LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution
Approved by AICTE & Permanently Affiliated to JNTUK, Kakinada
Accredited by NAAC with "A" Grade
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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

M.Tech (Power System and Control Automation)

Course Structure and Syllabus for R22 Regulation

(w.e.f the academic year 2022-23)

I Year -I Semester

S.No	Course Code	Subject	Category	L	P	Credits
1	EE-PSCA1101	Microcontrollers and its Applications	PC	3	- -	3
2	EE-PSCA1102	HVDC Transmission	PC	3	- -	3
3	EE-PSCA1103	Power System Operation and Control	PC	3	- -	3
4	EE-PSCA1104	Reactive Power Compensation & Management	PC	3	- -	3
5	EE-PSCA1105	**Professional Elective – I**	PE	3	--	3
	EE-PSCA1105.1	1. Electrical Distribution Systems				
	EE-PSCA1105.2	2. Analysis of Power Electronics Converters				
	EE-PSCA1105.3	3. Renewable Energy Systems				
	EE-PSCA1105.4	4. Power System Transients				
6	EE-PSCA1106	**Professional Elective – II**	PE	3	--	3
	EE-PSCA1106.1	1. Power System Security				
	EE-PSCA1106.2	2. Restructured Power Systems				
	EE-PSCA1106.3	3. Modern Control Theory				
	EE-PSCA1106.4	4. MOOCs				
7	EEE-PSCA1107	Simulation Laboratory	PC	--	4	2
Total Credits						**20**

I Year-II Semester

S.No	Course Code	Subject	Category	L	P	Credits
1	EE-PSCA1201	Power System Dynamics and Stability	PC	3	--	3
2	EE-PSCA1202	Flexible AC Transmission Systems	PC	3	--	3
3	EE-PSCA1203	Power System Automation	PC	3	--	3
4	EE-PSCA1204	Advanced Power System Protection	PC	3	--	3
5	EE-PSCA1205	**Professional Elective – III**	PE	3	--	3
	EE-PSCA1205.1	1. Smart Grid Technologies				
	EE-PSCA1205.2	2. Power Quality				
	EE-PSCA1205.3	3. Real Time Control of Power Systems				
	EE-PSCA1205.4	4. Energy Audit, Conservation & Management				
6	EE-PSCA1206	**Professional Elective – IV**	PE	3	--	3
	EE-PSCA1206.1	1. Optimization Techniques				
	EE-PSCA1206.2	2. Green Energy				
	EE-PSCA1206.3	3. Artificial Intelligence Techniques				
	EE-PSCA1206.4	4. MOOCs				
7	EE-PSCA1206	Power Systems Laboratory	PC	--	4	2
Total Credits						**20**

II Year -I Semester

S.NO	Course Code	Subject	Category	L	P	Credits
1	AC-ERPW2101	Audit Course 1: English For Research Paper Writing	MC	3	--	--
2	AC-SM1201	Audit Course 2**:** Stress Management	MC	3	--	--
3	EE-PSCA2103	Seminar – I	--	--	4	2
4	EE-PSCA2104	Project Stage – I	--	--	20	10
Total Credits						**12**

***The students shall be permitted to choose AICTE approved Audit courses through MOOCs**

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II Year -II Semester

S.NO	Course Code	Subject	L	P	Credits
1	EE-PSCA2201	Project Stage – II	--	32	16
Total Credits					**16**

I Year -I Semester Syllabus

Course Code	Course Title	L	P	Credits
EE-PSCA1101	Microcontrollers and Applications	3	0	3

Course Objectives: The objectives of the course are to make the students

- To understand the organization and architecture of 8051 microcontroller
- To understand the instruction sets for 8051 microcontroller
- To study and explain interrupts and timer circuits for input and output interfacing.
- Develop interfacing to real world devices and learn importance of microcontroller in designing embedded application.
- Learn use of operating system designed to manage hardware resources of an embedded system.

Course Outcomes: After the completion of this course students will be able to

1. Relate the basic architecture and addressing modes of a microcontroller (L2).
2. To classify various instructions sets for 8051 microcontroller (L2).
3. To understand interrupts and timer circuits for input and output interfacing (L2).
4. To analyze the interfacing of micro controller to real world devices (L4).
5. To analyze the use of software and hardware tools (L4).

UNIT-I:

OVERVIEW OF ARCHITECTURE & MICROCONTROLLER RESOURCES: Microcontroller architecture – Microcontroller resources – Resources in advanced and next generation microcontrollers – 8051 Microcontroller – Internal and External memories – Counters and Timers – Synchronous and asynchronous serial communications - Interrupts.

Learning outcomes: After completion of this unit students will be able to

- Understand the architecture and organization of 8051 architecture (L2)
- Understand addressing modes to access memory (L2)

UNIT-II:

8051- MICROCONTROLLERS INSTRUCTION SET: Basic assembly language programming – Data transfer instructions –Boolean or Bit manipulation instructions – Arithmetic instructions – Instructions for Logical operations on the test among the Registers, Internal RAM, and SFRs – Program flow control instructions – Interrupt control flow.

Learning outcomes: After completion of this unit students will be able to

- Learn programming language used in a microcontroller (L2).
- Understand various instruction sets for 8051 microcontroller (L2).

UNIT-III:

REAL TIME CONTROL INTERRUPTS: Interrupt handling structure of a MCU – Interrupt Latency and Interrupt deadline – Multiple sources of the interrupts – Non-maskable interrupt sources – Enabling or disabling of interrupt source – Polling to determine the interrupt source and assignment of the priorities among them – Interrupt structure in Intel

8051. TIMERS: Programmable Timers in the MCU's – Free running counter and real time control – Interrupt interval and density constraints.

Learning outcomes: After completion of this unit students will be able to

- Explain interrupts and its structure in 8051 microcontroller (L2).
- Understand time circuits for input and output interfacing (L2).

UNIT-IV:

SYSTEM DESIGN (DIGITAL & ANALOG INTERFACING METHODS):

Switch Interface, Keypad/Keyboard interface – LED and Array of LEDs – Keyboard-cum-Display controller (8279) – Alphanumeric Devices – Display Systems and its interfaces – Printer interfaces – Programmable instruments interface using IEEE 488 Bus – Interfacing with the Flash Memory – Interfaces – Interfacing to High Power Devices – Analog input and output interfacing – Optical motor shaft encoders – Industrial process control system – Prototype MCU based Measuring instruments – Robotics and Embedded control – DSP Applications

Learning outcomes: After completion of this unit students will be able to

- Understand analog and digital interfacing methods (L2).
- Analyze the interfacing of microcontroller to real world devices (L4).

UNIT-V:

REAL TIME OPERATING SYSTEM FOR MICROCONTROLLERS:

Real Time operating system – RTOS of Keil (RTX51) – Use of RTOS in Design – Software development tools for Microcontrollers. 16-BIT MICROCONTROLLERS: Hardware – Memory map in Intel 80196 family MCU system – IO ports – Programmable Timers and High-speed outputs and input captures – Interrupts – instructions. ARM 32 Bit MCUs: Introduction to 16/32 Bit processors – ARM architecture and organization – ARM / Thumb programming model – ARM / Thumb instruction set – Development tools.

Learning outcomes: After completion of this unit students will be able to

- Understand the use of real time operating system (L2).
- Analyze the use of software and hardware tools (L4).

TEXT BOOKS:

1. Microcontrollers Architecture, Programming, Interfacing and System Design, Raj Kamal, Pearson Education, 2005.
2. The 8051 Microcontroller and Embedded Systems, Mazidi and Mazidi, PHI, 2000.

REFERENCES:

1. Microcontrollers (Theory & Applications), A.V. Deshmuk, WTMH, 2005.
2. Design with PIC Microcontrollers, John B. Peatman, Pearson Education, 2005.
3. Microcontroller Programming, Julio Sanchez, Maria P. Canton, CRC Press.
4. The 8051 Microcontroller, Ayala, Cengage Learning.

Course Code	Course Title	L	P	Credits
EE-PSCA1102	HVDC Transmission	3	0	3

Course Objectives: The objectives of the course are to make the students learn about:

- Various schemes of HVDC transmission.
- The basic HVDC transmission equipment.
- The control of HVDC systems.
- The interaction between HVAC and HVDC system.
- The various protection schemes of HVDC engineering.

Course Outcomes: After completion of the course, the student will be able to:

1. Study the various schemes of HVDC transmission. (L2)
2. Understand the basic HVDC transmission equipment.(L2)
3. Understand the control of HVDC systems.(L2)
4. Understand the interaction between HVAC and HVDC system.(L2)
5. Study the various protection schemes of HVDC engineering.(L2)

UNIT-I

Limitation of EHV AC Transmission, Advantages of HVDC Technical economical reliability aspects. HVDC Transmission: General considerations, Power Handling Capabilities of HVDC Lines, Basic Conversion principles, static converter configuration. Types of HVDC links- Apparatus and its purpose.

Learning outcomes: After completion of this unit students will be able to

- Compare Technical and Economic considerations of HVDC (L2).
- Understand the static converter principles and configurations (L2).

UNIT-II

Static Power Converters: 6-pulse bridge circuit and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter special features of converter transformers. Comparison of the perform of diametrical connection with 6-pulse bridge circuit

Learning outcomes: After completion of this unit students will be able to

- Analyze Power Converters based on number of pulses (L4)
- Analyze Rectifier and inverter operations and HVDC link (L4)
- Explain Special features of converters (L2)

UNIT-III

Control of HVDC Converters and systems: constant current, constant extinction angle and constant Ignition angle control. Individual phase control, DC power flow control. Factors responsible for generation of Harmonics voltage and current harmonics effect of variation of α and μ.Filters Harmonic elimination.

Learning outcomes: After completion of this unit students will be able to

- Understand converter systems in HVDC (L2)
- Understand power control in HVDC (L2)

UNIT-IV

Interaction between HVAC and DC systems – Voltage interaction, Harmonic in stability problems and DC power modulation. Development of DC circuit Breakers, Multi-terminal DC links and systems; series, parallel and series parallel systems, their operation and control.

Learning outcomes: After completion of this unit students will be able to

- Understand MTDC operation connection and operations (L2)
- Study the development of DC circuit breakers(L2)

UNIT-V

Transient over voltages in HVDC systems: Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults. Converter faults and protection in HVDC Systems: Converter faults, over current protection-valve group and DC line protection, circuit breakers. Over voltage protection of converters, surge arresters.

Learning outcomes: After completion of this unit students will be able to

- Identify faults in HVDC system (L3)
- Determine protection in HVDC system.(L5)

Text Books

1. S Kamakshaihand V Kamaraju: HVDC Transmission-MG hill.
2. K.R. Padiyar: High Voltage Direct current Transmission, Wiley Eastern Ltd., New Delhi – 1992.

Reference Books

1. E.W. Kimbark : Direct current Transmission, Wiley Inter Science– New York.
2. J.Arillaga: H.V.D.C. Transmission Peter Peregrinus ltd., London UK 1983
3. Vijay K Sood: HVDC and FACTS controllers: Applications of static converters in power systems by, Kluwer Academic Press.

Course Code	Course Title	L	P	Credits
EE-PSCA1103	Power System Operation and Control	3	0	3

Course Objectives:

- To learn optimum generation allocation
- To impart the knowledge on the unit commitment problems
- To familiarize modeling of turbines and generator-load
- To know the load frequency control of single area and two area systems
- To learn Preventive, Emergency and Restorative Control

Course Outcomes: After completion of the course, the student will be able to:

1. Analyze the optimal scheduling of generators (L4)
2. Solve the unit commitment problems (L3)
3. Understand the generator-load modeling and load frequency control(L2)
4. Analyze the Load frequency control problem in single area and two area systems (L4)
5. Explain the Preventive, Emergency and Restorative Control (L2)

UNIT – I

Economic Operation

Power scenario in Indian grid – National and Regional load dispatching centres – requirements of good power system, heat rate curve – cost curve – incremental fuel and production costs, input-output characteristics, basic concept of load dispatching. Optimum generation allocation with and without line losses, general transmission line loss formula.

