Centurion University of Technology and Management Odisha

M. Tech in Power System & Control Engineering

(Two years Programme)

School of Engineering & Technology

Centurion University of Technology and Management, Odisha

2022

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Index

Programme Objectives; Job/Higher studies/Entrepreneurship

POs: Engineering Graduates will be able to;

PO	Outcomes
PO1	Engineering knowledge: Apply knowledge of mathematics, science, engineering fundamentals, and electrical engineering to the solution of engineering problems
PO2	Problem analysis: Identify, formulate, review literature and analyze Electrical and Electronics Engineering problems to design, conduct experiments, analyze data and interpret data
PO3	Design /development of solutions: Design solution for Electrical and Electronics Engineering problems and design system component of processes that meet the desired needs with appropriate consideration for the public health and safety, and the cultural, societal and the environmental considerations
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions in Electrical and Electronics Engineering
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to Electrical and Electronics Engineering activities with an understanding of the limitations
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to Electrical and Electronics Engineering practice
PO7	Environment and sustainability: Understand the impact of the Electrical and Electronics Engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the Electrical and Electronics Engineering practice
PO9	Individual and team work: Function affectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings in Electrical and Electronics Engineering
PO10	Communication: Communicate effectively on complex engineering activities with the engineering committee and with society at large, such as, being able to

	comprehend and write affective reports and design documentation, make effective presentations in Electrical and Electronics Engineering
PO11	Project Management and finance: Demonstrate knowledge & understanding of the Electrical and Electronics engineering principles and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments in Electrical and Electronics Engineering
PO12	Life- long learning: Recognize the need for, and the preparation and ability to engage in independent research and lifelong learning in the broadest contest of technological changes in Electrical and Electronics Engineering

PEOs/PSOs

PSO1. Graduates can use their skills gained in the domain to work in Industrial Automation/Transformer Manufacturing/Distribution of Power/Renewable Energy.

PSO2. Demonstrate proficiency in use of software & hardware to be required to practice Electrical Engineering profession.

PSO3. Graduates will able to qualify GATE and other PSU examinations.

Course Outcomes	Attributes
CO1	Knowledge
CO2	Analytical skill and Critical Thinking
CO3	Problem Solving and Decision taking ability
CO4	Use of Tool, Design and Development (Hands-on/Technical skill)
CO5	Research

Program Objective

Power System and Control

1. To define Automation and Control and explain the differences in the sense of power sector engineering.
2. Research-oriented studies on data monitoring and acquisition for power sector.
3. To acquire adequate knowledge about the latest technology and methods used in power system and control engineering.

Eligibility Criteria

Bachelor's degree in Engineering/Technology or equivalent degree in Electrical, Electronics & Electrical, Electrical & Electronics, Electronics & Tele-Comm., Electronics & Instrumentation, Electronics & Communication with minimum 6.5 (CGPA) or 60% of marks in B. Tech. or equivalent degree.

Selection Process

The selection process is through central counseling on the basis of merit in qualifying CUEE or PGAT or GATE score. GATE qualified candidates are eligible for scholarship through AICTE.

Degree Awarded

After successful completion of degree, student will be awarded with M. Tech. in **Power System and Control** by Centurion University.

Course Structure

This is a 2-year full-time post graduate program which involves first year (Semester- I & II) of intense coursework and second year (Semester- III & IV) internship and project work.

Total Credit: 70

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Department of Electrical & Electronics Engineering
M Tech in Power System & Control
Course Structure

First Year- 1st Semester

Sl. No.	Code	Subject	T	P	P	Credits
		Theory Courses				
1	MTPS1101	Computer Applications to Power System Analysis	3	0	0	3
2	MTPS1102	Non-Linear Control Systems	3	0	0	3
3		**Elective-1***	3	0	0	3
4	MTPS1103	MicroController Application with PLC	2	2	0	4
5	MTPS1104	SCADA- Compatible with all PLC	2	1	0	3
		Practice Courses				
6	MTPS1105	Advanced Electrical in Automation	0	2	0	2
7	MTPS1106	Sensors and VFD Interface to PLC and SCADA	0	2	0	2
		Total Credits				20

First Year - 2nd Semester

Sl. No.	Code	Subject	T	P	P	Credits
		Theory Courses				
1	MTPS1201	Digital Control System Applied to Power System	3	0	0	3
2	MTPS1202	Power System Dynamics & Stability	3	0	0	3
3		**Elective-2****	3	0	0	3
5	MTPS1203	SCADA-Compatible with fixed brand of PLC	2	1	0	3
6	ISRM1201	Research Methodology and IPR	2	0	0	2
		Practice Courses				
7	MTPS1204	Distributed Control System	1	1	0	2
8	MTPS1205	Power System Monitoring by HMI	1	1	0	2
		Total Credits				18

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Second Year - 3rd Semester

Sl. No.	Code	Subject	T	P	P	Credits
1	MTIP2101	Industry Internship and Project – I/Dissertation				16
		Total Credits				16

Second Year – 4th Semester

Sl. No.	Code	Subject	T	P	P	Credits
1	MTIP2102	Industry Internship and Project – II/Dissertation				16
		Total Credits				16

*ELECTIVE-1

Code	Subject	L	P	p	Credits
MTPS0101	High voltage Engineering	3	0	0	3
MTPS0102	Optimization Techniques in Power System	3	0	0	3
MTPS0103	Digital Power System Applications	3	0	0	3
MTPS0104	Power Quality Analysis	3	0	0	3
MTPS0105	Non-Conventional Renewable Energy	3	0	0	3

**ELECTIVE-2

Code	Subject	L	P	p	Credits
MTPS0106	Renewable Energy System Integration with Grid	3	0	0	3
MTPS0107	Concepts of Smart Grid Technology	3	0	0	3
MTPS0108	Distribution System Engineering	3	0	0	3
MTPS0109	Power System Security	3	0	0	3
MTPS0110	Digital Signal Processing Applications in Power System Protection	3	0	0	3

SEMESTER-1

COMPUTER APPLICATIONS TO POWER SYSTEM ANALYSIS

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on Economic operation of power system and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of power system.	PO2(3),
CO3	Use of software/design tools for operation of power system and control.	PO3(3)

Module-I

Power System Network Matrices

Graph Theory: Definitions, Bus Incidence Matrix, Admittance Matrix (Y) formation by Direct and Singular Transformation Methods, Numerical Problems.
Formation of Z Bus: Partial Network, Algorithm for the Modification of Z Bus Matrix for addition element for the following cases: Addition of element from a new bus to reference, Addition of element from a new bus to an old bus, Addition of element between an old bus to reference and Addition of element between two old busses (Derivations and Numerical Problems). Modification of Z Bus for the changes in the Network.

Module-II

Power Flow Studies

Necessity of Power Flow Studies, Data for Power Flow Studies, Derivation of Static Load Flow Equations.
Load Flow Solutions using Gauss-Seidel Method: Acceleration Factor, Load Flow Solution with and without P-V buses, Algorithm, and Flowchart. Numerical Load Flow Solution for Simple Power Systems (Max. 3-Buses), Determination of Bus Voltages, Injected Active and Reactive Powers

(Sample One Iteration only), and finding Line Flows/Losses for the given Bus Voltages. Load Flow Solution using Newton-Raphson Method in Polar and Rectangular Co-Ordinates, Load

Flow

Solution with or Without PV Busses, Derivation of Jacobian Elements, Algorithm and Flowchart.
Load Flow Solution using Decoupled and Fast Decoupled Methods, Comparison of Different Methods.
DC Load Flow.

