Nagar Yuwak Shikshan Sanstha's

Yeshwantrao Chavan College of Engineering

(An Autonomous Institution affiliated to Rashtrasant Tukadoji Maharaj Nagpur University)

(Accredited 'A++' Grade by NAAC with a score of 3.6)

Hingna Road, Wanadongri, Nagpur - 441 110

Master of Technology

SoE & Syllabus 2025

(Department of Electrical Engineering)

M.Tech in Integrated Power System (IPS)

Nagar Yuwak Shikshan Sanstha's
Yeshwantrao Chavan College of Engineering
(An Autonomous Institution affiliated to Rashtrasant Tukadoji Maharaj Nagpur University)
M.TECH. SCHEME OF EXAMINATION 2025
Department of Electrical Engineering

SoE No.
25IPS101

M.Tech in Integrated Power Systems

Sl. No.	Sem	Course Code	Course Title	T/P	Contact Hours				Credits	% Weightage		ESE Duration
					L	T	P	Hrs.		TA	ESE	
			I SEMESTER									
1	1	25IPS101	Advanced Power Electronics	T	3	0	0	3	3	20	80	3
2	1	25IPS102	**Lab :** Advance Power Electronics	P	0	0	2	2	1	60	40	
3	1	25IPS103	Analog & Digital Protection	T	3	0	0	3	3	20	80	3
4	1	25IPS104	**Lab :** Analog & Digital Protection	P	0	0	2	2	1	60	40	
5	1	25IPS105	Digital Control System	T	3	0	0	3	3	20	80	3
6	1	25IPS106	HVDC Power Transmission	T	3	0	0	3	3	20	80	3
7	1	25IPS107	Power System Modelling	T	3	0	0	3	3	20	80	3
8	1		**Professional Elective- I**	**T**	3	0	0	3	3	20	80	3
				Total	**18**	**0**	**4**	**22**	**20**			
List of Professional Electives-I												
1	1	25IPS111	**PE-I :** Electrical Drives and Controls									
2	1	25IPS112	**PE-I :** Renewable Energy System									
			II SEMESTER									
1	2	25IPS201	Power System Planning	T	3	0	0	3	3	20	80	3
2	2	25IPS202	Application of Power Electronics to Power System	T	3	0	0	3	3	20	80	3
3	2	25IPS203	Power Quality	T	3	0	0	3	3	20	80	3
4	2	25IPS204	**Lab :** Power System Simulation	L	0	0	2	2	1	60	40	
5	2	25IPS205	**Lab :** Power System Design	L	0	0	2	2	1	60	40	
6	2		**Professional Elective-II**	T	3	0	0	3	3	20	80	3
7	2		**Professional Elective-III**	T	3	0	0	3	3	20	80	3
8	2		**Professional Elective-IV**	T	3	0	0	3	3	20	80	3
				TOTAL	**18**	**0**	**4**	**22**	**20**			
List of Professional Electives-II												
1	2	25IPS211	PE II: Advanced Digital Signal Processing									
2	2	25IPS212	PE II: EHV Power Transmission									
3	2	25IPS213	PE II: Restructuring of Power System									
4	2	25IPS214	PE II: Wide Area Monitoring and Control									
5	2	25IPS215	PE II: Microgrid									
List of Professional Electives-III												
1	2	25IPS231	Power System Stability									
2	2	25IPS232	Electrical Distribution Systems									
3	2	25IPS233	Power System Operation and Control									
4	2	25IPS234	Transients in Power Systems									
5	2	25IPS235	Solar System Design									
List of Professional Elective- IV												
1	2	25IPS241	Distribtuted Automation									
2	2	25IPS242	Power Electronics for Renewable Energy Systems									
3	2	25IPS243	Control System Design									
			III SEMESTER									
1	3	25IPS301	Project Phase -I	P	0	0	20	20	10	100		
					0	**0**	**20**	**20**	**10**			
			IV SEMESTER									
1	4	25IPS401	Project Phase-II	P	0	0	36	36	18	60	40	
					0	**0**	**36**	**36**	**18**			
			GRAND TOTAL		**36**	**0**	**64**	**100**	**68**			

Chairperson	Dean (Acad. Matters)	Date of Release	Version	
		June, 2025	1.00	Applicable for AY 2025-26 Onwards

I Semester
25IPS101 – Advanced Power Electronics

Evaluation Scheme	MSEs *	TA**	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
1. To impart the knowledge of recent and advanced developments in the PE field. 2. To ensure the students having an in-depth understanding of the design and control of various converters	1. Apply knowledge of the power semiconductor devices, to select them for a range of applications. 2. Demonstrate and analyze techniques to design and assess the performance of thyristor-based converters, as well as, switch-mode DC/DC power electronic converters, resonant and DC/AC inverters. 3. Assess power quality specially, power factor and harmonic issues of various power electronic converters/inverters. 4. Analyze different modulation techniques for bridge as well as multilevel inverters. 5. Design, simulate, and test various converter/inverter circuits in the laboratory.(Lab component)

Unit	Syllabus
Unit-I	**Semiconductor Power Devices** Conventional semiconductor power devices:-Thyristor, Gate Turn Off thyristor(GTO),Metal Oxide Field Effect Transitor(MOSFET),Insulted Gate Bipolar Transistor(IGBT). Advanced semiconductor devices: MOS Turn Of Thyristor(MTO), Emitter Turn of Thyristor(ETO), Integrated Gate Commuted Thyristor(IGCT), MOS Controlled Thyristor(MCT), Static Induction Thyristor(SITH) - symbol, structure and equivalent circuit- comparison of their features. Significance of wide band gap materials (especially SiC and GaN).
Unit-II	**AC/DC Controlled Rectifier** Single phase half controlled and full controlled converters continuous and discontinuous mode, Three phase controlled rectifier continuous mode, Single phase series converter, single and three phase dual converters, Effect of source inductance, Evaluation of input power factor and harmonic factor.

Unit-III	**Non isolated DC/DC Converters** Principle of operation and analysis of buck, boost, buck-boost, Cuk and Single Ended Primary Inductance Converter (SEPIC) regulators in discontinuous and Continuous (DCM/CCM) mode, Input and output filter design.	**[8hrs]**
Unit-IV	**Isolated DC/DC converters** Introduction, transformer models, principle of operation and analysis of Flyback, Forward, double ended (Two Switch) forward, Push-Pull, half- bridge and full Bridge converters. Continuous and discontinuous mode operation and design consideration.	**[8hrs]**
Unit-V	**Multilevel Inverters** Single phase half and full bridge Voltage source Inverter(VSI),Three Phase Inverter, Evaluation of performance parameters. Multilevel inverter topologies- Neutral Point clamped (NPC), Flying capacitor (FC), Symmetrical and asymmetrical Cascaded Inverters etc., Other advanced inverters such as Multi-pulse, matrix inverter, Modulation techniques: Pulse Width Modulation (PWM), SHE, SHE PWM, Hysteresis, Space Vector modulation techniques for above inverters, Introduction to Current Source Inverter (CSI)	**[8hrs]**
Unit-VI	**Soft switching Converters** Resonant Converters- Classification of resonant converters, Basic resonant circuit concepts, Series parallel resonant converters, Zero voltage switching (ZVS) and Zero Current (ZCS) switching converters, steady state and dynamic analysis, modeling and control	**[7hrs]**

Textbooks:

1	Power Electronics Circuits Devices application	2004	M.H. Rashid	PHI third edition First Indian edition
2	Power Electronics: Converters, Application and Design	1996	Ned Mohan, Undeland and Robbin	John Wiley & Sons Third edition

Reference books:

1	Pulse width modulated DC-DC power converters	1993	Marian K Kazimierczuk	John Willey & Sons
2	High power converter and ac drives	2006	Bin Wu	Wiley-IEEE Press
3	Power electronics- principles and applications	1995	Joseph Vithayathil	McGraw hill Inc, New York
4	IEEE/IET publications		Various authors	On Internet site www.ieeexplore.ieee.org

I Semester
25IPS102 – Lab.: Advanced Power Electronics

Evaluation Scheme	TA	ESE	Total	ESE Duration
	60	40	100	---

Objective:

To develop experimental and analysis skill.
To develop intuition and deepen understanding of concepts.
To exercise curiosity and creativity by designing a procedure to test a hypothesis.

