SAGI RAMA KRISHNAM RAJU ENGINEERING COLLEGE
(AUTONOMOUS)
(Approved by AICTE, New Delhi, Affiliated to JNTUK, Kakinada)
Accredited by NAAC with 'A+' Grade.
Recognised as Scientific and Industrial Research Organisation
SRKR MARG, CHINA AMIRAM, BHIMAVARAM – 534204 W.G.Dt., A.P., INDIA

Regulation: R25	I - M.Tech. I - Semester

POWER SYSTEMS & AUTOMATION

COURSE STRUCTURE
(With effect from 2025-26 admitted Batch onwards)

Course Code	Course Name	Category	L	T	P	Cr	C.I.E.	S.E.E.	Total Marks
D2516601	Power System Operation & Control	PC	3	1	0	4	40	60	100
D2516602	Smart Grid Technologies	PC	3	1	0	4	40	60	100
D2516603	Reactive Power Compensation and Management	PC	3	1	0	4	40	60	100
#PE-I	Program Elective-I	PE	3	0	0	3	40	60	100
#PE-II	Program Elective-II	PE	3	0	0	3	40	60	100
D2516604	Power System Simulation Laboratory I	PC	0	1	2	2	40	60	100
D2516605	Power Systems Laboratory	PC	0	1	2	2	40	60	100
D2516606	Seminar-I	PR	0	0	2	1	100	--	100
	TOTAL		**15**	**5**	**6**	**23**	**380**	**420**	**800**

	Course Code	Course Name
#PE-I	D25166A0	Electrical Distribution Automation
	D25166A1	Advanced Power Systems Protection
	D25166A2	Electric Vehicles
#PE-II	D25166B0	HVDC Transmission
	D25166B1	Power Electronic Converters
	D25166B2	Programmable Logic Controllers & Applications

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2516601	**PC**	**3**	**1**	**--**	**4**	**40**	**60**	**3 Hrs.**

POWER SYSTEM OPERATION & CONTROL

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The unit commitment for economic load dispatch and optimal power flows
2.	The load frequency control of single area power system with and without control.
3.	The load frequency control of two area power system with and without control.
4.	The effect of generation with limited energy supply.
5.	The effectiveness of interchange evaluation in interconnected power systems

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

S.No	Outcomes	Knowledge Level
1.	**Obtain** the solution for unit commitment problem for economic load dispatch and optimal power flows.	K3
2.	**Explore** the load frequency control of single area system with and without control.	K3
3.	**Explore** the load frequency control of two-area system with and without control.	K3
4.	**Explore** the effect of fuel scheduling generation with limited energy supply.	K3
5.	**Illustrate** the interchange evaluation in interconnected power systems.	K3

SYLLABUS

UNIT-I (10Hrs)	**Unit commitment problem and optimal power flow solution:** Unit commitment: Constraints in UCP, UC solution methods. Priority list method, Dynamic programming Approach. Optimal power flow: OPF without inequality constraints, inequality constraints on control variables and dependent variables.
UNIT-II (10 Hrs)	**Single area Load Frequency Control:** Necessity of keeping frequency constant. Definition of control area, single area control, Block diagram representation of an isolated Power System, Steady State analysis, Dynamic Response-Uncontrolled case. Proportional plus Integral control of single area and its block diagram representation, steady state response.
UNIT-III (10 Hrs)	**Two area Load Frequency Control:** Block Diagram development of two-area system, uncontrolled case and controlled case, tie-line bias control, steady state representation. Optimal two-area LF control- performance Index and optimal parameter adjustment. Load frequency control and Economic dispatch control, Automatic generation control (AGC)

UNIT-IV (10 Hrs)	**Generation with limited Energy supply:** Take-or-pay fuel supply contract, composite generation production cost function. Solution by gradient search techniques, Hard limits and slack variables, Fuel scheduling by linear programming.
UNIT-V (10 Hrs)	**Interchange Evaluation and Power Pools Economy Interchange:** Economy interchange Evaluation, Interchange Evaluation with unit commitment, Multiple Interchange transactions, other types of Interchange, power pools, transmission effects and issues.

