choose from electives courses so as to fulfil the credit requirements.

Table – I

Credit requirements for PG programs

Departmental core (DC)		**Departmental Electives (DE)**	
Category	Credit	Category	Credit
Program core (PC)	38	Program Electives (PE)	14
Grand Total (DC+DE)			52

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 Lectures, 0 Tutorials and 2 Practical hours in a week. This subject will have 4 credits (3x1 + 0x1 + 2x.5 = 4). 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:

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

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

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	Designation	Qualification	Areas of Specialization
Aware M.V.	Professor	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.	Professor & **H.O.D**	Ph.D.	Digital Power System Protection, A.I. Applications
Borghate 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 to Amravti Univ. as VC
Kulkarni P.S.	Associate Professor	Ph.D.	Power Systems Operation & Control, Renewable Energy Systems
Keshri Ritesh *	Assistant Professor	Ph D	Power Electronics and Drives
Lokhande M.M.	Assistant Professor	Ph D	Power Electronics , Solar PV , Electric Vehicle
Patne N.R.	Assistant Professor	Ph.D.	Power Systems, Power Quality
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

*Will be joining on 14^{th} Aug. 2015

CREDIT REQUIREMENTS FOR M.TECH (INTEGRATED POWER SYSTEM)

Program Core (PC)		**Program Elective (PE)**	
Category	Credit	Category	Credit
Program Core (PC)	38	Program Electives (PE)	14
Grand Total PC + PE			52

Details of credits:

I Semester				**II Semester**			
CORE				**CORE**			
Code	**Course**	**L-T-P**	**Cr**	**Code**	**Course**	**L-T-P**	**Cr**
EEL501	Power System Analysis	3-0-0	3	EEL507	Power System Dynamics II	3-0-0	3
EEL502	Power System Dynamics I	3-0-0	3	EEP507	Power System Dynamics LAB	0-0-2	1
EEL504	Digital Protection of Power System	3-0-0	3	EEL526	Analysis of FACTS devices	3-0-0	3
EEP501	Power System Analysis Lab	0-0-2	1	EEP526	Analysis of FACTS devices lab	0-0-2	1
EEP504	Digital Protection of Power System Lab	0-0-2	1	EEL512	Distributed Generation	3-0-0	3
				EEP512	Distributed Generation Lab	0-0-2	1
ELECTIVE				**ELECTIVE (Any One Theory)**			
EEL409	HVDC Transmission	3-0-0	3	EEL531	Microcontrollers & digital signal processors	3-0-0	3
EEL516	OR Advanced Control theory	3-0-0	3	EEL506	Special Topics in Power Systems	3-0-0	3
EEL522	Power Electronic Converters	3-0-0	3	EEL431	Smart Grid	3-0-0	3
EEP522	*Power Electronics Converter Lab	0-0-2	1	EEL513	Reliability of Electric Systems	3-0-0	3
	OR						
EEL518	Electrical Drives-I	3-0-0	3				
EEP518	*Electrical Drives lab	0-0-2	1				
	Total No of Credits	**18**			**Total No of Credits**	**15**	

***Compulsory with theory course**

III Semester				IV Semester			
CORE				CORE			
Code	**Course**	**L-T-P**	**Cr**	**Code**	**Course**	**L-T-P**	**Cr**
EED501	Project Phase-I	---	3	EED502	#Project Phase-II (# prerequisite: Project Phase-I)	0-0-9	9
EEL503	Power System Management	3-0-0	3				
Elective (Any one (theory+ lab) combination)							
EEL521	Advanced Power Quality	3-0-0	3				
EEP521	* Advanced Power Quality Lab	0-0-2	1				
EEL505	AI Based Systems	0-0-3	3				
EEP505	*AI Based Systems Lab	0-0-2	1				
EEL515	Digital Control System	3-0-0	3				
EEP515	*Digital Control System Lab	0-0-2	1				
	Total No of Credits	**10**			**Total No of Credits**	**9**	

*Compulsory with theory course

FIRST SEMESTER MTech (IPS)

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

Objectives:

1. Understand the concepts of load flow as steady state solution of power system
2. Study various methods of load flow and their advantages and disadvantages
3. Understand how to analyze various types of faults in power system
4. Understand power system security concepts and study the methods to rank the contingencies
5. Understand need of state estimation and study simple algorithms for state estimation
6. Study voltage instability phenomenon

Syllabus:

Load flow: overview of Newton-Raphson Gauss-Siedel and fast decoupled methods, convergence properties, sparsity 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 faults, 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 load flow, voltage collapse proximity indices.

