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

Scheme of Teaching, Examination & Evaluation

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

Department: Electrical Engineering

1st Semester

<table>
<thead>
<tr>
<th>S. No</th>
<th>Board of Study</th>
<th>Subject Code</th>
<th>Subject</th>
<th>Periods per Week</th>
<th>Scheme of Examination</th>
<th>Total Marks</th>
<th>Credit</th>
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<td>1</td>
<td>Electrical Engg.</td>
<td>559111 (24)</td>
<td>Power System Dynamics</td>
<td>3 1</td>
<td>100 20 20</td>
<td>140</td>
<td>4</td>
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<td>2</td>
<td>Electrical Engg.</td>
<td>575111 (24)</td>
<td>Power System Optimization</td>
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<td>Electrical Engg.</td>
<td>559113 (24)</td>
<td>Power System Protection</td>
<td>3 1</td>
<td>100 20 20</td>
<td>140</td>
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<td>4</td>
<td>Electrical Engg.</td>
<td>575112 (24)</td>
<td>Non Linear Control</td>
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<td>6</td>
<td>Electrical Engg.</td>
<td>575121 (24)</td>
<td>Power System Protection Lab</td>
<td>- 3</td>
<td>75 - 75</td>
<td>150</td>
<td>2</td>
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<td>7</td>
<td>Electrical Engg.</td>
<td>575122 (24)</td>
<td>Control Systems Engg. Lab</td>
<td>- 3</td>
<td>75 - 75</td>
<td>150</td>
<td>2</td>
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</tbody>
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Total 15 5 6 650 100 250 1000 24

L- Lecture  T- Tutorial  P- Practical  ESE- End Semester Exam  CT- Class Test  TA- Teacher's Assessment

**TABLE -I**

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<thead>
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<th>ELECTIVE -I</th>
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<table>
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<tr>
<th>S. No</th>
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<tbody>
<tr>
<td>1</td>
<td>Electrical Engg.</td>
<td>575131 (24)</td>
<td>Flexible AC Transmission System</td>
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<tr>
<td>2</td>
<td>Electrical Engg.</td>
<td>559131 (24)</td>
<td>Power Electronics</td>
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<td>3</td>
<td>Electrical Engg.</td>
<td>559133 (24)</td>
<td>Distributed Generation</td>
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</tbody>
</table>

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

Branch: Electrical Engg.
Code: 559111 (24)
Total Tutorial Periods: 12

UNIT-1

UNIT-2

UNIT-3

UNIT-4

UNIT-5

Text Books:

Reference Books:
1. Power System Dynamic Stability and Control, Padiyar Interline Publisher Bangalore.
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 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:-
Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

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

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:
3. Helmut Ungrad , Willibald Winkler, Andrezej Wiszniewski, Protection techniques in electrical energy systems, Marcel Dekker, Inc.
Unit-1
State space analysis
State space Representation, Solution of state Equation, State Transition Matrix, canonical Forms-controllable canonical form, Observable canonical form, Jordan canonical form.

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

Text Books:
Chhattisgarh Swami Vivekanand Technical University Bhilai (C.G.)

Semester: **M.Tech./M.E. Ist**
Subject: **Flexible AC transmission System (Elect-I)**
Total Theory Periods: **40**
Total Marks in End Semester Exam.: **100**
Minimum number of class test to be conducted: **02**

Specialization: **Power Systems & Control Engg.**
Branch: **Electrical Engineering**
Code: **575131 (24)**
Total Tutorial Periods: **12**

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

**REFERENCES:**
2. “FACTS Controllers and applications” course book for STTP, 2003, Dr Ashok S & K S Suresh kumar
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

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

References:
2. Dewan & Straughen : Power Semiconductor Circuits John Wiley & Sons
4. IETE Press Book :Power Electronics
Unit 1
Concepts of Distributed Generation:

Unit 2
Solar energy:

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 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 Systemimplementation -case study, Geo Thermal Energy.

Text Books:-

Reference Books:
3. James Larminie , Andrew Dicks,Fuel Cell Systems,John Weily & Sons Ltd.
6. G.D. Rai, Non Conventional energy Sources, Khanna Publications, New Delhi
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 characteristics of salient pole synchronous machine.
5. Equivalent circuit of a 3 winding transformer.
7. Characteristics of static negative sequence relay.
   (i) Electromagnetic Type
   (ii) Microprocessor Type
9. Characteristics 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.
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.