DR. A P J ABDUL KALAM UNIVERSITY, INDORE

SYLLABUS

of

MASTER OF TECHNOLOGY (POWER SYSTEM)

Department of Electrical Engineering

(First Year)

(Session July- December 2016)

College of Engineering

Dr. A P J Abdul Kalam University, Indore

DR. A P J ABDUL KALAM UNIVERSITY, INDORE

Syllabus for Master of Technology (Power System)

Department of Electrical Engineering

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Unit 1: Introduction to DSP

Classification of signals, Multichannel and multi dimensional continuous v/s discrete time signals, continuous v/s discrete valued signals, continuous time sinusoidal signal, discrete time sinusoidal signals, sampling of analog signal, sampling theorem, quantification and coding of D/A conversion.

Unit 2: Discrete Time Signal and Systems

Discrete time signal, systems, Z-transform & Inverse Z-transform, analysis of discrete time, linear time invariant systems, co-relation of discrete time systems.

Unit 3: Frequency Analysis of Signals

Frequency analysis of analog signals, frequency analysis of discrete time signals. Properties of Fourier Transform, Frequency Domain Characteristics, Time Frequency Dualities, Sampling of signals in time and frequency domain, DFT & FFT.

Unit 4: Design of Digital Filter

Design of linear phase FIR filter using window & frequency sampling method. Design of equiripple linear phase filters. Comparision of design methods for linear phase FIR filters. Design of IIR filters from analog filters. Direct Design Technique for digital IIR filters.

Unit 5: DSP Application

Introduction to digital signal processors chips, case study of different DSP applications. Application of filters to analog & digital signal processor, FET spectrum analyzer.

References :

[1] Digital Signal Processing - W.D.Stanley
[2] Analog & Digital Signal Processing – Ashok Ambardar

Unit 1 Introduction to Power System Stability Problem:
Basic concepts and definitions: Rotor angle stability, voltage stability and voltage collapse, Midterm and long-term stability, Classification of stability, states of operation and system security system dynamic problems.

Unit 2 Review of Classical Method:
System model, some mathematical analysis of steady state stability, analysis of transient stability, simplified representation of excitation control.

Unit 3 Modeling of Synchronous Machine:
Introduction, synchronous machine, parks transformation, analysis of steady state performance per unit equivalent circuits of synchronous machine, determination of parameters of equivalent circuits, measurements for obtaining data, saturation models, transient analysis of a synchronous machine.

Unit 4 Excitation and Prime Mover Controllers:
Excitation system Modeling, system representation by state evasions, prime move control systems.

Unit 5 Transmission Line, Svc And Loads:
D-Q transformation using L-B variables, static var compensators, loads Dynamics of a synchronous generator connected to estimate bus: system model, synchronous machine model, calculation of initial conditions, inclusion of SVC Model, Analysis of single machine system, Small signal analysis with block diagram representation, synchronizing and damping torque analysis, small signal model, nonlinear oscillators.

References:

[1] K. R. Padiyar, Power system dynamics, stability and control, BS Pub. Hydbd
[2] P Kunder, Power system stability and control, TMH.
[3] P. W. Sauer & M A Pai: Power system dynamics and stability: Pearson.

Sub Code: MTPS103 Sub Name: Advance Power System Protection Relays 4 Credits

Unit-1: Protective Relays

Relaying review, characteristics and operating equations of relays. CT's and PT's differential relay, over-current relay, reverse power relay, distance relays, applications of relays.

Unit-2 : Static Relays

Introduction, advantages and disadvantages, classification logic ckts, smoothing circuits, voltage regulator square wave generator, time delay ckts level detectors, summation device, sampling circuit, zero crossing detector, output devices. COMPARATORS: Replica Impedance, mixing transformers, general equation of phase and amplitude comparator, realization of ohm, impedance and off set impedance characteristics, duality principle, static amplitude comparators, coincidence circuit, Hall effect devices, Magneto receptivity, zener diode phase comparator multi input comparators.

