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

SCHEME OF EXAMINATION
DEPARTMENT OF ELECTRICAL ENGINEERING

M.E. in Power Systems Engineering

FIRST SEMESTER

S. No.	Board of Study	Subject Code	Subject	Periods per week			Scheme of exam			Total Marks	Credit L+(T+P)/2
				L	T	P	Theory/Practical				
							ESE	CT	TA		
1.	Electrical Engg.	559111 (24)	Power System Dynamics	3	1	-	100	20	20	140	4
2.	Electrical Engg.	559112 (24)	Computer Aided Power System Analysis	3	1	-	100	20	20	140	4
3.	Electrical Engg.	559113 (24)	Power System Protection	3	1	-	100	20	20	140	4
4.	Electrical Engg.	559114 (24)	Flexible AC Transmission System (FACTS)	3	1	-	100	20	20	140	4
5.	Refer Table-I		Elective-I	3	1	-	100	20	20	140	4
6.	Electrical Engg.	559121 (24)	Power System - Lab I	-	-	3	75	-	75	150	2
7.	Electrical Engg.	559122 (24)	Protection Simulation Lab	-	-	3	75	-	75	150	2
TOTAL				**15**	**5**	**6**	**650**	**100**	**250**	**1000**	**24**

Table -I

Elective- I			
Sr. No.	**Board of Study**	**Subject Code**	**Subject**
1	Electrical Engg.	559131 (24)	Power Electronics
2	Electrical Engg.	559132 (24)	Digital Signal Processing
3	Electrical Engg.	559133 (24)	Distributed Generation

Lecture T- Tutorial P- Practical ESE- End Semester Exam
CT- Class Test TA- Teachers Assessment

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 examinations.

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

Semester: **M.E. Ist**
Subject: **Power System Dynamics**
Total Theory Periods: **40**
Total Marks in End Semester Exam. : **100**
Minimum number of class test to be conducted: **02**

Specialization: **Power Systems Engg.**
Branch: **Electrical Engineering**
Code: 559111 (24)
Total Tutorial Periods: **12**

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.E. Ist** Specialization: **Power Systems Engg.**
Subject: **Computer Aided Power System Analysis** Branch: **Electrical Engineering**
Total Theory Periods: **40** Code: 559112 (24)
Total Marks in End Semester Exam. : **100** Total Tutorial Periods: **12**
Minimum number of class test to be conducted: **02**

Unit-1
Network equations, graph theory, Bus admittance matrix by step by step method, primitive network, bus incidence matrix, formation of Ybus by singular transformation, bus impedance matrix by inversion of Ybus, algorithm for bus impedance matrix, addition of a branch, addition of link, modification of Zbus by changes in primitive network. Concept of using these matrices for load flow study and fault study.

Unit-2
Fault Analysis, [Z_{BUS}] Building algorithm, sequence matrices, Symmetrical And Unsymmetrical Short-Circuit Analysis of Large Power Systems, Phase Shift in sequence quantities due to transformers.

Unit-3
Load flow study, introduction, power system equations, solution technique ie Gauss Seidel, Newton Raphson and fast decoupled load flow, incorporation of voltage controlled busses, representation of transformer , introduction to optimal load flow technique..

Unit-4
Transient stability studies, introduction, swing equation, machine equations, power system equations, solution techniques, example of transient stability calculations, exciter and governor control system, description of transient stability program.

Unit-5
Power System Security, Factors affecting Security, State Transition Diagram, Contingency Analysis Using Network Sensitivity Method and AC Power Flow Method, Correcting the Generation Dispatch Using Sensitivity Methods, Introduction to State Estimation.

Text Books:-

1. George L. Kusic, .Computer Aided Power System Analysis., Prentice Hall of India (P) Ltd., New Delhi, 1989.
2. J. Arrilaga, C.P. Arnold, B.J. Harker, .Computer Modelling of Electric Power Systems..
3. G. W. Stagg and A. H. El- Abiad, Computer methods in Power System Analysis, Mc-Graw Hill Kogakusha Ltd 1968.

References Books:-

1 A.K. Mahaianabis, D.P. Kothari, S.I. Ahson, .Computer Aided Power System Analysis & Control. Tata McGraw Hill, New Delhi, 1988.

2 O.I. Elgard, .Electric Energy System Theory : An Introduction., 2nd Edition, McGraw Hill, New York, 1982.

3 A. Sadat, .Power System Analysis., McGraw Hill Co. Ltd., India, 2000.

4 I.J. Nagarath, D.P. Kothari, .Modern Power System Analysis., Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.

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

Semester: **M.E. Ist** Specialization: **Power Systems 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 Analysis, 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, Generator, 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,
9. Walter A. Elmore, J. L. Blackburn, Protective Relaying Theory and Applications, ABB T&D Co. Marcel Dekker, Inc.
10. Arun G. Phadke, James S. Thorp, Computer Relaying for Power Systems, Marcel Dekker, Inc.