List of Experiment

1. Design, analysis and simulation of fully controlled converter for continuous and discontinuous load current in controlled converters(single phase, six pulse fully twelve pulse-controlled or series-controlled converters.)
2. Performance analysis of non-isolated DC -DC converters such as buck, boost or buck- boost converters.
3. Investigation in performance of isolated DC -DC converters (Flyback, Forward or Push -Pull topology).
4. Examine the performance of single-phase step inverter.
5. Study, analysis and design of multilevel inverter topology such as NPC, FC or CHB topology with different modulation techniques.

I Semester
25IPS103 – Analog & Digital Protection

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
The course will prepare students to understand, 1. Traditional operating principle, design and planning of the protective system in a power system. 2. Protection scheme for low voltage and high voltage lines. 3. The modern numerical relaying basics and its related algorithms.	1) Explain & design protection scheme for Relay Coordination 2) Develop, Compare & Solve the problems of over current and distance protection 3) Explain and define the basics terms of Digital Protection 4) Compare and solve the different methods and techniques of digital protection 5) Explain and justify the recent advances in digital protection

Unit	Syllabus
Unit-I	**EHV line Protection** Relay coordination using over current relay, Drawback of over current relay, Distance protection of three phase lines, carrier aided schemes. Stability of protection on power swing
Unit-II	**Transformer & Machine Protection** Various faults occurring on transformers, alternators & large motors & complete protection against these faults.
Unit-III	**Basic elements of Digital Protection** Evolution of digital relays from electromechanical relays , Performance & operational characteristics of digital protection, Basic elements of digital protection, Signal conditioning, transducers, surge protection, analog filtering, analog multiplexer **Conversion system-** Sampling theorem, signal aliasing error, sample & hold circuit, multiplexer, analog to digital conversion, digital relay as a unit . Digital filtering system- Low pass, High pass, FIR & IIR Filters.
Unit-IV	**Algorithms-I** Sinusoidal wave based algorithm, first & second derivative method, two sample & three sample technique

Unit-V	**Algorithms-II** Fourier analysis & Fourier transform based algorithm. Walsh function based algorithm, Differential equation based technique.
Unit-VI	**Algorithm-III** Incident & reflected wave, coefficient of reflection, superimposed quantities & their properties & polarity versus fault location, reverse & forward faults, elliptical trajectory, Bergeron's equation, discriminant function for single phase lines. Recent advances Synchrophasors & Wavelet analysis

Text books:			
1 Fundamentals of Power System Protection	2005	Y.G.Paithankar & S.R.Bhide	Prentice Hall of India
2 Protection and Switchgear	2011	Bhalja, Maheshwari & Chothani	Oxford Higher Education
3 Digital Protection for power system		A.T.Johns & S.K.Salman	Peter Peregrinus Ltd.

Reference books:		
1 Transmission Network Protection	Y.G.Paithankar	Marcel Dekker Pub
2 Power System Protection (Static Relays)	T.S. MadhavaRao	Tata McGraw-Hill,
3 English Electric Relay Application Guide		
4 IEEE/IEE Publications		

I Semester

25IPS104 – Lab. : Analog & Digital Protection

Objective: To enable students to design different protection schemes including digital relaying algorithms

1. Design characteristic of ICM 21N (ABB) make IDMT over current relay.
2. Develop operating region for directional relay (CDD-26).
3. Develop operating region for Reactance relay (XCG-22).
4. Design characteristic of impedance relay (RAKZB).
5. To study of various characteristics of Numerical relay L & T make MC 61C.
6. Design relay co-ordination using SKM Power tool software.
7. Develop a biased differential protection scheme.
8. Design of radial feeder protection scheme.
9. To calculate peak value by full cycle window (Fourier Analysis)
10. Analytical Analysis by sample and derivative method
11. Analytical Analysis of first and second derivative method
12. Analytical Analysis by two sample method
13. Analytical Analysis by three sample method
14. To calculate peak values by Walsh coefficient

I Semester

25IPS105 – Digital Control System

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
• This course in Electrical Engineering introduces the fundamental concepts of Digital Control Systems and its mathematical modelling, stability. • Concept of state feedback and PID tuning. These concepts are essential for implementation of controllers in digital processors.	CO1: Explain the basics of discrete time signals. CO2: Apply Z transforms method for discrete systems and analyse the stability of digital control system. CO3: Evaluate using the preliminary concept of state variable analysis of discrete time control systems the parameters of pole placement and design through state feedback. CO4: Design the PID parameters through tuning and making use of optimal control for design.

Unit	Syllabus
Unit-I	**Introduction** Revive of state variable analysis, types of sampling operations, Sample and Hold operations, Sampling theorem, Basic discrete time signals, Discretisation of continuous time system.
Unit-II	**Analysis of Digital Control Systems and Stability Methods** Z-Transforms, Properties of Z-Transform, Inverse Z-Transforms, Pulse Transfer Function, Difference equations, Z-Transform method for solving the difference equations, Block diagram and signal flow graph analysis, Time response of digital control systems. Mapping between s-plane and z-plane, stability methods: Modified Routh's Criterion, Jury's method, Lyapunov stability analysis.
Unit-III	**Models of Control Systems** Problem of pole placement, effect of addition of poles & zeros to open loop transfer function, design of Digital compensator using root locus plots.
Unit-IV	**State Variable analysis of Digital Control Systems** State variable description of digital control systems, conversion of state variable models to transfer function and vice versa, solution of state difference equations, controllability and observability, design of state feedback and state estimation

Unit-V	**PID control** Conventional tuning methods such as Ziegler Nichols methods, Refined zeigler Nichols method etc., Introduction to optimization methods for tuning of PID controller; Particle swarm optimization (PSO), Genetic Algorithms (GA) etc.
Unit-VI	**Optimal and Robust control system design** Review of optimal control, Linear Quadratic Regulators (LQR), LQR tracking problem, H2-optimal control, H∞-optimal control, Introduction to multivariable robust controls.

Text books:

1.	Digital Control and State Variable Methods	M. Gopal	Tata Mc-Graw-Hill
2.	Discrete Time Control Systems	K.Ogata	Pearson Education, (Singapore) (Thomson Press India).
3.	Digital Control Systems	B.C Kuo	Prentice Hall
4.	Optimal control: Linear Quadratic Methods	B.D.O. Anderson	Dover publications
5.	Robust control design & optimal control Approach	Senglin	John Wiley & sons

Reference books:

1	Control System Engg	I.J. Nagrath&M.Gopal	John Wiley & sons
2	Control System Analysis and Design	K.K. Aggarwal	Khanna Publishers
3	Optimal Control	BDO Andersom, Moore	Dover Publications

I Semester
25IPS106 – HVDC Power Transmission

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
• To learn the principles of conventional High Voltage Direct Current Transmission and modern trends in it. • To learn Multiterminal HVDC systems are also studied. • To learn Voltage source converter technology is introduced.	1) Recall the principles, advantages and applications of a HVDC link. 2) Explain the operation of converters in a classical HVDC link and modern VSC HVDC technology. 3) Model valve and converter for simulation. 4) List various methods of control and protection, various faults, stability aspects relevant to HVDC system.

Unit	Syllabus
Unit-I	**Introduction to HVDC** Development of HVDC technology comparison between HVAC and HVDC, Applications of HVDC transmission, Type of DC transmission, Selection of converter configuration.
Unit-II	**Rectifier and inverter** Rectifier and inverter operation of Line commutated converters, Analysis of rectifier with two-valve condition, Analysis of rectifier with two- three valve conduction, Analysis of inverter with two valve conduction, Analysis of inverter with two-three valve conduction. Introduction to HVDC with Voltage Source Converters(VSC)
Unit-III	**Digital simulation** Digital simulation of converters, Generalized equation for simulation of converters, Derivation of converter equations with Two valve conduction, Three valve conduction.
Unit-IV	**Control of HVDC converters and system** Requirements of control system for HVDC converter, Rectifier compounding, Inverter compounding, Converter control characteristics, Converter firing schemes: Individual phase control (IPC) , Equidistant pulse control (EPC), Draw backs of individual phase control, Draw backs of EPC, Higher level controls, power controllers, Characteristics & non characteristics harmonics, Different methods to overcome problem of non-characteristics Harmonics.,Filters.Starting and stopping of DC links.

Unit-V	**Multiterminal HVDC system** Fault development and protection, Inter action between AC-DC power system, Over-voltage on AC/DC side Multi- terminal HVDC system, Control of MTDC system,
Unit-VI	**Modeling of HVDC system** Per unit system representation for power flow solution, Representation for stability studies. Effect of HVDC Link on Stability. Faults and Protection of HVDC Systems. HVDC circuit breaker

Text books:

1	High voltage direct current transmission		J. Arrillaga	Peter Peregrinus ltd. London, U.K.
2	Direct Current Transmission (Vol.I)	1971	E. W. Kimbark	Wiley Interscience
3	HVDC power Transmission Systems	1990	K. R. Padiyar	Wiley Eastern Ltd.