Unit-3: Generator and transformer protection

Protective devices for system. Protective devices for stator, rotor, and prime mover of generator, percentage differential relays protection, three winding transformer protection, earth fault protection, generator transformer unit protection.

Unit-4: Bus bar and transmission line protection

Distance protective schemes, directional wave detection relay. Phase compensation carrier protection. High impedance differential scheme, supervisory and check relay, Some features of 500 KV relaying protection.

Unit-5: Modern trends in power system protection

Different types of digital and computer aided relays, Microprocessor based relays, auto-reclosing, frequency relays, under and over frequency relays, di/dt relays. Algorithms for transmission line, transformer & bus bar protection; out-of-step relaying Introduction to adaptive relaying & wide area measurements

References:

[1] Power System Protection and Switchgear, B.Ram – Tata Mc-Graw Hill Pub.
[2] Switchgear and Protection, M.V.Deshpande - Tata Mc-Graw Hill Pub.
[3] Power System Protection & Switchgear, Ravindra Nath, M.Chander, Willy P
[4] Computer Relaying for power system, Arun Phadke, James Thorp, Johns W P
[5] Power System Protection, M.A.Date, Bharti Prakashan, Vallabh Vidya N,(Guj).

Sub Code: MTPS104 Sub Name: Power Electronics Applications in Power System 4 Credits

Unit- I Power System components:
Models formation of bus admittance matrix, algorithm for formation of bus impedance matrix. Reactive power capability of an alternator, transmission line model & loadability, Reactive power transmission & associated difficulties, Regulated shunt compensation, Models of OLTC & Phase shifting transformer, load flow study.

Unit-2 Sensitivity analysis:
Generation shift distribution factors, line outage distribution factors, Compensated shift factors. Power systems security levels, contingency selection & evaluation, security constrained economic dispatch. Pre-contingency corrective rescheduling.

Unit-3 Voltage stability:
Proximity indicators e.g. slope of PV curve, Minimum Eigen value of reduced load flow Jacobian participation factors based on modal analysis and application.

Unit-4 FACTS:
Flexible ac transmission system, reactive power control, brief description and definition of FACT's controllers, shunt compensators, configuration and operating characteristics of TCR, FC-TCR, TSC, Comparisons of SVCs.

Unit-5
Thyristor controlled series capacitor (TCSC) Advantages of the TCSC, Basic principle and different mode of operation, analysis variable reactance model and transient stability model of TCSC.

References:

[1] Modern power system analysis D.P. Kothari, I.J. Nagrath, TMH, 2003
[2] Power generation operation and control, A.J. Wood, B.F Woolenberg, John W
[3] Understanding facts: Concepts and technologies of flexible AC transmission system IEEE Press, 2001 N.G. Hingorani, L. Gyugyi
[4] Power system stability and control IEEE press P. Kundur, 1994
[5] Thyristor Based FACTS controllers for electrical Transmission systems- R.M. Mathur, R.K. Verma, Wieldy inter science, 2002

Unit 1 Review:
Primitive machine, voltage and torque equation. Concept of transformation, change of variables, m/c variables and transform variables. Application to D.C. machine for steady state and transient analysis, equation of cross field commutator machine.

Unit 2 Induction Machine:
Voltage, torque equation for steady state operation, Equivalent circuit, Dynamic performance during sudden changes in load torque and three phase fault at the machine terminals. Voltage & torque equation for steady state operation of 1-ö induction motor & scharge motor.

Unit 3 Synchronous Machine:
Transformation equations for rotating three phase windings, Voltage and power equation for salient and non salient alternator, their phasor diagrams, Simplified equations of a synchronous machine with two damper coils.

Unit 4 Operational Impedances and Time Constants of Synchronous Machines : Park's equations in operational form, operational impedances and G(P) for a synchronous machine with four Rotor Windings, Standard synchronous machine Reactances, time constants, Derived synchronous machine time constants, parameters from short circuit characteristics.