Learning outcomes: After Completion of unit, the student should be able to:

- Understand the concept of optimal Operation of Thermal Power Units (L2)
- Analyze the effect of Transmission Line Losses on Optimum Generation Allocation (L4)

UNIT–II

Hydrothermal Scheduling and Unit Commitment

Optimal scheduling of hydrothermal System: Scheduling problems-Short term hydrothermal scheduling problem. Statement of Unit Commitment (UC) problem; constraints in UC, UC solution methods: Priority-list methods, forward dynamic programming approach

Learning outcomes: After Completion of unit, the student should be able to:

- Understand optimal scheduling of hydro thermal systems (L2)
- Apply the concept of unit commitment problem to power systems (L3)

UNIT – III

Load Frequency Control-I

Necessity of keeping frequency constant, basics of speed governing system and modeling, block diagram representation of steam turbines and approximate linear Models, generator-load modeling. Definitions of control area – Single area control – Block diagram representation of an isolated power system – Steady state analysis – Dynamic response – Uncontrolled case.

Learning outcomes: After Completion of unit, the student should be able to:

- Understand the necessity of keeping frequency constant.(L2)
- Understand the dynamic response and steady state analysis of load frequency control.(L2)

UNIT – IV

Load Frequency Control-II

Proportional plus integral control of single area and its block diagram representation, steady state response – Load frequency control and economic dispatch control. Load frequency control of two-area system – Uncontrolled case and controlled case, Tie-Line bias control.

Learning outcomes: After Completion of unit, the student should be able to:

- Understand the concept of load frequency control and economic dispatch control (L2)
- Analyse the Two-Area Load Frequency Control under controlled and uncontrolled case (L4)

UNIT – V

Preventive, Emergency and Restorative Control

Introduction-Preventive, Emergency and Restorative Control, Power System State Estimation, Normal and Alert State in a Power System, Emergency Control, Blackout, Power System Restoration.

Learning outcomes: After Completion of unit, the student should be able to:

- Understand the concept of Preventive, Emergency and Restorative Control (L2)
- Explain the Power System Restoration (L2)

Text books:

1. Modern Power System Analysis,D.P.Kothari and I.J.Nagrath, Tata McGraw Hill Publishing Company Ltd., 3rd Edition, 2003, Ninth Reprint 2007.
2. Allen.J.Wood and Bruce F.Wollenberg, 'Power Generation, Operation and Control', 3rd/e, John Wiley & Sons, Inc., 2013.

References:

1. Power System Analysis and Design, J. Duncan Glover and M.S.Sharma, Thomson, 3rd Edition, 2008.
2. Electric Energy System Theory: An Introduction, OlleIngemar Elgerd, Tata McGraw Hill, 2nd Edition, 1982.
3. Power System Stability and Control, P Kundur, Tata McGraw Hill, 1994, 5th Reprint, 2008.
4. https://nptel.ac.in/courses/108101040

Course Code	Course Title	L	P	Credits
EE-PSCA1104	Reactive Power Compensation & Management	3	0	3

Course Objectives: The objectives of the course are to make the students learn about

- The basic objectives of reactive power compensation.
- The types of compensation and their behavior.
- The mathematical modeling of reactive power compensating devices.
- The reactive power compensation at distribution side and user side.
- The role of reactive power compensation at electric traction systems and arcfurnaces.

Course Outcomes: At the end of the course students will be able to

1. Understand the basic objectives of reactive power compensation. (L2)
2. Learn the various load compensations.(L2)
3. Obtain the mathematical model of reactive power compensating devices.(L3)
4. Study the reactive power compensation at distribution side and user side.(L2)
5. Study the application of reactive power compensation in electrical traction and arc furnaces (L2)

UNIT-I

Load Compensation: Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

Learning Outcomes: After completion of this unit student will be able to

- Study the objectives of reactive power compensation.(L2)
- Analyze the load compensator as voltage regulator.(L4)
- Understand the phase balancing and power factor correction of unsymmetrical loads.(L2)

UNIT-II

Reactive Power Compensation in Transmission System: Steady state- Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples Transient state Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation – compensation using synchronous condensers -examples.

Learning Outcomes: After completion of this unit student will be able to

- Study the various types of reactive power compensation in transmission system under steady state condition.(L2)
- Study the reactive power compensation using synchronous condensers. (L2)

UNIT-III

Reactive power coordination: Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady – state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences.

Learning Outcomes: After completion of this unit student will be able to

- Derive the mathematical modeling of reactive power compensating device. (L3)
- Understand the basic concepts of power quality and its disturbances. (L2)

UNIT-IV

Distribution side Reactive power Management: System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement -retrofitting of capacitor banks.

User side reactive power management: KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of 20available capacitor, characteristics and Limitations.

Learning Outcomes: After completion of this unit student will be able to

- Study the system losses and loss reduction methods. (L2)
- Understand the reactive power planning and its objectives. (L2)
- Understand the selection of capacitors and deciding factors for reactive power management. (L2)

UNIT-V

Reactive power management in electric traction systems and are furnaces: Typicallayout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace.

Learning Outcomes: After completion of this unit student will be able to

- Understand the typical layout of the traction systems. (L2)
- Learn the reactive power compensation at electric traction system and arc furnaces. (L2)

Text Books

1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons,1982.
2. Reactive power Management by D.M.Tagare, Tata McGraw Hill, 2004.

Course Code	Course Title	L	P	Credits
EE-PSCA1105.1	Electrical Distribution Systems	3	0	3

Course Objectives: The objectives of the course are to make the students learn about

- To learn the importance of economic distribution of electrical energy.
- To study the design of distribution feeders, and rating and location of a substation.
- To analyze the distribution networks for V-drops, Power Loss calculations and reactive power
- To understand the co-ordination of protection devices.
- To impart knowledge of capacitive compensation/voltage control.

Course Outcomes: After completion of this course the students will be able to:

1. Analyze a type of distribution system.(L4)
2. Design the types of distribution feeders and their loading effects.(L3)
3. Determine the voltage drop and power losses in distribution networks.(L4)
4. Identify the protective systems and their co-ordination.(L3)
5. Improve power factor by capacitive compensation.(L3)

UNIT-I

General : Introduction to Distribution systems, an overview of the role of computers in distribution system planning-Load modeling and characteristics - definition of basic terms like demand factor, utilization factor, load factor, plant factor, diversity factor, coincidence factor, contribution factor and loss factor-Relationship between the load factor and loss factor-Classification of loads (Residential, Commercial, Agricultural and Industrial) and their characteristics

Learning outcomes: students will be able to

- Analyze the type of distribution system.(L4)
- Identify the types of loads and their characteristics.(L3)

UNIT-II

Distribution Feeders and Substations: Design consideration of Distribution feeders: Radial and loop types of primary feeders, voltage levels, feeder-loading. Design practice of the secondary distribution system. Location of Substations: Rating of a Distribution Substation, service area with 'n' primary feeders. Benefits derived through optimal location of substations..

Learning outcomes: students will be able to

- Design different types of feeders.(L6)
- Estimate a place for location of substation and benefits derived through optimal location of substation.(L5)

UNIT-III

System analysis: Voltage drop and power loss calculations: Derivation for volt-drop and power loss in lines, manual methods of solution for radial networks, three-phase balanced

primary lines, non-three-phase primary lines.

Learning outcomes: students will be able to

- Determine the voltage drop and power loss calculations.(L4)
- Analyze of three-phase and non three-phase primary lines.(L4)

UNIT-IV

Protective devices and coordination: Objectives of distribution system protection, types of common faults and procedure for fault calculation. Protective Devices: Principle of operation of fuses, circuit reclosers, line sectionalizer and circuit breakers. Coordination of protective devices: General coordination procedure.

Learning outcomes: students will be able to

- Understand the objectives of distribution system protection.(L2)
- Evaluate fault calculation and types of fault occurrence.(L5)
- Identify the types of protective devices and their co-ordination.(L3)

UNIT-V

Capacitive compensation for power factor control: Different types of power capacitors, shunt and series capacitors, effect of shunt capacitors (Fixed and switched) power factor correction, capacitor location. Economic justification. Procedure to determine the best capacitor location. Voltage control: Equipment for voltage control, effect of series capacitors, effect of AVB/AVR, line drop compensation.

Learning outcomes: students will be able to

- Analyze the effect of different types of capacitors.(L4)
- Improve power factor by locating a capacitor .(L6)

Text Books

1. "Electric Power Distribution System Engineering "byTuranGonen, Mc.Graw-Hill Book Company,1986.
2. Electric Power Distribution-by A.S.Pabla, Tata McGraw-Hill Publishing Company, 4th edition, 1997.

Reference Books

1. Electrical Distribution V.Kamaraju-McGraw Hill
2. Handbook of Electrical Power Distribution – Gorti Ramamurthy-Universities press

Course Code	Course Title	L	P	Credits
EE-PSCA1105.2	Analysis of Power Electronic Converters	3	0	3

Course Objectives: The objectives of the course are to make the students learn about

- The control principle of ac to ac conversion with suitable power semiconductor devices.
- The knowledge of ac to dc conversion and single phases ac to dc converter topologies.
- The effect of operation of controlled rectifiers on p.f and improvement of p.f with PFC converters
- The knowledge on dc-ac converters and to know the different control techniques of dc-ac converters.
- Multilevel inverter configuration to improve the quality of the inverter output voltage.

Course Outcomes: At the end of the course students will be able to

1. Have the knowledge on principle of ac voltage controller and their control techniques.(L2)
2. Convert ac voltage to dc voltage and different control strategies of the single phase and three phase converter..(L3)
3. Control the power factor of single phase and three phase ac to dc converters. .(L4)
4. Understand the conversion of dc to ac and their control strategies..(L2)
5. Analyze different multilevel inverters to improve the quality of the output voltage of the inverter.(L4)

UNIT-I

AC voltage Controllers: Single Phase AC Voltage Controllers with RL and RLE loads-ac voltage controller's with PWM control-Effects of source and load inductances –synchronous tap changers –Application- numerical problems, Three Phase AC Voltage controllers-Analysis of Controllers with star and delta connected resistive, resistive –inductive loads-Effects of source and load inductances–Application- Numerical problems.

Learning outcomes: After completion of this unit student will be able to

- Understand the working principle of single phase ac voltage controller with different loads and it's applications (L2)
- Analyse single phase and three phase ac voltage controller with star and delta connected loads (L4)

UNIT-II

AC-DC converters for single phase: Single phase Half controlled and Fully controlled Converters with RL load– Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current-Power factor improvements-Extinction angle control-symmetrical angle control-PWM single phase sinusoidal PWM-Single phase series converters- numerical problems. Three Phase AC-DC Converters- Half controlled and fully controlled Converters with RL load– Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current-three phase dual converters-Power factor improvements-three phase PWM-twelve pulse converters- Numerical problems.