Module-III
Short Circuit Analysis
Per-Unit System Representation. Per-Unit Equivalent Reactance Network of a Three Phase Power System, Numerical Problems. Symmetrical Fault Analysis, Short Circuit Current and MVA Calculations, Fault Levels, Application of Series Reactors, Numerical Problems.
Symmetrical Component Theory: Symmetrical Component Transformation, Positive, Negative and Zero sequence components, Voltages, Currents and Impedances.
Sequence Networks: Positive, Negative and Zero sequence Networks, Numerical Problems. Unsymmetrical Fault Analysis: LG, LL, LLG faults with and without fault impedance, Numerical Problems.

Text Books:

1. M. A. Pai, "Computer Techniques in Power System Analysis", TMH Publications.
2. I. J. Nagrath & D. P. Kothari, "Modern Power system Analysis", Tata McGraw-Hill Publishing Company, 4th Edition, 2011.

Reference Books:

1. Grainger and Stevenson, "Power System Analysis", Tata McGraw-Hill.
2. A. R. Bergen, "Power System Analysis", Prentice Hall Inc.
3. Hadi Saadat, "Power System Analysis", by TMH Edition.
4. B. R. Gupta, "Power System Analysis", Wheeler Publications.

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NONLINEAR CONTROL SYSTEMS

Course Objectives

- To introduce the need and concept of nonlinear system.
- To impart knowledge about different strategies adopted in the analysis of nonlinear systems.
- To familiarize with the design of different types of nonlinear controllers.

Course Outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	The students will be able to design controllers for nonlinear systems.	PO1 (3),
CO2	Analyze the stability of nonlinear systems using various approaches.	PO2(3), PO5(2)
CO3	Acquire knowledge of state space and state feedback in modern control systems, pole placement, design of state observers and output feedback controllers.	PO3(3)

Module-I

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

Tests for controllability and observability for continuous time systems – Time varying case, minimum energy control, time-invariant case, Principle of Duality, Controllability and observability form Jordan canonical form and other canonical forms.

Module-II

Describing Function Analysis

Introduction to nonlinear systems, Types of nonlinearities, describing functions, describing function analysis of nonlinear control systems.

Phase-Plane Analysis

Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase-plane analysis of nonlinear control systems.

Stability Analysis

Stability in the sense of Lypanov, Lypanov's stability, and Lypanov's instability theorems. The direct method of Lypanov for the Linear and Nonlinear continuous-time autonomous systems.

Module-III

Modal Control

Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement. Full order observer and reduced-order observer.

Calculus of Variations

Minimization of functional of single function, constrained minimization. Minimum principle. Control variable inequality constraints. Control and state variable inequality constraints. Euler Lagrange Equation.

Optimal Control

Formulation of optimal control problem. Minimum time, Minimum energy, minimum fuel problems. State regulator problem. Output regulator problem. Tracking problem, Continuous-Time Linear Regulators.

Text Books:

1. M. Gopal, "Modern Control System Theory", New Age International Publishers, 2nd edition, 1996

Reference Books:

1. K. Ogata, "Modern Control Engineering", Prentice Hall of India, 3rd edition,1998
   J. Nagarath and M. Gopal, "Control Systems Engineering", New Age International(P) Ltd.
2. M. Gopal, "Digital Control and State Variable Methods", Tata McGraw-Hill Companies, 1997.
3. Stainslaw H. Zak, "Systems and Control", Oxford Press, 2003.

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MICROCONTROLLER APPLICATION WITH PLC

Subject	Code	Type of course	Prerequisite	T-P-Pr
Microcontroller Application with PLC		Theory + Practice	Nil	2-2-0

Course Objectives

- To allow students in Embedded System sectors to learn programming / Interfacing peripherals to ARM Cortex based Microcontroller
- To explore the controller operations in PLC for industrial operations

Course Outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain Knowledge about the architectural features and instructions of 32-bit ARM Cortex M3 microcontroller.	PO1(3)
CO2	Understand the basic hardware components and their selection method based on the characteristics and attributes of a Microcontroller and PLCs	PO2(3)
CO3	Understand various Sensors, Actuators & Interfacing Modules for Industrial Operations.	PO3(2), PO5 (2)

Module-I
Introduction
Definition of PLC. Brief description about PLC. Why to use PLC in industry. How to choose a PLC for industry, Introduction to controller Family, SLC 500&S7-300 features: Details about CPUs, Memory Organization, Program files and Data files.

Module-II
Architecture of Controllers
Architecture, Rack, slot, channel, full structure description and max expansion.

Module-III
Addressing
Physical I/O addressing (both Digital & Analog), Memory Instructions Addressing like Timer, Counters, Binary, Integers etc.

Module-IV
Hardware Linking
Hardware linking Using RS-Linx, details about protocols AB_DF1-1, TCP-1, EMU-500, MPI.

Practice:
a) Opening of RS-Linx & Symmetric Software and Setting the Parameters.

b) Setting the Communication Protocol.

Module-V

Programming Basics

Programming concept using Ladder diagram, Basics of Ladder Programming (rung, rail, rules, New rung, Rung branch, XIC, XIO, OTE, OTL, OUT.), NO-NC concept, Logic Gates implementation.

Practice:

a) Basic Ladder Logic Programming.
b) NO-NC Concept.
c) Digital Gate’s Logic Creation.

Module-VI

Timers, Counter, Compare

Timer basics, Detail programming of TON, TOF, RTO, RES with applications.
Basics of Counter, Detail Programming of CTU, CTD, RES with applications.
Basics of comparators, Implementation of LIM, MEQ, EQU, NEQ, LES, GRT, LEQ, GEQ.

Practice:

a) TON/TOF/RTO/RES Programming.
b) CTU/CTD/RES Programming.
c) LIM, MEQ, EQU, NEQ, LES, GRT, LEQ, GEQ programming.

Module-VII

Different Operational Blocks

Compute Math Block: CPT, ADD, SUB, MUL, DIV, SQR, NEG, TOD, FRD
Move Logic Block: MOV, MVM, AND, OR, XOR, NOT. CLR.
File Shift Block: BSL, BSR, SQC, SQL, SQO, FFL, FFU, LFL, LFU
Program Control Block: JMP, LBL, JSR, MCR, FC, FB, DB

Practice:

a) CPT, ADD, SUB, MUL, DIV, SQR, NEG, TOD, FRD.
b) MOV, MVM, AND, OR, XOR, NOT. CLR.
a) BSL, BSR, SQC, SQL, SQO, FFL, FFU, LFL, LFU.
b) JMP, LBL, JSR, MCR.

SCADA - COMPATIBLE WITH ALL PLC

Subject	Code	Type of course	Prerequisite	T-P-Pr
SCADA- Compatible with all PLC	ISPS1105	Theory + Practice	Nil	2-1-0

Course Objectives

To allow students in Industrial automation System sectors to learn programming / Interfacing input/output devices to SCADA and PLC.

Course Outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain Knowledge about the architectural features and instructions of SCADA with PLC	PO1(3)
CO2	Understand the basic hardware components and their selection method based on the characteristics and attributes of an industrial automation System.	PO2(3)
CO3	Understand various Sensors, Actuators & Interfacing Modules.	PO3(2), PO5 (2)

Module-I
Introduction of Scada
Introduction and SCADA Basics, General SCADA theory, Importance of SCADA in Industrial Automation, Benefit of SCADA, DATA ACQUISITION. Leading SCADA Vendors, Architecture of SCADA (Open & Proprietary).

Module-II
Introduction to Intouch
Introduction to InTouch, Basic operations related to Intouch Editor, types of windows, How to Open window, windows property.

Practice:
a) Basic operation of Intouch SCADA software.

Module-III

Toolbars

General toolbar, New window, Open window, close window, save window, save all, duplicate selection, cut to clipboard, copy, paste, undo and redo.

Practice:

a) Operation & Utility of General Toolbars.

Module-IV

Wizards

Wizard toolbar, Alarm display, Buttons, clock, lights, meter, runtime tools (for alarm monitor), slider, switches, SYMBOL FACTORY, Text Display, Trend, Value Display Fonts, Bold/Italic/Underline, Enlarge/Reduce font, Left/Centre/Right.