Reference Books :

1	High voltage direct current transmission	2011	S.Kamakshaih &V.Kamaraju	Tata McGraw Hill

I Semester
25IPS107 – Power System Modelling

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
• To understand the concept of modeling for generators and transmission lines. • To understand the demand side modeling concept or load modeling. • To understand the modeling of the excitation system used for thermal power generators for controlling the generated power.	1. Understand the general construction and relationship between the various fluxes of various electrical machines and its impact on induced emf during the small and transient disturbances. 2. Analyze the electrical machines in stationary and rotary frames of reference per unit for stability analysis. 3. Evaluate the electrical machine parameters for various power system components under static and dynamic load conditions. 5) Create mathematical models for stationary and rotating machines under steady state and transient conditions.

Unit	Syllabus
Unit-I	**General Background** Evolution of electric power system, structure of power system, power system control, design and operating criteria for stability. **Stability:** Basic Concepts & definition, rotor angle stability, voltage stability & Voltage collapse, mid-term & long term stability, Classification of Stability.
Unit-II	**Synchronous Machine Modeling I** Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, physical interpretation of dq0 transformation.
Unit-III	**Synchronous Machine Modeling II** Per Unit Representations: The Park's transformation, power-invariant form of Park's transformation; Equivalent Circuits for direct and quadrature axes, Steady state Analysis: Voltage, current and flux-linkage relationships, Phasor representation, Rotor angle, Steady-state equivalent circuit, Computation of steady-state values.

Unit-IV	**Excitation and prime-mover controllers** Excitation system, excitation system modeling, excitation system –standard block diagram, system representation by state equations, prime mover control system, examples.
Unit-V	**Transformer modeling & the per unit system** Introduction, single phase transformer model , three phase transformer connection , per phase analysis, p.u. normalization, p.u. three phase quantities, p.u. analysis of normal system , regulating transformer for voltage & phase angle control.
Unit-VI	**Load modeling** Basic load- modeling concept, static load models, dynamic load model, modeling of I.M., acquisition of load model parameters. **Transmission line Modeling** Introduction, derivation of terminal V,I relations, waves on transmission lines, transmission matrix, lumped circuit equivalent, simplified models, complex power transmission (short line,medium & long line, Radial line).

Text books:

1	Power System Stability and Control	1993	P. Kundur	McGraw-Hill
2	Power System Analysis	2nd Edition 1999	Arthur Bergen and Vijay Vittal	Pearson Publication

Reference books:

1	Dynamic Models for Steam and Hydro Turbines in Power System Studies			IEEE Committee Report
2	Power System Control and Stability	1978	P.M Anderson and A.A Fouad	Iowa State University Press, Ames, Iowa

I Semester
25IPS111 – PE I: Electrical Drives and Controls

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
• To understand the mathematical modeling of drives with latest technology. • To understand Vector control, space vector modulation control of induction motor and synchronous motor. • To understand Adaptive control and introduction to fuzzy and neural control of drives	1. Explain the working of DC motor, Induction motor, synchronous motor, brushless DC motor and Switched reluctance motors 2. Describe the operation of DC motor, Induction motor, synchronous motor, brushless DC motor and Switched reluctance motors. 3. Choose suitable converters for DC motor, Induction motor, synchronous motor, brushless DC motor and Switched reluctance motors. 4. Analysis of DC motor, Induction motor, synchronous motor.

Unit	Syllabus
Unit-I	**Analysis of DC Motor:** State variable representation of separately excited DC motor and DC shunt motor, Converters for DC drives, Average value analysis of DC drive. Machine control with voltage controlled converter, Machine control with current controlled converter.
Unit-II	**Analysis of Induction Motor:** Reference frame theory, Balanced Set,Transformation of resistance and flux linkages, Theory of symmetrical Induction motor, voltage and torque equations in machine variables and their transformation to arbitrary reference frame, state vector representation of the equations, free acceleration characteristics.
Unit-III	**Induction motor control systems** Voltage Source Inverter Drive with PWM,Current Source Inverter Drive, Forced commutated inverter drive control of Induction motor, Flux Vector control of Induction motors, Direct torque control.
Unit-IV	**Synchronous motors Drives:** Synchronous machines equations in different reference frames, Synchronous motor drives with sinusoidal waveforms, True Synchronous mode and Self controlled mode Load commutated inverter drives Synchronous motor drive with trapezoidal waveforms(Brushless DC motor).,Vector Control of Synchronous motors, Switched reluctance motor and its control.

Unit-V	**Space vectors:** Stator space current, stator voltage space vector, stator flux linkage space vector, transformation of space vector coordinates from one reference frame to another. Space vector Modulation, Control of Induction motor by Space vector Modulation.
Unit-VI	**Digital Control of Drives** Adaptive control principles, Gain scheduling,Self tuning control, Model reference adaptive control, Sliding Mode control, Idea of Fuzzy and Neural Control. Necessity and Application of Digital signal processors to control AC/DC Drives. Basic Architecture of Texas Instruments TMS320LF2407 processor ,Programming methods Idea of Field Programmable Gate Arrays(FPGA) Technology.

Text books:

1	Analysis of Electric Machinery		Paul, C. Krause	McGraw Hill
2	Modern Power Electronics and AC Drives		B.K. Bose	Prentice Hall
3	Texas Instruments TMS320LF2407 processor Manual			
4	Variable frequency AC motor Drive system		David Finney	IEE Press
5	Control of Electrical Drives	1996	W. Leonhard	Springer Verlag
6	Electric Drive		VedamSubramanyam	Tata McGraw Hill

Reference books:

1	High-Power Converters and AC Drives	2006	Bin Wu	Wiley & IEEE Press
2	Power Electronics, Converters, Applications and Design	3rd Edition	Ned Mohan, T. M. Undeland W. P. Robbins	Media Enhanced
3	'Power Semiconductor Controlled Drives	1989	G.K. Dubey	Prentice Hall, N. Jersey
4	Electric Drives	2002	Krishnan	Prentice Hall of India

I Semester
25IPS112 – PE I: Renewable Energy System

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
To study the major renewable energy sources including solar, wind, Biomass for different applications.	1) Apply knowledge of renewable energy sources to various solar, wind and other systems 2) Demonstrate and analyze techniques to design and assess the performance of solar PV panels and solar based energy converters 3) Assess the output of renewable energy systems under different environmental conditions 4) Analyze the performance of different renewable energy sources like solar, wind, geothermal and hybrid sources

Unit	Syllabus
Unit-I	**Introduction to Energy Sources** World Energy Futures, Conventional Energy Sources, Renewable Energy Sources, Prospects of Renewable Energy Sources. Environmental aspects of Electrical Energy Generation.
Unit-II	**Solar Energy -** a) Introduction to Solar Radiation and its measurement, Introduction to Solar Energy Collectors and Storage. b) Applications of Solar Energy: Solar Thermal Electric Conversion, Thermal Electric Conversion Systems, Solar Electric power Generation Solar Photo- Voltaics, Solar Cell Principle, Semiconductor Junctions, Conversion efficiency and power output, Basic Photovoltaic System for Power Generation. Solar photovoltaic modules, maximum power point tracking and algorithms
Unit-III	**Wind Energy:** a) Introduction to wind energy Conversion, the nature of the wind, Power in the wind. b) Wind Energy Conversion: Wind data and energy estimation, Site Selection Considerations, Basic Components of a Wind Energy Conversion System, Classification of WEC Systems, Schemes for Electric Generation using Synchronous Generator and Induction Generator, Wind energy Storage.