Textbooks:	
1.	Power Generation, Operation and Control - by A.J.Wood and F.Wollenberg, Johnwiley& sons Inc, 2nd edition, 2006.
2.	Modern Power System Analysis - by I.J.Nagrath & D.P.Kothari, Tata McGraw-Hill Publishing Company ltd, 2nd edition, 2011.
Reference Books:	
1.	Power system operation and control by PSR Murthy B.S publication, 2nd edition, 2011.
2.	Electrical Energy Systems Theory - by O.I.Elgerd, Tata McGraw-Hill Publishing Company Ltd, 2nd edition, 2005.
3.	Reactive Power Control in Electric Systems - by TJE Miller, John Wiley & sons, 1st edition, 1982.
e-Resources	
1.	https://nptel.ac.in/courses/108101040
2.	https://onlinecourses.nptel.ac.in/noc25_ee115
3.	https://onlinecourses.nptel.ac.in/noc25_ee169

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2516602	**PC**	**3**	**1**	**--**	**4**	**40**	**60**	**3 Hrs.**

SMART GRID TECHNOLOGIES

(**for Power Systems & Automation**)

Course Objectives: Students will learn about

1.	The concept of smart grid and developments on smart grid.
2.	The smart grid technologies and application of smart grid concept in hybrid electric vehicles.
3.	The smart substations, feeder automation and application for monitoring and protection.
4.	The Concepts of micro grid and applications
5.	The effects of power quality in smart grid and latest developments in ICT for smart grid.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the smart grid policies and its developments.	K3
2.	**Explore** the smart grid with smart meters, smart Sensors, Home & Building Automation and hybrid electrical vehicles.	K3
3.	**Explore** the smart grid with smart substations, feeder automation, smart storage, WAMS and GIS.	K3
4.	**Illustrate** the concepts of Microgrids.	K3
5.	**Illustrate** the power quality issues and management in Smart Grids.	K3

SYLLABUS

UNIT-I (10Hrs)	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient &Self-Healing Grid, Present development & International policies on Smart Grid. Case study of Smart Grid.
UNIT-II (10 Hrs)	**Smart Grid Technologies: Part-1:** Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.
UNIT-III (10 Hrs)	**Smart Grid Technologies: Part-2:** Smart Substations, Substation Automation, Feeder Automation. Geographic Information System (GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Phase Measurement Unit(PMU),Wide Area Measurement System (WAMS).
UNIT-IV (10 Hrs)	**Micro grids:** Concept of micro grid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid

UNIT-V (10 Hrs)	**Power Quality Management in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit
	.
Textbooks:	
1.	Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2.	Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press
Reference Books:	
1.	JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, AkihikoYokoyama, "Smart Grid: Technology and Applications", Wiley
2.	Jean Claude Sabonnadière, NouredineHadjsaïd, "Smart Grids", Wiley Blackwell 19
3.	Peter S. Fox Penner, "Smart Power: Climate Changes, the Smart Grid, and the Future of Electric Utilities", Island Press; 1 edition 8 Jun 2010
4.	S. Chowdhury, S. P. Chowdhury, P. Crossley, "Microgrids and Active Distribution Networks." Institution of Engineering and Technology, 30 Jun 2009
5.	Stuart Borlase, "Smart Grids (Power Engineering)", CRC Press
e-Resources	
1.	https://nptel.ac.in/courses/108107113
2.	https://onlinecourses.nptel.ac.in/noc23_ee60/preview

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2516603	PC	3	1	--	4	40	60	3 Hrs.

