Syllabus
of
M. Tech.
Electrical Engineering
(Power Systems)
K. E. Society’s
RAJARAMBAPU INSTITUTE OF TECHNOLOGY,
RAJARAMNAGAR
Department of Electrical Engineering
Curriculum structure for
M. Tech. Electrical (Power Systems)

Semester - I

<table>
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<tr>
<th>Course Code</th>
<th>Course</th>
<th>Teaching scheme</th>
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<td>EE501</td>
<td>Research Methodology</td>
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<td>EE503</td>
<td>Advanced Power System Protection</td>
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<td>EE505</td>
<td>Power System Deregulation</td>
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<td>EE507</td>
<td>Computer Aided Power System Analysis</td>
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<td>EE509</td>
<td>(Elective – I) Grid Integration of Renewable Energy</td>
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<td>Electrical Power Quality</td>
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<td>Power Converters</td>
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<td>Advanced Power System Protection Lab</td>
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<td>EE555</td>
<td>Seminar I</td>
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Total contact hours/week : 26   ISE = In Semester Evaluation, MSE = Mid Semester
Total credits : 24   ESE = End Semester Examination
### Semester - II

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<th>Course Code</th>
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<td>Power System Planning and Reliability.</td>
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<td>EE504</td>
<td>Power System Dynamics</td>
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<td>Power System Optimization Techniques</td>
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<td>EE508</td>
<td>Elective-II Advanced Control of Electric Drives</td>
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<td>EE510</td>
<td>Energy Management and Energy Audit</td>
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<td>EE512</td>
<td>Elective – III Distribution System Engineering</td>
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<td>EE514</td>
<td>Smart Grid Technologies &amp; Applications</td>
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<td>EE 516</td>
<td>Advanced Digital Signal Processing</td>
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**Total contact hours/week**: 26  
**Total credits**: 24
Objectives:
1. To orient students towards the research
2. To enable students to students the various techniques of design.

Unit –I
Research Methodology: An Introduction Objectives of Research, Types of Research, Research Methods and Methodology, Defining a Research Problem, Techniques involved in Defining a Problem

Unit –II

Unit –III
Measurement and Scaling Techniques Measurement in Research, Measurement Scales, Sources in Error, Techniques of Developing Measurement Tools, Scaling, Meaning of Scale, Scale Construction Techniques

Unit –VI
Methods of Data Collection and Analysis Collection of Primary and Secondary Data, Selection of appropriate method Data Processing Operations, Elements of Analysis, Statistics in Research, Measures of Dispersion, Measures of Skewness, Regression Analysis, Correlation

Unit –V
Techniques of Hypotheses, Parametric or Standard Tests Basic concepts, Tests for Hypotheses I and II, Important parameters limitations of the tests of Hypotheses, Chi-square Test, Comparing Variance, As a non-parametric Test, Conversion of Chi to Phi, Caution in using Chi-square test

Unit –VI
Analysis of Variance and Co-variance ANOVA, One way ANOVA, Two Way ANOVA, ANOCOVA Assumptions in ANOCOVA, Multivariate Analysis Technique Classification of Multivariate Analysis, factor Analysis, R-type Q Type factor Analysis, Path Analysis

Reference Books:
4. “Research Methodology- A step by step guide for beginners”, Ranjit Kumar, Pearson Education
5. “Management Research Methodology-Integration of principles, methods and Techniques”, K.N. Krishna swami and others, Pearson Education
Objectives:
1. To study fundamental principles of distance relaying and application to transmission system protection.
2. To study numerical relaying, DSP fundamentals and application to current and voltage phasor estimation.
3. To study numerical relaying algorithms for over current, distance and differential protection with application to transmission system, transformer and bus bar protection.

Unit-I
Digital Relay Advantages of Digital Relaying systems, Block diagram of Digital Relay, Anti aliasing filters, Data window, Facilities in commercial digital relays, Different relay algorithms such as least square error method, Walsh algorithm, Man and Morrison algorithm, Discrete Full Cycle and Half Cycle Algorithm, communication protocol (IEC 61850), Time Synchronization with Wide Area Measurements.

Unit-II
Advanced Protection of Transmission Line Coordination of over current relays in an interconnected system, LINKNET structure, Concept of Sympathy Trips, Coordination of Distance Relays, Protection of Series Compensated Lines: Problems & Solutions, Teed Line, Carrier Current Protection, Phase Comparison Carrier, Carrier Aided Distance Protection, Blocking Carrier, Carrier Intercropping and Carrier Acceleration, Philosophy of Adaptive Relaying.