Unit-IV	**Direct Energy Conversion Processes (Overview) :** a) Information on MagnetoHydroDynamic Power Generation: b) Thermo-Electric Generation: Basic principles of thermo-electric power generation, Seebeck, Peltier, Thomson effects, Thermo-Electric power generator, Analysis, materials. c) Thermionic Generation: Thermionic emission and work function, Basic thermionic generation. d) Fuel Cells H2O2Cell, Classification of fuel Cells, Types, Advantages, Electrodes, Polarization. e) Thermo Nuclear Fusion Energy: The basic Nuclear Function and Reactions Plasma Confinement, Thermo Nuclear function Reactions.
Unit-V	**Energy from Biomass:** a) Introduction: Biomass conversion technologies, photosynthesis, Biogas generation, types of biogas plants. b) Biomass as a Source of Energy: Method for obtaining energy from Biomass, Biological Conversion of Solar Energy.
Unit-VI	**Applications of Renewable energy** Wind Farms: Grid interfacing of wind farms, methods of grid connection, grid system and properties. Small hydro power, Hybrid systems: Wind- solar, wind photovoltaic etc

Text books:

1	Non-Conventional Sources of Energy	4th Edition, 2010	G.D. Rai	Khanna Publishers
2	Non Conventional Energy Sources	2nd Edition. 2009	B. H. Khan	The McGraw Companies Hill
3	Renewable energy sources and conversion technology	1990	N.K. Bansal, M. Kleemann, M. Heliss	Tata McGraw Hill

Reference books:

1	Direct Energy Conversion		R. A. Coombie	Pitman
2	Renewable energy sources and emerging technologies	1st Edition, 2008	D. P. Kothari	PHI
3	Related IEEE/IEE Publications			

II Semester
25IPS201– Power System planning

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
• To understand the load forecasting for the planning of power generation. • To do the generation planning considering reliability, environmental aspects. • How to design the optimal power availability • To know how to do security analysis and state estimation of Power Syste.	1) Illustrate various regulations by state and central government for energy generation and supply and apply them for planning integrated power systems. 2) Develop and examine the role of investors in a power plant portfolio for sustainable development 3) Interpret the load forecasting and recommend the generation, transmission, and distribution capacities for integrated power systems considering economical, reliable and optimal usage for sustainable development. 4) Predict the behavior of integrated power system for secure and reliable operation.

Unit	Syllabus
Unit-I	**Introduction** Introduction of power planning, National and Regional Planning, structure of P.S., planning tools, Electricity Regulation
Unit-II	**Load Forecasting & Generation Planning** Electrical Forecasting, forecasting techniques modeling. Generation planning, Integrated power generation cogeneration/captive power, Power pooling and power trading.
Unit-III	**Transmission planning and Power System Economics** Transmission and distribution planning, Power system Economics, Power sector finance, financial planning, private participation Rural Electrification investment, concept of Rational tariffs.
Unit-IV	**Reliability** Power supply Reliablity, Reliability planning, Reliability evaluation, Functional zones, Generation reliability, Generation & Transmission reliability, Quality of Supply.

Unit-V	**System Operation & Environmental Aspects in Planning** System operation planning, load management, load prediction, reactive power balance, online power flow studies, state estimation, computerized management, power system simulator. Computer aided planning, wheeling, Environmental effects, Greenhouse effect, Technological impacts, Insulation coordination, Reactive compensation.
Unit-VI	**Power System Security :** **Operation in Power System Security :-** Introduction, Factors affecting power system security, Contingency analysis, ac power flow security analysis, concentric relaxation, bounding area method. **State Estimation :-** Introduction, Method of least squares, Maximum likelihood weighted least square estimation, State estimation by orthogonal decomposition, Detection and identification of bad measurements, network observability and pseudo-measurements.

Text books:

1	Electrical Power System Planning		A.S.Pabla	Macmillan India Ltd.
2	Modern Power System Analysis	4th Edition	D.P. Kothari, I.J. Nagrath	Tata Mcgraw Hill Education Pvt. Ltd.
3	Electrical Power Systems – Analysis, Security and Deregulation	Third Printing	P.Venkatesh, B. V. Manikandan, S. Charles Raja, A. Srinivasan	PHI Learning Pvt. Ltd.

Reference books:

1	Power Generation, Operation & Control	2011	Allen J. Wood, B.F. Wollenberg	Wiley India, Reprint
2	Papers on planning published by referred journals.			

II Semester

25IPS202– Application of Power Electronics to Power System

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
1. To enable students to understand the problems faced by modern power utilities and how power electronic solutions can overcome these problems. 2. To provide understanding and enable students to design power electronics-based controllers that can control active and reactive power flow.	1. Demonstrate the knowledge of AC transmission constraints and decide the power electronics-based solutions. 2. Design and assess the performance of shunt and series thyristor-based controllers. 3. Interpret and compare the performance of various converter - based controllers 4. Analyze different control techniques for shunt/series/shunt-series and series-series controllers.

Unit	Syllabus
Unit-I	**Introduction to FACTS Controllers** Power flow in AC system, Transmission problems and needs. Overview of stability. The emergence of FACTS controllers and possible benefits of them.
Unit-II	**Static VAR Compensators (SVC)** Objectives of shunt compensation. Functional description and structures of Thyristor Controller Reactor (TCR), Thyristor Switched Capacitor (TSC), FC–TCR, Mechanically Switched Capacitor – TCR, TSC–TCR.Concepts of voltage control and applications
Unit-III	**Thyristor & GTO Based Series Compensators** Concept and objectives of series compensation. Operation, characteristics and controls of variable impedance type series compensators such as Thyristor-Switched Series Capacitor (TSSC), Thyristor-Controlled Series Capacitor (TCSC), & GTO Controlled Series Capacitor (GCSC).
Unit-IV	**Switching Converter type Shunt & Series Compensator** Structure, operation, & characteristics of Static Synchronous Compensator (STATCOM) and Static Synchronous Series Compensator (SSSC). Control schemes and applications. Comparative benefits over SVC and other series controllers.

Unit-V	**Static Voltage & Phase Angle Regulator** Purpose of voltage and phase angle compensation. Operation and structures of Thyristor Controlled Voltage and Phase Regulator TCVR & TCPAR. Fundamentals of converter-based voltage and angle regulators
Unit-VI	**Combined FACTS compensators and other special purpose FACTS Controllers** Objectives, need, and principle of operation of Unified Power flow Controller (UPFC), Interline power flow controller (IPFC). Comparative evaluation of UPFC with different controllers such as TSSC.TCSC, TCPAR & SSSC. NGHSSR damper. Thyristor Controlled Braking Resistor (TCBR).

Text books:

1	Thyristor – Based Facts Controllers for Electrical Transmission Systems	2002	R.MohanMathur, Rajiv K.Varma	IEEE press and John Wiley & Sons, Inc
2	Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems	1999	Narain G. Hingorani	Standard Publishers Distributors, Delhi
3	FACTS Controllers in Power Transmission and Distribution	2007	K.R.Padiyar	New Age International(P) Limited, Publishers, New Delhi

Reference books:

1	Flexible A.C. Transmission Systems	1999	A.T.John	Institution of Electrical and Electronic Engineers (IE1999EE)
2	HVDC and FACTS controllers – Applications of Static Converters in Power System	April 2004	V.K.Sood	Kluwer Academic Publishers

II Semester
25IPS203– Power Quality

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
• To understand the different power quality problems, its causes, effects and various mitigating custom power devices. • To analyze the different control strategies and algorithm.	1) Define, discuss and analyze the various power quality problem, their causes and effects in distribution system 2) Identify, discuss and analyze the different non-linear loads. 3) Define, explain, apply various measurements and transforms to analyze the power quality problems. 4) Describe, analyze and calculate the powers, harmonics indices and sequence components. 5) Explain, apply the various indices and develop load balancing algorithms. 6) Discuss, analyze, apply the various custom power devices, their reference generation algorithms and their applications.

Unit	Syllabus
Unit-I	**Introduction** Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.
Unit-II	**Non Linear Loads** Single phase / Three phase static converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.
Unit-III	**Measurement and Analysis Method** Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

Unit-IV	**Analysis and Conventional Mitigation Methods** Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices.
Unit-V	**Voltage Sag** Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.
Unit-VI	**Power Quality Improvement** Utility-Customer interface –Harmonic filters: passive,–Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC – control strategies: P-Q theory, Synchronous detection method – Custom power park – Status of application of custom power devices.

Text books:

1	Power Quality Enhancement Using Custom Power Devices	2002	ArindamGhosh	Kluwer Academic Publishers
2	Electric Power Quality	1994 (2nd edition)	G.T.Heydt	Stars in a Circle Publications
3	Power Quality		R.C. Duggan	Publisher

Reference books:

1	Power system harmonics	A.J. Arrillga
2	Power electronic converter harmonics	Derek A. Paice

II Semester
25IPS204 - Lab : Power System Simulation

II Semester

25IPS205 - Lab : Power System Design

II Semester
25IPS211– PE II: Advanced Digital Signal Processing

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Unit	Syllabus
Unit-I	**Introduction** Mathematical description of change of sampling rate – Interpolation and Decimation, Filter implementation for sampling rate conversion – direct form FIR structures, DTFT, FFT, Wavelet transform and filter bank implementation of wavelet expansion of signals
Unit-II	**Estimation Techniques** Discrete Random Processes – Ensemble averages, Stationary processes, Autocorrelation and Auto covariance matrices, Parseval's Theorem, Wiener-Khintchine Relation – Power Spectral Density, AR, MA, ARMA model based spectral estimation, Parameter Estimation.
Unit-III	**Prediction Techniques** Linear prediction – Forward and backward predictions, Least mean squared error criterion – Wiener filter for filtering and prediction, Discrete Kalman filter.
Unit-IV	**Digital Signal Processor** Basic Architecture – Computational building blocks, MAC, Bus Architecture and memory, Data Addressing, Parallelism and pipelining, Parallel I/O interface, Memory Interface, Interrupt, DMA.
Unit-V	**APPLICATION OF DSP** Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller, Application for Serial Interfacing, DSP based Power Meter, Position control.
Unit-VI	**VLSI IMPLEMENTATION** Basics on DSP system architecture design using VHDL programming, Mapping of DSP algorithm onto hardware, Realization of MAC & Filter structure.