Practice:

a) Wizard toolbar details, value display, user input.
b) Symbol Factory Toolbar.
c) Different Operational Properties.

Module-V

Intouch SCADA Features-1

Dynamic graphical display, how to use the dynamic features, Alarms, Real Trend, Historical trend.

Practice:

a) Dynamic graphical display.
b) Alarms.
c) Real trends/Historical trends.

Module-VI

Intouch SCADA Features-2

Data base connectivity, Report generation, Recipe management, Security.

Practice:

a) Data Base Connectivity.
b) Report Generation.
c) Recipe Management.
d) Security.

Module-VI

Intouch SCADA Features-3

Script, Networking, Device connectivity.

Practice:

a) Script.
b) Networking.
c) Device connectivity.

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ADVANCED ELECTRICAL IN AUTOMATION

Subject	Code	Type of course	Prerequisite	T-P-Pr
Advanced Electrical in Automation		Practice	Nil	0-2-0

Course Objectives

To allow students in electrical automation devices (I & O) to learn wiring concept and different power controlling devices.

Course Outcomes

Cos	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain Knowledge about the architectural features of PLC with power controlling devices.	PO1(3)
CO2	Understand the basic hardware components and their selection method based on the characteristics and attributes	PO2(3)
CO3	Understand various Sensors, Actuators & Interfacing Modules.	PO3(2), PO5 (2)

<u>Module-I</u>
Introduction
Fundamentals of electrical and electronic components required for electrical panel designing using PLC.

<u>Module-II</u>
Power Supply
Supply Systems, Conversion of 230 Vac to 24 V dc and vice-versa with circuit description, Basic concept of SMPS.

<u>Practice:</u>
a) Conversion of 230 Vac to 24Vdc, Transformers, Diodes and Regulator ICs.

<u>Module-III</u>
Basic Industrial Switches & Sensors
Pushbuttons, toggle switches, Limit switch, proximity switch, optical switch, pressure switch, etc.

<u>Practice:</u>
a) Checking the operations of different Sensors and switches.

Module-IV

Relay

Basic description of Relay, Practical uses of relay, Latching using relay, how to switch a 230Vac load using 24Vdc.

Practice:

a) Latching and unlatching circuit using relay.
b) Interlocking circuit using relay.
c) Switching of 220Vac devices using (24Vdc).

Module-V

Contactor

Basic description of contactors and auxiliary contacts, holding (latching) circuit & interlocking with Aux contacts.

Practice:

a) Latching and unlatching circuit using relay & contactor.
b) Interlocking circuit using relay & contactor.
c) Switching of 440Vac devices using PLC's output (24Vdc).

Module-VI

Panel Designing

Introduction to Control & Power Circuit, Control Wiring with PLC.

Module-VII

Starter Wiring

The control circuit of starter using PLC, power circuit of starter.

Practice:

a) DOL Starter control wiring, power wiring using PLC
b) FWD-REV Starter control wiring, power wiring using PLC
c) STAR-DELTA Starter control wiring, power wiring using PLC

SENSORS AND VFD INTERFACE TO PLC AND SCADA

Subject	Code	Type of course	Prerequisite	T-P-Pr
Sensors and VFD Interface to PLC and SCADA		Practice	Nil	0-2-0

Course Objectives

To allow students in electrical automation devices (I & O) to learn wiring concept and different power controlling devices.

Course Outcomes

Cos	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain Knowledge about the architectural features of VFD and sensors to be connected to PLC & SCADA	PO1(3)
CO2	Understand the basic hardware components and their selection method based on the characteristics and attributes	PO2(3)
CO3	Understand various Sensors, Actuators & Interfacing Modules.	PO3(2), PO5 (2)

Module-I

The interface of different sensors (Temp, CT, VT, OPTO) and DRIVE (VFD) to PLC & SCADA.

Module-II

Working knowledge of different brands of VFDs and their controland communications.

Elective-1

HIGH VOLTAGE ENGINEERING

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on the Economic operation of power systems and the importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of the power system.	PO2(3),
CO3	Use of software/design tools for the operation of power system and control.	PO3(3)

Module-I

Introduction to High Voltage Technology and Applications

Electric Field Stresses, Gas/Vacuum as Insulator, Liquid Dielectrics, Solids and Composites, Estimation and Control of Electric Stress, Numerical methods for electric field computation, Surge voltages, their distribution and control, Applications of insulating materials in transformers, rotating machines, circuit breakers, cable power capacitors and bushings.

Break Down in Gaseous and Liquid Dielectrics

Gases as insulating media, collision process, Ionization process, Townsend's criteria of breakdown in gases, Panchen's law. Liquid as Insulator, pure and commercial liquids, breakdown in pure and commercial liquids.

Break Down in Solid Dielectrics

Intrinsic breakdown, electromechanical breakdown, thermal breakdown, breakdown of solid dielectrics in practice, Breakdown in composite dielectrics, solid dielectrics used in practice.

Module-II

Generation of High Voltages and Currents

Generation of High Direct Current Voltages, Generation of High alternating voltages, Generation of Impulse Voltages, Generation of Impulse currents, Tripping and control of impulse generators.

Measurement of High Voltages and Currents

Measurement of High Direct Current voltages, Measurement of High Voltages alternating and impulse, Measurement of High Currents-direct, alternating and Impulse, Oscilloscope for impulse voltage and current measurements.

Module-III

Over Voltage Phenomenon and Insulation Co-Ordination

Natural causes for over voltages, Lightning Phenomenon, Overvoltage due to switching surges, system faults and other abnormal conditions, Principles of Insulation Coordination on High voltage and Extra High Voltage power systems.

Non-Destructive Testing of Material and Electrical Apparatus

Measurement of D.C Resistivity, Measurement of Dielectric Constant and loss factor, Partial discharge measurements.

High Voltage Testing of Electrical Apparatus

Testing of Insulators and bushings, Testing of Isolators and circuit breakers, testing of cables, Testing of Transformers, Testing of Surge Arresters, and Radio Interference measurements.

Text Books:

a) M. S. Naidu and V. Kamaraju, "High Voltage Engineering", TMH Publications, 3rd Edition.
b) E. Kuffel, W. S. Zaengl, J. Kuffel, "High Voltage Engineering: Fundamentals", Elsevier, 2nd Edition.

Reference Books:

a) C. L. Wadhwa, "High Voltage Engineering", New Age Internationals (P) Limited,1997.
b) Ravindra Arora, "High Voltage Insulation Engineering", Wolfgang Mosch, New Age International (P) Limited,1995.

OPTIMIZATION TECHNIQUES IN POWER SYSTEM

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	**Course Outcomes**	**Mapping COs with POs (High-3, Medium-2, Low-1)**
CO1	Able to gain knowledge on Economic operation of power system and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of power system.	PO2(3),
CO3	Use of software/design tools for operation of power system and control.	PO3(3)

Module-I

Economic Load Dispatch of thermal Generating Units: Introduction, Generator operating cost, Economic Dispatch problem on a bus bar, Optimal generation scheduling, Function of generation & loads.

Optimal Hydro thermal Scheduling: Introduction, Hydro plant performance Models, Short Range Fixed-Head Hydro thermal Scheduling, Newton-Raphson for short-range fixed –head hydro thermal scheduling, Approximate Newton-Raphson method for short –range fixed-head hydro thermal Scheduling, Short-Range variable-head hydro thermal scheduling-Classical Method, Hydro plant modeling for long term operation, Long-Range generation scheduling of hydro thermal systems.

Module-II

Multi-Objective Generation Scheduling: Introduction, Multi objective optimization- State of the art, Fuzzy set theory in power system, the surrogate worth trades of approach for multi objective thermal power dispatch problem, multi objective thermal power dispatch- weighing method, multi objective dispatch for active & reactive power balance.