Learning outcomes: After completion of this unit student will be able to

- Design of single phase half and fully controlled converters with RL load (L3)
- Evaluate input power factor and harmonic factor and power factor improvement methods (L5)

UNIT-III

Power Factor Correction Converters: Single-phase single stage boost power factor corrected rectifier, power circuit principle of operation, and steady state- analysis, three phase boost PFC converter

Learning outcomes: After completion of this unit student will be able to

- Understand different power factor correction converters (L2)
- Analyse three phase PFC boost converters (L4)

UNIT-IV

PWM Inverters: Principle of operation-Voltage control of single phase inverters - sinusoidal PWM – modified PWM – phase displacement Control – Trapezoidal, staircase, stepped, harmonic injection and delta modulation – numerical problems. Voltage Control of Three-Phase Inverters- Sinusoidal PWM- 60^0 PWM- Third Harmonic PWM- Space Vector Modulation- Comparison of PWM Techniques-current source inverters-Variable dc link inverter - Numerical problems

Learning outcomes: After completion of this unit student will be able to

- Understand the operation of different PWM inverters of single phase and three phase (L2)
- Understand the concepts of current source inverters and variable dc link inverters (L2)

UNIT-V

Multi level inverters: Introduction, Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter- Principle of Operation, Features of Flying Capacitors Inverter- Cascaded Multilevel Inverter- Principle of Operation- Features of Cascaded Inverter- Switching Device Currents-DC-Link Capacitor Voltage Balancing- Features of Multilevel Inverters- Comparisons of Multilevel Converters

Learning outcomes: After completion of this unit student will be able to

- Understand the concept of multilevel inverter and different types of multilevel inverters (L2)
- Compare different types of multilevel inverters and their outputs (L5)

Text books

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First Indian Reprint-2008.1
2. Power Electronics- Ned Mohan, Tore M.Undelan and William P.Robbins –John Wiley &Sons 2nd Edition.

Reference books

1. Power Electronics – Lander –Ed.2009
2. Modern power Electronics and AC Drives – B.K.Bose
3. Power Converter Circuits – William Shepherd & Li Zhang-Yes Dee Publishing Pvt Ltd.

Course Code	Course Title	L	P	Credits
EE-PSCA1105.3	Renewable Energy Systems	3	0	3

Course Objectives: The objectives of the course are to make the students

- To know about Solar radiation data and measurement, thermal collectors
- To understand about operation of wind energy conversion system
- To understand about bio mass energy based power plants
- To understand about Tidal and wave energy based system
- To classify Geo thermal energy sources

Course Outcomes: At the end of this course the students will be able to:

1. Analyze solar radiation data and solar thermal concentrators.(L4)
2. Explain operation of wind energy conversion system and its major components.(L2)
3. Understand the concept of Biomass energy resources and their classification, types of biogas Plants- applications.(L2)
4. Analyze the principle and operation of tidal & wave based power plants.(L4)
5. Classify and analyze Geothermal Energy sources for power generation.(L4)

UNIT-I

Solar Energy: - Availability - Solar radiation data and measurement - Estimation of average solar radiation - Solar water heater types - Heat balance – Flat plate collector efficiency – Efficiency of heat removal - Thermo siphon flow calculation - Forced circulation calculation -Evacuated collectors - Basics of solar concentrators Solar Energy Applications - Solar air heaters – Solar Chimney - Crop driers - Passive solar system - Active solar systems - Water desalination - Output from solar still – Principle of solar ponds. Numerical Problems and applications.

Learning Outcomes: At the end of this unit, the student is able to

- Analyze solar radiation data, extraterrestrial radiation, and radiation on earth's surface (L4)
- Understand the concepts of heat transfer methods (L2)
- Understand the operation of non concentric type solar collectors (L2)

UNIT-II

Nature of wind – Characteristics – Variation with height and time – Power in wind – Aerodynamics of Wind turbine – Momentum theory – Basics of aerodynamics – Aerofoil's and their characteristics – Blade element theory –Wind turbine loads–Yawed operation and tower shadow. Wind Energy Conversion System - Sitting – Rotor selection – Annual energy output – Horizontal axis wind turbine (HAWT) –Vertical axis wind turbine (VAWT) – Rotor design considerations – Number of blades– Upwind/Downwind – Yaw system – Tower – Braking system -Synchronous and asynchronous generators and loads – Integration of wind energy converters to electrical networks – Inverters – Control system – Requirement and strategies – Noise Applications of wind energy, Numerical problems and applications.

Learning Outcomes: At the end of this unit, the student is able to

- Explain wind energy conversion systems and wind power generators (L2)
- Understand Horizontal axis wind turbine, Vertical axis wind turbine design considerations (L2)

UNIT-III

Biomass Energy - Bio fuel classification – Examples of thermo chemical, Pyrolysis, biochemical and agrochemical systems – Energy farming – Direct combustion for heat – Process heat and electricity – Ethanol production and use – Anaerobic digestion for biogas – Different digesters – Digester sizing – Applications of Biogas - Operation with I.C. Engine, Applications.

Learning Outcomes: At the end of this unit, the student is able to

- Explain basic principle and working of biomass and biogas plant (L2)
- Understand the concept of pyrolysis, gasification, combustion and fermentation (L2)

UNIT-IV

Ocean Energy - OTEC Principle - Lambert's law of absorption - Open cycle and closed cycle - heat exchanger calculations – Major problems and operational experience. Tidal Power - Principles of power generation - components of power plant – Single and two basin systems – Turbines for tidal power - Estimation of energy – Maximum and minimum power ranges - tidal powerhouse, Wave Energy**–** Concept of energy and power from waves – Wave characteristics – period and wave velocities - Different wave energy conservation devices (Saltor duck, oscillating water column and dolphin types) – operational experience. Applications.

Learning Outcomes: At the end of this unit, the student is able to

- Understand the basic principle of conversion of Ocean Energy to electrical energy (L2)
- Identify the factors effecting energy equation to extract the maximum amount of energy (L2)
- Understand the principal and operation of Wave power plants (L2)
- Analyze the concept of Wave Energy and Different wave energy conservation devices. (L2)

UNIT-V

Geothermal Energy - Classification- Fundamentals of geophysics - Dry rock and hot aquifer energy analysis - Estimation of thermal power - Extraction techniques - Prime movers, Applications.

Learning Outcomes: At the end of this unit, the student is able to

- Classify different Geothermal Energy sources (L4)
- Understand the thermal power - Extraction techniques and Prime movers (L2)

Text Books

1. Renewable Energy Resources / John Twidell and Tony Weir / E&F.N.Spon
2. Solar Energy - Principles of thermal collection and storage/ S.P. Sukhatme /TMH

Reference Books

1. Renewable Energy Resources Basic Principles and Applications / G.N.Tiwari and M.K.Ghosal / Narosa
2. Solar Energy Thermal Processes,/Duffie& Beckman
3. Solar Heating and Cooling / Kreith&Kreider, CRC press.
4. Wind Energy Handbook / Tony Burton, David Sharpe, Nick Jenkins and Ervin Bossanyi / WileyWind
5. Electrical Systems / S.N.Bhadra, D.Kastha and S.Banerjee / Oxford
6. Biogas Technology - A Practical Hand Book / K.Khendelwal& S.S. Mahdi / McGraws Hill.

Course Code	Course Title	L	P	Credits
EE-PSCA1105.4	Power System Transients	3	0	3

Course Objectives: The objectives of the course are to make the student learn about

- The concepts of transients in three –phase power systems.
- The travelling waves in electrical power systems.
- The concept of Switching Transients incircuit breaker
- The Characteristics of the Transient Voltage and various standards.
- The phenomenon and effect of switching and lightning transients on power systems.

Course Outcomes: After completion of this course the students will be able to:

1. Examine the Transients in Three-Phase power Systems (L4)
2. Analyze the Reflection and Refraction of Travelling Waves (L4)
3. Understand the concept of Switching Transients in circuit breaker (L2)
4. Understand the standards of power system transients (L2).
5. Analyze lighting transient over voltages and their effects on power system (L4)

UNIT-I

Basic Concepts and Simple Switching Transients;-Switching an LR, LC, RLC circuits Transients Analysis of Three-Phase power Systems: – Symmetrical components in three-phase Systems, Sequence Components for Unbalanced Network Impedances, the Sequence Networks, analysis of Unsymmetrical Three-Phase Faults-single line-to-Ground Fault, Three phase-to-ground fault.

Learning Outcomes: After completion of this unit students will be able to

- Explain the Transient analysis in Three-Phase power Systems (L2)
- Analysis of Unsymmetrical Three-Phase Faults (L4)

UNIT-II

Travelling Waves:- Velocity of Travelling waves and Characteristic Impedance, Energy Contents of Travelling Waves, Attenuation and Distortion of Electromagnetic Waves, telegraph equations-lossless line, distortion less line. Reflection and Refraction of Travelling Waves, Reflection of Travelling Waves against Transformer-and-Generator-windings, the Origin Transient Recovery voltages, bewley-lattice diagram. Travelling waves and multi conductor system.

Learning Outcomes: After completion of this unit students will be able to

- Understand the Velocity of Travelling waves and Characteristic Impedance(L2)
- Explain the Attenuation and Distortion of Electromagnetic Waves (L2)
- Analyze Reflection and Refraction of Travelling Waves (L4)
- Explain the travelling waves and multi conductor system.(L2)

UNIT-III

Switching Transients:-arc interruption in circuit breaker , transient recovery voltage, arc-circuit interaction, interruption of capacitive currents, interruption of inverse currents,

interruption of fault current in transmission line and transformers.

Learning Outcomes: After completion of this unit students will be able to

- Understand the switching transients in circuit breaker (L2)
- Explain the interruption of fault current in transmission line and transformers (L2)

UNIT-IV

Power System Transient Recovery Voltages:- Characteristics of the Transient Voltage-Short-circuit test duties based on IEC 60056 (1987),ANSI/IEEE Standards, the Harmonization between IEC and ANSI/IEEE Standards with respect to Short-circuit Test duties, transient recovery voltage for Different types of faults.

Learning Outcomes: After completion of this unit students will be able to

- Demonstrate Characteristics of the Transient Voltage (L2)
- Classify different types of faults based on transient recovery voltage(L2)

UNIT-V

Lightning –Induced Transients: Mechanism of Lightning, wave shape of the lightning current, Direct lighting Stroke to transmission line towers, direct lightening stroke to a line, lightning protection scheme. Numerical simulation of electrical transients, The Electromagnetic Transient Program, principles of numerical techniques used in transient simulation.

Learning Outcomes: After completion of this unit students will be able to

- Understand the Mechanism of Lightning strokes, transients and wave shape of the lightning current (L2)
- Explain the Direct lighting Stroke to transmission line towers (L2).

Text Books:

1. Electrical Transients in Power System by Allen Greenwood, McGraw Hill 1990
2. Power system grounding & transients by A.P.Sakis Meliopolous.
3. “Transients in power systems” by Lou Van Sluis

Reference Books:

1. Bewley LV “travelling waves on transmission system” Dover publications Inc.,
2. Walter Diesendorf, Insulation co-ordination in high-voltage electric power systems, Butterworths, London, (1974),
3. J. G. Anderson: EHV Transmission Line Reference Book (Edison Electric Institute, New York, 1968) p. 126.

Course Code	Course Title	L	P	Credits
EE-PSCA1106.1	Power System Security	3	0	3

Course Objectives: The objectives of the course are to make the students are able :

- To analyze and simulate the short circuit analysis of AC power systems.
- To evaluate the short circuit analysis of balanced and unbalanced power systems.
- To understand the design and planning of short circuit limiters and their applications.
- To understand and analyze the concept of security by different approaches.
- To understand and apply the real time control on power systems and the softwareimplementation

Course Outcomes: At the end of this course, the students will be able to

1. Analyze and simulate the short circuit analysis of AC power systems. (L4)
2. Evaluate the short circuit analysis of balanced and unbalanced power systems. (L5)
3. Understand the design and planning of short circuit limiters and their applications(L2)
4. Analyze the concept of security by different approaches. (L4)
5. Apply the real time control on power systems and the software implementation (L3)

UNIT-I

short circuit analysis of AC power systems:

Short circuit analysis techniques in AC power Systems- Simulation of short circuit and open circuit faults using network theorems- fixed impedance short circuit analysis techniques-timedomain short circuit analysis in large scale power systems- analysis of time variation of AC and DC short circuit components.