Text books:

1	Adaptive Signal Processing	Third edition, 2004	Bernard Widrow, Samuel D. Stearns	Pearson Education
2	Statistical & Adaptive signal processing, spectral estimation, signal modeling, Adaptive filtering & Array processing	2000		McGraw-Hill International
3	Statistical Digital Signal Processing and Modelling		Monson H. Hayes	John Wiley and Sons, Inc

Reference books:				
1	Digital Signal Processing	2002	John G. Manolakis Proaks, Dimitris G.	Pearson Education
2	Digital Signal Processing		S. Salivahanan, A. Vallavaraj and C. Gnanapriya	TMH
3	Digital Signal Processing-Implementation using DSP Microprocessors with Examples from TMS320C54xx	**2004**	Avatar Sing, S. Srinivasan	Thomson India
4	DSP Integrated Circuits	1999	Lars Wanhammer	Academic press, New York
5	Digital Signal Processing: A Modern Introduction	2007	Ashok Ambardar	Thomson India 2007. edition,

II Semester

25IPS212– PE II: EHV Power Transmission

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
• To understand different configurations of EHV lines. • To impart knowledge regarding corona effect and elctrostatic field of EHV line	1) Explain mechanical consideration of transmission line and calculate line parameters. 2) Summarize voltage gradient on conductors. 3) Infer the losses due to corona and its radio interference field. 4) Analyze the effect of EHV line on humans, animals and plants.

Unit	Syllabus
Unit-I	**Introduction** Standard transmission voltages – different configurations of EHV and UHV lines – average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance
Unit-II	**Calculation of Line Parameters** Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation of sequence inductances and capacitances – line parameters for different modes of propagation – resistance and inductance of ground return, numerical example involving a typical 400/220kV line using line constant program.
Unit-III	**Voltage Gradients Of Conductors** Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on sub conductors of bundle - voltage gradients on conductors in the presence of ground wires on towers.
Unit-IV	**Corona Effects-I :** Power losses and audible losses: I^2R loss and corona loss - audible noise generation and characteristics - limits for audible noise - Day-Night equivalent noise level- radio interference.
Unit-V	**Corona Effects – II :-** Corona pulses (their generation and properties),Frequency spectrum,Properties of pulse trains and filter response ,Limits for radio interference fields ,the CIGRE formula,The RI excitation function,Procedure for obtaining excitation function from CIGRE Formula,Design of filter, television Interference.

Unit-VI	**Electrostatic Field of EHV Lines** Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants - measurement of electrostatic fields - electrostatic Induction in non energized circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference.

Text books:

1	Extra High Voltage AC Transmission Engineering	Second Edition, 1990	Rakosh Das Begamudre	New Age International Pvt. Ltd
2	Power Engineer's Handbook	6th Edition, Oct. 2002		TNEB Engineers' Association
3	Microtran Reference Manual www.microtran.com		Microtran Power System Analysis Corporation	

II Semester

25IPS213 – PE II: Restructuring of Power System

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	**Course Outcomes**
Students will be able to: 1) Understand Electricity Market and deregulation 2) Understand transmission sector reforms 3) Understand Indian power market and pricing	1. Discuss deregulation of electricity market and different models 2. Explain the transmission sector reforms in deregulated market 3. Examine the electricity pricing and forecasting 4. Illustrate Electricity Act 2003 and its implementation

Unit	**Syllabus**
Unit-I	**Overview** Introduction to power system deregulation, reform motivations, understanding restructuring process, electricity as commodity, entities involved in deregulation, traditional model, separation of ownership, competition and direct access in the electricity market, role of ISO and international experiences
Unit-II	**Restructuring Models** Different market models, pool model, ISO in pool market, bilateral trading, multilateral trade, bidding and auction mechanisms, market clearing and pricing, market power and its mitigation, ancillary services
Unit-III	**Transmission Open Access** Transmission open access, pricing, congestion management, ATC and factors affecting ATC, determination of ATC, ancillary services and management
Unit-IV	**Transmission Pricing** Cost components, marginal pricing of electricity postage stamp method, megawatt mile method, nodal pricing, zonal pricing, contract path method, congestion pricing, preventive and corrective measure, management of congestion, market clearing price
Unit-V	**Electricity Pricing** Introduction, electricity price volatility, electricity price indexes, challenges to electricity pricing, construction of forward price curves, price forecasting

Unit-VI	**Power Market Development** Electricity Act, 2003 and its impact on infrastructure and governance, Indian power market, power exchange in Indian market day ahead market, online power trading, challenges and synergies in the use of IT in power

Text books:				
1	Power System restructuring and deregulation	2001	Loi Lei Lai	John Wiley and Sons, UK.
2	Operation of Restructured Power Systems	2001	K. Bhattacharya, MHT Bollen and J.C Doolder	Kluwer Academic Publishers, USA
3	Power System Operation and Control		A.J Wood and B.F Wollenberg	John Wiley and Sons

Reference books:				
1	Computational Methods for large Sparse Power System Analysis: An Object Oriented Approach		S.A Soman, S.A Khafasok, ShubhaPandit	Kluwer Academic Publishers

II Semester

25IPS214 – PE II: Wide Area Monitoring and Control

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
• To create awareness about real time control of power system • To provide knowledge of PMU, Synchrophasors. • To understand state estimation in a power system.	At the end of the course, student will be able to, CO1: Demonstrate the real time operation of power system in LDC using SCADA CO2: Design wide area measurement systems and Apply PMU in real time control of power system CO3: Develop the understanding of State Estimation and Observability

Unit	Syllabus
Unit-I	**Load Dispatch Centre (LDC)** Functions & Responsibilities of NLDC, SLDC and RLDC, Equipments and Softwares in LDC and its operation
Unit-II	**Supervisory Control and Data Acquisition (SCADA)** Introduction to SCADA, Layout of substation, Generating Station, Main equipments, parameters in grid operation and control, Data Acquisition and processing in SCADA, Introduction to SCADA protocols and Communication Standards
Unit-III	**Phasor Measurement Units (PMU)** Introduction to Phasor measurement units (PMUS), global positioning system (GPS), Functional requirements of PMUs, phasor estimation of nominal frequency inputs
Unit-IV	**Phasor Measurement Architecture** Wide Area Monitoring Systems (WAMS) architecture, Sensors for PMUs, Transducer Impact on PMU Accuracy, Hardware for PMU and PMU Integration, PMU Architecture, Data Acquisition System, Synchronization Sources, Communication and Data Collector, Distributed PMU
Unit-V	**State Estimation** Formulation of the SE Problem, Network Observability-SE Measurement Model, SE Classification, State estimation with phasor measurements, Linear state estimation, Dynamic estimators.

Unit-VI	**WAMS applications** Real-time analysis and technologies to detect, locate and characterize power system disturbances, monitoring power system oscillatory dynamics- Interpretation and visualization of wide-area PMU measurements, power system control with phasor feedback, discrete event control. Improving the performance of power system protection using wide area monitoring systems.

Text Books:

SN	Title	Year	Author	Publications
1	Power System Generation, Operation and Control	1996	Allen J. Wood and Bruce Woolenberg	John Wiley and Sons
2	Synchronized Phasor Measurements and Their Applications	2008	A.G. Phadke, J.S. Thorp	Springer Publications
3	Power System Analysis	1994.	John J. Grainger and William D Stevenson Jr	McGraw Hill ISE
4	Power System control – Technology	1986	TorstenCegrell	Prentice Hall International

Reference Books :

SN	Title	Year	Author	Publications
1	Real Time Systems	1997	C.M. Krishna and Kangg. Shin	Mc Graw-Hill international
2	IEEE Transactions and Reputed journal articles			

II Semester
25IPS215 – PE II: Microgrid

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course Outcomes
• To enable the students to understand the concept of integration of Distributed Energy Sources, Microgrid architectures and controls. • To explore interfacing resources via power electronics, hierarchical architectures, load generation management • To understand specific issues and challenges in, controlling and coordinating multiple Microgrids	At the end of the course, the students will be able to, 1. Explain the concept and operation of Microgrid. 2. Discuss the control issues, control architectures and the improved intelligent controllers for Microgrid stability. 3. Identify the protection challenges and apply the suitable protections for Multi Microgrid and its coordination 4. Describe and analyze the DC Microgrid, controls techniques and applications.

