DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

M.TECH (POWER SYSTEMS AND AUTOMATION)

Scheme of Instruction and Examination
(Regulation: R16)

(with effect from **2016-2017** admitted batch onwards)

I - SEMESTER

Course Code	Course	Credits	Lecture hours	Lab hours	Total contact hours	Sessional Marks	Exam Marks	Total Marks
M16 PS 1101	Advanced Power System Operation and Control	4	4	--	4	30	70	100
M16 PS 1102	Optimization Techniques	4	4	--	4	30	70	100
M16 PS 1103	Advanced Drives and Control	4	4	--	4	30	70	100
M16 PS 1104	Advanced Control System Design	4	4	--	4	30	70	100
#1	Elective-I	4	4	--	4	30	70	100
M16 PS 1108	Power System Simulation Lab-I	2	--	3	3	50	50	100
M16 PS 1109	Seminar-I	2	--	3	3	100	--	100
	Total	**24**	**20**	**6**	**26**	**300**	**400**	**700**

	Course Code	Course
#1-Elective-I	M16 PS 1105	Renewable Energy Systems
	M16 PS 1106	Power System Modeling
	M16 PS 1107	Power System Planning

Code: M16 PS 1101

ADVANCED POWER SYSTEM OPERATION AND CONTROL

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

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

COURSE OUTCOMES:

Upon completion of this course, students will be able to

1. Develop generation dispatching schemes for thermal and hydro units
2. Apply control and compensations schemes on a power system
3. Adopt contingency analysis and selection methods to improve system security

SYLLABUS

Economic operation: Economic dispatch problem of thermal units without and with losses–Gradient method-Newton's method –Base point and participation factor method.

Unit Commitment Solution Methods:
Introduction to unit commitment, methods of unit commitment**:** Priority-List Methods, Dynamic-Programming Solution, Forward DP Approach, Lagrange relaxation solution.

Hydro-thermal co-ordination: Hydro electric plant models–short term hydro thermal scheduling problem-gradient approach.

Optimal Power Flow: Solution of OPF, gradient method, Newton's method, linear programming method with only real power variables, linear programming with AC power flow variables, security-constrained optimal power flow.

Power system security: Contingency analysis–linear sensitivity factors–AC power flow methods–contingency selection – concentric relaxation – bounding-security constrained optimal power flow.

The control problem: The two-area system, Tie-line Bias control; steady state Instabilities: Torsional Oscillatory Modes-Damper windings and negative damping, effect of AVR loop: AGC Design using kalman method-state variable form of the dynamic model, Optimum control Index, state Trajectories, the RICCATTI equations, preventive and emergency control, computer control.

TEXTBOOKS:

1. Allen J. Woodand Wollenberg B.F., ‘Power Generation Operation and control’, John Wiley & Sons, Second Edition,1996.
2. Electric Energy systems Theory - An Introduction' OlleI Elgard, TMH Second Edition

REFERENCE BOOKS:

1. Kirchmayer L.K., ‘Economic Control of Interconnected Systems’, John Wiley & Sons, 1959.
2. Nagrath, I.J. and Kothari D.P.,‘Modern Power System Analysis’,TMH, New Delhi,2006.

Code: M16 PS 1102

OPTIMIZATION TECHNIQUES

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVE:

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

COURSE OUTCOME:

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

SYLLABUS

Introduction to Optimization: Introduction, Historical Development, Engineering Applications of Optimization, Statement of Optimization Problem.

Classical Optimization Techniques: Introduction, Single variable optimization, Multi variable optimization with no constraints; Multi variable optimization with Equality constraints–Solution by Direct Substitution method, Method of constrained variation, Method of Lagrangian multipliers; Multi variable optimization with in equality constraints: Kuhn-Tucker conditions.

Linear Programming: Introduction, Applications of Linear Programming, Standard Form of a Linear Programming, Basic Terminology and Definitions, Exceptional cases, Simplex method, Big-Mmethod, Two-phase method, Revised Simplex method, Duality, Decomposition Principle.

Non-Linear Programming-I: Unconstrained optimization-Univariate method, Pattern Directions, Hookand Jeeves Method, Powell's method, Gradient of a function, Steepest descent method, Conjugate Gradient Method, Newton's method, Marquardt Method,Quai-Newton Methods, Davidon-Fletcher-Powell Method, Broyden-Fletcher-Goldfarb- Shanno Method.

Non-Linear Programming-II: Constrained optimization-Characteristics of a Constrained Problem, Sequential linear programming, Basic approach in the methods off easible directions, Zoutendijk's method off easible directions, Sequential Quadratic Programming.

TEXT BOOKS:

1. Engineering Optimization: Theory and Applications 'By S.S. Rao, New Age International Publishers, revised Third Edition 2005.
2. Optimization for Engineering Design (Algorithms & Examples)' by Kalyanmoy Deb, PHI Pvt. Ltd, New Delhi.

REFERENCE BOOKS:

1. Optimization Techniques' by Chander Mohan, Kusum Deep, New Age International Publishers, 2009.
2. Optimization Methods, Theory and Applications' by Honglei Xu, Song Wang , Soon-Yi Wu, Springer, 2015.

Code: M16 PS 1103

ADVANCED DRIVES & CONTROL

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. To Study about the transfer functions of D.C motors
2. To Study about the dq equivalent circuits of induction and synchronous motors.
3. To introduce the P and PI Control for controlling the DC and AC Motors.