Unit-III
Unit -IV

Unit -V
Introduction, Rate of Frequency Decline, Load-Shedding, Frequency Relays, KF Induction-Cylinder Under frequency Relay, Digital Frequency Relays, Microprocessor-Based Frequency Relay, Formulating a Load-Shedding Scheme, Maximum Anticipated Overload, Number of Load-Shedding Steps, Size of the Load Shed at Each Step, Frequency Settings, Time Delay, Location of the Frequency Relays, Special Considerations for Industrial Systems.

Unit -VI
Shunt Reactor Applications, Rate-of-Rise-of-Pressure Protection, Overcurrent Protection, Differential Protection, Reactors on Delta System, Turn-to-Turn Faults, Capacitor Bank Protection

Reference Books:
1. Date, Oza, Nair –Power System Protection - Bharti Prakashan
Objectives:
1. To provide in-depth understanding of operation of deregulated electricity market systems
2. To examine topical issues in electricity markets and how these are handled world-wide in various markets
3. To enable students to analyze various types of electricity market operational and control issues using new mathematical models

Unit –I
Deregulation, Reconfiguring Power systems, unbundling of electric utilities, Background to deregulation and the current situation around the world, benefits from a competitive electricity market after effects of deregulation

Unit –II
Role of the independent system operator, Operational planning activities of ISO: ISO in Pool markets, ISO in Bilateral markets, Operational planning activities of a GENCO: Genco in Pool and Bilateral markets, market participation issues, competitive bidding

Unit –III
Power wheeling, Transmission open access, pricing of power transactions, security management in deregulated environment, and congestion management in deregulation

Unit –VI
General description of some ancillary services, ancillary services management in various countries, reactive power management in some deregulated electricity markets

Unit –V
Reliability analysis: interruption criterion, stochastic components, component models, Calculation methods, Network model: stochastic networks, series and parallel connections, minimum cut sets, reliability cost

Unit –VI
Generation, transmission and distribution reliability, Reliability and deregulation: conflict, reliability analysis, effects on the actual reliability, regulation of the market
Reference Books:

Objectives:
1. To update the knowledge in the emerging and upcoming topics in this area.
2. To make the students conversant with the different software used for computer aided power system analysis.

Unit –I
Network Modeling and Power Flow I:
System graph, loop, cutest and incidence matrices, y-bus formation, sparsity and optimal ordering, power flow analysis, Newton Rapson method.

Unit –II
Network Modeling and Power Flow II:
Decoupled and fast decoupled method, formulation of three phase load flow, dc load flow, formulation of AC-DC load flow, sequential solution technique.

Unit –III
Analysis of three phase symmetrical and unsymmetrical faults in phase and sequence domain, Phase shift in sequence quantities due to transformer, open circuit faults.

Unit –IV
Stability Studies: Transient stability analysis, swing equation, stability of multimachine system using modified Euler method and Runge-Kutta method

Unit –V

Unit –VI
AC power flow method, introduction to state estimation.
Reference Books:

Objectives:

1. To study the fundamentals of wind and solar energy conversion techniques.
2. To study various methods of resource assessment for renewables
3. To study stochastic models of wind energy for generation scheduling

Unit – I
Dispersed photovoltaic, solar, wind, fuel cell and conventional dispersed generation technologies, economic factors and technical impact on utility distribution systems, interfacing and optimal location of dispersed generation, protective relaying and system interconnection issues, islanding, voltage flicker effects, power quality effects.

Unit – II
Principles of wind energy extraction, electromechanical energy conversion, characteristics of wind turbines, Photovoltaic and Thermo-solar power generation profiles, Aerodynamics of wind turbines, aerodynamic power controls, pitch, stall, active stall, rotor power characteristics CP-λ, Power curves

Unit – III
Wind energy conversion systems, Induction generator, Synchronous generator with full scale power electronic block, variable speed operations, doubly fed induction generation.

Unit – VI
Wind data analysis, Weibull distribution, Rayleigh distribution, Energy estimation of wind regimes, Weibull based approach, Rayleigh based approach, Power curve of the wind turbine, Capacity factor, matching the turbine with wind regime, economic dispatch model incorporating wind Power, overestimation and to the cost of underestimation of available wind power, economic emission dispatch.

Unit – V
Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.
Unit –VI

Wind integration operational issues such as frequency control, load following, reserve requirements, integrating wind in the competitive electricity market.