Text Books:

1. J.J. Grainger & W.D.Stevenson, "Power system analysis ", Mc Graw Hill ,2003
1. A. R. Bergen & Vijay Vittal , "Power System Analysis" ,Pearson , 2000
2. L.P. Singh , "Advanced Power System Analysis and Dynamics", New Age International, 2006

Reference Books:

1. G.L. Kusic, "Computer aided power system analysis" ,Prentice Hall India, 1986
2. A.J. Wood, " Power generation, operation and control" , John Wiley, 1994
3. P.M. Anderson, "Faulted power system analysis" , IEEE Press , 1995
4. L.L. Grisby, "Power system stability and control" , CRC press,2007
5. V. Ajjarapu , "Computational techniques for assessment of voltage stability and control", Springer 2006

Course outcomes:

Students are able to

1. calculate voltage phasors at all buses , given the data using various methods of load flow
2. calculate fault currents in each phase
3. rank various contingencies according to their severity
4. estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps , CB status etc
5. estimate closeness to voltage collapse and calculate PV curves using continuation power flow

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

Objectives:

- **Study of system dynamics and its physical interpretation**
- **Development of mathematical models**

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 modeling, Modeling of Induction Motors, Prime mover controllers.

Text Books:

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

Reference Books:

1. P.Kundur, "Power System Stability and Control", McGraw Hill Inc., 1994.
2. E.W. Kimbark, "Power system stability", Vol. I & III, John Wiley & Sons, New York 2002

Course Outcomes:

Students are able to:

i. Understand the modeling of synchronous machine in detail.
ii. Carry out simulation studies of power system dynamics using MATLAB-SIMULINK.
iii. Carry out stability analysis with and without power system stabilizer (PSS).
iv. Understand the load modeling in power system.

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

Objectives:

- ***Study of numerical relays***
- ***Developing 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, Schweitzer Engineering Laboratories (SEL) , 2010.
4. Emmanuel Ifeachor, B.W.Jervis, “Digital Signal Processing :A Practical Approach’, Pearson 2007
5. S.R. Bhide, “Digital Power System Protection”, PHI Learning Pvt. Ltd ., 2014

Course outcomes:

Students are able to

- ***Understand the importance of digital relays.***
- ***Understand various protection algorithms.***
- ***Appreciate limitations of the algorithms.***
- ***Code the algorithms in MATLAB and experiment with them.***
- ***Cope up with further advances in digital protection.***

EEP501: POWER SYSTEM ANALYSIS LAB (0-0-2-Credits -1)

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-Siedel 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 ready-made industry standard / commercial software packages for above analysis
8) Write a program to form Z_{bus} matrix.

EEP504: DIGITAL PROTECTION OF POWER SYSTEMS LAB (0-0-2- Credits- 1)

List of Experiments:

1) Familiarization with various features of Scilab / MATLAB/Simulink environment.
2) Demonstrating the phenomenon of aliasing due to under-sampling.
3) Implementation of algorithms based on undistorted sine wave 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:

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

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

Objectives:

- ***To expose the students to the state of the art HVDC technology.***
- ***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.

Course outcomes:

Students are able to

- ***Understand, analyze and model the HVDC long distance bulk power transmission systems.***
- ***Simulate converters using MATLAB SIMULINK.***
- ***Understand necessity of HVDC under deregulated environment.***
- ***Know different control methods and protective schemes of HVDC systems***

EEL516: ADVANCED COTROL THEORY (3-0-0- Credits -3)

Objectives:

- ***The course provides glimpses into the advanced methods of modeling and analysis of the dynamical systems***
- ***The course is a strong step in inculcating the research aptitude in the students.***

Syllabus:

Math Modeling of Dynamical Systems: Newtonian and Lagrangian approaches, concept of dynamical state of a system, concept of equilibrium point, linearisation of non-linear model.

Review of Linear Algebra concepts: Field, Vector space, linear combination, linear independence, bases of a vector space, representation of any vector on different basis, matrix representation of a linear operator, change of basis, rank, nullity, range space and null space of a matrix, Eigen value and Eigen vector of a matrix, similarity transform, diagonalisation.