COURSE OUTCOMES:

1. Student can design the transfer functions and obtain the performance of d.c motors
2. Student can design the dq equivalent circuits of induction and synchronous motors and evaluate the performance it.
3. Student can design the values of P and PI Controllers for controlling the DC and AC Motors

SYLLABUS

DC drives: System model, motor rating, motor mechanism dynamics, drive transfer function, effect of armature current wave form, torque pulsations, adjustable speed drives, chopper fed and single-phase converter fed drives, effect of field weakening.

Induction Motor drives: Basic Principle of operation of 3 Phase motor, equivalent circuit, MMF space harmonics due to fundamental current, fundamental spatial MMF distributions due to time harmonics simulation, effect of time and space harmonics, speed control by varying stator frequency and voltage, impact of non sinusoidal excitation on induction motors, variable square wave VSI drives, variable frequency CSI drives, line frequency variable voltage drives.

Induction Motor drives: Review of induction motor equivalent circuit, effect of voltage, frequency and stator current on performance of the machine, effect of harmonics, dynamic d-. q model, small signal model, voltage and current fed scalar control, direct and indirect vector control, sensor less vector control, direct torque and flux control.

Synchronous motor drives: Review of synchronous motor fundamental, equivalent circuit, dynamic d- q model, synchronous reluctance, sinusoidal and trapezoidal back emf permanent magnet motors, sinusoidal SPM machine drives, trapezoidal SPM machines drives, wound field machine drives, switched reluctance motor drives.

Closed loop control: Motor transfer function-P, PIand PID controllers, current control-Design procedure, phase locked loop (PLL) control-microcomputer control.

TEXT BOOKS:

1. B. K. Bose, “Modern Power Electronics and AC drives”, Pearson Education, Asia, 2003.
2. M. H. Rashid, “Power Electronics”, Third Edition, PHI
3. G. K. Dubey, “Fundamentals of Electrical Drives”, Narosa Publishing house.

REFERENCE BOOKS:

1. V. Subrahmanyam, “Electric Drives-Concepts and Applications”, TMH 2.G. K. Dubey, “Power Semiconductor controlled drives”, PH 1989.
2. R. Krishnan, “Electric Motor Drives: Modelling, Analysis and Control”, PH, 1998.
3. P. Vas, “Sensor less vector and direct torque control”, Oxford Press, 1998.
4. W.Leonard,“ Control of ElectricDrives”, Springer Verlag,1985.

Code: M16 PS 1104

ADVANCED CONTROL SYSTEM DESIGN

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. Design of Linear Control Systems
2. MIMO Control design
3. PID Controller
4. State space analysis
5. Integral square error compensation
6. State feedback compensation
7. Design of digital control system

COURSE OUTCOMES:

At the end of the course, the student will be able to

1. Design the controllers for linear continuous systems using frequency domain, time domain, state feed compensation and ISE compensation
2. Design the controllers for discrete-time systems using Z-plane and W-plane method
3. Design the PID controller using Ziegler Nicholas tuning method
4. Design the MIMO Control design

SYLLABUS

Design of Linear Control Systems: Review of compensation techniques to obtain desired performance, Reshaping of Bode & Root locus plots to obtain desired response, Initial condition and forced response, a simple lag– lead design.

Integral-square error compensation: parameter optimization using Integral-square error criterion with and without constraints, principles of State variable Feedback compensation of continuous-time and discrete-time systems, simple problems to understand the concept.

MIMO Control design: Principles of Linear Quadratic Optimal Regulators, Discrete Time Optimal Regulators, Observer Design, Linear Optimal Filters, State Estimate Feedback, Transfer Function Interpretation, simple problems to understand the concept.

PID Controller: PID controller, Simulation of multi-loop control system using P, PI, PD, PID controller, Standard compensator structures (P, PD, PI and PID control).

Design of digital control system: Protocol of Digital controller design, Classical Compensation of Discrete-time control systems: Forward path continuous, Forward-path Digital Z-plane Synthesis approaches, Deadbeat performance.

TEXT BOOKS:

1. G. C. Goodwin, S. F. Graebe, M. E. Salgado, “Control System Design”, Prentice Hall of India
2. Gupta and Hasdorf, 'Fundamentals of Automatic control Willey Eastern, 1970.
3. B.C. Kuo, Automatic control systems' (5th Edition), Prentice Hall of India, 1988.

REFERENCE BOOKS:

1. M. Gopal, “Digital Control and State Variable Method”, Tata McGraw Hill
2. HadiSaadat, “Computational Aids in Control System Using MATLAB”, McGraw Hill International.
3. Ogata K.,“Modern Control Engineering”, 4th Edition, Prentice Hall
4. Norman S. Nise, “Control Systems Engineering”, 3rd Edition, Wiley

Code: M16 PS 1105

RENEWABLE ENERGY SYSTEMS

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. To familiarize students regarding World Energy Scenario and Power Generation.
2. To familiarize students with Features of Conventional and Renewable Generation.
3. To Gain knowledge on Power balance /Frequency control of Renewable energy system.
4. To Study Renewable Energy generation in Power system.
5. To familiarize students with Power System Economics and the Electricity Market.
6. To understand the future towards a Sustainable Electricity supply.

COURSE OUTCOMES:

1. Students will be able to understand the World Energy Generation and consumption Over the past and present;
2. Students will be able to outline the technologies that are used to harness the Energy from Conventional and Non-conventional Sources.
3. Students will be able to understand power governing, dynamic frequency control of large systems, Impact of Renewable generation on Frequency control
4. Students will be able to explain the Issues Regarding Renewable Energy System in Power System
5. Students will be able to outline the Power system economics and Electricity Market
6. Students will have vision towards sustainable supply systems in Future.