Reference Book:

2. Wind Energy Explained: Theory, Design and Application: James Manwell, J. F. Manwell,
M. Tech. Electrical (Power Systems)
EE 511: Electrical Power Qualities
SEM-I

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Objectives:

1. To Study the different causes of power quality issues.
2. To study the effect of harmonics and voltage fluctuations on power system performance.
3. To study the design aspects of filters to mitigate harmonics and voltage fluctuations.

Unit -I
Electric power quality phenomena- IEC and IEEE definitions - power quality disturbances-voltage fluctuations-transients-unbalance-waveform distortion-power frequency variations

8

Unit -II
Voltage variations, Voltage sags and short interruptions flicker-longer duration variations sources range and impact on sensitive circuits-standards solutions and mitigations equipment and techniques.

8

Unit -III

8

Unit -IV
Harmonics – sources – definitions & standards – impacts - calculation and simulation

8

Unit -V
Harmonic power flow - mitigation and control techniques – filtering – passive and active

8

Unit -VI
Power Quality conditioners – shunt and series compensators-DStatcom-Dynamic voltage restorer-unified power quality conditioners-case studies

8

Reference Books:

M. Tech. Electrical (Power Systems)  
EE513: Power Converters  
SEM-I

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Objectives:
1. To Study the different power converter technologies.
2. To design various inverters, harmonic reduction techniques.

Unit-I
An overview of PSDs, 1-Phase and 3-Phase Controlled rectifiers-Average output voltages and currents for R-L. Load performance parameters of rectifier 1-Phase and 3-Phase converter.

Unit-II
DC-DC converters: Buck, Boost, Buck-boost and Cuk converters, linear power supplies. Switch mode DC Power supplies, Fly back converter, Forward converter, push pull converter, half bridge and full bridge converter.

Units-III
Basic concepts of switch mode inverter, pulse width modulated switching scheme, unipolar and bipolar Switching scheme, 1-ô inverters, push pull inverters, 3-Phase inverters, PWM in 3-Phase voltage source inverters. Reduction of Harmonies, square wave pulse switching, programmed Harmonic elimination switching, SVM technique.

Unit-IV
Resonant pulse Converters: Classification of resonant Converters, series Resonant Inverter: Series Resonant inverters with unidirectional switches, series resonant inverters with bi directional switches. Parallel Resonant Inverters, Zero current switching resonant converters, zero voltage switching resonant converters.

Unit-V
Multi-level inverters – switching dc power supplies – power conditioners & UPS, AC voltage controllers – matrix converter

Unit-VI
Design aspects of converters, Protection of devices and circuits.

Books for Reference
1. Power electronics, Circuits, devices. Application by M.H.Rashid (PHI)
M. Tech. Electrical (Power Systems)
EE551: Advanced Power System Protection Lab
SEM-I

It should consist of minimum 8 to 10 practical/simulation assignments.

M. Tech. Electrical (Power Systems)
EE553: Computer Aided Power System Analysis Lab
SEM-I

It should consists of 8 to 10 MATLAB based simulation assignments.
Objectives:

1. To understand the different power system planning and forecasting techniques.
2. To study the reliability evaluation in terms of basic reliability indices.

Unit –I

Unit –II
Reliability concepts – exponential distributions – meantime to failure – series and parallel system MARKOV process – recursive technique. Generator system reliability analysis

Unit –III
Probability models for generators unit and loads – reliability analysis of isolated and interconnected system – generator system cost analysis – corporate model – energy transfer and off peak loading.

Unit –IV
Transmission system reliability model analysis – average interruption rate-LOLP method-frequency and duration method

Unit –V
Two plant single load system-two plant two load system-load forecasting uncertainly interconnections benefits.

Unit –VI
Introduction to system modes of failure – the loss of load approach – frequency & duration approach – spare value assessment – multiple bridge equivalents

Reference Books:
Objectives:
1. To discuss importance of system Dynamics in power system operation and control
2. To present historical development of PSD
3. To Study Transient Energy functions and its applications for on-line detection of loss of Synchronism

Unit –I

Unit –II

Unit –III
Excitation systems & Prime Mover Controllers: Simplified Representation of Excitation Control, Excitation systems, Modeling, Std. Block Diagram, State Equations, Prime Mover Control System, Transmission Line & Load Modeling

Unit –IV
Dynamics of Synchronous Generator Connected to Infinite Bus System Model, Synchronous Machine Model, System Simulation, Consideration of other Machine Models including SVC Model

Unit –V
Small signal Stability -Single and multi-machine system, Damping and Synchronizing torque Analysis, Power System Stabilizers

Unit –VI
Transient Stability and Voltage Stability Evaluation and Simulation, application of energy functions for direct stability evaluation, TS controllers. Voltage Stability: Introduction, affecting factors, analysis, comparison with angle stability
Reference Books:

3. Benjamin C. Kuo, Automatic Control system, Prentice Hall of India Pvt Ltd.
Objectives:
1. To study classical optimization techniques.
2. To study nonlinear programming techniques.
3. To study the application of constrained optimization technique to economic load dispatch.