Unit	Syllabus
Unit-I	**The Microgrids Concept** The Microgrid Concept as a Integrate Distributed Generation, Introduction to Renewable Energy Sources (PV, Wind), Diesel Generator, Battery, Loads. Classification of the Micrograds, Architecture of Microgrid, Operation and Control of Micrograds, Integration with Renewable energy sources, Microgrid Applications.
Unit-II	**Micrograds Control Issues** Control Functions, Information and Communication Technology, Microgrid Control Architecture,
Unit-III	**Intelligent Local Controllers** Inverter Control Issues in the Formation of Micrograds, Frequency and Voltage Droop Concepts, Innovative Local Controls.
Unit-IV	**Microgrid Protection** Challenges for Microgrid Protection, Adaptive Protection for Micrograds, Effective Protection in Islanded Operation.
Unit-V	**Operation of Multi-Micrograds** Multi-Microgrid Control and Management Architecture, Coordinated Voltage/VAR Support, Coordinated Frequency Control.

Unit-VI	**DC Microgrid Control Architecture** DC Microgrid System Architecture and AC interface, DC Microgrid dynamics and modelling, controls of DC Microgrid, stability analysis, Applications.

Text Books:

SN	Title	Year	Authors	Publication
1	Microgrids: Architectures and Control	2013	Nikos Hatziargyriou	John Willey & Sons, Inc., IEEE Press.
2	Microgrid Technology and Engineering Application	2015	Li, Fusheng; Li, Ruisheng; Zhou, Fengquan	Academic Press (Imprint – Elsevier)
3	Microgrid: Advanced Control Methods and Renewable Energy System Integration	2017	Magdi S. Mahmoud	Elsevier

Reference Books:

1	Microgrid Design and Operation	2018	Bracco, Stefano; Brignone, Massimo; Delfino, Federico	Artech House
2	Microgrid Dynamics and Control	2017	Hassan Bevrani, Bruno Francois, Toshifumi Ise	John Willey & Sons, Inc., IEEE Press.
3	Related IEEE Transactions and reputed journal papers			

II Semester
25IPS231 – PE III : Power System Stability

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Objectives: To understand various types of stabilities in power system, their analysis and means to overcome the instability.

Unit	Syllabus
Unit-I	**Introduction** Power System Operation and Control, power system stability, classification of stability, mid-term and long term stability, Impact on Power System Operation, classical representation of synchronous machine in a single machine infinite bus system (SMIB), limitations of classical model
Unit-II	**Excitation and Prime Mover** Characteristics and types of excitation systems, IEEE type-I excitation system, Prime mover and energy supply systems, mathematical modeling of simple excitation system, power system stabilizers
Unit-III	**Steady state and transient characteristics of system** Phasor diagrams in terms of voltages Eq, Eq', and Vg for salient and non salient pole machines, Derivation of power expressions, saliency, Characteristics of system with generator operating at synchronous speed
Unit-IV	**Steady state stability** Steady state stability, characteristics, effect of damping, positive, negative resistance and turbine regulation, effect of induced currents in field winding, stability analysis with excitation
Unit-V	**Transient stability** Transient stability, swing equation, equal area criterion, solution of swing equation, Numerical methods- Modified Euler's method, Runge-Kutta method, Multimachine stability, Extended equal area criterion
Univ-VI	**Voltage stability** Classification of voltage stability, voltage stability analysis: static and dynamic, comparison with angle stability, Voltage collapse, prevention of voltage collapse

Text books:			
1	Power System Stability and control	Prabha Kundur	Mc Graw Hill Inc
2	Power System Stability Vol. III	Edward Kimbark	IEEE Press, Wiley Inter science John Wiley & Sons Publication
3	Power System Dynamics : Stability and Control	K.R. Padiyar	2nd edition BS Publications
4	Computational Techniques for voltage stability assessment and control	Aijarapu V	. Springer

Reference books:			
1	Power System Dynamics : Stability Control	Jan Machowski	John Wiley & Sons (2nd Edition)
2	Power System Analysis	Grainger, Stevenson	McGraw-Hill series in Electrical & Computer Engineering

II Semester

25IPS232 – PE III : Electrical Distribution Systems

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	**Course outcomes**
• To understand the various aspects of distribution systems • To understand distribution system, voltage levels, • To understand equipment's used in protection etc.	1. Student will be able to understand regulations, acts, codes about distribution applicable in India 2. Student will learn to analyze structure of feeder systems and voltage levels 3. Student will learn Reliability indices used in Distribution systems 4. Student will learn protection schemes and bus bar arrangements in distribution

Unit	**Syllabus**
Unit-I	Introduction to Distribution systems, Regulations, Electricity Act 2003, Energy conservation act-2001, electricity rules-2005, electricity authority regulations, distribution code, consumer values, consumer satisfaction, measurement standards of consumer satisfaction, Model distribution system. Explanation 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. Load, Management Strategies: Differential tariff, load staggering, interruptible load, supplies, maintenance of essential services, integrated system operation, use of captive generation & cogeneration in distribution network, distribution system measures, conservation
Unit-II	Feeders: Radial and loop types, Engineering considerations for voltage levels and loading, causes of unbalance and unequal drops. System analysis: Voltage drop and power loss calculations, manual methods of solution of radial networks, three-phase & non-three-phase primary lines load flow and symmetrical component applications.
Unit-III	**Voltage control:** Equipment for voltage control, effect of series capacitors, effect of AVB/AVR, line drop calculations and compensations, Reactive power requirements, economic consideration & best location.
Unit-IV	**Distribution System Reliability:** Basic definition, Appropriate levels of distribution reliability, Series & Parallel System, Markov Processes, Distribution reliability Indices, System and customer-based indices, load and energy based indices, usage of reliability indices.

Unit-V	**Introduction** to Distribution Automation, Data acquisition system and decentralized control, data acquisition and protection considerations of control panel. Circuit breaker, reclosers, sectionalizers, location of sectionalizers, fuses, low voltage and current limiting fuses, expulsion fuses, fuses applications considerations, lightning protection, disconnect switches, non-load break disconnect switches, break disconnect switches., relays. Earthing System: Earth and safety, nature of an earth electrode, earth conductor size, design of earthing electrode, electrode earth resistance, temporary earthing, system earthing, line and substation earthing, substation earthing mat, consumer installation earthing.
Univ-VI	**Substation :-** Substation layout, selection criteria, voltage and spacing load, space and location, distribution substation protection needs, distribution substation construction methods, trends in distribution substation, insulation coordination, voltage regulation, distribution substation layout, one feeder substation, single bus substation, two transformer distribution substation, automatic switching, double bus substation, bus arrangements, fault, distribution substation protection, zones of protection, transformer and bus protection, feeder overcurrent protection, substation grounding.

Text books:				
1	Electric Power Distribution	4^{th} edition, 1997	A.S.Pabla, , .	Tata McGraw-Hill Publishing Company
	References			
2.	Electric Power Distribution System Engineering	2nd Edition 2008	Turan Gonen	CRC Press
3	A Text Book of Electric Power Distribution Automation	Edition (Year of publication)	. Khedkar and Dr. G. M. Dhole,.	Laxmi Publications

II Semester
25IPS233 – PE III : Power System Operation and Control

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course outcomes
• To impart knowledge regarding importance of load estimation and different models for load prediction • To make the students aware regarding different state estimation methods	**On completion of this course, the student will be able to** 1) Define and explain basic components of power system and representation of its elements in terms of per unit. 2) Analyze and evaluate the transmission line parameters which limits the transmission capacity of a line. 3) Classify, evaluate and determine the performance of distribution and transmission system. 4) Choose, Compare and select the type of insulators and underground cables and improve the performance of system.