SYLLABUS

Energy and Electricity: The World Energy Scene, The Environmental Impact of Energy Use, Generating Electricity, The Electrical Power System

Features of Conventional and Renewable Generation: Introduction, Conventional Sources: Coal, Gasand Nuclear, Hydroelectric Power, Wind Power, PV and Solar Thermal Electricity, Tidal Power, Wave Power, Biomass, Summary of Power Generation Characteristics, Combining Sources.

Power Balance/Frequency Control: Introduction, Electricity Demand, Power Governing, Dynamic Frequency Control of Large Systems, Impact of Renewable Generation on Frequency Control and Reliability, Frequency Response Services from Renewable, Frequency Control Modelling, Energy Storage.

Renewable Energy Generation in Power Systems: Distributed Generation, Voltage Effects, Thermal Limits, Other Embedded Generation Issues, Islanding, Fault Ride-through, Generator and Converter Characteristics.

Power System Economics and the Electricity Market: Introduction, The Costs of Electricity Generation, Economic Optimization in Power Systems., External Costs, Effects of Embedded Generation, Support Mechanisms for Renewable Energy, Electricity Trading.

The Future–Towards a Sustainable Electricity Supply System: Introduction, The Future of Wind Power, The Future of Solar Power, The Future of Bio fuels, The Future of Hydro and Marine Power, Distributed Generation and the Shape of Future Networks.

TEXT BOOKS:

1. Renewable Energy in Power Systems, BY Leon Freris, David Infield, WILEY PUBLISHERS, July 2008
2. Our Energy Future: Resource, Alternatives and the Environment, by Christian Ngo, Joseph Natowitz, Wiley Publishers, Aug 2009.

REFERENCE BOOKS:

1. Renewable Energy Resources' by John Twidell and Tony Weir, Taylor & Francis, Second edition, 2006.
2. Renewable Energy Systems by Henrik Lund, Elsevier Inc. 2014.

Code: M16 PS 1106

POWER SYSTEM MODELING

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. To enable the students to understanding of power system components.
2. To understand the concept of 2-axis representation of an Electrical machine.
3. To understand the importance of 3-phase to 2-phase conversion.
4. To know the representation of 3-phase induction motor in various reference frames
5. To know the modelling of 3-phase synch. Motor in 2- axis representation.
6. To know the modelling Transmission line, SVC and load

COURSE OUTCOMES:

At the end of the course student able to

1. Model the synchronous and induction machine by using different reference frame theories
2. Model the Transmission line, SVC and load

SYLLABUS

Modelling of Power System Components: The need for modelling of power system, Simplified models of non- electrical components like boiler, steam & hydro-turbine & governor system. Transformer modelling such as auto- transformer, tap-changing & phase-shifting transformer.

Reference Frame Theory: Static and rotating reference frames–transformation of variables–reference frames –transformation between reference frames–transformation of a balanced set–balanced steady state phasor and voltage equations –variables observed from several frames of reference.

Synchronous machine modeling: Voltage and Torque Equation–voltage Equation in arbitrary reference frame and rotor reference frame–Park equations-rotor angle and angle between rotor–steady state analysis– dynamic performances for torque variations-dynamic performance for three phase fault–transient stability limit – critical clearing time –computer simulation.

Transmission line, SVC and load modelling: Transmission line, d-q transformation using μ-b variables, static VAR compensators, loads modelling.

Induction Machines: Voltage and toque equations–transformation for rotor circuits–voltage and toque equations in reference frame variables–analysis of steady state operation–free acceleration characteristics– dynamic performance for load and torque variations–dynamic performance for three phase fault–computer simulation in arbitrary reference frame.

TEXT BOOKS:

1. Power Systems Dynamics – K.R. Padiyar, B.S. Publications
2. Power System Control and Stability – Vol. – I – Anderson & Foud, IEEE Press, New York.

REFERENCE BOOKS:

1. Power System Dynamics & Control– Kundur, IEEE Press, New York
2. Power System Operation & Control – P.S.R. Murthy, CRC press
3. "Electrical Energy System Theory– an introduction" by OlleElgerd. TMH Publishing Company 2^{nd} Edition, New Delhi
4. "Power System Analysis"–John J .Granierand W.D. Stevenson Jr, 4^{th}Edition, McGraw Hill International student edition.

Code: M16 PS 1107

POWER SYSTEM PLANNING

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. The course is designed to teach load forecasting, power system planning, and reliability issues in power system.
2. It aims to arm the students with the concepts of evaluation of generation and transmission system reliability and their impacts on system planning.
3. To learn the automation analysis for expansion of existing generation and transmission system planning.

COURSE OUTCOMES:

After completing the Power System and Automation course,
1. Students will be able to perform load forecasting for better planning of system.
2. Graduates are able to know the reliability of power system and do planning accordingly.
3. Graduates can carry out overall energy planning by automation.

SYLLABUS

Introduction: The electric utility industry, generation systems and transmission systems.

Load forecasting: Classification and characteristics of loads, approaches to load forecasting, load forecasting methodology, energy forecasting, peak demand forecasting, non-weather sensitive forecast (NWSF), weather sensitive forecast, total forecast.

Generation system reliability analysis: Probabilistic generating unit models, probabilistic load models, effective load, reliability analysis of anisolated system and interconnected systems.

Generation system cost analysis: Cost analysis, corporate models, production analysis, production costing, fuel inventories, energy transactions and off-peak loading, environmental cost.

Transmission system reliability analysis: Deterministic contingency analysis, probabilistic transmission system, reliability analysis, capacity state classification by subsets, subset decomposition for system LOLP and (DNS) calculations, single area and multi area reliability analysis.

Automated transmission system expansion planning: Basic concepts, automated network design, automated transmission planning, a DC method, automated transmission planning by interactive graphics.