Learning outcomes: After completion of this unit, students will be able to

- Analyze and simulate the short circuit and open circuit faults using network theorems.(L4)
- Analyze large scale power systems through time domain short circuit analysis.(L4)

UNIT-II

Short circuit analysis of balanced and unbalanced power systems

Fixed impedance Short circuit analysis of large scale power systems-general analysis of balanced, unbalanced and open circuit faults- 3-phase short circuit analysis in large scale power systems, Network equivalents and practical short circuit current assessments in large scale Ac power systems-general studies- uncertainties in short circuit current calculations-probabilistic Short circuit analysis.

Learning outcomes: After completion of this unit, students will be able to

- Evaluate balanced and unbalanced open circuit faults.(L5)
- Analyze short circuit currents in large scale AC Power systems.(L4)
- Assess uncertainties in short circuit currents.(L5)

UNIT-III

Short circuit limiters and their applications

Risk assessment and safety considerations-control and limitation of high short circuit currents-limitation of short circuit currents in power system operation, design and planning, Types of short circuit fault current limiters- earthing resistor or reactor connected to transformer neutral-pyrotechnic fault current limiters- series resonant current limiters-saturable reactor limiters-other types of fault current limiters and their applications.

Learning outcomes: After completion of this unit, students will be able to

- Evaluate the limitations of short circuit currents in power system operation, designand planning.(L5)
- Understand the operation and application of current limiters.(L2)

UNIT-IV

Power System Security analysis

Power System Security analysis- concept of security- security analysis and monitoring-factors affecting power system security- detection of network problems. contingency analysis for generator and line outages by ILPF method – fast decoupled inverse Lemma-based approach, network sensitivity factors –contingency selection –concentric relaxation and bounding.

Learning outcomes: After completion of this unit, students will be able to

- Understand the concept of security and the factors affecting.(L2)
- Identify network problems.(L3)
- Apply the different approaches on contingency selection.(L3)

UNIT-V

Real time control on power systems

Computer control power systems – need for real time and computer control of power systems- operating states of power system – SCADA- implementation considerations – software requirements for implementing above functions.

Learning outcomes: After completion of this unit, students will be able to

- Understand the need of real time and computer control of power systems.(L2)
- Apply the implementation on software requirements.(L3)

Text Books

1. Allen J. Wood and Bruce Woolen berg: Power System Generation, Operation and Control , John Willey andsons,1996.
2. John J.Grainger and William D Stevenson Jr.: Power System analysis, McGraw-Hill, ISE,1994.

Reference Books

1. Nasser D.Tleis : Power System Modeling and fault analysis, Elsevier,2008.
2. Hand book of Power Systems, GrigsBee., CRCPress, Newyork.

Course Code	Course Title	L	P	Credits
EE-PSCA1106.2	Restructured Power System	3	0	3

Course Objectives: The objectives of the course are to make the students learn about:

- To provide in-depth understanding of operation of deregulated electricity market systems.
- To understanding the fundamentals of economics
- To examine Operational planning activities of ISO – in pool and bilateral markets
- To Analyzing Types of Transmission services and Pricing of Power Transactions
- To understanding the Ancillary Services Management in variouscountries

Course Outcomes: At the end of the course, the student will be able to

1. Understand the need for restructuring of Power Systems. (L2)
2. Explain the fundamentals of economics (L2)
3. Examine the functioning and planning activities of ISO. (L4)
4. Analyze the transmission open access pricing issues and congestion management. (L4)
5. Understand the ancillary services and reactive power as ancillary service (L2)

UNIT I:

INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY

Introduction - Reasons for restructuring / deregulation of power industry; Understanding the restructuring process; Introduction to issues involved in deregulation; Reasons and objectives of deregulation of various power systems across the world

Learning Outcomes:

- Understand the necessity of restructuring process (L2)
- Explain the objectives of deregulation (L2)

UNIT II:

FUNDAMENTALS OF ECONOMICS

Introduction: fundamentals of Economics; Consumer behavior; Supplier behavior; Market equilibrium; Short-run and Long-run costs; Various costs of production; Perfectly competitive market.

Learning Outcomes:

- Understand the Consumer and Supply behavior (L2)
- Explain Perfectly competitive market (L2)

UNIT III:

POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT

Introduction; Role of the Independent System Operator; Operational planning activities of ISO– in pool and bilateral markets; Market participation issues; Unit Commitment in DeregulatedEnvironment; Competitive Bidding.

Learning Outcomes:

- Explain the operation of ISO in a bilateral market using transaction matrix (L2)
- Compare Transfer capability and Transmission Capacity. (L4)

UNIT IV:

TRANSMISSION OPEN ACCESS, PRICING ISSUES AND CONGESTION MANAGEMENT

Introduction; Power Wheeling; Transmission Open Access – Types of Transmission services, cost components; Pricing of Power Transactions– Embedded Cost Based Transmission Pricing, Incremental Cost Based Pricing; Congestion Pricing –Congestion Pricing Methods, Transmission Rights; Management of Inter-zonal/Intra-zonal congestion.

Learning Outcomes:

- Classify different methods of Transmission Pricing (L4)
- Outline the advantages and disadvantages of Transmission Pricing(L2)

UNIT V:

ANCILLARY SERVICES MANAGEMENT

General description of some ancillary services; Ancillary Services Management in various countries; Reactive Power as an Ancillary Service

Learning Outcomes:

- Summarize the role of ancillary services in a restructured environment (L2)
- Understand the ancillary services in different countries. (L2)

TEXT BOOKS:

1. Kankar Bhattacharya, Math H.J. Boller, JaapE. Daalder, Operation of Restructured Power System, Klumer Academic Publisher –2001. (Unit I,III, IV)
2. Mohammad Shahidehpour, and Muwaffaq alomoush, Restructured Electrical Power systems, Marcel Dekker Inc., 2001. (Unit II, V)

Reference Books:

1. https://nptel.ac.in/courses/108101005
2. Loi Lei Lai; Power System Restructuring and Deregulation, John Wiley & Sons Ltd.,England

Course Code	Course Title	L	P	Credits
EE-PSCA1106.3	Modern Control Theory	3	0	3

Course Objectives:

- To facilitate the Evolution of state variable Approach for the Analysis of Control systems.
- To examine the importance of controllability and observability in Modern Control Engineering for Time Variant and Time-invariant systems.
- To enable Students to Analyze various types of nonlinearities and describing function analysis of non-linear systems.
- To construct trajectories using describing functions and phase plane analysis.
- To study the analysis of stability and instability of continuous time invariant system

Course Outcomes: After completion of this course the students will be able to:

1. Understanding the State variable approach is suitable for higher order.(L2)
2. Analyze the concepts of controllability and observability for Time variant and invariant systems.(L4)
3. Attain knowledge on various nonlinearities through describing functions(L4)
4. Construct trajectories and analyze the various nonlinearities through phase plane analysis.(L4)
5. Generate Lyapunov's functions and understand the typical issues of stability and instability in continuous Time invariant systems.(L3)

UNIT-I

State Variable Analysis: The Concept of state – State Equations for Dynamic systems – State Diagram - Linear Continuous time model for physical Systems – Existence and Uniqueness of Solutions to Continuous – Time State Equations – Solutions – Linear Time Invariant Continuous – Time State Equations – State transition matrix and it's properties

Learning outcomes: Students should be able to:

- Understand the concept of state and state equations. (L2)
- Obtain solutions for linear time invariant continuous systems (L2)
- Find state transition matrix**.** (L2)

UNIT-II

State Variable Techniques: General concept of Controllability - General concept of Observability Controllability tests for Continuous &Time Invariant systems - Observability tests for Continuous &Time Invariant systems - Controllability and Observability of state model in Jordan Canonical form - Controllability and Observability Canonical forms of State model – State feedback controller design through pole assignment

Learning outcomes:

- Analyze the concept of Controllability for continuous Time variant and Time invariant systems. (L4)

- Analyze the concept of Observability for continuous Time variant and Time invariant systems. (L4)

UNIT- III

Non-Linear Systems – I: Introduction – Nonlinear Systems – Types of Non – Linearities – Saturation – Dead – Zone – Backlash – Jump Phenomenon etc.; - Singular Points – Introduction to Linearization of nonlinear Systems, properties of Non-Linear Systems – Describing function – describing function Analysis of nonlinear systems- Stability Analysis of Non – Linear systems through describing functions.

Learning outcomes:

- Attain knowledge on non-linear systems and its types and properties. (L2)
- Analyze describing function and stability analysis of non-linear systems. (L4)

UNIT-IV

Non-Linear Systems – II: Introduction to phase – plane Analysis, Method of Isoclines for Constructing Trajectories, singular points, phase – plane analysis of nonlinear control systems.

Learning outcomes:

- Construct Trajectories by using the method of Isoclines. (L4)
- Analyze the phase-plane analysis on nonlinear control systems. (L4)

UNIT-V

Stability Analysis: Stability in the sense of Lyapunov, Lyapunov's stability and Lyapunov's instability Theorems, Stability Analysis of the Linear Continuous time invariant systems by Lyapunov second method-Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.

Learning outcomes:

- Understand Lyapunov's stability and instability theorems. (L2)
- Determining Lyapunov's functions by variable gradient and Krasooviskis method. (L3)

Text Books:

1. Modern Control System Theory by M. Gopal – New Age International –1984.
2. Modern Control Engineering by Ogata. K – Prentice Hall –1997.

Reference Books:

1. Nonlinear systems, Hassan K. Klalil, Prentice Hall,1996.
2. Modern control systems, Richard C. Dorf and Robert H. Bishop, 11th Edition, Pearson Edu, India,2009.

Course Code	Course Title	L	P	Credits
EE-PSCA1107	Simulation Laboratory	0	4	2

Course Objectives:

- To understand the modeling of various aspects of Power System analysis.
- Develop the MATLAB programming for Power systems.

Course Outcomes: After completing this course the student will be able to:

1. Simulate the Load Flow Solution using different methods (L6)
2. Analyze the formation of Y and Z bus (L4)
3. Analyze the Symmetrical and Unsymmetrical faults using Z-bus (L4)
4. Simulate the Economic Load Dispatch and Load frequency control of different systems (L6)
5. Understand the Stability analysis of Using Point by Point Method. (L2)

List of Experiments

1. Formation of Y- Bus by Direct-Inspection Method.
2. Load Flow Solution Using Gauss Siedel Method.
3. Load Flow Solution Using Newton Raphson Method.
4. Load Flow Solution Using Fast Decoupled Method.
5. Formation of Z-Bus by Z-bus building algorithm.
6. Symmetrical Fault analysis using Z-bus.
7. Unsymmetrical Fault analysis using Z-bus.
8. Economic Load Dispatch with & without transmission losses.
9. Transient Stability Analysis Using Point by Point Method.
10. Load Frequency Control of Single Area Control& Two Area Control system with and without controllers.

I Year -II Semester Syllabus

Course Code	Course Title	L	P	Credits
EE-PSCA1201	Power System Dynamics and Stability	3	0	3

Course Objectives: The objectives of the course are to make the students learn about

- The modeling of synchronous machines.
- The stability studies of synchronous machines.
- The solution method of transient stability.
- The effect of governor action and excite on power system stability.
- The effect of different excitations.

Course Outcomes: At the end of the course students will be able to

1. Determine the model of synchronous machines.(L3)
2. Understand the stability studies of synchronous machines.(L2)
3. Understand the different solution methods of transient stability.(L2)
4. Explain the effect of governor action and excitation on power system stability.(L2)
5. Understand the effect of different excitation systems.(L2)

UNIT-I

System Dynamics: Synchronous machine model in state space from computer representation for excitation and governor system-modeling of loads and induction machines.

Learning Outcomes: After completion of this unit student will be able to

- Design the synchronous machine model in state space representation for excitation and governor system.(L3)
- Develop the induction machine model in state space representation.(L3)

UNIT-II

Steady state stability-steady state stability limit: Dynamics Stability limit – Dynamic stability analysis – State space representation of synchronous machine connected to infinite bus-time response – Stability by Eigen value approach.