Modern Control Analysis: Concept and computation of systems modes, controllability theorem and its proof, observability theorem and its proof, controllable and observable subspaces.

Stability Analysis: Stability of linear systems, stability types and their definitions for any general system, stability of an equilibrium point, Lyapunov stability theory for LTI systems, quadratic forms and Lyapunov functions.

Modern Control Design: Converting the math model to controllable canonical form and its use for pole placement, concept of linear observer and its design, design of reduced order observer, compensator design using separation principle, poles of compensator, open-loop and close-loop systems.

Optimal Control Theory: Introduction to the philosophy of optimal control, formulation of optimal control problem, different performance criterion, linear quadratic regulator (LQR) and optimum gain matrix, Riccati equations, conceptual models and statistical models for random processes, Kalman filter.

Text Books:

1. Bernard Friedland, " Control System Design: An Introduction to State-Space Methods" , Dover Publications, Inc. Mineola, New York , 2012
2. Thomas Kailath, " Linear Systems", Prentice-Hall Inc., New Jersey, 1986

Reference Books:

1. M. Gopal, "Modern Control System Theory", , New Age International (P) Limited, New Delhi, 2000
2. Chi-Tsong Chen, " Linear System Theory and Design", Oxford University Press Inc., New York,1998

Course Outcomes:
Students are able to

- ***Obtain mathematical model of dynamical systems.***
- ***Appreciate concepts of linear algebra and their applications to control system***
- ***Analyze the system dynamics and Lyapunov stability theory***
- ***Design linear quadratic controller***

EEL522: POWER ELECTRONICS CONVERTERS (3-0-0- Credits-3)

Objectives:

- **To get insight into power semiconductor switching devices**
- **Understand different converter topologies**

Syllabus:

1. Review of power semiconductor devices, VI-Characteristics (ideal and practical), gate driver circuits.
2. DC-DC Converters: various types, analysis, control of converter, duty ratio control, current & voltage control.
3. Voltage Source Inverters (VSI): principle and steady state analysis of VSI, methods for controlling inverter, equivalent circuit.
4. AC To DC Converters: line commutated & PWM converter, multi-quadrant operation, regeneration, input current and reactive power requirements.
5. Converter applications

Text Books:

1. N. Mohan, T. Undeland, and W. Robbins, "Power Electronics Converters, Applications, and Design," Third edition, John Wiley and Sons Inc., 2003,
2. M.H. Rashid. "Power Electronics, circuit, Devices and applications," Prentice Hall of India, 2004

Reference Books:

1. Robert W Erickson , "Fundamentals of Power Electronics" , Springer. Second edition-2000,
2. Marian K. Kazimierczuk ,"Pulse-Width Modulated DC_DC power converter ", John Wiley & sons Ltd. ,2008
3. M P. Kaźmierkowski, R Krishnan , F Blaabjerg "Control in Power Electronics" , Elsevier Science (USA), 2002,

Course outcomes:

Students are able to
1. Appreciate the use of semiconductor devices in different applications.
2. Design magnetic circuits.
3. Implement different PWM techniques.

EEP522: POWER ELECTRONICS CONVERTERS Lab (0-0-2- Credits-1)

List of experiments:

1. To Study DC-DC BUCK Converter
2. To Study DC-DC BOOST Converter
3. To Study DC-DC BUCK-BOOST Converter
4. To Study DC-DC Cuck Converter
5. To Study DC-DC Forward Converter
6. To Study DC-DC Flyback Converter
7. To Study AC-DC fully controlled Inverter
8. To Study different PWM techniques. (FFT, Crest Factor, P.F, DPF).

EEL518: ELECTRIC DRIVES-I (3-0-0- Credits-3)

Objectives:

- ***Introduction to basic electrical drives and their analysis.***
- ***Design of controller for drives.***
- ***Understand scalar control of electrical drives.***

Syllabus:

Dynamics of Electric Drives: Fundamentals of torque equations, speed torque convention and multi-quadrant operation, components of load torques, classification of load torques, steady state stability, load equation. Speed control and drive classification, close loop control of drives.

DC motor drives- Modeling of DC machines, steady state characteristics with armature and speed control, phase controlled dc motor drives, chopper controlled DC motor drives.