Unit –I
Introduction to optimization and classical optimization techniques Linear Programming: Standard form, geometry of LPP, Simplex Method of solving LPP, revised simplex method, duality, decomposition principle, and transportation problem.

6

Unit –II
Non-Linear Problem (NLP): One dimensional methods, Elimination methods, Interpolation methods

6

Unit –III
Non-Linear Programming (NLP): Unconstrained optimization techniques-Direct search and Descent methods, constrained optimization techniques, direct and indirect methods.

6

Unit –VI
Dynamic Programming: Multistage decision processes, concept of sub-optimization and principle of optimality, conversion of final value problem into an initial value problem CPM and PERT

6

Unit –V
Genetic Algorithm: Introduction to genetic Algorithm, working principle, coding of variables, fitness function. GA operators; Similarities and differences between Gas and traditional methods; Unconstrained and constrained optimization using Genetic Algorithm, real coded gas, Advanced Gas, global optimization using GA.

6

Unit –VI
Applications to Power system: Economic Load Dispatch in thermal and Hydro-thermal system using GA and classical optimization techniques, Unit commitment problem, reactive power optimization. Optimal power flow, LPP and NLP techniques to optimal flow problems.

6
Reference Books:
Objectives:
1. This course is intended primarily to provide a fundamental knowledge of modeling, analysis and integration of Electrical components
2. This course covers the theory and basic principles of power electronic controllers

Unit –I
Need for advanced controls, Principal factors affecting the choice of drive, Parameter identification techniques for electric motors, Electromagnetic compatibility of electrical drives, Different options for an adjustable speed electric drive, Simulation of electrical drives

Unit –II
Advanced control strategies for electrical drives. DC drives open and closed loop control. Induction m/c modeling and transformations

Unit –III
Scalar control open loop and closed loop control. Vector control, direct and indirect vector control. Direct torque control

Unit –IV
Inverter, operation principle, Inverter Switching, unipolar, Bipolar, Inverter Dead Time, Inverter Modulation, Different Types, Sine Triangle Analysis of Sine Triangle Modulation, Trapezoidal Modulation, Third harmonic Modulation, Analysis of Third harmonic Modulation, output filter requirement for different PWM Techniques

Unit –V
source/level components for voltage source Inverter operated in square wave Mode, Synchronously Rotating Reference frame, Space Vector Modulation (SVM), principle of SVM, SVM compared to regular sampled PWM phase Lag reference or SVM, Naturally Sampled SVM, Analytical solution for SVM, Harmonic losses for SVM, placement of the Zero space vector, Discontinuous Modulation, phase lag Reference for Discontinuous PWM, Harmonic losses for Discontinuous PWM, Single edge SVM, Switched pulse sequence. Topology of Three phase inverter, Three Phase Modulation with Sinusoidal reference, Third harmonic Reference Injection

Unit –VI
DC & AC Servo drives - block diagram, control strategies. Diagnosis of electrical drives, networking of electric drives, Ethernet communication
Reference Books:

4. Hamid A. Toliyat and Steven G. Campbell, DSP Based Electromechanical Motion Control, CRC Press, 2004
M. Tech. Electrical (Power Systems)
EE 510: Energy Management and Energy Audit
SEM-II

Objectives:
1. This course intents to provide knowledge about energy management skills
2. To enable students to learn about the implementation of energy efficiency projects.

Unit –I
Energy Scenario: Primary energy resources, Commercial and Non-commercial energy, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment.