TEXT BOOKS:

1. Power system planning, R. Sullivan ,McGraw International book Co., New Yorkand New Delhi (chapters1- 4,6,7of the text book).
2. Electric Power System Planning: Issues, Algorithms and Solutions' by Hossein Seifi, Mohammad Sadegh Sepasian, Springer Science & Business Media, 2011.
3. Power System Engineering: Planning, Design, and Operation of Power Systems and Equipment' by Juergen Schlabbach, Karl-Heinz Rofalski, John Wiley & Sons, 2014.
4. Smart and Sustainable Power Systems: Operations, Planning, and Economics of Insular Electricity Grids' by João P. S. Catalão, CRC Press, 2015

REFERENCE BOOKS:

1. Power System Planning' by H.M.Merrill, CRC Press.
2. Probabilistic Methods for Planning and Operational Analysis, G.T. Heydt and P.W. Sauer.

Code: M16 PS 1108

POWER SYSTEM SIMULATION LAB-I

Lab	**: 3 Periods**	**Sessionals**	**: 50**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 50**
		Credits	**: 2**

COURSE OBJECTIVES:

1. To practice the basic theories of Electrical Power system.
2. To provide hands-on experience to the students, so that they are able to apply theoretical concepts in practice.
3. To use computer simulation tools such as MATLAB to carry out design experiments as it is a key analysis tool of engineering design.
4. To give a specific design problem to the students, which after completion they will verify using the simulation software or hardware implementation.

COURSE OUTCOMES:

1. Graduate will demonstrate the ability to identify, formulate and solve Power System engineering problems.
2. Graduate will demonstrate the ability to design and conduct experiments, analyze and interpret data.
3. Graduates will demonstrate the ability to design a electrical systems or process as per needs and specifications
4. Graduate will demonstrate the skills to use modern engineering tools, softwares and equipment to analyze problem.

LIST OF EXPERIMENTS:

1. Series RLC circuit
2. MATLAB Program to Simulate Ferranti Effect.
3. MATLAB Program to Model Transmission Lines.
4. MATLAB Program to Form Y bus by Singular Transformation
5. MATLAB Program to Solve Load Flow Equations by Gauss-Seidel Method
6. MATLAB Program to Find Optimum Loading of Generators Neglecting Transmission Losses.
7. MATLAB Program to Find Optimum Loading of Generators with Penalty factors.
8. MATLAB Program to Solve Swing Equation.
9. Simulink Model of Single Area Load Frequency Control with and without PI Controller in Simulink.
10. Simulink Model for Two Area Load Frequency Control
11. Simulink Model for Evaluating Transient Stability of Single Machines Connected to Infinite Bus.

REFERENCE BOOKS:

1. Elements of Power System Analysis' by by William Stevenson, McGraw Hill Higher Education; 4th Revised edition.
2. Power System Analysis Hadi Saadat, PSA Publishing, 2010.
3. Modern Power System Analysis' by D.P. Kothari and I.J. Nagrath, McGraw-Hill Companies, Incorporated, 2006.
4. Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers' by Rudra Pratap, Oxford University Press, 2010
5. MATLAB: An Introduction with Applications, 5th Edition Amos Gilat, Wiley Global Education, 2014.

Code: M16 PS 1109

SEMINAR-I

Lab : 3 Periods **Sessionals : 100**
Exam : 3 Hrs. **Credits : 2**

The viva-voce for the seminar shall be held with the faculty member, PG coordinator, and Head of the Department. The marks shall be awarded in the ratio of 40, 20 and 40 percent by the members respectively.

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II – SEMESTER

Course Code	Course	Credits	Lecture hours	Lab hours	Total contact hours	Sessional Marks	Exam Marks	Total Marks
M16 PS 1201	Power System Dynamics and Stability	4	4	--	4	30	70	100
M16 PS 1202	Automation in Power Systems	4	4	--	4	30	70	100
M16 PS 1203	Intelligent Systems and Control	4	4	--	4	30	70	100
M16 PS 1204	Optimal Control Theory	4	4	--	4	30	70	100
#2	Elective-II	4	4	--	4	30	70	100
M16 PS 1208	Power System Simulation Lab-II	2	--	3	3	50	50	100
M16 PS 1209	Seminar-II	2	--	3	3	100	--	100
	Total	**24**	**20**	**6**	**26**	**300**	**400**	**700**

	Course Code	Course
#2-Elective-II	M16 PS 1205	High Voltage AC/DC Transmission
	M16 PS 1206	Power Quality
	M16 PS 1207	Power Electronic Applications in Power Systems

Code: M16 PS 1201

POWER SYSTEM DYNAMICS AND STABILITY

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

At the end of the course the student is expected to

1. Give basic knowledge about the dynamic mechanisms behind angle and voltage stability problems in electric power systems, including physical phenomena and modelling issues.
2. Learn the concepts of Dynamics, Stability, Excitation and SMIB of Power Systems.
3. Learn the modeling of synchronous machine, Excitation systems and Transmission lines.
4. Do simulation of system dynamics.
5. Learn the requirements of power system modeling and stability
6. Learn problem solving techniques for existing problems in power systems.

COURSE OUTCOMES:

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

1. Will be able to solve the reactive power problems in power system
2. Will learn the concepts of Dynamics, Stability, Excitation and SMIB of Power Systems.
3. Will be able to do machine modeling.
4. Will do modeling of Excitation systems and Transmission lines.
5. Will be able to understand the effect of excitation system on small signal stability.
6. Understand the significance of power system stabilizer in power system stabilities.