Poly-phase induction machines- Dynamic modeling of induction machines, small signal equations, control characteristics of induction machines. Phase-controlled induction machines, stator voltage control, slip energy recovery scheme, frequency controlled induction motor drives.

Industrial drives- Traction motors, stepper motor, servo motor.

Text Books:

1. G.K, Dubey, "Power semiconductor controlled Drives", Prentice Hall international, New Jersey, 1989.
2. R.Krishanam, "Electric Motor drives Modelling, analysis and control", PHI-India-2009.

Reference Books:

1. G. K. Dubey, " Fundamentals of electric Drives, Narosa Publishing House", 2nd edition, 2011.
2. W. Leonhard, "Control of Electrical drives", Springer, 3rd edition, 2001.
3. P.C. Krause, "Analysis of Electric Machine", Wiley-IEEE press 3rdedition , 1995
4. B. K. Bose, " Modern Power Electronics and AC Drives", Prentice Hall publication, 1st edition, 2001

Course outcomes:

Students are able to

- ***Select and implement the drives for industrial processes.***
- ***Design of scalar control drive for industrial application.***
- ***Implement various variable speed drives in electrical energy conversion systems.***

EEP519: ELECTRICAL DRIVES LAB (0-0-2-Credits -1)

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 .
8) ABC to DQ transformation of machine variables.
9) *v/f* control of induction motor drive.

SECOND SEMESTER

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

Objectives:

- ***Study of power system dynamics***
- ***Interpretation of power system dynamic phenomena***
- ***Study of various forms of stability***

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. L. Leonard Grigsby (Ed.); "Power System Stability and Control", Second edition, CRC Press, 2007.
2. V. Ajjarapu, "Computational Techniques for voltage stability assessment & control"; Springer, 2006.

Course Outcomes

Students are able to:

i. ***Gain valuable insights into the phenomena of power system including obscure ones.***
ii. ***Understand the power system stability problem.***
iii. ***Analyze the stability problems and implement modern control strategies.***
iv. ***Simulate small signal and large signal stability problems.***

EEP507: POWER SYSTEMS DYNAMICS LAB (0-0-2- Credits -1)

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.

EEL526: ANALYSIS OF FACTS DEVICES (3-0-0 Credits -3)

I. **Introduction**-brief discussions on Transmission line theory, use of Voltage source inverter (VSI) for reactive power support Flexible AC transmission systems (FACTS): Basic realities & roles, Types of facts controller. Comparison between Series and Shunt Capacitor.

II. **Thyristor controlled shunt Compensation** SVC (TSC, TCR, FCTCR): Controller Configuration, Analysis, Modelling of SVC, Voltage Regulator Design, application, Numerical.

III. **Thyristor controlled Series Compensation, (TCSC, GCSC)** Operation, Analysis, control, Modelling application, Numerical.

IV. **Static Synchronous Compensator (STATCOM) Introduction,** Principle of operation, Six Pulse VSC, multipulse VSC, Multilevel VSC, Modelling and Active and reactive power control, Numerical

V. **Static Synchronous Series Compensator (SSSC)** Introduction, Principle of operation, Modelling and Control of SSSC, SSSC with an Energy Source, Numerical

VI. **Unified Power Flow Controller**: Introduction, analysis, Principle of operation, power flow control

Text Books:

1. E. Acha., T J E Miller, VG Agelidis, O Anaya-Lara, " Power Electronic control in Electrical Systems.", Elsevier
2. K. R. Padiyar, "FACTS Controllers in Power Transmission and Distribution", NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS

Reference Books:

1. Yong Hua Song, "Flexible AC transmission system (FACTS)".
2. IEE and IEEE papers.

Course outcomes:

Students will be able to

1. ***Design thyristorised shunt and series compensation.***
2. ***Model and analyze VSC based shunt compensator.***
3. ***Model and analyze VSC based series compensator.***
4. ***Appreciate importance of unified power flow controller.***

EEP526: ANALYSIS OF FACTS DEVICES **LAB: (0-0-2- Credits-1)**

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).

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

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, Geothermal Energy, Biomass 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', 2nd Ed. , Prentice Hall of India , 2011

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', 3rd Ed, 2010.
4. James F.Manwell, Jon G.Mc Gowan, Anthony L.Rogers, "Wind energy explained: Theory Design and Application", John Wiley and Sons 2nd Ed,2010.