Unit	Syllabus
Unit-I	**Load Forecasting** Introduction – Estimation of Average and trend terms – Estimation of periodic components – Estimation of Stochastic components : Time series approach – Auto- Regressive Model, Auto-Regressive Moving – Average Models – Kalman Filtering Approach – On-line techniques for non stationary load prediction
Unit-II	**Unit Commitment** Constraints in unit commitment – Spinning reserve – Thermal unit constraints – Other constraints – Solution using Priority List method, Dynamic programming method - Forward DP approach Lagrangian relaxation method – adjusting
Unit-III	**Generation Scheduling** The Economic dispatch problem – Thermal system dispatching with network losses considered – The Lambda – iteration method – Gradient method of economic dispatch – Economic dispatch with Piecewise Linear cost functions – Transmission system effects – A two generator system – coordination equations – Incremental losses and penalty factors-Hydro Thermal Scheduling using DP.

Unit-IV	**Control of Power Systems** Review of AGC and reactive power control -System operating states by security control functions – Monitoring, evaluation of system state by contingency analysis – Corrective controls (Preventive, emergency and restorative) - Energy control center – SCADA system – Functions – monitoring , Data acquisition and controls – EMS system.
Unit-V	**State Estimation** Maximum likelihood Weighted Least Squares Estimation: - Concepts - Matrix formulation - Example for Weighted Least Squares state estimation ; State estimation of an AC network: development of method – Typical results of state estimation on an AC network – State Estimation by Orthogonal Decomposition algorithm.
Unit-VI	**Advance Measurements** Introduction to Advanced topics : Detection and Identification of Bad Measurements , Estimation of Quantities Not Being Measured , Network Observability and Pseudo – measurements – Application of Power Systems State Estimation .

Text books:

1	Electric Energy System Introduction Theory	**2002**	O.I.Elgerd	Tata McGraw Hill, New Delhi
2	Power System Stability and Control		P.Kundur	EPRI Publications, California
3	Power System Operation and Control		A.J Wood And B.F Wollenberg	John Wiley and Sons

Reference books:

1	Computer Aided Power System Analysis and Control	**1984**	A.K.Mahalanabis, D.P.Kothari. and S.I.Ahson	Tata McGraw Hill publishing Ltd

II Semester
25IPS234 – PE III : Transients in Power Systems

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course outcomes
(1) To impart knowledge about the concept of traveling waves. (2) Study about different transients and their protection that are introduced in the power system. (3) To explain the phenomenon of switching surges and lightning surges and its modeling. (4) To impart knowledge of the criteria of insulation coordination and its protection level with various type of lightning arrester.	At the end of the course, the students will be able to, 1. Explain the concept and operation of Travelling Waves on Transmission Lines. 2. Discuss the digital computation problems, simulations results using EMTP 3. Identify the lightning phenomenon and understand the behavior of winding oscillation. 4. Describe and analyze transformer surge conditions and problems , insulation coordination approach and protection level with different types of lightning arresters.

Unit	Syllabus
Unit-I	**Traveling Waves On Transmission Line** Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Traveling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion – Multi-conductor system and Velocity wave.
Unit-II	**Computation Of Power System Transients** Principle of digital computation – Matrix method of solution, Modal analysis,Z transforms, Computation using EMTP – Simulation of switches and non-linear elements.
Unit-III	**Lightning, Switching And Temporary Overvoltages** Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Factors contributing to line design – Switching: Short line or kilometric fault – Energizing transients - closing and re-closing of lines - line dropping, load rejection - Voltage induced by fault – Very Fast Transient Overvoltage (VFTO)
Unit-IV	**Behavior Of Winding Under Transient Condition** Initial and Final voltage distribution - Winding oscillation - traveling wave solution –
Unit-V	**Transformer under Surge Condition** Behavior of the transformer core under surge condition – Rotating machine – Surge in generator and motor

Unit-VI	**Insulation Coordination** Principle of insulation coordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, coordination between insulation and protection level – overvoltage protective devices – lightning arresters, substation earthing.

Text books:

1	Electromagnetic transients in Power System	1996.	Pritindra Chowdhari	John Wiley and Sons Inc
2	Electrical Transients in Power System	1991	Allan Greenwood	Wiley & Sons Inc. New York
3	Surges in High Voltage Networks	1980	Klaus Ragaller	Plenum Press, New York

Reference books:

1	Extra High Voltage AC Transmission Engineering	Second edition,1980	Rakosh Das Begamudre	Newage International (P) Ltd., New Delhi
2	High Voltage Engineering	2004	Naidu M S and Kamaraju V	Tata McGraw-Hill Publishing Company Ltd., New Delhi
3	IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000			

II Semester

25IPS235 – PE III : Solar System Design

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course outcomes
To develop the knowledge of students regarding Solar Thermal and Solar Photovoltaic System design	At the end of the course, the students will be able to: 1. Apply the knowledge of Solar cells and related parameters to design a solar PV system 2. Compare the different types PV Systems depending on connection scheme 3. Explain Battery performance and Determine the economic parameters associated with Solar Systems.

Unit	Syllabus
Unit-I	**Design of Solar Cells** Upper limits of Cell parameters, Losses in Solar Cells, Solar cell design, Design for high Isc, Design for high Voc, Design for high fill factor (FF)
Unit-II	**Photovoltaic System Design** Standalone PV System configurations, Design methodology of PV systems, Wire sizing in PV System, Precise sizing of PV System
Unit-III	**Hybrid PV System** Need of Hybrid System, Types of Hybrid PV Systems ,Issues with hybrid systems
Unit-IV	**Grid connected PV System** Performance parameters for grid connection, Single stage grid connected PV System, Government policies for solar rooftop system.
Unit-V	**Batteries for PV System and sizing PV** Battery parameters, Factors affecting battery performance, Battery charging and discharging methods, Batteries C-rate.
Unit-VI	**Economic Analysis** Introduction, Embodied Energy Analysis, Energy Density, Energy Payback time,Energy Production Factor, Life cycle Conversion efficiency, Lifecycle costing

Text books:

SN	Title	Year	Author	Publication
1	Solar Photovoltaic: Fundamentals, Technologies and Applications	2011	C.S.Solanki	Third Edition, PHI Publication
2	Solar Energy, Fundamentals, Design, Modeling and Applications	2002	G. N. Tiwari	Narosa
3	Solar Energy: Principles of Thermal Collection and Storage	2006	S. P. Sukhatme and J. K. Nayak	Tata McGraw Hill

Reference books:

1	Renewable energy sources and emerging technologies	2008	D. P. Kothari	1st Edition PHI
2	Energy Technology : Non -conventional, Renewable and Conventional	2013	S. Rao and B.B. Parulekar	Khanna Publisher, New Delhi
3	NPTEL Videos on 'Design of Solar PV System'		Prof.L. Umanand	

II Semester

25IPS241 – PE IV: Distributed Automation

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course outcomes
To make student aware about:- ● Automation in the power system ● Application of communication in power system automation ● Methods of technical evaluation and estimate the cost estimation of automated system.	**Students will be able to :-** 1. Demonstrate the knowledge of power distribution automation 2. Organize the resources for integration of the power system for a better economy. 3. Make use of communication system for distribution system. 4. Evaluate the technical benefits of automation to the power system.

Unit	Syllabus
Unit-I	**Distribution Automation and the utility system** Introduction to Distribution Automation (DA), control system interfaces, control and data requirements, centralized (Vs) decentralized control, DA System (DAS), DA Hardware, DAS software.
Unit-II	**Distribution Automation Functions** DA capabilities, Automation system computer facilities, management processes, Information management, system reliability management, system efficiency management, voltage management, Load management.
Unit-III	**Communication Systems for DA** DA communication requirements, Communication reliability, Cost effectiveness, Data rate requirements, Two way capability, Ability to communicate during outages and faults, Ease of operation and maintenance, Conforming to the architecture of data flow.
Unit-IV	**Communication systems used in DA** Distribution line carrier (Power line carrier), Ripple control, Zero crossing technique, telephone, cable TV, Radio, AM broadcast, FM SCA, VHF Radio, UHF Radio, Microwave satellite, fiber optics, Hybrid Communication systems, Communication systems used in field tests.
Unit-V	**Technical Benefits** DA benefit categories, Capital deferred savings, Operation and Maintenance savings, Interruption related savings, Customer related savings,tOperational savings, Improved operation, Function benefits, Potential benefits for functions, function shared benefits, Guide lines for formulation of estimating equations, Parameters required, economic impact areas, Resources for determining benefits impact on distribution system, integration of benefits into economic evaluation.