SYLLABUS

Modelling: Basic concepts, Review of classical methods, modelling of synchronous machine, Park’s transformation, Analysis of steady state performance, Excitation system, excitation system modelling, Excitation systems-standard block diagram, System representation by state equations, Prime mover control system, Transmission lines, SVC and Loads modelling, D-Q transformation using α-β variables.

Dynamics of a Synchronous generator connected to infinite bus: System model, synchronous machine model, Application model (1.1), Calculation of initial conditions, System simulation, Consideration of other machine models, Inclusion of SVC model.

Small Signal Stability Analysis: Analysis of single machine system, small signal analysis with block diagram representation, Characteristic equation and application of Routh-Hurwitz criterion, synchronizing and damping torque analysis, small signal model state equations.

Application of Power System Stabilizers: Introduction, Basic concepts in applying PSS, Control signals, structure and tuning of PSS.

Analysis of Multi-machine system: As implified system model, detailed models, Case I and II, Inclusion of load and SVC dynamics, modal analysis of large power systems.

TEXT BOOKS:

1. Power System Dynamics, stability and control by K.R. Padiyar, Interline Publishing private limited, Bangalore, India.
2. Power system control and stability by P.M .Anderson and A. A. Fouad, Ezalgotia publications

REFERENCE BOOKS:

1. Power System Stability, Vol-3, by Edward Wilson Kinbark, Wiley-Interscience, A John wiley & Sons.
2. Power System Dynamics and Stability by Peter W. Sauer, M.A. Pai Prentice Hall, 1998

Code: M16 PS 1202

AUTOMATION IN POWER SYSTEMS

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. To know what are the elements of automatic power control systems.
2. To clearly understand the role of central control room management and operations in the DA solution.
3. To familiarize with Supervisory control and data acquisition (SCADA).
4. To gain the awareness of the problems and challenges of the present day distribution sector.
5. To gain the knowledge of Principles of Distribution Automation (DA)
6. To gain the knowledge of various communication technologies available for DA.
7. To clearly understand the Technical Benefits of automation of distribution system.

COURSE OUTCOMES:

At the end of the course, the student will be able to

1. Learn various activities of central control room management.
2. Understand about SCADA
3. Gain the knowledge on application of automation to distribution system.

SYLLABUS

Introduction: Purpose of automatic power control systems, elements of automatic power control systems, automatic power control and controllers relays and relaying devices.

Operation and control: Operations environment of distribution networks, evolution of distribution management systems, basic distribution management system functions, basis of a real-time control system (SCADA),data acquisition, monitoring and event processing, control functions, data storage, archiving, and analysis, hardware system configurations, SCADA system principles.

Distribution automation: Problems with existing distribution system, need for distribution automation, characteristics of distribution system, distribution automation, feeder automation.

Substation automation: Definition, functions of substation automation state and trends of substation automation, intelligent affordable substation monitoring and control.

Feeder automation: Losses in distribution systems, system losses and loss reduction, network reconfiguration, improvement in voltage profile, capacitor placement for reactive power compensation, Algorithm for location of capacitor.

TEXT BOOKS:

1. Automation in Electrical power systems by, P.I. Zabolotny, MIR Publishers, Moscow
2. Control and Automation of Electrical Power Distribution Systems (PowerEngineering) James Northcote- GreenJames Northcote-Green, Taylor & Francis,2007.
3. A Textbook of Electric Power Distribution Automation By Dr.M.K.Khedkar, Dr.G.M.Dhole, university science press, NewDelhi 2010

REFERENCE BOOKS:

1. Sunil S. Rao, Switch gearand Protections, Khanna Publication
2. Stuart A Boyer: SCADA supervisory control and data acquisition, ISA
3. Gordan Clark, Deem Reynders, Practical Modem SCADA Protocols

Code: M16 PS 1203

INTELLIGENT SYSTEMS AND CONTROL

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. To introduce the students with the concepts of learning methods.
2. To provide students with the artificial neural networks and their architecture.
3. To familiarize the students with the various applications of artificial neural networks.
4. To introduce the concepts of the fuzzy logic control and their real time applications.

COURSE OUTCOMES:

1. Define the advances in neural networks
2. Evaluate the design and control of fuzzy systems.
3. Articulate the applications of fuzzy control block sets.
4. Evaluate the design of various models in neural networks
5. Techniques for analyzing of various types of neural networks
6. Evaluate the design and control of associative memories
7. Techniques to Design fuzzy logic system
8. Learn the unified and exact mathematical basis as well as the general principles of various soft computing techniques.
9. Provide detailed theoretical and practical aspects of intelligent modeling, optimization and control of non-linear systems.
10. Prepare the students for developing intelligent systems through case studies, simulation examples and experimental results.

SYLLABUS

Neural Networks: Artificial Neural Networks: Basic properties of Neurons, Neuron Models, Feed forward networks–Perceptrons, Multilayer networks–Exact and approximate representation, Back propagation algorithm, variants of Back propagation, Unsupervised and Reinforcement learning; Competitive learning and self organizing networks, Hybrid Learning.

ANN based control: Introduction: Representation and identification, modelling the plant, control structures– supervised control, Model reference control, Internal model control, Predictive control, Case study-application to electrical engineering.

Fuzzy Logic: Overview of classical logic, Fuzzy setsvs Crispset, Membership function, Methods of Membership function, Value Assignment, Defuzzification–Methods of defuzzification, fuzzy rule based and Approximation, Aggrigation of Fuzzy rules, Fuzzy inference system –Mamadani and Sugeno methods.

Fuzzy Controllers: Preliminaries–Basic architecture and operation of Fuzzy controller–Analysis of static properties of fuzzy controller–Analysis of dynamic properties of fuzzy controller–simulation studies–case studies –application to electrical engineering.