Course Outcomes

Students are able to

i. ***Understand the working of distributed generation system in autonomous/grid connected modes***
ii. ***Know the Impact of Distributed Generation on Power System***
iii. ***Know the protection and Economics of Distributed Generators***

EEP512: DISTRIBUTED GENERATION LAB (0-0-2- Credits-1)

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.

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

Objectives:

- ***To acquaint the students with topics in field of power system.which he has not studied as a part of regular syllabus***

Syllabus: The syllabus will be dynamic and this would cover those topics which the student has not studied in his course as part of regular syllabus.

So the topics covered under can be

1. ***Topics on which currently a lot of research is being carried out***
2. ***Topics which are just touched upon in the syllabus but have stabilized in the industry but at present is not included as the scheme is yet to be revised***
3. ***Topics on which the faculty is carrying out research and has real expertise in the same***

Text Books:

Reference material: From research papers published in IEEE Transactions and other technical literature

Outcomes:

- ***The students can expand on research topic and can take it up as M.Tech or Ph.D. topic for research.***

EEL531: MICROCONTROLLERS & DIGITAL SIGNAL PROCESSORS (3-0-0-Credits-3)

Objectives

- ***To learn architectures and programming for the 8051 microcontroller and dsPIC digital signal controller.***
- ***To study microcontroller interfacing concepts and applications in area of power system and power electronics.***
- ***To learn architectural features and programming of digital signal processer***

Introduction to the 8051microcontroller and dsPIC digital signal controller, Review of Architecture, Pin description, Special Function Registers, Addressing Modes, Instruction Set, Assembler directives, 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 of microcontroller with external memory chips, LED, LCD and Keyboard interfacing, Interfacing data converters and sensors, RTC interfacing and programming

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, microcontroller based Protective Relays etc.

Introduction to digital signal processor architecture, Fixed and floating-point processors, TMS320 series family

Number Representations in DSP processors: Number formats and operations: Fixed point 16 bit numbers representations of signed integers and fraction, Q-15 numbers and its operations, floating point numbers. Assembly language programming, Binary file formats, COFF file structure for TMS320 processor.

Digital algorithms for signal filtering, measurement algorithms of the most commonly-used protection criteria values and decision-making methods in protective relays, generation of PWM signals, sine PWM, ADC interface etc.

Text books

1. Kenneth J. Ayala, Dhananjay V. Gadre, Anurag Chugh, "The 8051 Microcontroller and Embedded Systems using Assembly and C", Cengage Learning, Third Reprint, 2011
2. M.A.Mazidi, J.G.Mazidi, R.D.McKinlay, "The 8051 Microcontroller and Embedded Systems using Assembly and C", Pearson Education, Second Edition, 2008
3. Rebizant, Waldemar, "Digital Signal Processing in Power System Protection and Control", Springer-Verlag Pub., 2011.
4. Digital Signal Processors, Architecture, Programming and Applications, Second Edition, B. Venkataramani, M. Bhaskar, TMH, 2010

Reference Books

1. David Calcutt, Frederick Cowan, and Hassan Parchizadeh, "8051 Microcontroller: An Applications based Introduction", Newnes Pub., 2004
2. Thomas Schultz, "C and the 8051", 4th Edition, Wood Island Prints, 2008
3. Sen M Kuo, Woon-Seng S. Gan, "Digital Signal Processor Architecture, Implementations and Applications", Pearson, 2009

Course Outcomes:

Students are able to

- ***Understand the architecture of the microcontroller, digital signal controller and digital signal processor.***
- ***Write assembly language and C language programs for microcontrollers and digital signal processor.***
- ***Interface external peripheral devices with the microcontroller and digital signal processor.***
- ***Understand the microcontroller and digital signal processor based applications in electrical engineering.***

EEL431 : SMART GRID (3-0-0-Credits -3)

Objectives:

The students will be able to :

- ***Understand concept of smart grid and its advantages over conventional grid***
- ***Know smart metering techniques***
- ***Learn wide area measurement techniques***
- ***Appreciate problems associated with integration of distributed generation & its solution through smart grid.***

Syllabus:

Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self Healing Grid, Present development & International policies in Smart Grid.

Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation

Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).