Unit 5 Approximate Methods for Generator & System Analysis: The problem of power system analysis, Equivalent circuit & vector diagrams for approximate calculations, Analysis of line to line short circuit, Application of approximatemethod to power system analysis.

References:

[1] Analysis of Electric Machinery - P.C.Krause
[2] The General theory of Electrical Machines - B.Adkins
[3] The General theory of AC Machines - B.Adkins & R.G.Harley
[4] Generalised theory of Electrical m/c - P.S.Bhimbra
[5] Electro Mechanical Energy Conversion - White & Woodson

Sub Code: MTPS106	Sub Name: LAB-I Power Electronics Lab.	6 Credits

Suggested List of Experiments:

[1] Study of characteristics of various power electronics devices.

[A] Characteristics of SCR.

[B] Characteristics of MOSFET.

[C] Characteristics of IGBT.

[2] To study various type of forced Commutation techniques.

[3] To study the single phase half-controlled bridge Rectifier

[4] To study the single phase fully controlled converter using R and RL load and to observe the output waveforms.

[5] To study the three-phase full wave half-controlled bridge rectifier

[6] To study the operation of resistance, resistance capacitance and UJT triggering circuits of SCR.

[7] Application of power electronics in speed control of various electrical machines.

Sub Code : MTPS107	Sub Name : LAB-II Power System Lab.	6 Credits

Suggested List of Experiments:

[1] Study of Bucholz relay.

[2] To determine the characteristics of inverse time current relay.

[3] To determine the dielectric strength of transformer oil.

[4] Separation of eddy current & iron losses of single phase transformer.

[5] O.C. and S.C. Test of 1- Phase and 3-Phase transformer.

[6] Power measurement using 3V & 3A method.

[7] Power measurement using 3W method.

[8] To perform slip test on synchronous machine and to determine d-axis & q-axis reactances.

[9] To measure the direct axis subtransient reactance of synchronous machine.

[10] To measure the quadrature axis subtransient reactance of synchronous Machine.

Unit -1 Description and definition of Introduction to FACTS:

Basic Types of controllers – Benefits from FACTS technology- Static Var Compensator (SVC):Principle of operation, configuration and control. Thyristor Controlled Series compensator (TCSC): Principle of operation, configuration and control, Application for damping electromechanical Oscillations, Application for mitigation of SSR. Static Compensator (STATCOM): Principle of operation, configuration and control. Static Synchronous Series Compensator (SSSC): Principle of operation, configuration and control. Thyristor Controlled Phase Angle Regulator (TCPAR): Principle of operation, configuration and control, Unified Power Flow Controller (UPFC): Principle of operation, configuration and control, Simulation of UPFC, Steady state model of UPFC. Interline Power Flow Controller (IPFC): Principle of operation, configuration and control.

Unit -2 Oscillation Stability Analysis and Control:

Introduction – Linearised model of power systems installed with FACTS based Stabilisers – Heffron-Phillips model of a SMIB system installed with SVC, TCSC and TCPS – Heffron-Phillips model of a SMIB system with UPFC – Heffron-Phillips model of a Multi-machine system installed with SVC, TCSC and TCPS

Unit -3 Analyses and Design of FACTS based stabilizers:

Analysis of damping torque contribution by FACTS based stabilisers installed in SMIB systems, Design of robust FACTS based stabilisers installed in SMIB systems by phase compensation method. Selection of installing locations and feed back signal for FACTS based stabilizers

Unit- 4 Transient Stability control with FACTS:

Introduction – Analysis of Power systems installed with FACTS devices: Power transmission control using Controllable Series Compensation(CSC), Power Transmission Control using SSSC, Power Transmission Control using UPFC, Power Transmission Control using Phase Shifting Transformer(PST), Power Transmission Control using UPFC, Control of FACTS devices for transient stability improvement – General considerations of FACTS control strategy: CSC,SSSC, SVC, STATCOM and UPFC control strategy – General Structure of the FACTS devices control.