Learning Outcomes: After completion of this unit student will be able to

- Understand the concept of different stability limits.(L2)
- Explain the state space representation of synchronous machine connected to infinite bus.(L2)

UNIT-III

Digital Simulation of Transient Stability: Swing equation machine equations – Representation of loads – Alternate cycle solution method – Direct method of solution – Solution Techniques: Modified Euler method – Runge Kutta method – Concept of multi machine stability

Learning Outcomes: After completion of this unit student will be able to

- Understand the different solution methods for transient stability.(L2)

- Understand the Modified Euler and Runge Kutta Method applied for multi machine stability.(L2)

UNIT-IV

Effect of governor action and excite on power system stability effect of saturation saliency &automatic voltage regulators on stability.

Learning Outcomes: After completion of this unit student will be able to

- Understand the effect of governor action and excitation on power system stability.(L2)
- Study the automatic voltage regulators on stability.(L2)

UNIT-V

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 and Exciter, Rotating Amplifier and Static Voltage Regulator – Static excitation scheme brushless excitation system.

Learning Outcomes: After completion of this unit student will be able to

- Explain the Rotating Self-excited Exciter with direct acting Rheostatic type voltageregulator .(L2)
- Understand the Rotating main and Pilot Exciters with Indirect Acting Rheostatic Type Voltage Regulator.(L2)
- Understand the Rotating Amplifier and Static Voltage Regulator.(L2)
- Understand the brushless excitation system.(L2)

Text Books

1. Power System Stability by Kimbark Vol.I&II, III, Willey.
2. Power System control and stability by Anderson and Fund, IEEE Press

References Books

1. Power Systems stability and control by PRABHA KUNDUR, TMH.
2. Computer Applications to Power System-Glenn. W.Stagg & Ahmed. H.EI.Abiad,TMH.
3. Computer Applications to Power System – M.A.Pai, TMH.
4. Power Systems Analysis & Stability – S.S.Vadhera Khanna Publishers.

Course Code	Course Title	L	P	Credits
EE-PSCA1202	Flexible AC Transmission Systems	3	0	3

Course Objectives:

- To study the performance improvements of transmission system with FACTS.
- To study the effect of static shunt compensation.
- To study the effect of static series compensation.
- To study the effect of UPFC and IPFC.

Course Outcomes: After completing this course the student will be able to:

1. Understand the concept of power flow control in transmission lines using FACTS controllers. (L2)
2. Acquire knowledge on operation and control of voltage source and current source converter .(L2)
3. Explain compensation methods to improve stability and reduce power oscillations in the transmission lines.(L5)
4. Identify the methods of compensations by using series compensators.(L3)
5. Explain the operation of modern power electronic controllers.(L2)

UNIT-I

Concepts of Flexible Ac Transmission Systems: FACTS concepts, Transmission interconnections, power flow in an AC System, loadingcapability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, benefits from FACTS controllers, Applications.

Learning outcomes: Student should be able to

- Understand the concept of Power flow in transmission systems (L2)
- Classify basic types of FACTS controllers (L2)

UNIT-II

Voltage and Current Sourced Converters: Basic concept of voltage and current source converters, Single-Phase Full-Wave Bridge Converter Operation, Square-Wave Voltage Harmonics for a Single-Phase Bridge, Three-Phase Full-Wave Bridge Converter, comparison of current source converters with voltage source converters.

Learning outcomes: Student should be able to

- Understand the concept of Voltage Sourced Converters (L2)
- Compare the performance of voltage sourced and current sourced converters(L2)

UNIT-III

Static Shunt Compensators: Objectives of shunt compensation, midpoint voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, methods of controllable var generation, variable impedance type static var generators, switching converter type var generators, hybrid var generators.SVC and STATCOM : The regulation and slope transfer function and dynamic performance, transient

stability enhancement and power oscillation damping, operating point control.

Learning outcomes: Student should be able to

- Explain the Objectives of Shunt Compensation (L5)
- Classify the Methods of Controllable VAR Generation (L3)

UNIT-IV

Static Series Compensators: Static series compensators : Concept of series capacitive compensation, improvement oftransient stability, power oscillation damping, functional requirements. GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC), control schemes for GSC, TSSC and TCSC.

Learning outcomes: Student should be able to

- Understand the objectives of Series Compensation (L2)
- Identify different Types of series Compensating methods (L3)

UNIT-V

Power Flow Controllers: Unified Power Flow Controller (UPFC): Basic operating principle, conventional transmission control capabilities, independent real and reactive power flow control, Interline Power Flow Controller (IPFC), Basic Operating Principles and Characteristics, Control Structure.

Learning outcomes: Student should be able to

- Explain the operation of Unified Power Flow Controller(L2)
- Explain the operation of Interline Power Flow Controller (L2)

Text Books

1. Understanding FACTS – Concepts and technology of Flexible AC Transmission systems, Narain G. Hingorani, Laszlo Gyugyi, IEEE Press, WILEY, 1st Edition, 2000, Reprint 2015.
2. FACTS Controllers in Power Transmission and Distribution, Padiyar K.R., New Age International Publishers, 1st Edition, 2007.

Reference Books

1. Flexible AC Transmission Systems: Modelling and Control, Xiao – Ping Zhang, Christian Rehtanz, Bikash Pal, Springer, 2012, First Indian Reprint, 2015.
2. FACTS – Modelling and Simulation in Power Networks, Enrigue Acha, Claudio R. Fuerte Esquival, Huge Ambriz – perez, Cesar Angeles – Camacho, WILEY India Private Ltd., 2004, Reprint 2012.

Course Code	Course Title	L	P	Credits
EE-PSCA1203	Power System Automation	3	0	3

Course Objectives:

- Understand the Operation of power system automation and its evolution with SCADA.
- Analyze Energy Management System and the role of program logic controller in EMS.
- Learn the fundamentals of SCADA and its various classification to various applications
- Understand substation automation structure and its applications functions
- Familiarize control schemes of distribution automation and know its technical benefits.

Course Outcomes: After the completion of this course students should be able to

1. Understand the need of structure and operation of power system automation and its evolution with SCADA. (L2)
2. Understand the Energy Management System and the role of program logic controller in EMS. (L2)
3. Analyze SCADA and its various classification to various applications (L4)
4. Illustrate the substation automation structure and its applications functions.(2)
5. Explore various control schemes of distribution automation and know its technical benefits.(L4)

UNIT I: Power System Automation:

Introduction –Evolution of automation system – Benefits of power system automation, Structure of power system automation, Electrical Protection, Control, Measurement, Monitoring- Architecture for power system automation – Classification of power system automation – Substation automation and Distribution automation – Problems with Data acquisition - implementation of power system automation and protection using SCADA.

Learning Outcomes:

- Understand the Evolution of automation system and its benefits in power system automation. (L2)
- Identify the Problems with Data acquisition & implementation of power system automation and protection using SCADA. (L2)

UNIT II: Energy Management Systems & PLC:

Introduction, EMS in Power Systems, Objectives of EMS, Evolution of EMS, Functions and Benefits of EMS, EMS Architecture, Working of EMS, Evolution of EMS.

Programmable Logic Controllers:

Introduction – Basic Operation – PLC architecture and components – Programming Languages – PLC's Applications to Power System Automation.

Learning Outcomes:

- Understand the Objectives of EMS, Evolution of EMS, Functions and Benefits of EMS. (L2)
- Understand the basic operation of PLC architecture and components.(L2)

UNIT III: SCADA Fundamentals:

Introduction – Building Blocks of SCADA - SCADA in power systems – Its application functions in Generation, Transmission and Distribution – Advantages of SCADA - SCADA Communication systems - RTUs – Components of RTUs –Communication Protocols – Advanced RTU functionalities, IEDs, Data concentrators and merging units, Human Machine Interface, Classification of SCADA systems Single master–single remote, Single master–multiple RTU, Multiple master–multiple RTUs, Single master, multiple submaster, multiple remote.

Learning Outcomes:

- Need of SCADA in power systems – Its application functions in Generation, Transmission and Distribution. (L2)
- Categorize the SCADA systems into various master – various remote systems. (L4)

UNIT IV: Substation Automation:

Why Substation automation (SA)? Why now?, Role of IEDs in SA, Conventional substations: Islands of automation, Substation automation issues, SA architectures, application functions, Enterprise- level application functions, Benefits of data analysis to utilities.

Learning Outcomes:

- Understand the importance of Substation automation. (L2)
- Understand the Benefits of data analysis to utilities. (L2)

UNIT V: Distribution Automation:

Introduction to Distribution Automation (DA), control system interfaces, control and data requirements, centralized (Vs) decentralized control, DA System (DAS), DA Hardware, DAS software, Distribution Automation Functions-Information management, system reliability management, system efficiency management, voltage management, Load management, Communication systems used in DA - DA communication requirements, Communication reliability, Cost effectiveness, Data rate Requirements, Two way capability, Technical Benefits of DA.

Learning Outcomes:

- Categorize the Distribution Automation systems. (L4)
- Understand the Distribution Automation Functions. (L3)

TEXT BOOKS

1. Power system SCADA and smart grids, Mini S Thomas, John D Mcdonald, CRC Press, 2015.
3. Control and Automation of Electrical Distribution Systems, James. Northcote, Green Robert Wilson, CRC Press.
4. Electric Power Distribution Automation, Dr. M. K. Khedkar, Dr. G.M.Dhole, University Science press.
5. PLCs and SCADA- Theory and Practice, Rajesh Mehra, Vikrant Vij, Laxmi Publications, First edition, 2016.

REFERENCES

1. NPTEL course on Energy Management Systems and SCADA

Course Code	Course Title	L	P	Credits
EE-PSCA1204	Advanced Power System Protection	3	0	3

Course Objectives: The objectives of the course are to make the students

- To learn about classification and operation of static relays.
- To understand the basic principles of amplitude and phase comparators.
- To learn about static version of different types of relays.
- To assess the basic pilot relaying protection schemes.
- To understand about numerical protection techniques.

Course Outcomes: After completion of this course the students will be able to:

1. Explain the operation and applications of static relays.(L2)
2. Understand the Operation and application of Amplitude and phase comparators.(L2)
3. Analyze the static version of different types of relays.(L4)
4. Analyze the various PILOT relaying protection schemes.(L4)
5. Apply the concepts of microprocessor based protective relays and digital relaying algorithms. (L3)

UNIT-I

Static Relays classification and Tools: Comparison of Static with Electromagnetic Relays, Basic classification, Level detectors and Amplitude and phase Comparators – Duality – Basic Tools – Schmitt Trigger Circuit, Multivibrators, Square wave Generation – Polarity detector -Zero crossing detector – Thyristors and UJT Triggering Circuits. Phase sequence Filters – Speed and reliability of static relays, Applications.

Learning Outcomes: At the end of this unit, the student is able to

- Understand the classification and operation of static relays.(L2)
- Understand the significance of various electronic circuits in static relays.(L2)

UNIT-II

Amplitude and Phase comparators:

Generalized equations for Amplitude and Phase comparison – Derivation of different characteristics of relays – Rectifier Bridge circulating and opposed voltage type amplitude comparators – Averaging & phase splitting type amplitude comparators – Principle of sampling comparators, Phase Comparison comparators: Block Spike and phase Splitting Techniques – Transistor Integrating type, phase comparison, Rectifier Bridge Type Comparison – Vector product devices, Applications.