Neuro–Fuzzy Controllers: Neuro–fuzzy systems: A unified approximate reasoning approach–Construction of role bases by self learning: System structure and learning algorithm–A hybrid neural network based Fuzzy controller with self learning teacher. Fuzzified CMAC and RBF network based self-learning controllers, case studies –application to electrical engineering

TEXT BOOKS*:*

1. Bose and Liang, Artificial Neural Networks, Tata Mcgraw Hill, 1996.
2. Kosco B, Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence, Prentice Hall of India, New Delhi, 1992.

REFERENCE BOOKS:

1. Klir G.J and Folger T.A, Fuzzy sets, Uncertainty and Information, PHI, New Delhi 1994.
2. Simon Haykin, Neural Networks, ISA, Research Triangle Park,1995.
3. Bose, NirmalK.;Bose, N.K.; Liang, Ping, Neural Network Fundamentals with Graphs, Algorithms, and Applications (McGraw-Hill Series in Electrical & Computer Engineering)
4. Robert Fuller, Introduction to Neuro-Fuzzy Systems, Springer,2000
5. J.-S. R. Jang, C.-T. Sun, and E. Mizutani , Neuro-Fuzzy and Soft Computing
6. Berenji, Hamid R , Fuzzy and neural control (May 1, 1992)
7. Fuzzy logic with Fuzzy Applications– T.J. Ross – Mc Graw Hill Inc, 1997.
8. Fuzzysets, Fuzzylogic, fuzzy systems by – loft Asker Zadeh
9. TimothyJ Ross – Fuzzy Logic with Emergency Applications
10. Hans Jurgen Zimmerman –Fuzzy Theoryand its Applications

Code: M16 PS 1204

OPTIMAL CONTROL THEORY

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. To give exposure to problem formulation and performance measures for different type of optimal control problems.
2. To introduce concepts needed to solve optimal controller using Dynamic Programming Approach and H-J-B equation.
3. To introduce concepts of functional, variation of functional, the fundamental theorem of calculus of variation to solve simplest variational problem.
4. To introduce concepts needed to solve linear regulatory problem using Pontryagin's minimum principle.
5. To introduce concept of iterative numerical techniques needed to solve two-point boundary value problems using steepest descent algorithm.

COURSE OUTCOMES:

After completing this course the students should be able to:

1. Have familiarity with problem formulation and different forms of performance measures as applied to variety of optimal control problems.
2. Apply optimal control law and dynamic programming computational procedure to solve optimal control problems.
3. Apply Hamilton-Jacobi-Bellman equations to solve linear regulator problem
4. Have complete familiarity with Calculus of Variation.
5. Have familiarity with Pontryagin's minimum principle.
6. Apply numerical techniques like steepest descent algorithm to determine optimal trajectories.

SYLLABUS

Introduction: Problem formulation-State variable representation of systems–Performance measures for optimal control problems– selecting a performance measure.

Dynamic programming: The optimal control law-principle of optimality and its application-optimal control system-interpolation-recurrence relation of dynamic programming-computational procedure for solving optimal control problems–characteristics of dynamic programming solution-analytical results-discrete linear regulator problems- Hamilton-Jacobi-Bellman equation-continuous linear regulator problems.

The Calculus of variations: Fundamental concepts-linearity of functional-closeness of functions-the increment of a functional-The variation of a functional-maxima and minima of functional-the fundamental theorem of the calculus of variations- Functional of a single function-the simplest variational problem

The variational approach to optimal control problems: Necessary conditions for optimal control-Linear regulator problem-Pontryagin's minimum principle and state inequality constraints.

Iterative numerical techniques for finding optimal controls: Two-point boundary-value problems-The method of steepest descent-Features of the steepest descent algorithm.

TEXT BOOKS:

1. Optimal control theory-An Introduction by Donald E. Kirk -Prentice Hall Networks series.
2. Optimal control: Linear Quadratic Method by B.D.O Anderson & J.B. Moor, PHI,1990.

REFERENCE BOOKS:

1. Optimal Control Systems by Desineni Subbaram Naidu, CRC Press.
2. Optimal control: An Introduction to the Theory and Its Applications, by Athans. M & P.L.Flab.

Code: M16 PS 1205

HIGH VOLTAGE AC/DC TRANSMISSION

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. To learn HVAC and HVDC transmission systems.
2. To analyse phenomenon's of Lightning, Travelling waves and switching Transients.
3. To have an idea about Protection Devices in HVAC Transmission.
4. To design filters for reduction of harmonics.
5. To Model and analyse AC and DC systems interaction.

COURSE OUTCOMES:

At the end of the course students will be able:

1. To understand the basic concepts of EHV AC and HVDC transmission.
2. To identify the electrical requirements for HVDC lines.
3. To identify the components used in AC to DC conversion.
4. To understand the operation of HVDC conversion technology.
5. To understand the fundamental requirements of HVDC transmission line design.
6. To identify factors affecting AC-DC transmission.
7. To Design Filters for reduction of harmonics and Become familiarize with the use of protection equipment

SYLLABUS

EHVAC Transmission: Principles, configuration, special features of high voltage AC lines, power transferability, reactive power compensation, audible noise, corona, electric field, right of way, clearances in a tower, phase to phase, phase to ground, phase to tower, factors to be considered, location of ground wire.

Lightning, Travelling waves and switching Transients: Mathematical model to represent lightning-Travelling wave in transmission lines-Circuits with distributed constants-Wave equations-Reflection and Refraction of travelling waves-Travelling waves at different line terminations-effect of short length of cables-Shape and attenuation and distortion of travelling waves-Switch intransient -the circuit closing transient-the recovery transient initiated by the removal of the short circuit.