Module-III

Stochastic Multi Objective Generation Scheduling: Introduction, multi-objective stochastic optimal thermal power dispatch- ∈ -constant method, multi-objective stochastic optimal thermal power dispatch- The surrogate worth trade-off method, multi-objective stochastic optimal thermal power dispatch- weighing method, stochastic economic-emission load dispatch, multiobjective optimal thermal dispatch- risk/dispersion method, stochastic multi-objective short term hydro thermal scheduling, stochastic multi -objective long-term hydro thermal scheduling.

Text Books:

1. D. P. Kothari and J. S. Dhillon, "Power System Optimization" – PHI Private Limited.
2. J. James and A. Momoh, "Electric Power System Application of Optimization", CRC Press.

Reference Books:

1. S. S. Rao, "Engineering Optimization-Theory and Practice Power", 2009 John Willey & Sons, New York, USA.
2. D. Belegundu, T. R. Chandrupatla, "Optimization Concepts and Applications in Engineering", Cambridge, University Press.

DIGITAL POWER SYSTEM APPLICATIONS

Course Objectives

To learn the basic control technique involved in power system operation
To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on Economic operation of power system and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of power system.	PO2(3),
CO3	Use of software/design tools for operation of power system and control.	PO3(3)

Module-I

Introduction to Computer Relaying: Development of computer relaying, Historical background, Expected benefits of computer relaying, Computer relay architecture, Analog to digital converter, Anti-aliasing filter, Substation computer hierarchy, Relaying Practices: Introduction to protection systems, Functions of a protection system, Protection of transmission lines, Transformer, reactor & generator protection, Bus protection, Performance of current & voltage transformers. Mathematical Basis for Protective Relaying Algorithms: Introduction, Fourier series, Other orthogonal expansion, Fourier transform, Use of Fourier transform, Discrete Fourier transform, Introduction to probability & random processes, Random processes, Kalman filtering.

Module-II

Transmission Line Relaying: Introduction, Sources of error, relaying as parameter estimation, Beyond parameter estimation, Symmetrical component distance relay, protection of series compensated lines. Protection of Transformers, Machines & Buses: Introduction, Power transformer algorithms,

Generator protection, Motor protection, Digital bus protection. Hardware Organization in Integrated Systems: The nature of hardware issues, Computers for relaying, The substation environment, Industry environmental standards, Countermeasures against EMI, Supplementary equipment, Redundancy & backup, Servicing, training & maintenance.

Module-III

System Relaying & Control: Introduction, Measurement of frequency & phase, Sampling clock synchronization, Application of phasor measurements to state estimation, Phasor measurement in dynamic state estimation, Monitoring. Developments In New Relaying Principles: Introduction, Traveling waves on single-phase lines, Traveling waves on three-phase lines, Traveling waves due to faults, Directional wave relays, Traveling wave distance relay, Differential relaying with phasors, Traveling ` wave differential relays, Adaptive relaying, Examples of adaptive relaying, fault location algorithms, Other recent developments.

Text Books:

1. G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", John Wiley and Sons, 1994.
2. Stanley H. Horowitz and Arun G. Phadke, "Power System Relaying", Research Studies Press Ltd., England.

Reference Books:

1. J. L. Blackburn, “Protective Relaying”, Marcel Dekker, Inc., 1987.
2. "Computer Relaying", IEEE Tutorial Course (79EH0148-7-PWR), IEEE Power Engineering Society, NJ, 1979.

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POWER QUALITY ANALYSIS

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on the Economic operation of posystemsstem the and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of the power system.	PO2(3),
CO3	Use of software/design tools for the operation of power system and control.	PO3(3)

Module-I

Introduction to Power Quality

Terms and definitions: Overloading - under voltage - over voltage. Concepts of transients - short duration variations such as interruption - long duration variation such as sustained interruption. Sags and swells - voltage sag - voltage swell - voltage imbalance - voltage fluctuation - power frequency variations. International standards of power quality. Computer Business Equipment Manufacturers Associations (CBEMA) curve.

Voltage Sags and Interruptions

Sources of sags and interruptions - estimating voltage sag performance. Thevenin's equivalent source- analysis and calculation of various faulted conditions. Voltage sag due to induction motor starting. Estimation of the sag severity - mitigation of voltage sags, active series compensators. Static transfer switches and fast transfer switches.

Module-II

Overvoltage

Sources of overvoltages, Capacitor Switching, Lightning - Ferro Resonance. Mitigation of Voltage Swells, Surge Arresters, Low Pass Filters, Pand ower Conditioners. Lightning Protection, Shielding – Line Arresters, Protection of Transformers and Cables.
An Introduction to Computer Analysis Tools for Transients, PSCAD, and EMTP.

Harmonics

Harmonic Sources from Commercial and Industrial Loads, Locating Harmonic Sources. Power System Response Characteristics, Harmonics vs Transients. Effect of Harmonics, Harmonic Distortion, Voltage and Current Distortion, Harmonic Indices, Inter-Harmonics, Resonance.

Harmonic Distortion Evaluation, Devices for Controlling Harmonic Distortion, Passive and Active Filters. IEEE and IEC Standards.

Module-III

Power Quality Monitoring

Monitoring Considerations - Monitoring and Diagnostic Techniques for Various Power Quality Problems - Modelling of Power Quality (Harmonics and Voltage Sag) Problems by Mathematical Simulation Tools, Power Line Disturbance Analyzer, Quality Measurement Equipment, Harmonic/Spectrum Analyzer, Flicker Meters, Disturbance Analyzer. Applications of Expert Systems for Power Quality Monitoring.

Text Book:

1. Math H. Bollen 'Understanding Power Quality Problems: Voltage Sags and Interruptions', Wiley-IEEE Press, 1999.
2. Arindam Ghosh and Gerard Ledwich, "Power Quality Enhancement Using Custom Power Devices (Power Electronics and Power Systems)", Springer, 2002.
3. Surya Santoso, H. Wayne Beaty, Roger C. Dugan, and Mark F. McGranaghan, 'Electrical Power Systems Quality', McGraw-Hill Professional, 2002.

Reference Book:

1. Narain G. Hingorani and Laszlo Gyugy, 'Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems', Wiley-IEEE Press, 1999.

NON-CONVENTIONAL RENEWABLE ENERGY

Course Objective

To understand power generation and economics To design the transmission line parameters To understand the mechanical design of transmission lines

Course Outcomes

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain Knowledge on installation power plans and electrical transmission equipment	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on electric power system	PO2(3),
CO3	Use of software/design tools to design the conventional power plant	PO3(3)
CO4	Able to produce sustainable energy for future	PO7(3)

Module-I

Introduction to Renewable Energy Sources

Introduction to Non-conventional/Renewable Energy Sources & Technologies, Their Importance for Sustainable Development and Environmental Protection. SOLAR RADIATIONS: Measurement and Prediction of Solar Radiations; Instruments for Solar Radiation; Characteristics of Solar Spectra including Wavelength Distribution; Radiation Properties and Spectral Characteristics of Materials; Selective Surfaces & Basics of Solar Collectors.

Solar Thermal System: Solar Collection Devices; Solar Collector Characteristics; Solar Pond; Application of Solar Energy to Space Heating.

Module-II

Wind Energy

Basic Principle; Basic components of a WECS, Classification of W.E.C., Their types, Applications of Wind Energy, Environmental aspects, Wind Energy Developments in India.

Tides

Origin and nature of Tides, Tidal Heads & Duration; Principles of Tidal Energy Conversion, Site Selection– Single and Multiple Bay System; Cycles & Load Factors; Regulation and Control of

Tidal Power Generator (Ocean Thermal Energy Conversion): Temperate & Tropical Oceans; Principles of OTEC Systems; Site Selection; Power Cycles; Selection of Working Fluids; Pumps and Turbines; Heat Exchanger Criteria; Bio-fuelling; Secondary Applications such as Fresh Water Production, Maniculture, etc., Power Transmission and System Efficiency.