Learning Outcomes: At the end of this unit, the student is able to

- Understand the generalized equations for Amplitude and Phase comparison.(L2)
- Understand the principle and operation of different Amplitude comparators. (L2)

UNIT-III

Static over current (OC) relays: Instantaneous, Definite time, Inverse time OC Relays, static distance relays, static directional relays, static differential relays, measurement of

sequence impedances in distance relays, multi input comparators, elliptic & hyperbolic characteristics, switched distance schemes, Impedance characteristics during Faults and Power Swings, , Applications, Numerical Problems.

Learning Outcomes: At the end of this unit, the student is able to

- Analyze the operating characteristics of different types of Static over current relays.(L4)
- Understand the operation of different Static over current relays during fault conditions.(L2)

UNIT-IV

PILOT Relaying schemes: Wire pilot protection: circulating current scheme – balanced voltage scheme – translay scheme – half wave comparison scheme - carrier current protection: phase comparison type – carrier aided distance protection – operational comparison of transfer trip and blocking schemes – optical fibre channels, , Applications.

Learning Outcomes: At the end of this unit, the student is able to

- Analyze the concept of static distance protection and pilot relaying schemes.(L4)
- Analyze Different types of carrier current protection schemes.(L4)

UNIT-V

Microprocessor based relays and Numerical Protection: Introduction – over current relays-impedance relay – directional relay – reactance relay.

Numerical Protection: Introduction - numerical relay - numerical relaying algorithms - mann- morrison technique - Differential equation technique and discrete fourier transform technique - numerical over current protection - numerical distance protection. , Applications.

Learning Outcomes: At the end of this unit, the student is able to

- Explain and apply the principles of digital protection to electrical apparatus.(L2)
- Apply the digital relaying algorithms for power system protection.(L3)

Text Books:

1. Power System Protection with Static Relays – by TSM Rao,TMH.
2. Power system protection & switchgear by Badri Ram & D N viswakarma,TMH.

Reference Books:

1. Protective Relaying Vol-II Warrington,Springer.
2. Art & Science of Protective Relaying - C R Mason,Willey.
3. Power System Stability KimbarkVol-II,Willey.
4. Electrical Power System Protection –C.Christopoulos and A.Wright-Springer Protection & Switchgear–BhaveshBhalaja, R.PMaheshwari, NileshG.Chothani-Oxford publisher

Course Code	Course Title	L	P	Credits
EE-PSCA1205.1	Smart Grid Technologies	3	0	3

Course Objectives: The objectives of the course are to make the students learn about:

- Overview of the technologies required for the smart grid
- Switching techniques and different means for data communication
- Standards for information exchange and smart metering
- Methods used for information security on smart grid
- Smart metering, and protocols for smart metering

Course Outcomes: After completion of the course, the student will be able to:

1. Understand the constraints and identify the initiative operations, technologies on smart grid (L2)
2. Understand the necessity and apply the switching techniques of data communication technologies (L2)
3. Analyze the encryption, decryption and importance of standards for information exchange security on smart grid (L3)
4. Understand the importance of smart metering and analysis of different area networks, protocols on demand side integration (L2)
5. Analyze the importance of data sources and techniques, modeling tools required on transmission management system (L3)

UNIT – I

The Smart Grid

Introduction, Ageing Assets and Lack of Circuit Capacity, Thermal Constraints, Operational Constraints, Security of Supply, National Initiatives,

Early Smart Grid Initiatives, Active Distribution Networks, Virtual Power Plant, Other Initiatives and Demonstrations, Overview of The Technologies Required for The Smart Grid.

Learning Outcomes: The students are able to

- Understand the constraints on smart grid(L2)
- Identify the initiative operations and technologies required for the smart grid (L3)

UNIT – II

Communication Technologies

Data Communications: Introduction, Dedicated and Shared Communication Channels, Switching Techniques, Circuit Switching, Message Switching, Packet Switching, Communication Channels, Wired Communication, Optical Fiber, Radio Communication, Cellular Mobile Communication, Layered Architecture and Protocols, The ISO/OSI Model, TCP/IP.

Learning Outcomes: The students are able to

- Understand the necessity of data communication technologies (L2)
- Apply the switching techniques of data communication (L3)

UNIT – III

Information Security for the Smart Grid

Introduction, Encryption and Decryption, Symmetric Key Encryption, Public Key Encryption, Authentication, Authentication Based on Shared Secret Key, Authentication

Based on Key Distribution Center, Digital Signatures, Secret Key Signature, Public Key Signature, Message Digest, Power Systems Management And Association Information Exchange – Data and Communication Security – Applications.

Learning Outcomes: The students are able to

- Understand the importance of encryption and decryption on smart grid (L2)
- Understand the importance of standards for information exchange and security on smart grid (L2)

UNIT – IV

Smart Metering and Demand Side Integration

Introduction, smart metering – evolution of electricity metering, key components of smart metering, smart meters: an overview of the hardware used – signal acquisition, signal conditioning, analogue to digital conversion, computation, input/output, and communication. Communication infrastructure and protocols for smart metering- Home area network, Neighborhood Area Network, Data Concentrator, meter data management system, Protocols for communication. Demand Side Integration- Services Provided by DSI, Implementation of DSI, Hardware Support, Flexibility Delivered by consumers from the Demand Side, System Support from DSI – Applications.

Learning Outcomes: The students are able to

- Understand the importance of smart metering (L2)
- Analyze the different area networks and protocols on demand side integration (L3)

UNIT – V

Transmission Management Systems

Data Sources, Energy Management System, Wide Area Applications, Visualization Techniques, Data Sources and Associated External Systems, SCADA, Customer Information System, Modeling and Analysis Tools.

Learning Outcomes: The students are able to

- Understand the importance of data sources on transmission management system (L2)
- Apply the techniques and modeling tools required in transmission management system (L3)

Text Books:

1. Smart Grid, Janaka Ekanayake, Liyanage, Wu, Akihiko Yokoyama, Jenkins, Wiley Publications, 2012, Reprint 2015.
2. Smart Grid: Fundamentals of Design and Analysis, James Momoh, Wiley, IEEE Press., 2012, Reprint 2016.

Reference Books:

1. The Smart Grid – Enabling Energy efficiency and demand response, Clark W. Gellings, P.E., CRC Press, Taylor & Francis group, First Indian Reprint. 2015.
2. Smart Grid – Applications, Communications, and Security Edited by Lars Torsten Berger, Krzysztof Iniewski, WILEY, 2012, Reprint 2015.
3. Practical Electrical Network Automation and Communication Systems, Cobus Strauss, ELSVIER, 2003.

Course Code	Course Title	L	P	Credits
EE-PSCA1205.2	Power Quality	3	0	3

Course Objectives:

- To understand the different Power quality issues and its standards.
- To understand the sources of sags, swells and interruptions and devices for voltage regulation
- To explain Categories and Characteristics of Electromagnetic Phenomena in Power Systems and principles of voltage regulation.
- To understand the sources of harmonics, harmonic indices and Devices for controlling harmonic distortion.
- To discuss Power quality monitoring considerations and its standards.

Course Outcomes: After completion of the course, the student will be able to

1. Discuss power quality issues to ensure meeting of standards(L2)
2. Apply concept of compensation for sags ,swells using Voltage regulating devices (L3)
3. Understand the Concept harmonic distortion and harmonic sources (L2)
4. Evaluate harmonic distortion and its mitigation (L5)
5. Explain power quality measurement data according to standards (L2)

UNIT I

Introduction

Overview of power quality – Concern about the power quality – General classes of power quality and voltage quality problems – Transients – Long–duration voltage variations – Short–duration voltage variations – Voltage unbalance – Waveform distortion – Voltage fluctuation – Power frequency variations - CBEMA and ITI Curves.

Learning outcomes: The students are able to

- Understand the knowledge of power quality definitions and standards(L2)
- Classify various power quality issues(L4)

UNIT II

Voltage Imperfections in Power Systems

Power quality terms – Voltage sags – Voltage swells and interruptions – Sources of voltage sag, swell and interruptions – Nonlinear loads – IEEE and IEC standards. Source of transient over voltages – Principles of over voltage protection – Devices for over voltage protection – Utility capacitor switching transients.

Learning outcomes: The students are able to

- Understand the knowledge of short and long duration voltage variations(L2)
- Apply concept of compensation for sags ,swells using Voltage regulating devices (L3)

UNIT III

Voltage Regulation and Power Factor Improvement

Principles of regulating the voltage – Device for voltage regulation – Utility voltage regulator application – Capacitor for voltage regulation – End–user capacitor application – Regulating utility voltage with distributed resources – Flicker – Power factor penalty – Static VAR compensations for power factor improvement.

Learning outcomes: The students are able to

- Explain the principle of voltage regulation and power factor improvement methods (L2)
- Illustrate static VAR compensation technique (L3)

UNIT IV

Harmonic Distortion and Solutions

Voltage distortion vs. Current distortion – Harmonics vs. Transients – Harmonic indices – Sources of harmonics – Effect of harmonic distortion – Impact of capacitors, transformers, motors and meters – Point of common coupling – Passive and active filtering – Numerical problems.

Learning outcomes: The students are able to

- Describe various harmonic indices (L2)
- Apply the Principles of Controlling Harmonics for using harmonic distortion regulating devices (L3).
- calculate the parameters for passive and active filters (L3)

UNIT-V

Power Quality Monitoring

Power quality monitoring and considerations – Historical perspective of PQ measuring instruments – PQ measurement equipment – Assessment of PQ measuring data – Application of intelligent systems – PQ monitoring standards.

Learning outcomes: The students are able to

- Discuss various power quality monitoring considerations and locations(L2)
- Explain power quality measurement data according to standards(L2)

Text Books:

1. Electrical Power Systems Quality, Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H.WayneBeaty, McGraw Hill Education (India) Pvt. Ltd., 3rd Edition, 2012.
2. Power quality, C. Sankaran, CRC Press, 2001.

Reference Books:

1. Understanding Power quality problems – Voltage Sags and Interruptions, Math H. J. Bollen IEEE Press Series on Power Engineering, WILEY, 2007.
2. Power quality – VAR Compensation in Power Systems, R. SastryVedam, Mulukutla S. Sarma, CRC Press, 2009, First Indian Reprint 2013.
3. Fundamentals of Electric Power Quality, Surya Santoso, Create Space, 2012.

Course Code	Course Title	L	P	Credits
EE-PSCA1205.3	Real Time Control of Power Systems	3	0	3

Course Objectives: The objectives of the course are to make the students learnabout

- The importance of state estimation in power systems.
- The importance of security and contingency analysis.
- SCADA, its objectives and its importance in power systems.
- The voltage stability in powers system.
- The applications of AI to power systems problems.

Course Outcomes: At the end of the course students will be able to

1. Understand the concept of state estimation and different state estimation techniques.(L2)
2. Apply security and contingency analysis for Generator and line outages.(L3)
3. Understand about Supervisory control and data acquisition in power systems.(L2)
4. Analyze the voltage stability in mature power systems.(L4)
5. Analyze Real time software application to state estimation and application of AI in power system.(L4)

UNIT-I

State Estimation: Different types of State Estimations, Theory of WLS state estimation, sequential and non-sequential methods to process measurements. Bad data Observability, Bad data detection, identification and elimination.

Learning Outcomes: After completion of this unit student will be able to

- Understand the importance of state estimation and different methods of state estimation in power systems (L2).
- Understand the concepts of Bad data observability, Bad data detection, identification and elimination.(L2)

UNIT-II

Security and Contingency Evaluation: Security concept, Security Analysis and monitoring, Contingency Analysis for Generator and line outages by iterative linear power flow method, Fast Decoupled model, and network sensitivity methods.