Micro-grids and Distributed Energy Resources: Concept of micro-grid, need & applications of micro-grid, formation of micro-grid, Issues of interconnection, protection & control of micro-grid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuel-cells, micro-turbines, Captive power plants, Integration of renewable energy sources.

Power Quality Management in Smart Grid: 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.

Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols.

Text Books:

1. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE,2011
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press , 2009
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, "Smart Grid: Technology and Applications", Wiley 2012
4. Jean Claude Sabonnadière, Nouredine Hadjsaïd, "Smart Grids", Wiley ISTE 2012

Reference books

1. James Momoh, "Smart Grid Fundamentals of Design and Analysis," Wiley, 2012
2. A. Keyhani, "Smart Power Grid Renewable Energy Systems," Wiley 2011

Course Outcomes:

Student should be able to

1. **Appreciate the difference between smart grid & conventional grid**
2. **Apply smart metering concepts to industrial and commercial installations**
3. **Formulate solutions in the areas of smart substations ,distributed generation and wide area measurements**
4. **Come up with smart grid solutions using modern communication technologies**

EEL513: RELIABILITY OF ELECTRICAL SYSTEMS (3-0-0-Credits- 3)

Objectives:

- ***Necessity and importance of condition monitoring and reliability.***
- ***Idea about conventional and recent techniques.***
- ***Development of algorithms and software packages.***

Necessity of assessment and reliability issues of electrical systems, economic aspects of assessment, cost versus benefit analysis
Traditional methods (Measurement of insulation resistance), Diagnostic Testing: Routine tests, type tests, special tests (offline tests).
Advanced methods (offline), Dissolved Gas Analysis (DGA), Dissipation Factor (tanδ), Sweep Frequency Response Analysis (SFRA), Partial Discharge (PD), Time Domain Dielectric Response (TDDR).
Recent methods (online), vibration and temperature monitoring, sensor and data acquisition system, Introduction to modern algorithms and signal processing techniques. Image processing and its techniques.
Application of signal processing tools for assessment of various electrical components such as transformer, induction motor, synchronous generator and motor, DC motor, CT and PT, case study
Calculation of Power Equipment Reliability for Condition-based Maintenance Decision-making, Optimum Reliability-Centered Maintenance, Cost Related Reliability Measures for Power System Equipment, Reliability based replacement refurbishment/planning

Text Books:

1. P. Vas, "Parameter estimation, condition monitoring and diagnosis of electrical machines", Clarendon Press Oxford.
2. P. Tavner, Li Ran, J. Penman and H. Sedding, "Condition monitoring of rotating electrical machines", IET press
3. S.V. Kulkarni and S.A. Khaparde, "Transformer Engineering: Design, Technology and Diagnostics", CRC Press.

References Books:

1. Xose M Lo´pez, Ferna´ndez, H Bu¨lent Ertan, J Turowski, "Transformers analysis, design, and measurement", CRC Press.
2. M.J. Heathcote, " The J & P Transformer Book", Newnes Publication.
3. R. Billinton and R. N. Allan, " Reliability Evaluation of Power Systems, 2nd ed. New York", NY, USA: Plenum, 1996.

Video:

1. Transformer condition evaluation with ABB's Mature Transformer Management Program
2. Videos hosted by ABB, Siemens, General Electricals on their websites

Course outcome:
Students are able to

- ***Design and develop condition monitoring tools/ algorithms/Systems.***
  Apply CM and R model to various equipments in power systems.
- ***Analyze and determine of life expectancy and reliability.***
- ***Make comparison and determine more effective techniques***

THIRD SEMESTER MTech (IPS)

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

Objectives:

- **To develop the ability to study a topic in depth and understand and simulate work done till now by other researchers in a given topic**
- **To inculcate culture of handling all aspects of solution of a practical problem**
- **To understand, formulate and analyze the problem resulting into a novel solution**

Syllabus:

Become familiar with the problems in areas of power system as proposed by faculty members by working in depth on the given topic and understand tools for analysis of given topic and present seminars based on the work done

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

Objectives

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

Contents

Working of Restructured Power System, Transactions: Poolco, Bilateral and Power Exchange,
Role of NRLDC, RLDC, SLDC, ALDC, Energy Management System, SCADA, PLCC

Optimum Power Flow: Problem formulation, Solution Techniques - Gradient Method, Newton Method, Linear Programming, Interior Point Method, Security Constrained Optimum Power Flow