Other Renewable Sources of Energy

Waves Nature and availability of Energy from waves Onshore & Off-shores: Principles of Wave Converters–Raft, Duck, Oscillating Water Columns, Tapered Channels & Buoys; Energy Conversion and Transmission; Secondary Applications of Waves such as Harbour Wall, Seawater Pumping.

Module-III

Biomass

Biomass as an Energy Source; Energy Plantations; Conversion Technologies, Thermal, Chemical and Biological, Photosynthesis, Biogas generation, Classification of Biogas plants.

Biogas: Principles of Bioconversion: Types of Bioreactors – Batch, Continuous, Plug-flow, Stirred Tank & Film, Reaction Kinetics, Reactor Design and Analysis, Materials-Municipal Refuse, Sewerage, Industrial Wastes, Agricultural Wastes, Animal and Human Wastes; Landfill systems; Properties and Uses of Biogas,

Biofuels: Bioconversion Techniques, Direct Combustion, Pyrolysis, Flash Pyrolysis Fermentation and Gasification; Utilization of Industrial Wastes such as Bagasse; Household and Community Combustion Systems – Improved Cook-stoves; Industrial Biomass Combustion Systems; Gasification; Sizing; Beneficiation of Fuels, Thermodynamics & Kinetics of Gasification;

Types of Gasifiers–Downdraft, Updraft, Crossflow, Fluidized, Combustion Characteristics of Biofuels; Utilization in Conventional Engines and or Power Generation including Cogeneration.

Geothermal Energy

Name of Geothermal Resources, Location ,and Potential Assessment, Classification & Characteristics of Geothermal Resources– Hot Rock, Hot Water & Steam, Chemical & Physical Properties of Geothermal Brines: Control of Scale Deposition, Drilling, Logging & Cementing Operations for Geothermal Wells; Principles of Power Production System& Cycles: Refrigeration, Two-PhaseFlow Turbines; Thermal Phase Flow Turbines; Thermal Utilization & Mineral Recovery; Ecological and Safety Considerations.

Text Books:

1. S. P. Sukhatme, “Solar Energy: Principles of Thermal Collection and Storage”, Tata Mc-Graw Hill.
2. H. P. Garg and Jai Prakash, “Solar Energy: Fundamentals and Applications”, Tata Mc-Graw Hill.
3. S. Hasan Saeed and D. K. Sharma, “Non-Conventional Energy Resources”, S. K. Kataria & Sons, Third Edition 2012.
4. Chang, “Energy Conversion”, Prentice Hall.

Reference Books:

1. John O’M Bockris and S. Srinivasan, “Fuel Cells: Their Electrochemistry”, Mc-Graw Hill. First Edition, 1969.
2. Duffic and Beckman, “Solar Engineering of Thermal Processes”, John Wiley.

SEMESTER-2

DIGITAL CONTROL SYSTEM APPLIED TO POWER SYSTEM

Course Objectives

- To understand the characteristics of various types of nonlinearities present in physical systems.
- The ability to carry out the stability analysis of non-linear control systems.
- To learn the basic control technique involved in power system operation.

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to understand the analysis and design techniques for digital control systems.	PO1 (3),
CO2	Able to solve problems related to State space representation of discrete-time systems.	PO2(3), PO5 (2)
CO3	Able to design digital controllers for industrial applications.	PO3(3)

<u>Module-I</u>

Sampling and Reconstruction

Introduction, Examples of Data Control Systems, Digital to Analog Conversion and Analog to Digital Conversion, Sample and Hold Operations.

The Z–Transforms

Introduction, Linear Difference Equations, Pulse Response, Z–transform, Theorems of Z–Transforms, The Inverse Z–transforms, Modified Z-Transforms.

Z-Plane Analysis of Discrete-Time Control System

Z-Transform Method for Solving Difference Equations; Pulse Transforms Function, Block Diagram Analysis of Sampled – Data Systems, Mapping Between s-Plane and z-Plane.

<u>Module-II</u>

State Space Analysis

State Space Representation of Discrete-Time Systems, Pulse Transfer Function, Matrix Solving Discrete-Time State Space Equations, State Transition Matrix and it's Properties, Methods for Computation of State Transition Matrix, Discretization of Continuous Time State–Space Equations.

Controllability and Observability

Concepts of Controllability and Observability, Tests for Controllability and Observability. Duality between Controllability and Observability, Controllability and Observability Conditions for Pulse Transfer Function.

Module-III

Stability Analysis

Mapping between the S-Plane and the Z-Plane, Primary Strips and Complementary Strips, Constant Frequency Loci, Constant Damping Ratio Loci, Stability Analysis of Closed Loop Systems in the Z-Plane. Jury Stability Test, Stability Analysis by use of the Bilinear Transformation and Routh Stability criterion.

Design of Discrete Time Control System by Conventional Methods

Transient and Steady–State Response Analysis, Design based on the Frequency Response Method, Bilinear Transformation and Design Procedure in the W-Plane, Lead, Lag and Lead-Lag Compensators and Digital PID Controllers.

.

State Feedback Controllers and Observers

Design of State Feedback Controller through Pole Placement, Necessary and Sufficient Conditions, Ackerman’s Formula. State Observers – Full Order and Reduced Order Observers.

Text Books:

1. K. Ogata, “Discrete-Time Control systems”, Pearson Education/PHI, 2nd Edition.

Reference Books:

1. B. C. Kuo, “Digital Control Systems”, Oxford University Press, 2nd Edition,2003.
2. M. Gopal, “Digital Control and State Variable Methods”, by TMH Publications.

POWER SYSTEM DYNAMICS & STABILITY

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on Economic operation of power system and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of power system.	PO2(3),
CO3	Use of software/design tools for operation of power system and control.	PO3(3)

Module-I

System Dynamics: Synchronous machine model in state space form, computer representation for excitation and governor systems–modeling of loads and induction machines.
Stability – steady state stability limit – Dynamic Stability limit – Dynamic stability analysis.

Module-II

State space representation of synchronous machine connected to the infinite bus, Time response–Stability by Eigen value approach.

Digital Simulation of Transient Stability: Swing equation, Machine equations Concept of Multi machine Stability, Multi-machine Transient Stability Under Different Faulted Conditions.

Module-III

Effect of governor action and exciter on power system stability. Effect of saturation, saliency & automatic voltage regulators on stability.
Excitation Systems: Rotating Self-excited Exciter with direct-acting Rheostatic type, voltage regulator – Rotating main and Pilot Exciters with Indirect Acting Rheostatic Type Voltage Regulator.
Rotating Main Exciter, Rotating Amplifier, and Static Voltage Regulator – Static excitation scheme – Brushless excitation system.

Text Books:

1. E. W. Kimbark, “Power System Stability, Vol. I & II, III”, Dover Publication Inc, New York 1968.
2. P. M. Anderson and A. A. Fouad, “Power System control and stability, Vol – I”, Galgotia Publications 3B/12, Uttari Marg Rajender Nagar, New Delhi–110060, 1981.

Reference Books:

1. K. R. Padiyar, “Power System Dynamics Stability and Control”, B. S. Publications, Second Edition 2002.
2. Glenn W. Stagg & Ahmed. H. El. Abiad, “Computer Applications to Power Systems”, McGraw Hill Publication, 1968.
3. S. S. Vadhera, “Power Systems Analysis & Stability”, Khanna Publishers, 2009.
4. Haidi Saadat, “Power System Analysis”, Tata-McGraw Hill Publications. 4th Edition, 2019.
5. John J. Graniger, William D. Stevenson. JR., “Power System Analysis”, Tata McGraw Hill Publications, 1994.