Learning Outcomes: After completion of this unit student will be able to

- Understand the need and methods of analyzing security in power systems.(L2)
- Apply Security and Contingency Analysis for Generator and line outages.(L3)

UNIT-III

Computer Control of Power Systems: Need for real time and computer control of power systems, operating states of a power system, SCADA - Supervisory control and Data Acquisition systems implementation considerations, energy control centres, software requirements for implementing the above functions

Learning Outcomes: After completion of this unit student will be able to

- Understand the operating states of a power system and need of real time and computer control.(L2)
- Understand the operation of SCADA and software requirements for implementing it. (L2)

UNIT-IV

Voltage Stability Analysis: Voltage Stability, voltage collapse, and voltage security, relation of voltage stability to rotor angle stability, Voltage stability analysis. Introduction to voltage stability analysis `P-V' curves and `Q-V' curves, voltage stability in mature power systems, long-term voltage stability, power flow analysis for voltage stability, voltage stability static indices and Research Areas.

Learning Outcomes: After completion of this unit student will be able to

- Understand the basic concepts of voltage stability.(L2)
- Relate the voltage stability to rotor angle stability.(L6)
- Apply the power flow analysis for voltage stability, voltage stability static indices.(L3)

UNIT-V

Application of AI and ANN in Power System: Basic concepts and definitions, algorithms for load flow, short term load forecasting, fault diagnosis and state estimation.

Learning Outcomes: After completion of this unit student will be able to

- Apply AI techniques for load forecasting in power systems.(L3)
- Apply AI techniques for fault diagnosis and state estimation.(L3)

Text Books

1. John J.Grainger and William D.Stevenson, Jr. : Power System Analysis, McGraw-Hill,1994, International Edition
2. PrabhaKundur : Power System Stability and Control -, McGraw Hill,1994

Reference Books

1. Allen J.Wood and Bruce F.Wollenberg : Power Generation operation and control, JohnWiley & Sons,1984
2. R.N.Dhar : Computer Aided Power Systems Operation and Analysis, Tata McGraw Hill,1982
3. L.P.Singh : Advanced Power System Analysis and Dynamics, Wiley Eastern Ltd.1986
4. P.D.Wasserman : `Neural Computing : Theory and Practice' Van Nostr and Feinhold,NewYork.

Course Code	Course Title	L	P	Credits
EE-PSCA1205.4	Energy Audit, Conservation & Management	3	0	3

Course Objectives: The objectives of the course are to make the students learn about

- To understand energy efficiency, scope, conservation and technologies.
- To design energy efficient lighting systems.
- To estimate/calculate power factor of systems and propose suitable compensationtechniques.
- To understand energy conservation in HVAC systems.
- To calculate life cycle costing analysis and return on investment on energy efficienttechnologies.

Course outcomes: At the end of this course, students will demonstrate the ability to

1. Understand the concept of energy audit, energy management, energy conservationschemes and representation of energy consumption (L2).
2. Design energy efficient lighting systems (L3).
3. Design suitable power factor correcting equipment in electrical system and energymonitoring system to analyze the energy consumption in an organization. (L3).
4. Understand energy conservation in HVAC systems; improve the thermal efficiencyfor heat recovery and co-generation (L2).
5. Study economic and financial analysis of energy efficient technologies investment(L2).

UNIT–I

Basic Principles of Energy Audit and management: Energy audit – Definitions – Concept

– Types of audit – Energy index – Cost index – Piecharts –Sankey diagrams – Load profiles – Energy conservation schemes and energy savingpotential – Numerical problems – Principles of energy management – Initiating, planning,controlling, promoting, monitoring, reporting – Energy manager – Qualities and functions –Language – Questionnaire – Check list for top management.

Learning Outcomes:

- Understand energy efficiency, scope, conservations and technologies(L2).
- Understand energy conservation act-2001(L2).
- Develop the energy flow diagram of an industry and identify the energy wasted or a waste stream, Energy monitoring system to analyze the energy consumption in an organization (L3).

UNIT–II

Lighting: Modification of existing systems – Replacement of existing systems – Priorities**:** Definition of terms and units – Luminous efficiency – Polar curve – Calculation of illumination level – Illumination of inclined surface to beam – Luminance or brightness – Types of lamps – Types of lighting – Electric lighting fittings (luminaries) – Flood lighting –

White light LED and conducting Polymers – Energy conservation measures.

Learning Outcomes:

- Evaluate the techno economic feasibility of the energy conservation technique adopted in lighting (L5).
- Design of energy efficient lighting systems (L3).

UNIT–III

Power Factor and energy instruments: Power factor – Methods of improvement – Location of capacitors – Power factor with non linear loads – Effect of harmonics on Power factor – Numerical problems. Energy Instruments –Watt–hour meter – Data loggers–Thermocouples – Pyrometers – Lux meters – Tong testers – Power analyzer.

Learning Outcomes:

- Estimate/Calculate power factor of systems and propose suitable compensation Techniques(L5)
- Utilize suitable energy monitoring equipment to monitor various quantities in anorganization.(L3)

UNIT–IV

Space Heating and Ventilation: Ventilation – Air–Conditioning (HVAC) and Water Heating**:** Introduction – Heating of buildings – Transfer of Heat–Space heating methods – Ventilation and air–conditioning – Insulation–Cooling load – Electric water heating systems-Energy conservation methods.

Learning Outcomes:

- Improve the thermal efficiency by designing suitable systems for heat recovery and co generation (L3)
- Understand energy conservation in HVAC systems (L2).

UNIT–V

Economic Aspects and Financial Analysis: Understanding energy cost - Economics Analysis – Depreciation Methods – Time value of money – Rate of return – Present worth method – Replacement analysis – Life cycle costing analysis – Energy efficient motors (basicconcepts) – Economics of energy efficient motors and systems.

Computation of Economic Aspects: Need of investment, appraisal and criteria - Calculation of simple payback period–Return on investment – Net present value – Internal rate of return –numerical examples – Power factor correction – Lighting – Applications of life cycle costing analysis – Return on investment –Numerical examples.

Learning Outcomes:

- Calculation of life cycle costing analysis and replacement analysis and Depreciation methods (L5)
- Understand return on investment on energy efficient technologies (L2)
- Calculate life cycle costing analysis and return on investment on energy efficient technologies.(L5)
- Calculate most economical power factor and economic analysis on Power Factor correcting devices(L5)

Text Books

1. Hand Book of Energy Audit by Sonal Desai- Tata McGraw hill
2. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd–2nd edition,1995

Reference Books

1. Energy management by W.R. Murphy & G. Mckay Butter worth, Elsevier publications.2012
2. Electric Energy Utilization and Conservation by S C Tripathy, Tata McGraw hill publishing company Ltd. New Delhi.
3. Energy management by Paul o' Callaghan, Mc–Graw Hill Book company–1st edition,1998.
4. Energy management hand book by W.C.Turner, John wiley and sons.
5. Energy management and conservation –k v Sharma and p.venkataseshaiah-I K International Publishing House pvt.ltd, 2011.

Course Code	Course Title	L	P	Credits
EE-PSCA1206.1	Optimization Techniques	3	0	3

Course objectives:

- To define an objective function, constraint functions in terms of design variables, and then states the optimization problem.
- To state single variable and multi variable optimization problems, without and with constraints.
- To explain linear programming technique to an optimization problem, define slack and surplus variables, by using Simplex method.
- To study and explain nonlinear programming techniques, unconstrained or constrained, define exterior, interior penalty functions for optimization problems.
- To understand Evolutionary Programming Methods such as PSO and GA, and solve complex problems.

Course Outcomes: After completion of the course, the student will be able to:

1. Analyze the various optimization problems without and with constraint design variables (L4)
2. Identify the optimal solution of problems involving continuous and differential functions (L3)
3. Identify the optimal solution in a function whose equations are represented by linear relationships (L3)
4. Analyze the optimization problem where some of the constraints or objective functions are nonlinear (L4)
5. Apply Genetic Algorithm and PSO technique in various types of engineering problems (L3)

UNIT – I:

Introduction and Classical Optimization Techniques:

Historical Development; Engineering applications of Optimization; – Formulating an Optimization problem – objective function – constraints and constraint surface - classification of Optimization problems.

Learning Outcomes: The students are able to

- Understand the optimization problem, without and with constraint design variables (L2)
- Analyze the various optimization problems (L4)

UNIT – II:

Classical Optimization Techniques

Single and multivariable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints. Solution by method of Lagrange multipliers – multivariable Optimization with inequality constraints – Kuhn Tucker conditions. Numerical Problems.

Learning Outcomes: The students are able to

- Understand the classical optimization techniques to minimize or maximize objective function, without or with constraints (L2)
- Apply Lagrange multipliers & Kuhn – Tucker conditions for solving multivariable Optimization with inequality constraints (L3)

UNIT – III:

Linear Programming

Standard form of a linear programming problem – geometry of linear programming problems– definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – motivation to the simplex method – simplex algorithm - Duality in Linear Programming – Dual Simplex method. Applications

Learning Outcomes: The students are able to

- Solve the linear simultaneous equations (L3)
- Apply linear programming for Simplex method, dual Simplex method (L3)

UNIT – IV:

Nonlinear Programming:

Unconstrained cases - One dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method - Univariate method. Constrained cases - Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods, Introduction to convex Programming Problem.

Learning Outcomes: The students are able to

- Explain various non-linear programming techniques for unconstrained & constrained cases (L2)
- Analyze the exterior and interior penalty functions for various optimization problems (L4)

UNIT – V:

Introduction to Evolutionary Methods:

Evolutionary programming methods - Introduction to Genetic Algorithms (GA)– Control parameters –Number of generation, population size, selection, reproduction, crossover and mutation – Operator selection criteria – Simple mapping of objective function to fitness function – constraints – Genetic algorithm steps – Stopping criteria –Simple examples. Basic Partial Swarm Optimization – Characteristic features of PSO procedure of the global version – Parameters of PSO – Comparison with other evolutionary techniques – Engineering applications of evolutionary methods.

Learning Outcomes: The students are able to

- Understand the Evolutionary Programming Methods to find solutions for complex problems (L2)
- Choose the parameters in the use of Evolutionary Computation (L1)

- Apply partial swarm optimization and genetic algorithm method to solve the various real time problems (L3)

Text Books

1. "Engineering optimization: Theory and practice"-by S. S. Rao, New Age International (P) Limited, 3rd edition, 1998.
2. Soft Computing with Matlab Programming by N. P. Padhy& S. P. Simson, Oxford University
3. Press – 2015

Reference Books:

1. "Optimization methods in operations Research and Systems Analysis" by K. V. Mital and C. Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.
2. Genetic Algorithms in search, optimization, and Machine Learning by David Goldberg, ISBN:978-81-7758-829-3, Pearson by Dorling Kindersley (India) Pvt. Ltd.
3. "Operations Research: An Introduction" by H. A. Taha, PHI pvt. Ltd., 6 edition.
4. Linear Programming by G. Hadley, Addison Wesley, 1962.

Course Code	Course Title	L	P	Credits
EE-PSCA1206.2	Green Energy	3	0	3

Course objectives:

- Understand the link between energy, environment and sustainable development
- Familiarize with energy ecosystems and its impact on environment
- Classify energy conversion system in solar and wind energy systems.
- Learn basics of various types of renewable and clean energy technologies
- Explain about Hydropower, Nuclear fission and fusion-Geothermal energy (L2)

Course Outcome: After completion of the course, the student will be able to:

1. Understand the relationship between energy, environment and sustainable development (L2).
2. To know about energy ecosystems and its impact on environment (L2)
3. Classify energy conversion system in solar and wind energy systems (L4).
4. Learn basics of various types of ocean and bio-energy technologies(L2)
5. Understand about Hydropower, Nuclear fission and fusion-Geothermal energy (L2)

Unit I:

Energy Sources:

Introduction to the nexus between energy, environment and sustainable development, Energy sources over view and classification, sun as the source of energy, fossil fuel reserves and resources - overview of global/ India's energy scenario. Energy consumption models – Specific Energy Consumption

Learning Outcomes:

- Understand about different sources of energy (L2).
- Know about global/India's energy scenario (L2).

