Chhattisgarh Swami Vivekananda Technical University, Bhilai (C.G.)

Scheme of Teaching, Examination & Evaluation

M.Tech/M.E. in Power System and Control

Department: Electrical Engineering

1st Semester

S. No	Board of Study	Subject Code	Subject	Period s per Week			Scheme of Examination Theory / Practical			Total Mark s	Credit L+(T+P) / 2
				L	T	P	ESE	CT	TA		
1	Electrical Engg.	559111 (24)	Power System Dynamics	5	1	-	100	25	25	150	4
2	Electrical Engg.	575111 (24)	Power System Optimization	5	1	-	100	25	25	150	4
3	Electrical Engg.	559113 (24)	Power System Protection	5	1	-	100	25	25	150	4
4	Electrical Engg.	575112 (24)	Non Linear Control	5	1	-	100	25	25	150	4
5	***Refer Table – I***		***Elective –I***	5	1	-	100	25	25	150	4
6	Electrical Engg.	575121 (24)	Power System Protection Lab	-	-	4	100	-	25	125	2
7	Electrical Engg.	575122 (24)	Control Systems Engg. Lab	-	-	4	100	-	25	125	2
Total				**25**	**5**	**8**	**700**	**125**	**175**	**1000**	**24**

L- Lecture **T- Tutorial** **P- Practical** **ESE- End Semester Exam** **CT- Class Test**

TA- Teacher's Assessment

TABLE –I			
ELECTIVE -I			
S. No	**Board of Study**	**Subject Code**	**Subject**
1	Electrical Engg.	575131 (24)	Flexible AC Transmission System
2	Electrical Engg.	559131 (24)	Power Electronics
3	Electrical Engg.	559133 (24)	Distributed Generation

Note (1) 1/4th of total strength of students subject to minimum of twenty students is required to offer an elective in the college in a Particular academic session.

Note (2) Choice of elective course once made for an examination cannot be changed in future examination

Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E. Ist.**
Branch: **Electrical Engg.**
Subject : Power System Dynamics
Specialization: **Power Systems & Control Engg.**
Total Theory Periods: 40
Code: **559111 (24)**
Total Marks in End Semester Exam. : **100**
Total Tutorial Periods: **12**
Minimum number of class test to be conducted: **02**

UNIT-1
Elementary Mathematical Model: Swing Equation, Units, Mechanical Torque, Electrical Torque, Power - Angle Curve of a Synchronous Machine , Natural Frequencies of Oscillation of a Synchronous Machine, System of One Machine against an Infinite Bus-The Classical Model , Equal Area Criterion , Classical Model of a Multimachine System, Classical Stability Study of a Nine-Bus System, Shortcomings of the Classical Model, Block Diagram of One Machine.

UNIT-2
Synchronous Machine: Park's Transformation , Flux Linkage Equations , Voltage Equations , Formulation of State - Space Equations , Current Formulation , Per Unit Conversion , Normalizing the Voltage Equations, Normalizing the Torque Equations , Torque and Power , Equivalent Circuit of a Synchronous Machine , The Flux Linkage State-Space Model , Loaf Equations , Sub transient and Transient Inductances and Time Constants , Turbine Generator Dynamic Models

UNIT-3
Simulation of Synchronous Machine: Steady-State Equations and Phasor Diagrams, Machine Connected to an Infinite Bus through a Transmission Line, Machine Connected to an Infinite Bus with Local Load at Machine Terminal, Determining Steady- State Conditions, Initial Conditions for a Multimachine System , Determination of Machine Parameters from Manufacturers' Data , Analog Computer Simulation of the Synchronous Machine, Digital Simulation of Synchronous Machines .
Linear Model of Synchronous Machine: Linearization of the Generator State -Space Current Model, Linearization of the Load Equation for the One-Machine Problem, Linearization of the Flux Linkage Model, Simplified Linear Model, Block Diagrams, State-Space Representation of Simplified Model.

UNIT-4
Excitation Systems: Simplified View of Excitation Control, Control Configurations, Typical Excitation Configurations, Excitation Control System Definitions, Voltage Regulator, Exciter Buildup, Excitation System response, State – Space Description of the Excitation System, State Space Representation of the Excitation system, Computer Representation of Excitation Systems, Typical Systems Constants, The effect of Excitation on Generator Performance.
Effect of Excitation on Stability: Effect of Excitation on Generator Power limits, Effect of the Excitation System on Transient Stability, Effect of Excitation on Dynamic Stability, Root – Locus Analysis of a Regulated Machine Connected to an Infinite Bus , Approximate System Representation, Supplementary Stabilizing Signals, Liner Analysis of the Stabilized Generator. General Comments on the Effect of Excitation on Stability.