SCADA–COMPATIBLE WITH FIXED BRAND OF PLC

Subject	Code	Type of course	Prerequisite	T-P-Pr
SCADA-Compatible with Fixed Brand of PLC	ISPS1205	Theory + Practice	Nil	2-1-0

Course Objectives

- To learn the basic control technique involved in power system operation using SCADA and PLC
- To provide a solid foundation in different brands of PLC & SCADA.

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on SCADA and connectivity of PLC.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems of industrial Automation.	PO2(3),
CO3	Use of software/Hardware tools for operation of power system and control.	PO3(3)

Module-I
Introduction of SCADA
Introduction and SCADA Basics, General SCADA theory, Importance of SCADA in Industrial Automation, Benefit of SCADA, DATA ACQUISTION. Leading SCADA Vendors, Architecture of SCADA (Open & Proprietary).

Module-II
Introduction to Rs-View 32
Introduction, Basic operations related to RS-View32 Editor, types of windows, how to Open window, windows property.

Practice:
a) Basic Operation of RS-View32 SCADA software.

Module-III
Toolbars
General toolbar, New window, Open window, close window, save window, save all, duplicate selection, cut to clipboard, copy, paste, undo and redo.

Practice:
a) Operation & utility of general toolbars.

Module-IV

Wizards

Wizard Toolbar, Alarm Display, Buttons, Clock, Lights, Meter, Runtime Tools (for Alarm Monitor), Slider, Switches, Symbol Factory, Text Display, Trend, Value Display Fonts, Bold/Italic/Underline, Enlarge/Reduce Font, Left/Centre/Right.

Practice:

a) Wizard toolbar details, value display, user input.
b) Symbol factory toolbar.
c) Different operational properties.

Module-V

Rs-View 32 SCADA Features

Dynamic graphical display, how to use the dynamic features, Alarms, Real Trend, Historical trend.

Practice:

a) Dynamic graphical display.
b) Alarms
c) Real trends / Historical trends.

Module-VI

Rs-View 32 SCADA Features

Data base connectivity, Report generation, Recipe management, Security.

Practice:

a) Database connectivity.
b) Report Generation.
c) Recipe Management.
d) Security.

Module-VII

RS-View 32 SCADA Features Script, Networking, and Device connectivity.

Practice:

a) Script.
b) Networking.
c) Device connectivity.

RESEARCH METHODOLOGY AND IPR

Code	Subject	T	P	P	Credits
ISRM1201	Research Methodology and IPR	2	0	0	2

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on Economic operation of power system and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of power system.	PO2(3),
CO3	Use of software/design tools for operation of power system and control.	PO3(3)

Module-I

Principles of Research Methodology & Literature Review

A) Introduction:
Meaning and Objectives, Types of Research - Basic and Applied Researches. Research Approaches
- Discrete vs Analytical Research, Applied vs Fundamental Research, Qualitative vs Quantitative Research, Conceptual vs Experimental (or Empirical) Research. Steps in Research Process. Research Methods and Methodology - Criteria for Good Research – Research Objectives.

B) Research Problem:
Definition of Research Problem - Problem Selection - Techniques Involved. Research Design - Meaning and Need for Research Design. Features of Good Design - Concepts Relating to Research Design.

C) Literature Review:
Significance of Literature Review. Steps in Conducting Literature Review - Steps in Conducting Literature Review - Guidelines on Style, Mechanics and language usage - Writing up to the literature Reviewed – Some Examples.

Module-II

Design of Experiments and Data collection

A) Design of Experiments:

Types of Experiments - Experimental Design Factors - Experimental Design Factors - Experimental Design Protocol Numerical and Analytical Experiments - Computer Simulation and Software usage.

B) General Data Collection:

Types of Data - Different Approaches of Data Collection - Primary and Secondary Data - General Procedure for Data Collection. Sampling Techniques and sample size.

C) Experimental Data Collection and Transmission:

Basic Electrical Measurements and Sensing Devices - Analog and Digital Meters, Amplifiers, Power Suppliers, Signal Conditioning.

D) Topics for Other than Computer Science Branch:

Transducers - Types of Transducers and working principles. Force, Torque and strain Measurements - Electrical - Resistant Strain gauges - Temperature compensation calibration of Instruments.

Topics for Computer Science Branch Only: Computer Networking - Packet Tracers - Data Transfer. Operating Systems - Scheduling Algorithms - Dealing Dead Lock. Deductive Methods in Computer Science - Ordinary Mathematical Problems - Probabilistic Cache Analysis - Algorithm Analysis. Inductive Methods - Mathematical Induction - Recursive Definitions and Proofs by Induction.

E) Data Transmission:

Analog Digital and Digital to Analog Conversion - Data Storage and Display.

Module-III

Data Analysis and Disseminating Knowledge (Documentation & Publication) [No external evaluation for this Module-III]

A) Data Analysis:

Data Errors - Identification of Data Errors - Causes and Types of Data Errors. Error Analysis - Evaluation of uncertainties for complicated Data Reduction. Statistical Analysis of Experimental Data - Probability Distribution - Gaussian and other Distributions. Chi-square test of Goodness of Fit Method of least squares - Correlation Coefficient Multivariable Regression-Standard deviation Student's t-Distribution. Graphical Analysis and Curve Fitting - Choice of Graph's Formats - General considerations in Data Analysis.

B) Thesis and Report Writing:

Definition and significance of a Thesis, Level of work for Doctoral and Graduate Thesis. General Requirements of a good Thesis - Originality, Style, Presentation, Definitions and Terminology - Terms and Phrases to be avoided. Grammar and logic Bellman's rule of 3 in

Report writing. Canonical organization of chapters in thesis documents suggested Thesis structure for Master's Thesis.

C) Research Publication:
Citation Styles, Style guides and avoiding plagiarism - APA style of research publication.

Writing of a Research paper for a conference or journal - Concepts of a Research Article - Content & Style - Journal Style - Sections of a paper - Significance of sections on results, Discussion and conclusion

REFERENCES

1. C. R. Kothari, "Research Methodology - Methods and Techniques", New Age International (P) Ltd., 1985.
2. J. P. Holman, "Experimental Methods for Engineers", Tata McGraw-Hill Publications, 1993.
3. Krishnan Nallaperumal, "Engineering Research Methodology", Manonmaniam Sundaranar University, 2013.
4. Rafal Kicinger and R. Paul, "Wiegand Experimental Design & Methodology".
5. Research Methodology-Handout on Literature Review (Personal Communication)
6. References on Computer Networking - To be included
7. References on Operating Systems - To be included

Module	**Section**	**Reference & Chapters**
Module I	A and B	Ref.1, Ref. 3 Ch. 1
	C	Ref. 5
Module II	A	Ref. 2 Ch. 15, Ref. 4
	B	Ref.1 Ch. 6
	C	Ref. 2 Ch. 4 to 11 (for other thanCSE) Ref. 3 Ch. 5, Ref. 6 & Ref. 7 (forCSE)
	D	Ref. 2 Ch. 14
Module III	A	Ref. 2 Ch. 3, Ref. 4, Ref. 1 Ch. 7, 10 & 11
	B & C	Ref.1 Ch. 14

DISTRIBUTED CONTROL SYSTEM

Subject	Code	Type of course	Prerequisite	T-P-Pr
Distributed Control System		Theory + Practice	Nil	1-1-0

Course Objectives

- To learn the basic control technique involved in DCS.
- To provide a good working concept on DCS with its programming technique and commissioning.

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on distributed control systems.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on DCS based industrial automation.	PO2(3),
CO3	Use of software/Hardware tools for operation of DCS in industry.	PO3(3)

Module-1

Module-2

Introduction to DCS 800F (ABB)

Introduction to Basic operations related to DCS 800F (ABB) Types of windows, How to Open window, windows property.

Practice:

a) The Basic operation of DCS 800F (ABB) software.

Module-3

Toolbars

General toolbar, New window, Open window, close window, save window, save all.

Practice:

a) Operation & utility of general toolbars.

Module-4

Engineering Station

Use of engineering station, Setting parameters of engineering station. System configuration, Commissioning, Documentation.