Protective device in HVAC transmission: Basic ideas about protection–surge diverters-surge absorbers- ground fault neutralizers-Protection of lines and stations by shielding-Ground wires–counterpoises-Driven rods- Modern lightning arrestors.

HVDC Transmission: General aspects of HVDC transmission, HVD Clinks-comparison–Economic, Technical performance–Reliability–Limitations-Properties of thyrist or converter circuits-assumptions-Choice of best circuit for HVDC converters-Transformer connections–Analysis with gate control but no overlap less than 60 degrees- operation of inverters.

Bridge converters-Analysis, Control, Protection and Harmonics Filters: Converter/Inverter circuits for HVDC Transmission-basic means of control –Power reversal-desired features of control–actual control characteristics .Converter disturbance by pass action in bridges-commutation failure-basics of protection-DC Reactors-Voltage and current oscillations-Circuit breakers-Over voltage protection-Characteristics and non- characteristic harmonics-design of ac and dc filters.

Modeling and analysis of AC and DC systems interaction: System models, application of switching functions, torsional interactions with HVDC systems, harmonic interaction, control interaction.

TEXT BOOKS:

1. Allen Greenwood,` Electrical Transients in power system', Wiley Inter science,1971
2. EHV AC Transmission by Rakosh Das Begamudre, New Age Publishers
3. Kim bark, E.W., `Direct current transmission-Vol.1', Wiley Inter science, New York, 1971

REFERENCE BOOKS:

1. Arrilaga,J. ,`High Voltage Direct current transmission ',Peter Pereginver Ltd., London,UK.,1983
2. Diesendorf,W., `Over voltage on High voltage system' Rensselaer Book store, Troy, New York,1971
3. Klaus Ragallea, `Surges and high voltage networks', Plenum Press, 1980.
4. Padiyar, K.R.,` HVDC Transmission system', Wiley Eastern Limited ., NewDelhi, 1992.
5. An Introduction to High Voltage Engineering by SubirRay, Prentice Hall of India Private Limited, New Delhi – 110 001.
6. HVDC Transmission- Adamson C. Hingorani N.G.
7. Power Transmission by DC UhimannE.
8. HVAC and HVDC Transmission, Engineering and practice : S.Rao,Khanna Publisher, Delhi.
9. Electric Power Systems: B.M. Weddy and B.J. Cory, John Wiely and Sons,Fourth edition (2002)
10. Power System Analysis and Design: J. Duncan Glover, Mulukutla S .Sarma, Thomson Brooks/cole/Third Edition (2003)
11. Power System Analysis and Design, B.R. Gupta, S.Chand and Company (2004)

Code: M16 PS 1206

POWER QUALITY

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. Understand the various power quality issues, their origin, and monitoring and mitigation methods.
2. To understand the power quality problems like voltage sag, swell, flickers, harmonics etc
3. Understand the effects of various power quality phenomenon in various equipment.
4. To know the knowledge on voltage standard characteristics, PQ survey etc.

COURSE OUTCOMES:

1. Students are able to possess the necessary skills to understand and handle power quality related problems.
2. Students are able to identifying the cause or source of the problem and assessing the severity of each problem with respect to the vulnerability of the affected devices.
3. Students expected to be familiar with power quality terminologies, and ready to tackle power quality related challenges.
4. Students will be able to identify the standard characteristics and PQ survey.

SYLLABUS

Introduction: Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring

Long Interruptions: Interruptions–Definition–Difference between failure, outage, Interruptions–causes of Long Interruptions–Origin of Interruptions–Limits for the Interruption frequency–Limits for the interruption duration–costs of Interruption–Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

Short Interruptions: Short interruptions – definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping– voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

Voltage sag–characterization–Single phase/Three-phase: Voltage sag–definition, causes of voltage sag, voltage sag magnitude, monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non radial systems, meshed systems, voltage sag duration. Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags

Power Quality and EMC Standards: Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys

TEXT BOOKS:

1. "Understanding Power Quality Problems" by Math H J Bollen. IEEEPress.
2. Power Quality in Electrical Systems' by Alexander Kusko, The McGraw-Hill Companies, 2007.

REFERENCE BOOKS:

1. Power Quality in Power System' by Mohammad A.S. Masoum, Ewald F.Fuchs, Elsevier, Academic Press, 2015.
2. Electrical Power Systems Quality by Roger C.Dugan, Electrotek Concepts lnc.

Code: M16 PS 1207

POWER ELECTRONIC APPLICATIONS IN POWER SYSTEMS

Theory	**: 4 Periods**	**Sessionals**	**: 30**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 70**
		Credits	**: 4**

COURSE OBJECTIVES:

1. To enable the students acquire a comprehensive ideas on various aspects of FACTS systems.
2. To acquire the knowledge on Flexible AC Transmission System and its importance for FACTS devices.
3. To understand the various FACTS controllers operation on FACTS systems.
4. To Gain Knowledge about STATCOM.

COURSE OUTCOMES:

After completion of the course, the student will be able to

1. Understand the importance of FACTS controllers and its benefits.
2. Know the objectives of shunt, series compensations and role of FACTS devices on system stability, voltage control.
3. Analyze the functional operation and control of SVC and STATCOM.
4. Describe the principle, operation and control of SPST.

SYLLABUS

Introduction: Basics of Power Transmission Networks - Control of Power Flow in AC Transmission Line- Flexible AC Transmission System Controllers, Basic types of FACTS Controllers, Brief Descriptions and Definitions of FACTS Controllers. Benefits from FACTS technology, HVDC vs. FACTS.