References:

1. Reactive Power Control in Power Systems, T J E Miller John Wiley.
2. Computer modeling of Electrical Power Systems, J Arriliga, N R Watson, Wiley
3. Understanding FACTS' N G Hingorani and L Gyugyi, IEEE Press.
4. Flexible ac Transmission Systems (FACTS), Y.H. Song, A.T.Johns,IEEE P.

Sub Code: MTPS202 Sub Name: Energy Conservation and Mgt 4 Credits

Unit-1

General energy problem: Energy use patterns and scope for conservation. Energy audit: Energy monitoring, Energy accounting and analysis, Auditing and targeting. Energy conservation policy, Energy management & audit, Energy audit, Types of energy audit, energy management (audit), qualities and function of energy managers, language of an energy manager, Questionnaire, Check list for top management, Loss of energy in material flow, energy performance, Maximizing system efficiency, Optimizing, input energy requirements, Energy auditing instruments, Material load energy balance diagram.

Unit 2

Thermodynamics of Energy Conservation, Basic principle, Irreversibility and second law, efficiency analysis of systems, Primary energy sources, optimum use of prime-movers, energy efficient house keeping, energy recovery in thermal systems, waste heat recovery techniques, thermal insulation, Thermal energy audit in heating, ventilation and air conditioning. Maintenance and Energy audit, friction, lubrication and tribo-logical innovations. Predictive and preventive maintenance

Unit 3

Load curve analysis, load management DSM, Energy storage for power systems (Mechanical, Thermal, Electrical & Magnetic) Restructuring of electric tariff from energy conservation consideration, Economic analysis depreciation method, time value of money, Evaluation method of projects, replacement analysis, special problems inflation risk analysis. Pay back period, Energy economics, Cost Benefit Risk analysis, Pay back period.

Unit 4

Energy efficient electric drives, Energy efficient motors V.S.D. power factor improvement in power system, Energy Conservation in transportation system especially in electric vehicle. Energy flow networks, Simulation & modeling, formulation & Objective & constraints, alternative option, Matrix chart.

Unit 5

Energy conservation task before industry, Energy conservation equipments, Co-Generation, Energy conservation in Sugar, Textiles, Cement, process industry, Electrical Energy Conservation in building, heating, lighting, domestic gadgets

References :

[1] Energy Management – W.R. Murphy & G. Mckey Butler worths.

[2] Energy Management Head Book- W.C. Turner, John Wiley

[3] Energy Management Principles- Craig B. Smith, Pergamon Press

[4] Energy Conservation- Paul O Callagan- Pergamon Press

[5] Design & Management of energy conservation. Callaghan,

[6] Elect, Energy Utilization & Conservation. Dr. Tripathi S.C.,

Sub Code: MTPS 203 Sub Name: Power Quality and Conditioning 4 Credits

UNIT 1

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

UNIT 2

Causes and effects of harmonics, converter configuration and their contribution to supply harmonics, other sources of harmonics

UNIT 3

Radio interference, supply standards, elimination/suppression of harmonics, classical solutions & their drawbacks, passive input filters,design of harmonic filters,Improved power quality converter topologies,(single and three phase), transformer connections, Elimination/suppression of harmonics using active power filters – topologies, and their control methods, PWM converter as a voltage source active filter, current source active filter,

UNIT 4

Active waveshaping of input line current, constant frequency control, constant tolerance band control, variable tolerance band control, discontinuous current control,Electromagnetic interference(EMI), EMI generation ,EMI standards,and elimination.

References:

[1] Power Quality – by R.C. Duggan
[2] Power system harmonics – by A.J. Arrillga
[3] Power electronic converter harmonics – by Derek A. Paice
[4] Power Electronics –Mohan,Undeland,Robbins

Unit I Introduction to Restructuring of Power Industry

Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production

Unit 2 Transmission Congestion Management

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - Non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method.