Unit II:

Ecology and Environment

Concept and theories of ecosystems, - energy flow in major man-made ecosystems-agricultural, industrial and urban ecosystems - sources of pollution from energy technologies and its impact on atmosphere - air, water, soil, and environment - environmental laws on pollution control, The environmental protection act :Effluent standards and ambient air quality, innovation and sustainability, eco-restoration: phyto-remediation.

Learning Outcomes:

- Familiarize with the ecology and environmental concepts (L2).
- To know about environmental protection act. (L2)

Unit III: Solar and Wind Energy

Solar Energy: Solar radiation: measurements and prediction. Indian's solar energy potential and challenges, solar energy conversion principles and technologies: Photosynthesis, Photovoltaic conversion and Photo thermal energy conversion.

Wind Energy: Atmospheric circulations, atmospheric boundary layers, classification, factors influencing wind, wind shear, turbulence, wind energy basics and power Content, wind speed monitoring, Betz limit, wind energy conversion system: classification, characteristics and applications.

Learning Outcomes:

- Understand the basic principles of solar energy conversion (L2).
- Classify the wind energy conversion systems. (L4)

Unit IV:

Ocean and Bio-Energy

Ocean Energy: Ocean energy resources-ocean energy conversion principles and technologies: ocean thermal, ocean wave & ocean tide

Bio-energy: Biomass as energy resources; bio-energy potential and challenges, Classification and estimation of biomass; Source and characteristics of biofuels: Biodiesel, Bioethanol, Biogas. Types of biomass energy conversion systems - waste to energy conversion technologies.

Learning Outcomes:

- Understand the ocean energy conversion principles and technologies(L2).
- To know about bio-energy potential and challenges (L2).

Unit V:

Other Energy Sources and Systems

Hydropower, Nuclear fission and fusion-Geothermal energy: Origin, types of geothermal energy sites, site selection, geothermal power plants; hydrogen energy, Magneto-hydro-dynamic (MHD) energy conversion – Radioisotope Thermoelectric Generator (RTG), Bio-solar cells, battery & super capacitor, energy transmission and conversions.

Learning Outcomes:

- Understand about geothermal power plants (L2).
- Understand about MHD energy conversion (L2)

Textbooks:

1. Energy and Environment Set: Mathematics of Decision Making, Loulou, Richard; Waaub, Jean- Philippe; Zaccour, Georges (Eds.), 2005.
2. Energy and the Challenge of Sustainability, World Energy assessment, UNDP, N York, 2000.
3. Solar Energy: principles of Thermal Collection and Storage, S.P. Sukhatme, Tata McGraw-Hill (1984).
4. Geothermal Energy: From Theoretical Models to Exploration and Development by Ingrid Sober and Kurt Bucher, Springer, 2013.
5. Ocean Energy: Tide and Tidal Power by R. H. Charlier and Charles W. Finkl, Springer 2010

Reference Books:

1. Energy and the Environment, Ristinen, Robert A. Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A., 2nd Edition, John Wiley, 2006,
2. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.
3. Wind Energy Conversion Systems, L.L. Freris, Prentice Hal 1990.

Course Code	Course Title	L	P	Credits
EE-PSCA1206.3	Artificial Intelligence Techniques	3	0	3

Course Objectives:

- To understand the fundamental theory and concepts of neural networks, neuro-modeling, several neural network paradigms and its applications.
- To understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic control and other machine intelligence applications of fuzzy logic.
- To understand the basics of an evolutionary computing paradigm known as genetic-algorithms and its application to engineering optimization problems.

Course Outcome: After learning the course, the students able to:

1. Understand how the soft computing techniques can be used for solving the problems of power systems operation and control. (L3)
2. Design of ANN based systems for function approximation used in load forecasting. (L3)
3. Design of Fuzzy based systems for load frequency control in power systems (L3)
4. Solve problem of Optimization in power systems. (L3)
5. Apply GA to power system optimization problems (L3)

UNIT-I: Introduction

Introduction, definition of AI, difference between soft computing Techniques and hard computing systems, expert systems brief history of ANN, Fuzzy and GA.

Learning Outcomes:

- Understanding soft computing techniques and hard computing systems, expert systems(l2)
- Learn the brief history of ANN, Fuzzy and GA (L2)

UNIT-II: Artificial Neural Networks

Introduction, History of neural network research, Basic concepts of Neural Networks, Human brain, Model of Artificial Neuron, Neural Network architectures, Single layer feed forward Network, Multilayer feed forward network, recurrent networks, and characteristics of NN. Learning Methods Perceptron, ADALINE MADALINE Networks. Architecture of Back propagation Network, Nonlinear activation operators, single and multilayer ANN, learning methods like Back propagation, LM etc. training and testing of ANN.

Learning Outcomes:

- Design of ANN based systems for function approximation used in load forecasting(L3)
- Understanding of Algorithmic based methods and knowledge-based methods(L2)

UNIT-III: Fuzzy Logic

Introduction, Comparison between Fuzzy and crisp logic, Fuzzy sets, Membership function,

Basic fuzzy set operations, properties of Fuzzy set, fuzzy relations, Fuzzy interference system, Mamdani, Sugeno, Fuzzy rule-based system, defuzzification methods.

Learning Outcomes:

- Understand the concept of fuzziness involved in various systems and fuzzy set theory(L2)
- Comprehend the fuzzy logic control and adaptive fuzzy logic to design electrical systems(L3)

UNIT-IV: Genetic Algorithm

Working principles, difference between GA and traditional methods, Different types of coding methods, fitness function, different types of GA operators 1. Roulette wheel selection 2. Stochastic remainder Roulette wheel selection, Rank selection, Tournament selection and stochastic universal sampling, different types of cross over methods in GA, Mutation, Schema theorem, elite preserving operator, GA's for constrained optimization, understating of working of GA using flow chart.

Learning Outcomes:

- Understanding various types of coding methods, fitness function, different types of GA operators(L2)
- Apply GA to power system optimization problems(L3)

UNIT-V: Applications

Applications of ANN, Fuzzy logic and GA in power systems operation and control for solving problems of load forecasting, voltage control, voltage stability, security assessment, feeder load balancing, AGC, Economic load dispatch, Unit commitment, Condition monitoring, Optimal Power Flow, Optimal Reactive Power Dispatch, Available Transfer Capability.

Learning Outcomes:

- Analyze the application of fuzzy logic control to power systems(L4)
- Analyze the application of ANN to power systems(L4)

Text Books:

1. Neural Networks, Fuzzy logic and Genetic algorithms By S. Rajasekaran, G. A. VijayalakshmiPai PHI publication,
2. Optimization for Engineering Design by Kalyanmoy Deb PHI publication
3. Multi-objective Optimization using Evolutionary Algorithms By Kalyanmoy Deb Willey Publication
4. Artificial intelligence techniques in power systems by KEVIN WARWICK, ARTHUR EKWUE RAJ AGRAWAL

Course Code	Course Title	L	P	Credits
EE-PSCA1207	Power Systems Laboratory	0	4	2

Course Objectives: The objectives of the course are to make the students learn about

- Acquire knowledge o n sequence impedance of Alternator andTransformer.
- Understand of transmission line parameters and Ferranti Effect.
- Determine the Parameters of Three winding transformer.
- Design and simulation for power angle characteristics ofa salient pole synchronous machine.
- Access the performance of transmission line without and with shunt compensation.

Course Outcomes: After completion of this course the students will be able to:

1. Determine the sequence impedance of Alternator and Transformer.(L5)
2. Determine the transmission line parameters ,voltage regulation of transmission lineswithout and with shunt regulation and study the Ferranti effect.(L5)
3. Perform the experiment on 3-winding transformer and calculate the parameters of Transformer.(L4)
4. Design and simulation of the power angle characteristics of a salient pole Synchronous Machine.(L6)
5. Perform the experiment on 3-single phase Transformer and measure the phase displacement (L4).

List of Experiments

1. Determination of Sequence Impendence of an Alternator by direct method.
2. Measurement of sequence impedance of a Three Phase Transformer by application of Sequence Voltage using Fault Analysis.
3. Power angle characteristics of a salient pole Synchronous Machine.
4. Poly-phase connection on three single phase Transformers and measurement of phasedisplacement.
5. Determination of equivalent circuit of 3-winding Transformer.
6. Measurement of ABCD parameters on Transmission Line model.
7. Performance of long transmission line without compensation.
8. Study of Ferranti effect in long transmission line.
9. Performance of long transmission line with shunt compensation.
10. Short circuit analysis for L-G and L-L fault using MATLAB

II Year -I Semester Syllabus

Course Code	Course Title	L	P	Credits
AC-ERPW2101	Audit Course 1: English For Research Paper Writing	3	0	0

Course Objectives:

- Study on how to improve your writing skills and level of readability.
- Study about what to write in each section
- Study the skills needed when writing a Title

Course Outcomes: After completion of this course the students will be able to:

1. Understand that how to improve your writing skills and level of readability (L2).
2. Learn about what to write in each section (L2).
3. Learn about how to do Literature survey (L2).
4. Learn about how to do Abstract(L2).
5. Understand the skills needed when writing a manuscript and article (L2).

UNIT-I

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT-II

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

UNIT-III

Review of the Literature, Methods, Results, Discussion, Conclusions, the Final Check.

UNIT-IV

Key skills are needed when writing a Title; key skills are needed when writing an abstract, key skill are needed when writing an Introduction, skills needed when writing a Review of the Literature.

UNIT-V

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions, useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Reference Books

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)

2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM.Highman'sbook.
4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London,2011.

Course Code	Course Title	L	P	Credits
AC-ERPW2102	Audit Course 2**:** Stress Management	3	0	0

COURSE OBJECTIVES:

- To enhance of Physical strength and flexibility.
- To learn to relax and focus.
- To relieve physical and mental tension
- To improve work performance/ efficiency.
- To gain knowledge about yoga and meditation

COURSE OUTCOMES: After completion of this course the students will be able to:

1. Identify different types of stresses and their consequence (L3)
2. Explain time Management Techniques (L2)
3. Identify Career Plateau and Importance of Sabbaticals (L3)
4. Understand the Crisis Management and its Controlling (L2)
5. Understand about yoga and meditation (L2)

Unit-I

Understanding Stress: Meaning – Symptoms – Work Related Stress – Individual Stress – Reducing Stress -sources of stress –consequence of stress-burnout-symptoms of Burnout-stress verses Burnout-model of stress-strategies for coping stress (individual and organizational strategies) –case study

Unit-II

Time Management: Techniques – Importance of Planning the day –developing concentration – Prioritizing Beginning at the start – Techniques for conquering procrastination – Sensible delegation – Taking the right breaks – Learning to say "No"

Unit-III

Career Plateau: Career plateau – Identifying Career plateaus – Structural and Content - Plateauing – Making a fresh start – Importance of Sabbaticals – Counselling out – Executive leasing – Sustaining a marketable Career.

Unit-IV

Crisis Management: Implications – People issues – Structure issues – Environmental issues – Learning to keep calm - Preventing interruptions – Controlling crisis – Pushing new ideas – Empowerment – Work place Humor, developing a sense of Humor – Learning to laugh – role of group cohesion and team spirit.

Unit-V

Self-Development: Improving personality – Leading with Integrity – Enhancing Creativity – Effective decision making – Sensible Communication – The Listening Game – Managing Self – Mediation for peace – Yoga for Life

TEXT BOOKS

1. The Executive Track: An Action Plan for Self-Development, R.L Bhatia, Wheeler Publishing, New Delhi.
2. Human Values for Manager, Charavathy.S.K, McGraw Hill/Henely Management Series.

REFERENCES

1. Managing Stress, Jeffr Davison, Prentice Hall of India, New Delhi.
2. Comprehensive Stress Management, Jerrold S Greenberg, Jain Books, 2009.