Static shunt compensators: SVC and STATCOM:- Objectives of Shunt compensation, Methods of controllable VAR generation, Static VAR compensators: SVC and STATCOM, comparison between SVC and STATCOM, Static VAR systems.

Static Synchronous Compensator (STATCOM): Introduction-Principle of Operation of STATCOM-A Simplified Analysis of a Three Phase Six Pulse STATCOM-Analysis of a Six Pulse VSC Using Switching Functions-Multi-pulse Converters Control of Type 2 Converters-Control of Type1Converters-Multi level Voltage Source Converters- Harmonic Transfer and Resonance in VSC Applications of STATCOM

Static Phase Shifting Transformer: General-Basic Principle of a PST-Configurations of SPST Improvement of Transient Stability Using SPST -Damping of Low Frequency Power Oscillations - Applications of SPST

Static Series compensators: GCSC, TSSC, TCSC and SSSC:- Objectives of series compensation, Variable impedance type series compensators, Switching converter type series compensators, External(System) Control for Series Reactive Compensators, Summery of Characteristics and Features.

TEXT BOOKS:

1. N.G. Hingorani, 'Understanding Facts', IEEE Press 1999.
2. K.R Padiyar, "FACTS Controllers in power transmission and distribution, New Age International (P) Limited, Publishers,2007"

REFERENCE BOOKS:

1. Yomg Hua Song, 'Flexible AC Transmission Systems' (FACTS) IEE Press, 1999.
2. E. Acha,V.G. Agelidis, O.Anaya-Lara, T.J.E. Miller, 'Power Electronic Control in Electrical Systems' Newnes Power Engineering Series,Oxford,2002.

Code: M16 PS 1208

POWER SYSTEM SIMULATION LAB-II

Lab	**: 3 Periods**	**Sessionals**	**: 50**
Exam	**: 3 Hrs.**	**Ext. Marks**	**: 50**
		Credits	**: 2**

COURSE OBJECTIVES:

1. To Simulate and compare the various aspects economic load dispatch and load flows.
2. To Simulate and observe the stability studies of transient and steady state
3. To simulate and observe behaviour of a system during the Short circuit
4. To Conduct experiments on a given system to know performance when subjected to various faults
5. To Conduct experiments on different types of relays

COURSE OUTCOMES:

1. The student will be able to validate the adaptability of economic load dispatch and load flow for a given situation by simulation results.
2. Design a controller for FACTS application by simulation
3. Demonstrate the effects of different sequence reactance of a synchronous machine by experimentation.
4. Acquainted with the characteristics of different relays by experimentation
5. Know how to use the simulation software to design a real time power system .

LIST OF EXPERIMENTS:

1. Implementing the newton Raphson method for load flow using matlab
2. Load flow analysis by Decoupled method using matlab
3. Load flow analysis by fast Decoupled method using matlab
4. Obtain positive and negative sequences under un symmetrical fault analysis using matlab
5. Solve the dynamics of synchronous machine using matlab
6. Obtain Swing curves of a synchronous machine for a 3 phase fault
7. Optimal load frequency control of a two area system
8. Obtain the transient and subtransients of a synchronous generators
9. Obtain the sequence impedences of the transmission lines
10. Improving voltage profile by using series compensation
11. Design of statcom

REFERENCE BOOKS:

1. Elements of Power System Analysis' by by William Stevenson, McGraw Hill Higher Education; 4th Revised edition.
2. Power System Analysis Hadi Saadat, PSA Publishing, 2010.
3. Modern Power System Analysis' by D.P. Kothari and I.J. Nagrath, McGraw-Hill Companies,Incorporated, 2006.

4. Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers' by Rudra Pratap, Oxford University Press, 2010
5. MATLAB: An Introduction with Applications, 5th Edition Amos Gilat, Wiley Global Education, 2014

Code: M16 PS 1209

SEMINAR-II

Lab : 3 Periods **Sessionals : 100**
Exam : 3 Hrs. **Credits : 2**

The viva-voce for the seminar shall be held with the faculty member, PG coordinator, and Head of the Department. The marks shall be awarded in the ratio of 40, 20 and 40 percent by the members respectively.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

M.TECH (POWER SYSTEMS AND AUTOMATION)

Scheme of Instruction and Examination
(Regulation: R16)

(with effect from **2016-2017** admitted batch onwards)

III – SEMESTER

Course Code	Course Title	Credits	Scheme of Examination	Exam Marks	Total Marks
M16 PS 2101	Thesis Work - Preliminary	10	Review	100	100

1. Candidates can do their thesis work within the department or in any industry/research organization for two semesters (i.e. 3rd and 4th semesters). In case of thesis done in an industry/research organization, one advisor (Guide) should be from the department and one advisor (Co-Guide) should be from the industry/research organization.
2. The Thesis Work -Preliminary should be submitted at the end of 3rd semester and it will be evaluated through Review by a committee consisting of Head of the Department, External Examiner, PG coordinator and guide. The marks shall be awarded in the ratio of 20, 40, 20 and 20 percent by the members respectively.

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IV – SEMESTER

Course Code	Course Title	Credits	Scheme of Examination	Exam Marks	Total Marks
M16 PS 2201	Thesis Work-Final	14	Viva-voce	100	100

1. A publication of a paper on the thesis work in a National/International Journal at the end of 4th semester is mandatory for the submission of thesis work.
2. The Thesis should be submitted at the end of 4th semester and it will be evaluated through Viva–Voce examination by a committee consisting of Head of the Department, External Examiner, PG coordinator and thesis guide. The marks shall be awarded in the ratio of 20, 40, 20 and 20 percent by the members respectively.