UNIT-5
Multimachine Systems with Constant Impedance Load: Statement of the Problem, Matrix representation.of a Passive Network, Converting Machine Coordinates to System Reference, Relation Between Machine.Currents & Voltages, System Order, Machines Represented by Classical Methods, Linearized Model for the.Network, Hybrid Formulation, Network Equation with Flux Linkage Model, Total System Equation,. Multimachine System Study.

Text Books:

1. Power System Control and Stability Vol -I By P. M. Anderson & A. A. Fouad.
2. Power System Stability and Control by Prabha Kundur- EPRI. Mc Graw Hill Inc.

Reference Books:

1. Power System Dynamic Stability and Control, Padiyar Interline Publisher Bangalore.

Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E. Ist**
Specialization: **Power Systems & Control Engg.**
Subject: **Power System Optimization**
Branch: **Electrical Engineering**
Total Theory Periods: **40**
Code: **575111 (24)**
Total Marks in End Semester Exam. : **100**
Total Tutorial Periods: **12**
Minimum number of class test to be conducted: **02**

Unit-1
Linear Programming
Introduction to optimization and classical optimization techniques, linear programming- standard form geometry of LPP, simplex method pf solving LPP, revised simplex method, duality, decomposition principle and transportation problem.

Unit-2
Non-Linear Programming
Non-linear problem(NLP): one dimensional method, elimination method, interpolation method, nonlinear programming(NLP) : unconstrained optimization techniques-direct search and descent method, steepest descent, direct and indirect methods, Hessian based algorithm-newton, quasi-newton method

Unit-3
Constrained Optimization Problem
Necessary and sufficient conditions, Equality and Inequality constraints, Lagrange variables, Karush-Kuhn-Tucker conditions, gradient projection method, Penalty method, Quadratic programming, Iterative schemes for constrained problems, sequential quadratic programming method.

Unit-4
Dynamic Programming
Multistage decision processes, concept of sub optimization and principle of optimality, conversion of final value problem into an initial value problem, CPM & PERT.

Unit-5
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 & NLP techniques to optimal flow problem.

Text Books:-

1. Optimization – Theory and Applications, S.S. Rao, Wiley–Eastern Ltd.
2. Introduction of Linear and Non-linear programming, David G. Luenberger, Wesley Publishing Company.
3. Optimization for Engineering Design: Algorithms & Examples, Kalyanmaoy deb, PHI
4. Advanced Power System Analysis & Dynamics, L.P.Singh, Wiley Eastern Ltd.
5. Power System Analysis, Hadi Saadat, TMH Publication.

Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E. Ist**
Specialization: **Power Systems & Control Engg.**
Subject: **Power System Protection**
Branch: **Electrical Engineering**
Total Theory Periods: **40**
Code: **559113 (24)**
Total Marks in End Semester Exam. : **100**
Total Tutorial Periods: **12**
Minimum number of class test to be conducted: **02**

Unit 1
Protective Relaying - Qualities of relaying, Definitions, Codes, Standards, Characteristic Functions, Classification, analog-digital - numerical, schemes and design, factors affecting performance, zones and degree of protection, faults types and evaluation, Instrument transformers for protection.

Unit 2
Basic static relay units, sequence networks, fault sensing data processing units, FFT and Wavelet based algorithms, Phase& Amplitude Comparators, Duality, Zero Crossing/Level Defectors, Relay Schematics and An alysis, Over Current Relay, Instantaneous/Inverse Time –IDMT Characteristics; Directional Relays; Differential Relays, Restraining Characteristics; Distance Relays: Types, Characteristics;

Unit 3
Protection of Power System Equipment, Generato r, Transformer, Generator, Transformer Units, Transmission Systems, Bus-bars, Motors; Pilot wire and Carrier Current Schemes; System grounding, ground faults and protection, Load shedding and frequency relaying, Out of step relaying, Re-closing and synchronizing.

Unit 4
Numerical relays, Characteristics, Functional Diagrams, architecture, algorithms, Microprocessor & DSP based relays, sampling, aliasing, filter principles, Integrated and multifunction protection schemes, SCADA based protection systems, FTA, Testing of Relays.