Practice:

a) System Configuration.

b) Commissioning
c) Documentation

Module-5
Process Station
Designing of Hardware structure, Setting of time cycle, Networking, Language setting.

Practice:
a) Hardware structure design.
b) Time cycle setting.
c) Language setting.

Module-6
Operators Station
Working on Digital visualization, Faceplate, trends, and animation.

Practice:
a) Digital visualization.
b) Faceplate checking.

Module-7
Programming and SCADA
Programming concept in FBD, SCADA designing.

Practice:
a) Functional block diagram programming
b) Networking
c) SCADA designing and control.

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Pedagogy

<table>
<tr><th rowspan="2">Sl. No.</th><th>Topic</th><th rowspan="2">Teaching Method</th><th rowspan="2">Reference /Tool</th><th colspan="3">Instructional Hours</th></tr>
<tr><th>Module–1 (INTRODUCTION OF DCS)</th><th>Theory</th><th>Video</th><th>Practical</th></tr>
<tr><td>1</td><td>Introduction and distributed control system Basics, Importance of DCS in Industrial Automation, Benefit of DCS, DATA ACQUISITION. Leading DCS Vendors, Architecture of DCS (Open & Proprietary).</td><td>CRT, PPT</td><td></td><td>2</td><td>0</td><td>0</td></tr>
<tr><td colspan="7">Module–2 (INTRODUCTION TO DCS 800F (ABB))</td></tr>
<tr><td>2</td><td>Introduction to Basic operations related to DCS 800F (ABB) Types of windows, How to Open window, windows property.</td><td>CRT</td><td></td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>3</td><td>Basic operation of DCS 800F (ABB) software.</td><td>Practice</td><td></td><td>0</td><td>0</td><td>2</td></tr>
<tr><td colspan="7">Module–3 (TOOLBARS)</td></tr>
<tr><td>4</td><td>General toolbar, New window, Open window, close window, save window, save all.</td><td>CRT, PPT</td><td></td><td>2</td><td>0</td><td>0</td></tr>
<tr><td>5</td><td>Operation of general toolbars.</td><td>Practice</td><td></td><td>0</td><td>0</td><td>2</td></tr>
<tr><td colspan="7">Module–4 (ENGINEEARING STATION)</td></tr>
<tr><td>6</td><td>Use of engineering station.
Commissioning, Documentation</td><td>CRT</td><td></td><td>2</td><td>0</td><td>0</td></tr>
<tr><td>7</td><td>Setting parameters of engineering station</td><td>CRT</td><td></td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>8</td><td>Commissioning, Documentation</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td>9</td><td>System Configuration.
Commissioning
Documentation</td><td>Practice</td><td></td><td>0</td><td>0</td><td>6</td></tr>
<tr><td colspan="7">Module–5 (PROCESS STATION)</td></tr>
<tr><td>10</td><td>Designing of Hardware structure, Setting of time cycle, Networking, Language setting</td><td>CRT</td><td></td><td>2</td><td>0</td><td>0</td></tr>
<tr><td>11</td><td>Hardware structure design.
Time cycle setting
Language setting</td><td>Practice</td><td></td><td>0</td><td>0</td><td>8</td></tr>
<tr><td colspan="7">Module–6 (OPERATORS STATION)</td></tr>
<tr><td>12</td><td>Working of Digital visualization, Faceplate, trends, animation</td><td>CRT</td><td></td><td>2</td><td>0</td><td>0</td></tr>
<tr><td>13</td><td>Digital visualization
Faceplate checking</td><td>Practice</td><td></td><td>0</td><td>0</td><td>6</td></tr>
<tr><td colspan="7">Module–7 (PROGRAMMING AND SCADA)</td></tr>
<tr><td>14</td><td>Programming concept in FBD, SCADA designing</td><td>CRT</td><td></td><td>2</td><td>0</td><td>0</td></tr>
</table>

15	Functional block diagram programming Networking SCADA designing and control.	Practice		0	0	6
Total: 45 Hrs				**15**	**0**	**30**
Assessment:		**IPR: 50, EPR:50**				

POWER SYSTEM MONITORING BY HMI

Subject	Code	Type of course	Prerequisite	T-P-Pr
Power System Monitoring by HMI		Theory + Practice	Nil	1-1-0

Course Objectives

- To learn the basic control technique involved in industrial operation using HMI & PLC
- To provide a solid foundation in HMI graphical presentation and communication.

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on Human machine interface techniques.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on HMI based control systems in industrial automation.	PO2(3),
CO3	Use of software/Hardware tools for operation of HMI and PLC.	PO3(3)

Module-1
Introduction
Introduction Details of Human Machine Interface, HMI Basics, Difference between SCADA & HMI, Requirements, Leading Vendors, Specification of Panel view family, Features, Communication settings in HMI & PC.

Module-2
Application Development
New application development, HMI Screen development, Dashboard, Terminal setting, file transfer

Module-3
Working on Software
Introduction to software, tag declaration, tag type, screen type, control, screen, property.
Practice:
a) Opening of software and setting the parameters.
b) Setting the communication protocol.

Module-4
Control Window
Entry, display, Drawing tools, Advance, Library.

Practice:

a) Display & Drawing tools operation and application.
b) Advance Library operation and utility.

Module-5

Property Window Basics

Property window, Appearance, Common, Navigation, Connections, Screen.

Practice:

a) Working of property window.
b) Navigation operation.
c) Connection screen configuration.

Module-6 (2+10 Hours)

Designing of Application

Designing of application, Discrete type, Analog type.

Practice:

a) Discreet type display design.
b) Analog type display design.

Module-7 (3+8 Hours)

Different Dynamic Displays

Alarm, Trend, Security, Recipe, Device Connectivity.

Practice:

a) Alarm, Trend, Security
b) Recipe, Device Connectivity

ELECTIVE-2

RENEWABLE ENERGY SYSTEM INTEGRATION WITH GRID

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on Economic operation of power system and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of power system.	PO2(3),
CO3	Use of software/design tools for operation of power system and control.	PO3(3)

Module-I

Control of frequency and voltage of distributed generation in Stand-alone and Grid-connected mode, use of energy storage and power electronics interfaces for the connection to grid and loads. Design and optimization of size of renewable sources and storages.

Module-II

Concept of microgrid, operation of microgrid in grid-connected as well as isolated mode, power quality problems and fault-ride through capability of microgrid.

Module-III

Integration of large capacity renewable sources to grid: Operation and control, present trends, challenges, future technological needs viz., advanced characteristics of renewable energy generating units and plants, improved flexibility in conventional generation, transmission technology.

Text Books:

1. Math J. Bollen and Fainan Hassan, "Integration of Distributed Generation in the Power System', IEEE Press, 2011.
2. S. Heier and R. Waddington, "Grid Integration of Wind Energy Conversion Systems', Wiley, 2006.

Reference Books:

1. Loi Lei Lai and Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators", Wiley-IEEE Press, 2007.

CONCEPTS OF SMART GRID TECHNOLOGY

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on Economic operation of power system and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of power system.	PO2(3),
CO3	Use of software/design tools for operation of power system and control.	PO3(3)

Module-I

Review of Basic Elements of Electrical Power System, Desirable Traits of a Modern Grid, Principal Characteristics of the Smart Grid, Key Technology Areas. Smart Grid Communication: Two-way Digital Communication Paradigm, Network Architectures, IP-Based Systems, Power Line Communications, Advanced Metering Infrastructure.

Module-II

Renewable Generation: Renewable Resources: Wind and Solar, Micro grid Architecture, Tackling Intermittency, Distributed Storage and Reserves.

Module-III

Wide Area Measurement: Sensor Networks, Phasor Measurement Units, PMU Communications, Infrastructure, Fault Detection and Self-Healing Systems, Application and Challenges.