Unit-VI	**Economic Evaluation Methods** Development and evaluation of alternate plans, Select study area, Select study period, Project load growth, Develop Alternatives, Calculate operating and maintenance costs, Evaluate alternatives, Economic comparison of alternate plans, Classification of expenses and capital expenditures, Comparision of revenue requirements of alternative plans, Book Life and Continuing plant analysis, Year by year revenue requirement analysis, short term analysis, end of study adjustment, Break even analysis, Sensitivity analysis computational aids.

Text books:			
1	A Text Book of Electric Power Distribution Automation	Khedkar and Dr. G. M. Dhole,.	Laxmi Publications
2	Electric Power Distribution	A. S. Pabla	Tata McGraw Hill Publication, New Delhi
3	Distribution Automation	IEEE Tutorial Course	

II Semester

25IPS242 – PE IV: Power Electronics for Renewable Energy Systems

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course outcomes
To overview the different renewable energy system and generator used and to understand their different configurations and topology. The objective is to study the various Grid interactive power converter topologies used in Wind and solar energy conversion system and their hybrid combination and the related power quality issues.	1) Describe the impact and significances of different renewable energy sources. 2) Explain solar thermal and solar photovoltaic applications 3) Describe and analyse the various solar photovoltaic inverters topologies and configurations, and characteristics. 4) Discuss and categorize wind energy conversion systems based on the generators, controls and operation. 5) Examine and apply various power converters for Wind energy systems and its controls. 6) Define and explain the need of hybrid systems, discuss its various configurations and various power quality issues in grid integrations.

Unit	Syllabus
Unit-I	**Introduction** Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.
Unit-II	**Solar Thermal and Photovoltaic System** Solar Thermal: Different Solar Concentrators and solar thermal applications Solar Photovoltaic: PV cell equivalent and V-I, P-V characteristics, DC-DC Converters and its role in Maximum Power Point Tracking (MPPT), MPPT techniques (Direct and Indirect)
Unit-III	**Solar PV converters and Configurations** PV inverters: PV inverter Configurations, PV based transformerless inverter topologies. Configuration: Standalone, Grid interactive, Bi-Modal systems, Grid synchronization (time and frequency Domain), Islanding and detection methods, Generic control for PV inverters.
Unit-IV	**Wind Energy Conversion System (WECS)** WECS: Introduction to WECS, Wind turbine technologies, WECS configurations and fundamentals of WECS controls, wind MPPT control, operation and analysis of wind generators (IG, PMSG, SCIG, DFIG)

Unit-V	**Power Converters, Configurations and Controls for Wind Energy Systems** Power Converters: AC Voltage Controllers, PWM inverters, Grid interactive inverters Configurations and Controls: Fixed speed WECS, Variable speed WECS (converter configurations for IG, PMSG based WECS and their controls)
Unit-VI	**Hybrid Renewable Energy System and Power Quality (PQ)** Need for Hybrid Systems and type of Hybrid systems, PQ issues in grid interconnections, measurement of voltage flicker, voltage dip, voltage swell, harmonics in grid integration and remedial measures.

Text books:

1	Power Electronics Hand book	2001.	Rashid .M. H	Academic press,
2.	Power Electronics for Modern Wind Turbines	2006	F. Blaabjerg and Z. Chen	Morgan & Claypool Publishers, 2006
3	Non-conventional Energy Sources	2006	B. H. Khan	Tata McGraw Hill,
4	Modern Power Electronics and AC Drives	2001	B. K. Bose	Prentice Hall PTR

Reference books:

1	Wind energy system		Gray, L. Johnson	Prentice Hall inc
2	Power Conversion and Control of Wind Energy System	2011	Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro	John Willey & Sons Inc., Publications , IEEE Press.2011
3.	Grid Converters for Photovoltaic and Wind Power Systems	2011	Remus Teodorescu. Marco Liserre, Pedro Rodriguez	John Willey & Sons Inc., Publications , IEEE Press.2011
4.	Analysis of Electric Machinery and Drive Systems		P. C. Krause, O. Wasynzuk, and S. D. Sudhoff	John Willey & Sons Inc., Publications , IEEE Press.
5.	Wind Power in Power System	2005	T. Ackermann	John Willey & Sons Inc., Publications , IEEE Press.2005

II Semester
25IPS243 – PE IV: Control System Design

Evaluation Scheme	MSEs *	TA	ESE	Total	ESE Duration
	30	20	50	100	3 Hrs

Course Objectives	Course outcomes
• Control system design subject explains the design method for control systems in time and frequency domain. • Modern control methods in state space for desired stability is also introduced. • The optimal control for performance index improvements are also covered	CO1: Recall and explain the basics of conventional design method in time and frequency domain CO2: Apply and solve problems for design of discrete systems and analyse the stability of digital control system. CO3: Understand the preliminary concept of discrete time state variable analysis pole placement and design through state feedback. CO4: Explain the concepts of optimal control formulation of optimal control.

Unit	Syllabus
Unit-I	**CONVENTIONAL DESIGN METHODS IN TIME DOMAIN** Design specifications, Fixed configuration design, Time domain interpretations of PI, PD and PID controllers and lead, lag and lag-lead compensators- Root locus based design, Design examples.
Unit-II	**CONVENTIONAL DESIGN METHODS IN FREQUENCY DOMAIN** Frequency domain specifications, Correlation between time and frequency domain, Frequency domain interpretations of PI, PD and PID controllers and lead, lag and lag-lead compensators, Design examples
Unit-III	**DESIGN IN DISCRETE TIME DOMAIN** Design of Discrete-time control system by conventional methods: Introduction, Digital implementation of analog controller (PID and lead-lag controllers) : Digital controllers, Realization of pulse transfer function by direct, Cascade and parallel programming. Design based on root locus method. Dead beat controller.
Unit-IV	**DISCRETE DESIGN IN FREQUENCY DOMAIN** Mapping between S plane and Z plane, Bilinear transformation, Design based on frequency domain for PID and lag lead compensators. . Design examples
Unit-V	**DISCRETE STATE VARIABLE DESIGN** Discrete pole placement- state and output feedback-estimated state feedback, state feedback with integral control, State Estimation Problem -State estimation- Luenberger's observer and reduced order observer. Concept of Sliding Mode controller.

Unit-VI	**OPTIMAL CONTROL** Formation of optimal control problems-Results of Calculus of variations- Hamiltonian formulation-solution of optimal control problems- Evaluation of Riccati's equation. State and output Regulator problems-- dynamic programming-Design examples.

Text books:				
1	Modern control system Theory	2005	M. Gopal	New Age International
2	Digital control systems	2004	Benjamin C. Kuo	Oxford University Press
3	Discrete time control systems	2002	Katsuhiko Ogata	Pearson Education Asia
4	Control systems principals and design	2003	M. Gopal	TMH
Reference books:				
1	Control system Design	2003	Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado	PHI (Pearson), 2003
2	Digital Control of Dynamic Systems	2002.	G. F. Franklin, J. D. Powell and M Workman	PHI (Pearson),

III Semester
25IPS301 – Project Phase - I

Evaluation Scheme	Continuous Evaluation	ESE	Total	ESE Duration
	60	40	100	

Course Objectives	Course outcomes
1. To apply knowledge of mathematics, science and engineering in a global, economic, environmental and societal context and engage in life-long learning. 2. To design a model, a system or components considering environmental, economic, social, political, ethical and sustainability and analyze and interpret the data. 3. To work on multidisciplinary teams, tackle engineering problems, understand professional and ethical responsibility and communicate effectively. 4. To apply knowledge of contemporary issues and use the techniques, skills, and modern engineering tools necessary for engineering practices.	1) **Identify** the research area of project work in Electrical Engineering. 2) **Summarize** the literature review in the area identified, **propose** the objectives of project work. 3) **Organize** requisite components with specifications for the project software/hardware prototype and **apply** suitable software/hardware tool in project work 4) **Compile**, **discuss** and **conclude** the results in project report and give presentation by effective communication

IV Semester
25IPS401 – Project Phase - II

Evaluation Scheme	Continuous Evaluation	ESE	Total	ESE Duration
	60	40	100	

Course Objectives	Course outcomes
1. To apply knowledge of mathematics, science and engineering in a global, economic, environmental and societal context and engage in life-long learning. 2. To design a model, a system or components considering environmental, economic, social, political, ethical and sustainability and analyze and interpret the data. 3. To work on multidisciplinary teams, tackle engineering problems, understand professional and ethical responsibility and communicate effectively. 4. To apply knowledge of contemporary issues and use the techniques, skills, and modern engineering tools necessary for engineering practices.	1) Develop and inspect the prototype of the project work 2) Analyse and conclude the results on proposed work on project 3) Compile project work to prepare a thesis report and present a research paper on project