Unit 3 Locational Marginal Prices and Financial Transmission Rights

Mathematical preliminaries: - Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights – Risk hedging functionality - Simultaneous feasibility test and revenue adequency – FTR issuance process

Unit 4 Ancillary Service Management and Pricing of Transmission Network

Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services

Transmission pricing – Principles – Classification – Rolled in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Merits and demerits of different paradigm.

Unit 5 Reforms in Indian Power Sector

Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff – Power exchange – Reforms in the near future.

References :

[1] Understanding electric utilities and de-regulation, Lorrin Philipson, H. Lee Willis, Marcel Dekker Pub., 1998

[2] Power system economics: designing markets for electricity Steven Stoft, John Wiley & Sons, 2002.

[3] Operation of restructured power systems. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, Kluwer Academic Pub., 2001.

[4] Restructured electrical power systems: operation, trading and volatility Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker Pub., 2001

UNIT 1

Origin and nature of transients and surges. Equivalent circuit representations. Lumped and distributed circuit transients. Line energisation and de-energisation transients. Earth and earthwire effects.

UNIT 2

Current chopping in circuit breakers. Short line fault condition and its relation to circuit breaker duty. Trapped charge effects. Effect of source and source representation in short line fault studies. Control of transients.

UNIT 3

Lightning phenomena. Influence of tower footing resistance and earth resistance. Traveling waves in distributed parameter multi-conductor lines, parameters as a function of frequency.

UNIT 4

Simulation of surge diverters in transient analysis. Influence of pole opening and pole closing. Fourier integral and Z transform methods in power system transients. Bergeron methods of analysis and use of EMTP and EMTDC/PSCAD package.

UNIT 5 Insulation Coordination

Overvoltage limiting devices, dielectric properties, breakdown of gaseous insulation, tracking and erosion of insulation, high current arcs.

References :

[1] Power System Transients by Vanikov
[2] Power System Transients by C. S. Indulkar and D.P. Kothari
[3] Power Circuit breaker theory and design by Flurscheim C.H.
[4] EMTP Rulebook
[5] EMTDC/PSCAD Rulebook

Sub Code: MTPS 206 Sub Name: LAB-111 Advance Power System Lab 6 Credits

Suggested List of Experiments:

[1] Small-signal stability analysis of single machine-infinite bus system using classical machine model

[2] Small-signal stability analysis of multi-machine configuration with classical machine model

[3] Induction motor starting analysis

[4] Load flow analysis of two-bus system with STATCOM.

[5] Transient analysis of two-bus system with STATCOM

[6] Available Transfer Capability calculation using an existing load flow program

[7] Study of variable speed wind energy conversion system- DFIG

[8] Study of variable speed wind energy conversion system- PMSG

[9] Computation of harmonic indices generated by a rectifier feeding a R-L load

[10] Design of active filter for mitigating harmonics.

Sub Code: PS 207 Sub Name: LAB-IV Computer applications in Power System Lab 6 Credits

Suggested List of Experiments:

[1] To study and program of BUS Admittance matrix.

[2] Study of Newton Raphson Method Algorithm and Flowchart with program.

[3] Study of Gauss-Seidel Method Algorithm and Flowchart with program.

[4] Study of Runge Kutta Method Flowchart with program.

[5] Study of Transmission Line Parameters with program.

[6] Study of Ferranti Effect with program.

[7] Study of various Electrical Toolbox i.e Power System, Power Electronics, Control system, Electrical Measurement, Flexible AC Transmission.

[8] Developing Simulation Models for single and three phase Rectifier, Inverter, and Converter for different load models.

[9] Developing Simulation Models using FACTs Devices i.e STATCOM, SVC, TCSC, SSSC, IPFC and UPFC in power system transmission lines.