Security and Privacy: Cyber Security Challenges in Smart Grid, Defence Mechanism, Privacy Challenges.

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Text Books:

1. James Momoh, “Smart Grid: Fundamentals of Design and Analysis”, Wiley-IEEE Press, 2012.

Reference Books:

1. Philllip F. Schewe, “The Grid: A Journey Through the Heart of our Electrified World”, Joseph Henry Press, 2006.

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DISTRIBUTION SYSTEM ENGINEERING

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on Economic operation of power system and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of power system.	PO2(3),
CO3	Use of software/design tools for operation of power system and control.	PO3(3)

Module-I

Distribution system planning: Short term planning, Long term planning, Dynamic planning, Sub-transmission and substation design, Sub-transmission networks configurations, Substation bus schemes, Distribution substations ratings, Service areas calculations, Substation application curves.

Module-II

Distributed Generation: Standards, DG potential, Definitions and terminologies; current status and future trends, Technical and economic impacts, Definitions and terminologies; current status and future trends, Technical and economic impacts. DG Technologies, DG from renewable energy sources, DG from non-renewable energy sources, Distributed generation applications, Operating Modes, Base load; peaking; peak shaving and emergency power, Isolated, momentary parallel and grid connection.

Module-III

Primary and secondary system design considerations, Primary circuit configurations, Primary feeder loading, secondary networks design, Economic design of secondaries, Unbalance loads and voltage considerations, 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.

Text Books:

1. Anthony J. Pansini "Electrical Distribution Engineering", CRC Press.
2. H Lee Willis, "Distributed Power Generation Planning and Evaluation", CRC Press.
3. James A Momoh, "Electric Power Distribution Automation Protection and Control" CRC Press.

Reference Books:

1. James J. Burke "Power distribution engineering: fundamentals and applications", CRC Press.
2. T. Gonen, "Electric Power Distribution System Engineering", McGraw-Hill, 1986.

POWER SYSTEM SECURITY

Course Objectives

- To learn the basic control technique involved in power system operation
- To provide a solid foundation in mathematical and engineering fundamentals required to control the governing system in turbine models

Course Outcomes

Cos	Course Outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Able to gain knowledge on Economic operation of power system and importance of LFC power plans.	PO1 (3), PO2 (2)
CO2	Able to identify and resolve the problems on Load frequency control of power system.	PO2(3),
CO3	Use of software/design tools for operation of power system and control.	PO3(3)

Module-I

Introduction to Power System

Structure of Power Systems, Modelling of Power System Components, Single Line Diagram or One Line Diagram, Network Modelling, Formation of Bus Admittance Matrix.

Operations in Power System Security

Factors Affecting Power System Security, Contingency Analysis, AC Power Flow Security Analysis, AC Power Flow Security Analysis with Contingency, Concentric Relaxation, Bounding Area Method, Contingency Analysis Using Simulator.

State Estimation

Methods of Least Squares, Maximum Likelihood Weighted Least-Squares Estimation, State Estimation by Orthogonal Decomposition, Detection and Identification of Bad Measurements, Network Observability and Pseudo-measurements.

Optimal Power Flow

Optimal Power Flow Formulation, Optimal Power Flow Solution Technique, Lagrange Multiplier Method, Linear Programming OPF (LPOPF), Interior Point Method, Unit Commitment, Unit Commitment Solution Methods.

Module-II

Security Assessment

Detection of Network Problems, Network Equivalent for External System, Network Sensitivity Methods, Calculation of Network Sensitivity Factors, Fast Contingency Algorithms, Contingency Ranking, Dynamic Security Indices, On-line Security Assessment.

Module-III

Security Enhancement

Correcting the Generator Dispatch by Sensitivity Methods, Compensated Factors, Security Constrained Optimization, Preventive, Emergency and Restorative Control through NLP and LP Methods, DC Power Flow, Linear Sensitivity Factors, Generation Shift Factors, Line Outage Distribution Factor, Algorithm for Contingency Analysis.

Recent Techniques

Voltage Security Assessment-Transient Security Assessment-Methods-Comparison.

Text Books:

1. P. Venkatesh, B. V. Manikandan, S. Charles Raja and A. Srinivasan, "Electrical Power Systems: Analysis, Security and Deregulation", PHI Learning Private Limited, New Delhi, 2012.
2. Wood, A. J. and Wollenberg, B. F., "Power Generation, Operation and Control", John Wiley and Sons, 1984.

Reference Books:

1. Abdullah Khan, M (Editor), "Real Time Control of Power System for Security", vol. 2, Proceedings of summer school, College of Engineering, Madras, 1976.
2. Wood, A. J. and Wollenberg, "Power Generation Operation for Security", John Wiley and sons, 1989.
3. Handsching E. (Editor), "Real Time Control of Electric Power Systems", Elsevier Publishing Co., Amsterdam, 1972.

DIGITAL SIGNAL PROCESSING APPLICATIONS IN POWER SYSTEM PROTECTION

Module-I

Abnormal States in Power Systems and Criteria for Their Recognition

Faults and Abnormal Phenomena n Power Networks, Criteria Signals, Requirements for Protective Devices.

Hardware and Functional Development of Protection Devices and Systems

Protection Generation, Functional Blocks of a Digital Protection Device, Hierarchical Structure of Protection and Control.

Fundamentals of System Analysis and Synthesis

Fourier Series, Fourier Transform, Laplace Transform, Z-Transform for Sampled Data, Fourier Transform of Sampled Data, Discrete Fourier Transform, Description of Discrete Dynamic Systems in Time and Frequency Domains.

Infinite Impulse Response (IIR) Filters

IIR Filter Fundamentals, Synthesis of IIR Filters, Application of Bilinear Transformation, Application of Impulse Response Invariance Method.

Finite Impulse Response (FIR) Filters

Finite Impulse Response Filters Fundamentals, Analysis of Standard FIR Filters, Synthesis of FIR Filters.

Module-II

Measurement Algorithms for Digital Protection

Fundamentals of Digital Measurements, Measurement of Protection Criterion Values.

Characteristic of Measurement of Criterion Values and Adaptive Algorithms

Dynamics of the measurement process, Dynamical Correction of Measurement of Criterion Values, Frequency Characteristics of Measurement Algorithms, Adaptive Frequency Insensitive Estimators.

Decision Making in Protective Relays

Deterministic Decision Making, Statistical Hypothesis Testing, Decision Making with Multiple Criteria, Adaptive Decision Scheme.

Application of Artificial Neural Network

Neuron Models and Neural Network Structures, ANN Design and Training Issues, ANN Applications for Power System Protection.

Module-III

Genetic and Evolutionary Algorithms for Power System Protection

Basics of Evolution and Genetics for Genetics for Technical Problems, Application Examples.

Expert Systems

Components of an Expert Systems, Knowledge Processing Methods, Designing of an Expert System, Expert System Applications.

Artificial Intelligence: Summary and Hybrid Schemes

Comparison, Advantages and Disadvantages of AI Techniques, Hybrid Solutions.

Text Books:

1. Waldemar Rebizant, Janusz Szafran and Andrzej Wiszniewski, "Digital Signal Processing in Power System Protection and Control", Springer Publications, 2011.

Reference Books:

1. Richard G. Lyons, "Understanding Digital Signal Processing", Third Edition, Pearson Education, Inc., 2011.
2. S. Mallat, "A Wavelet Tour of Signal Processing: The Sparse Way", Academic Press, 2010.
3. J. G. Proakis, and D. G. Manolakis, "Digital Signal Processing", Pearson, 2009.
4. P. Stoica, and R. Moses, "Spectral Analysis of Signals", Prentice Hall, 2008.
5. S. O. Haykin, "Adaptive filter theory", Prentice Hall, 2001.
6. G. Strang, and T. Nguyen, "Wavelets and Filter Banks", Wellesley-Cambridge Press, 1996.
7. Research publications that will be suggested during the course.