Characteristics of Power Generating Units, Economic Dispatch of Thermal Units with and without Network Losses, The Lambda – Iteration Method, Gradient Method, Newton's Method, Base point and Participation factors, Economic Dispatch with AGC, Multi-objective Economic Dispatch

Unit Commitment with constraints, Dynamic Programming, Priority List, Lagrange Relaxation Methods

Hydro-Thermal Co-ordination: Introduction, Short Term Hydro-thermal Scheduling Problem, Gradient Method, Dynamic Programming and Linear Programming Methods

Co-ordination of Steam, Hydro and Nuclear Power Stations, Loss Minimization by Reactive Power Control.

Text Reference Books

1. P.S.R. Murthy, "Power System Operation and Control", Tata McGraw-Hill, New Delhi, 1984
2. L.K. Kirchmayer, "Economic Operation of Power System, Economic Operation of Power System", John Wiley, New York, 1958

Reference Books

1. A.J. Wood and B.F. Wollenberg, "Power Generation Operation and Control", John Wiley & Sons Inc, 1984
2. Nagrath and Kothari, "Power System Engineering", Tata McGraw-Hill, 2003
3. Jizhong Zhu, "Optimization of Power System Operation", IEEE Press, 2009.

Course Outcomes:
Students are able to

i. ***Learn about reactive power control, coordination between generating stations.***
ii. ***Understand various optimization techniques.***
iii. ***Understand the operation and control of power system.***
iv. ***Study the working of power system under deregulation.***

EEL521: Advanced Electrical Power Quality (3-0-0-credits 3)

Objective:

- ***Various issues related to power quality in power distribution systems.***
- ***Fundamental load compensation techniques for unbalanced linear loads.***
- ***Control theories of load compensation and mitigation***

Syllabus:

Definitions of various powers, power factor and other figures of merit under balanced, unbalanced and non-sinusoidal conditions applied to single phase as well as three phase circuit.
Fundamental of load compensation, voltage regulation, phase balancing and power factor correction of unbalanced load. Generalized approach for load compensation using symmetrical components.
Introduction to custom power devices and their applications in power system. There operating principles.
Detailed modeling, analysis and design aspects, DVR. Modeling analysis and design aspects of DSTATCOM
Compensators to mitigate power quality related problems. Realization of DVR and DSTATCOM by using VSC

Text book:

1. A. Ghosh and G. Ledwich, "Power quality enhancement using custom power devices", Kluwer Academic Publication, 2002.
2. C. Shankran. "Power quality", CRC Press, 2001.
3. Roger C. Dugan et al, "Electrical power systems quality", Tata McGraw-Hill, 2002.

Reference Books:

1. Angelo Baggini (Ed), "Handbook of power quality", John Wiley & Sons, 2008.
2. H. Akagi et al , "Instantaneous power theory and application to power conditioning", IEEE Press, 2007.

Related Web-Links:

1. nptel.ac.in
2. Power Standards Lab - Tutorials & Standards
   Website: www.powerstandards.com/tutor.htm

***Course outcomes*:**
Students will be able to

- ***Analyze of three phase circuits under different conditions***
- ***Do correct load compensation in presence of harmonics and unbalance.***
- ***Design compensators at distribution level to mitigate power quality issues.***

EEP522: ADVANCED POWER QUALITY LAB (0-0-2- Credits-1)

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 on neutral current , in a three phase circuit
7. To study the effect of ground loop.
8. To study the effect of voltage flicker .
9. To calculate the distortion power factor.
10. Study the effect of harmonics on energy 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.

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

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 fields 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. J.M. Zurada, "Introduction to Artificial Neural Network Systems", Jaico Publishing House, 2003

Reference Books:

1. S.Rajasekaran, G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", Prentice Hall of India.
2. Kevin Warwick, " Arthur Ekwue and Raj Aggarwal.; "Artificial Intelligence Techniques in Power Systems", The Institution of Electrical Engineers , London, 1989.
3. T.S. Dillon and M.A Laughtonm; "Expert system applications in power systems", Prentice Hall International, 1992.
4. Jacek M. Zurada, "Introduction to artificial neural Systems," Jaico Pub. House, 2003.
5. DanW. Patterson, "Introduction to artificial intelligence & Expert System", Prentice Hall of India, 2004.
6. Bart Kosko , " Neural networks and Fuzzy Systems", Prentice Hall of India, 1990.