Unit 5
AC Circuit Breakers : Current interruption, Transient Recovery Voltage (TRV) , Rate of rise of TRV, Resistance switching, Damping of TRV, Opening Resistors, Inductive & Capacitive current interruptions , Current chopping , Rated characteristics of Circuit breakers, Types of Circuit Breakers, Testing of High Voltage AC Circuit Breakers

Text Books:-

1 C.R. Mason, The art and science of protective relaying, John Wiley & Sons.

2 A.R.Warrington, Protective Relays, Vol .1&2, Chapman and Hall.

REFERENCES:

1. T.S.Madhav Rao, Power system protection static relays with microprocessor applications, Tata McGraw Hill Publication.
2. Power System Protection Vol. I, II , III&IV, The Institution Of Electrical Engineers, Electricity Association Services Ltd., 1995
3. Helmut Ungrad , Wilibald Winkler, Andrzej Wiszniewski, Protection techniques in electrical energy systems, Marcel Dekker, Inc.
4. Badri Ram , D.N. Vishwakarma, Power system protection and switch gear, Tata McGraw Hill.
5. Blackburn, J. Lewis ,Protective Relaying, Principles and Applications, Marcel Dekker, Inc., 1986.
6. Anderson, P.M, Power System Protection,. McGraw-Hill, 1999
7. Singh L.P ,Digital Protection, Protective Relaying from Electromechanical to Microprocessor, John Wiley & Sons, 1994
8. Wright, A. and Christopoulos, C, Electrical Power System Protection,. Chapman & Hall, 1993.

Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E. Ist**
Specialization: **Power Systems & Control Engg.**
Subject: **Non-linear Control**
Branch: **Electrical Engineering**
Total Theory Periods: **40**
Code: **575112 (24)**
Total Marks in End Semester Exam. : **100**
Total Tutorial Periods: **12**
Minimum number of class test to be conducted: **02**

Unit-1
State space analysis
State space Representation, Solution of state Equation, State Transition Matrix, canonical Forms- controllable canonical form, Observable canonical from, Jordan canonical from.

Controllability and observability
Test for controllability and observability for continuous time system- Time varying case. Minimum energy control, time invariant case, principle of duality, Controllability and Observability form Jordan canonical form and other canonical forms.

Unit-2
Describing function analysis
Introduction to nonlinear systems, Types of nonlinearities, describing functions, describing function analysis of nonlinear control systems, Production of limit cycles

Phase-plane analysis
Introduction to phase-plane analysis. Method of isoclines for constructing Trajectories, Singular points, Phase-plane analysis of nonlinear control systems.

Unit-3
Stability Analysis
Stability in the sense of Lypanov, Lypanov's stability and Lypanov's instability theorems. Direct method of Lypanov for the linear and Nonlinear continuous time autonomous systems. Perturbation techniques, Lure's formulation, Popov stability criteria, circle criteria.

Unit-4
Control Design Techniques
Feedback Linearization, I/O Linearization, Full state linearization of SISO & MIMO system , variable structure control, sliding surface design, approximation of switching laws.

Unit-5
Robust Control
Introduction, definition of robust control, classification of robust control, elements of robust control theory, modeling, design objectives and specifications, additive and multiplicative perturbations, plant-controller configuration. Modeling of Parametric Uncertain Systems, robust stability analysis, Boundary crossing theorem, Schur stability test, Hurwitz stability test, robustness under perturbations, small gain theorem, stability margins.

Text Books:

1. Slotine, J.J.E and W. Lee, Applied Non-linear Control, Prentice Hall Inc., 1991
2. Mohlar R.R., Non-linear systems Dynamics & Control, Prentice Hall Inc., 1991
3. Control System Engg. , I.J. Nagrath & M. Gopal, New Age Intl, (P) Ltd.
4. Alberto Isidori, Non Linear control systems, Springer Veriag, 1999.
5. M. Vidyasagar, Non-linear System Analysis, Prentice Hall, 1993.

Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E. Ist**
Specialization: **Power Systems & Control Engg.**
Subject**: Flexible AC transmission System (Elect-I)**
Branch: **Electrical Engineering**
Total Theory Periods: **40**
Code: **575131 (24)**
Total Marks in End Semester Exam. : **100**
Total Tutorial Periods: **12**
Minimum number of class test to be conducted: **02**

Unit I
FACTS Concept and General System Considerations, Power Flow in AC System, Definitions on FACTS, Basic Types of FACTS Controllers. Converters for Static Compensation, Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM), GTO Inverters, Multi -Pulse Converters and Interface Magnetics,

Unit II
Transformer Connections for 12 , 24 and 48 pulse operation, Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM), Multi-level inverters of Cascade Type and their modulation, Current Control of Inverters

Unit III
Static Shunt Compensators, SVC and STATCOM, Operation and Control of TSC, TCR, STATCOM, Compensator Control, Comparison between SVC and STATCOM, STATCOM for transient and dynamic stability enhancement

Unit IV
Static Series Compensation, GCSC, TSSC, TCSC and SSSC, Operation and Control, External System Control for Series Compensators, SSR and its damping, Static Voltage and Phase Angle Regulators, TCVR and TCPAR, Operation and Control

Unit V
UPFC and IPFC, The Unified Power Flow Controller, Operation, Comparison with other FACTS devices, control of P and Q, Dynamic Performance, Special Purpose FACTS Controllers, Interline Power Flow Controller, Operation and Control**.**

Text Books:
1. N.G. Hingorani & L. Gyugyi: Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems. IEEE Press, 2000.

2. T.J.E Miller, Reactive Power Control in Electric Systems John Wiley & Sons

REFERENCES:
1. Ned Mohan et.al: Power Electronics.John Wiley and Sons.

2. 'FACTS Controllers and applications" course book for STTP, 2003, Dr Ashok S & K S Suresh kumar

Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E. Ist**
Specialization: **Power Systems & Control Engg.**
Subject: **Power Electronics**
Branch: **Electrical Engineering**
Total Theory Periods: **40**
Code: **559131 (24)**
Total Marks in End Semester Exam. : **100**
Total Tutorial Periods: **12**
Minimum number of class test to be conducted: **02**

Unit: - 1
Overview of power semi conductor device, Ideal and Real switches Power diodes Structure and I-V characteristic, Switching characteristic, Breakdown voltage consideration. Schottky diodes. Power BJT, Basic structure and Switching characteristic, Safe operating area. Power MOSEETS &IGBT'S: -Structure and I-V Characteristics, Switching characteristic, safe operating area G TO'S: - Baric Structure, V-I characteristic, Physics of Turn off operation, G TO'S Protection

Unit: -2
AC switching controllers, Single-phase resistive load, Integral half cycle control and phase control, Single phase R -L Load. Three-phase application of switching control for Star and Delta connected loads.

Unit: -3
Inverters: - Type of Inverters VSI, CSI and current regulated inverters Single phase half bridge Inverter - Circuit configuration and switching. Single phase full bridge configuration Control of AC frequency and voltage, PWM switching scheme, Implementation of SPWM in Half Bridge and Full Bridge Inverters. Three phase inverters, circuit configuration and switching sequence, waveform of current for star and delta connected loads, Waveform shaping using SPWM.

Unit: -4
Buck, Boost, Buck-Boost SMPS Topologies . Basic Operation- Waveforms - modes of Basic Operation- Waveforms - modes of operation –Continuous and discontinuous, Cuk dc-dc converters Output voltage ripple .

Unit: -5
Introduction to Resonant Converters. Classification of Resonant Converters. Basic Resonant Circuit Concepts. Load Resonant Converter. Resonant Switch Converter.

Text Books:

1. Ned Mohan et.al : Power Electronics, John Wiley and Sons

2.Mohammed Rashid : Power Electronics, Tata McGrawHill Publication .

References:

1. G.K.Dubey et.al : Thyristorised Power Controllers Wiley Eastern Ltd.
2. Dewan & Straughen : Power Semiconductor Circuits John Wiley & Sons
3. G.K. Dubey & C.R. Kasaravada, Power Electronics & Drives Tata McGraw Hill
4. IETE Press Book :Power Electronics
5. Joseph Vithaythil : Power Electronics, McGraw Hill Publication

Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E. Ist**
Specialization: **Power Systems & Control Engg.**
Subject: **Distributed Generation**
Branch: **Electrical Engineering**
Total Theory Periods: **40**
Code: **559133 (24)**
Total Marks in End Semester Exam. : **100**
Total Tutorial Periods: **12**
Minimum number of class test to be conducted: **02**

Unit 1
Concepts of Distributed Generation:
Centralised Generation : Main features, Economics, Advantages & Disadvantages De-centralised/ Distributed/ Embeded/Dispersed Generation, Operation of Distributed Generation Systems, Consideration of Reliability & Economics Advantages & Disadvantages, Introduction to energy conversion, Principles of renewable energy systems-technical and social implication.

Unit 2
Solar energy:
Overview of solar energy conversion methods, Solar radiation components-collector measureme nts-estimation, Solar water heating –Calculation- Types analysis economics- Applications, Solar thermal power generation.