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

Semester: **M.E. Ist**
Specialization: **Power Systems Engg.**
Subject**: Flexible AC transmission System (FACTS)**
Branch: **Electrical Engineering**
Total Theory Periods: **40**
Code: 559114 (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.E. Ist** Specialization: **Power Systems 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 Sngle 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.E. Ist** Specialization: **Power Systems Engg.**
Subject: **Digital Signal Processing** Branch: **Electrical Engineering**
Total Theory Periods: **40** Code: 559132 (24)
Total Marks in End Semester Exam. : **100** Total Tutorial Periods: **12**
Minimum number of class test to be conducted: **02**

Unit 1
Discrete time signals, systems and their representations:
Discrete time signals, Linear shift invariant systems, Stability and causality, Sampling of continuous time signals, Discrete time Fourier transform, Discrete Fourier series, Discrete Fourier transform, Z, transform, Properties of different transforms, Linear convolution using DFT, Computation of DFT

Unit 2
Digital filter design and realization structures
Design of IIR digital filters from analog filters, Impulse invariance method and Bilinear transformation method, FIR filter design using window functions, Comparison of IIR and FIR digital filters, Basic IIR and FIR filter realization structures, Signal flow graph representations
Unit 3
Analysis of finite word-length effects
Quantization process and errors, Coefficient quantisation effects in IIR and FIR filters, A/D conversion noise, Arithmetic round, off errors, Dynamic range scaling, Overflow oscillations and zero input limit cycles in IIR filters
Unit 4
Statistical signal processing
Linear Signal Models, All pole, All zero and Pole, zero models, Power spectrum estimation, Spectral analysis of deterministic signals, Estimation of power spectrum of stationary random signals, Optimum linear filters, Optimum signal estimation, Mean square error estimation, Optimum FIR and IIR filters.

Unit 5
Discrete Hilbert Transform
Real and imaginary part sufficiency of the fourier transform for causal sequences, sufficiency theorems for finite length sequences, relationship between magnitude and phase, Hilbert transform relation for complex sequences.

Text Books:-

1. Alan V . Oppenheim, Ronald W. Schafer, Discrete-Time Signal Processing, Prentice-Hall of India Pvt. Ltd., New Delhi, 1997
2. John G. Proakis, and Dimitris G. Manolakis, Digital Signal Processing(third edition), Prentice-Hall of India Pvt. Ltd, New Delhi, 1997

References Books:

1. Sanjit K Mitra, Digital Signal Processing: A computer-based approach ,Tata Mc Grow-Hill edition .1998
2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, Statistical and Adaptive Signal Processing, Mc Grow Hill international editions .-2000
3. Emmanuel C. Ifeachor, Barrie W. Jervis , Digital Signal Processing-A practical Approach, Addison . Wesley,1993
4. Abraham Peled and Bede Liu, Digital Signal Processing, John Wiley and Sons, 1976

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

Semester: **M.E. Ist** Specialization: **Power Systems 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 ba ck up-Systems design-Lighting and water pumping applications:

Unit 4
Wind energy:
Wind power characteristics-power extraction-types of wind machines, Dynamics matching-performance 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 System-implementation –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.E. Ist**
Subject: **Computer Aided Power System**
Total Practical Periods: **40**
Total Marks in End Semester Exam. : **75**

Specialization: **Power System Engg.**
Branch: **Electrical Engineering**
Code: 559121 (24)

List of Experiments:

Development of algorithms & flowcharts and digital simulation of the following using MATLAB/PSCAD Software package:

- Introduction to MATLAB and other Simulation software
- Z-bus and Y-bus formulation and their inversion.
- Load flow studies (Gauss-Siedle method, Newton Raphson method)
- Flow study with Fast Decoupled Method.
- Fault analysis (balanced and unbalanced)
- Solution of Swing equations by modified Euler's method.
- Simulating Power Systems with Simulink
- Solution of Power System equations using Modified Euler's Method.
- Solution of Swing equations using Runge – Kutta method (RK4).
- Power system simulation by MATLAB using the Sim Power Systems Toolbox

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

Semester: **M.E. Ist**

Specialization: **Power Systems Engg.**

Subject**: Power System Protection**

Branch: **Electrical Engineering**

Total Practical Periods: **40**

Code: 559122 (24)

Total Marks in End Semester Exam. : **75**

List of Experiments:

- Ratio Test of a C.T and determination of error.
- Determination of knee point voltage of a CT.
- Summation Transformer characteristics.
- Study of CT Connection for E/F protection.
- Study of Open delta PT Connection for earth fault indication.
- Protection of 3 ph. Alternater (simulation study).
- Protection of 3 ph. Induction Motor (simulation study).
- Over current / under voltage / Negative seq Relay Characteristics (simulation study).
- Simulation of Transmission line protection.
- Study of differential protection of transformer (simulation study).