Unit –II
Energy management : Definition, significance and objectives of energy management, principle of energy management , sectors of supply side management , Energy and economy, electricity tariff, load management and maximum demand control, power factor improvement, selection and location of capacitors ,optimizing the input energy requirements, fuel and energy substitution

Unit –III
Energy strategies and energy planning: Energy Action Planning: Key elements, force field analysis, Energy policy purpose, Energy planning flow for supply side, essential data for supply side energy planning, roles and responsibilities of energy manager, Energy Audit: Definition, need of energy audit, types of energy audit, intermediate and comprehensive energy audit, end use of energy consumption profile, procedure of energy auditing, site testing and measurement. Energy security, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, energy audit instruments, Energy Conservation Act-2001

Unit –VI
Energy Conservation and Recycling: Energy conservation and its importance, Listing of energy conservation opportunities (ECOs ),Electrical ECOs, ECOs in process industry, small industries building and shopping complexes, waste management, Recycling of discarded materials and energy recycling

Unit –V
Energy Monitoring and Targeting: Defining monitoring and targeting, elements of monitoring and targeting, data and information-analysis, On line energy monitoring: Various aspects and techniques of on line energy monitoring,

Unit –VI
Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams. Financial analysis techniques-simple payback period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis, financing options, energy performance contracts .
References Books:
2. Introduction to energy technologies – V.A.Venikov ,E.V.Putiatin , Mir, Moskow -2006
Objectives:
1. To give an overview of the function of an electrical power distribution in an electric power system.
2. To derive the tools for distribution analysis
3. To have the wider knowledge on planning and design of a distribution infrastructure.

Unit –I
Distribution system planning Short term planning, Long term planning, Dynamic planning, Sub-transmission and substation design.

Unit –II
Sub-transmission networks configurations, Substation bus schemes, Distribution substations ratings, Service areas calculations, Substation application curves

Unit –III
Distributed Generation Standards, DG potential, Definitions and terminologies; current status and future trends, Technical and economical impacts, Definitions and terminologies; current status and future trends, Technical and economical impacts DG Technologies, DG from renewable energy sources, DG from non-renewable energy sources

Unit –VI
Distributed generation applications, Operating Modes, Base load; peaking; peak shaving and emergency power, Isolated, momentary parallel and grid connection

Unit –V
Primary and secondary system design considerations Primary circuit configurations, Primary feeder loading, secondary networks design Economic design of secondary’s, Unbalance loads and voltage considerations

Unit –VI
Distribution system performance and operation Distribution automation and control, Voltage drop calculation for distribution networks, Power loss Calculation, Application of capacitors to distribution systems, Application of voltage regulators to distribution systems
Reference Book:

Unit I
Introduction to Smart Grid:
Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid.

Unit II
Smart Grid Technologies:
Part 1: Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.

Unit III
Smart Grid Technologies:
Part 2: 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).

Unit IV
Micro grids and Distributed Energy Resources:

Unit V
Power Quality Management in Smart Grid:

Unit VI
Information and Communication Technology for Smart Grid:
Text Books:


Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley


5. Peter S. Fox-Penner, “Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities”
M. Tech. Electrical (Power Systems)
EE516: Advanced Digital Signal Processing
SEM-II

Objectives:
1. To study different transforms for spectrum analysis
2. To study adaptive filtering techniques using LMS algorithm and to study the applications of adaptive filtering.
3. To introduce the student to wavelet transforms and some practical applications of the Wavelet Transform

Unit –I
Fourier transform- power and limitations short time Fourier transformation – The Gabor transform – Discrete Time Fourier transformation and filters banks

Unit –II
Adaptive signal processing FIR adaptive filters-steepest descent adaptive filter, adaptive recursive filters

Unit –III
LMS algorithms – conversions of LMS applications –noise cancellation –channel equalization

Unit –IV
Wavelet transforms- continuous Wavelet transform ,Wavelet transform ideal case ,perfect reconstruction filter banks and Wavelets, Recursive multi resolution decomposition , Haar Wavelet Daubechies Wavelet

Unit –V
TMS320 Family overview 320C24x series of DSP controllers, Architecture overview , C24x CPU Internal Bus Structure, Memory Central Processing unit , Memory and I/O Spaces , Overview of Memory and I/O Spaces, Program control Address Modes System Configuration and Interrupts clocks and low Power Modes Digital input / output (I/O)

Unit –VI
Assembly language Instruction , Instruction Set summary , Instruction Description „, Accumulator, arithmetic and logic Instruction , Auxiliary Register and data page Pointer Instructions , TREG, PREG, and Multiply Instruction ,Branch Instructions , Control Instructions I/O and Memory Instruction
Reference Books:

1. Hamid A. Toliyat and Steven G. Campbell, DSP Based Electromechanical Motion Control, CRC Pres, 2004


M. Tech. Electrical (Power Systems)
EE552: Power System Dynamics Lab
SEM-II

It should consist of 8 to 10 MATLAB based simulation assignments.

M. Tech. Electrical (Power Systems)
EE554: Advanced Digital Signal Processing Lab
SEM-II

It should consist of 8 to 10 MATLAB based simulation assignments.