Unit 3
Direct energy conversion (DEC)
DEC devices-photo voltaic system-solar cells-cell efficiency-Limitations-PV modules-Battery back up-Systems design -Lighting and water pumping applications:

Unit 4
Wind energy:
Wind power characteristics-power extraction-types of wind machines, Dynamics matchingperformance of wind generators, Wind mills-application-economics of wind power.

Unit 5
Other Energy Sources:
Fuel cells, types-losses in fuel cell, Application: MHD generators- application of MHD generation, Biofuels-classification -biomass conversion process-application,ocean thermal energy conversion systems, Tidal and wave power-applications, Micro and mini hydel power, Hybrid Energy Systemimplementation
–case study, Geo Thermal Energy.

Text Books:-
1. J.N.Twidell & A.D.Weir-Renewable Energy Sources, University press, Cambridge

2. S.L.Soo,Direct Energy Conversion, Prentice Hall Publication.

Reference Books:
1. Sukhatme, S.P., Solar Energy -Principles of Thermal Collection and Storage, Tata

McGraw -Hill ,New Delhi.

2. Kreith, F.,and Kreider,J.F.Principles of Solar Engineering ,Mc-Graw-Hill Book Co.

3. James Larminie , Andrew Dicks,Fuel Cell Systems,John Weily & Sons Ltd.

4. J.F. Manwell, J.G. McGowan, A.L. Rogers, Wind Energy Explained John Willy & Sons Ltd.

5. E.J. Womack MHD Power Generation Engineering aspects, Chapman and Hall Publication.

6. G.D. Rai, Non Conventional energy Sources, Khanna Publications, New Delhi

Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E. Ist**
Specialization: **Power Systems & Control Engg.**
Subject**: Power System & Protection Lab**
Branch: **Electrical Engineering**
Total Practical Periods: **40**
Code: **575121 (24)**
Total Marks in End Semester Exam. : **75**

List of Experiments:

1. Determination of various reactances of a synchronous machine.
2. Determination of sequence impedances of a cylindrical rotor synchronous machine.
3. Fault analysis of
    (i) L-G Fault
    (ii) L-L Fault
    (iii) L-L-G Fault
    (iv) L-L-L-G Fault
4. Power angle charactestics of salient pole synchronous machine.
5. Equivalent circuit of a 3 winding transformer.
6. Characterstics of IDMT overcurrent relay (Electromagnetic type).
7. Characterstics of static negative sequence relay.
8. Characterstics of overvoltage relay.
    (i) Electromagnetic Type
    (ii) Microprocessor Type
9. Characterstics of percentage biased differential relay
    (i) Electromagnetic Type
    (ii) Static Type
10. Simulation of 220 kV transmission line model.
    (i) Ferranti Effect
    (ii) Transmission line parameter
    (iii) Surge Impedance Loading
    (iv) Voltage control Methods
11. Transformer oil testing.

Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E.Ist**
Specialization: **Power Systems & Control Engg.**
Subject: **Control System Engg. Lab**
Branch: **Electrical Engg.**
Total Practical Periods: **40**
Code: **575122 (24)**
Total Marks in End Semester Exam. : **100**

List of Experiments:

1. To obtain the Torque speed characteristics of DC machine and its parameters, and hence determine the transfer function of a DC machine. Obtain the closed loop system response using P,PI and PID controllers.
2. To obtain the torque speed characteristics of a 2-phase ac servomotor and hence determine the incremental transfer function at different operating condition.
3. To obtain position and speed control of a DC motor (i) with/without velocity feedback (ii) with PID controller
4. To regulate the outlet water temperature of process control system using (i) on-off controller (ii) industrial controllers (P,PI,PID controllers).
5. To obtain mathematical model of liquid level system and control the water level of a coupled tank setup using different control laws.
6. To obtain the galvanometer constants and its response in the time domain and frequency domain respectively.
7. Familiarization with MATLAB programs and obtain the response of dynamic systems and its stability analysis using MATLAB programs.
8. Response of a simple DC drive system with load torque using MATLAB simulink software.
9. To obtain (i) the parameters of an electronic oven and hence find its transfer function (ii) the time response of thermal system using on/off (or relay) and P, PI, PID controllers. (selecting control parameters using Ziegler and Nichols tuning technique.)
10. To design compensator using Bode plot & Nyquist plot.
11. Transform given dynamical system from input/output model to state variable model and vice versa.