Course Outcomes:

Students are able to

1. understand the theory behind Neural Network, Fuzzy Logic, Genetic Algorithm and Expert System.

2. select appropriate soft computing technique to solve problems in power system.

3. design and build simple fuzzy inference systems and neural network based systems.

4. solve optimization problems using Genetic algorithm.

EEL505: AI BASED SYSTEMS Lab(0-0-2- Credits-1)

List of Experiments

1. Write a program to simulate a perceptron network for pattern classification and function approximation.
2. Write a program to solve a XOR function using feed-forward neural network trained using back-propagation algorithm.
3. Write a program to implement adaptive noise cancellation using ADALINE neural network.
4. Given the region to be de-fuzzified, write programs to discuss the various methods that might be chosen.
5. Implementation of simple Over Current Relay using fuzzy logic.
6. Simulation and comparison of fuzzy PID controller with conventional PID controller for a given plant.
7. Solve optimal relay coordination as a linear programming problem using Genetic Algorithm.
8. Solve optimal relay coordination as a non-Linear programming problem using Genetic algorithm.
9. Solve economic load dispatch problem using Genetic algorithm.
10. Assignment based on research papers.

Note: The above experiments may be implemented using Scilab / Matlab programming language, Simulink and various toolboxes.

EEL515: DIGITAL CONTROL SYSTEMS (3-0-0- Credits-3)

Objectives:

- ***The basics of sampling and data processing are covered.***
- ***Data in sampled form is used for controlling purpose.***

Syllabus:

Sampling and Data Reconstruction Processes: Sampled – Data Control Systems, Ideal Sampler, Sampling Theorem, Sample and Hold Operations, Frequency Domain Considerations

Z-Transforms; Properties, Inverse, Applications to Solution of Difference Equations, Convolution Sums.

Stability of Discrete Systems: Location of Poles, Jury's Stability Criterion, Stability Analysis through Bilinear Transforms.

Design of Digital Control Systems: PID Controllers and Frequency Domain Compensation Design.

State Variable Methods and the Discrete Linear Regulator Problem.

Text Books:

1. M. Gopal, "Digital Control Engineering and State Variable Methods", 4th Ed., Tata McGraw-Hill.2012
2. Katsuhiko K Ogata, "Discrete time Control Systems", 2nd Ed., Prentice Hall , 2005
3. B.Kuo, " Digital Control Systems" , Oxford University Press, 1995

Reference Books:

1. K.J. Astrom and B. Wittenmark, "Computer Controlled Systems", Prentice-Hall India, 1994.
2. R. Isermann, "Digital Control Vol.1", Narosa Publications, 1993.

Course outcomes:

Student will be able to:

1) Model digital filters and systems
2) Analyse digital systems in time domain and frequency domain.
3) Model and analyse digital systems in state space representation.
4) Design controllers for digital systems in state space representation.

EEP515: DIGITAL CONTROL SYSTEMS Lab (0-2-0- Credits-1)

List of Experiments

1) Voice signal and image signal – sampling and reconstructing, effect of sampling frequency on retrieval of signal
2) Representation of system in ‘z’ domain transfer function. Study of ‘z’ and ‘inverse z’ transform
3) Study of Zero Order Hold and First Order Hold circuit
4) Study of design of filters using series, parallel and ladder topology
5) Study of mapping between ‘s’ plane and ‘z’ plane.
6) Study of transient response of digital system
7) Study of digital PID controllers
8) Study of Root Locus of a system in ‘z’ domain. Effect of addition of pole and zero.
9) Study of frequency response of a system in ‘z’ domain
10) Design problem on pole placement

<u>FOURTH SEMESTER</u> MTech (IPS)

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

<u>Objectives :</u>

- **To develop the ability to propose a new solution to an existing problem**
- **To develop ability to refine the proposed solution by comparing results with similar solutions suggested by other researchers**
- **To develop ability to test the proposed solution on new systems/ configurations and establish the proposed solution as a better solution in terms of computing time/ simplicity/ storage/ hardware requirements**

Syllabus:

Find solution to the problems in areas of power system as proposed by faculty members in earlier phase and present seminars and submission of project report based on the work done.