REACTIVE POWER COMPENSATION AND MANAGEMENT

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The objectives and specifications of Load Compensation
2.	The steady state and transient state Characteristic time period of Line Compensation
3.	The reactive power coordination
4.	The Reactive power management on the distribution side and user side
5.	The reactive power control in electric traction systems and arc furnaces

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

S.No	Outcomes	Knowledge Level
1.	**Determine** the load compensation for voltage profile improvement	K3
2.	**Determine** the reactive power compensation in transmission lines	K3
3.	**Demonstrate** the mathematical models of reactive power compensating devices	K3
4.	**Explore** the distribution side and user side reactive power management	K3
5.	**Explore** the reactive power compensation in electrical traction & arc furnaces.	K3

SYLLABUS

UNIT-I (10Hrs)	**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.
UNIT-II (10 Hrs)	**Line compensation:** 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
UNIT-III (10 Hrs)	**Reactive power coordination: Objective** – Mathematical modelling – 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.
UNIT-IV (10 Hrs)	**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 available capacitor, characteristics and Limitations.
UNIT-V (10 Hrs)	**Reactive power management in electric traction systems and arc furnaces**: Typical layout 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.

Textbooks:

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

Reference Books:

1.	FACTS: Modelling and Applications" – N.G. Hingorani & L. Gyugyi, Wiley India Pvt Ltd,2011
2.	Power System Stability and Control by Prabha Kundur, McGraw-Hill Education-2007

e-Resources

1.	https://nptel.ac.in/courses/108107157
2.	https://nptel.ac.in/courses/117103149

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25166A0	**PE**	**3**	**0**	**--**	**3**	**40**	**60**	**3 Hrs.**

ELECTRICAL DISTRIBUTION AUTOMATION

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The importance of economic distribution of electrical energy
2.	The design considerations of distribution feeders and substations
3.	The protection of distribution system.
4.	The principles of capacitive compensation and voltage control in distribution system.
5.	The concepts of distribution system automation.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the distribution system concepts.	K3
2.	**Illustrate** the design considerations of the distribution system feeders and sub-stations.	K3
3.	**Explore** various protective devices and its coordination techniques to distribution system	K3
4.	**Explore** the capacitive compensation techniques for voltage control in distribution systems.	K3
5.	**Demonstrate** the application of distribution system automation functions in power systems.	K3

SYLLABUS

UNIT-I (10Hrs)	**Introduction to Distribution systems:** Introduction, an overview of the role of computers in distribution system planning-Load modelling 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.
UNIT-II (10 Hrs)	**Distribution Feeders and Substations:** Design consideration of Distribution feeders: Radial and loop types of primary feeders, voltage levels, and 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
UNIT-III (10 Hrs)	**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; types of coordination.

UNIT-IV (10 Hrs)	**Capacitive compensation and Voltage 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.
UNIT-V (10 Hrs)	**Distribution automation functions:** Electrical system automation, EMS functional scope, DMS functional scope functionality of DMS- Steady state and dynamic performance improvement; Geographic information systems-AM/FM functions and Data base management; communication options, supervisory control and data acquisition: SCADA functions and system architecture; Synchro phasors and its application in power systems.
Textbooks:	
1.	"Electric Power Distribution System Engineering", by Turan Gonen, Tata Mc Graw-Hill Book Company, 3rd Edition.
2.	"Distribution System Analysis and Automation", by Juan M.Gers, The Institution of Engineering and Technology, 2nd Edition.
Reference Books:	
1.	"Electric Power Distribution", by A.S.Pabla, Tata Mc Graw-Hill Publishing Company, 4th Edition.
2.	"Electrical Power Distribution Systems", by V.Kamaraju – Tata Mc Graw Hill Publishing Company, 8th Edition
3.	"Handbook of Electrical Power Distribution", Gorti Ramamurthy-Universities press 2nd Edition
e-Resources	
1.	https://nptel.ac.in/courses/117103149
2.	https://nptel.ac.in/courses/108107112

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25166A1	**PE**	**3**	**--**	**--**	**3**	**40**	**60**	**3 Hrs.**

ADVANCED POWER SYSTEM PROTECTION

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The working principles, operation, applications and advantages of static relays
2.	The amplitude and phase comparator principles used in relay protection schemes.
3.	The comparator-based characteristics of static relays, and relay performance under various fault and power swing conditions.
4.	The working principles of various pilot relaying schemes
5.	The microprocessor-based relays and numerical protection techniques.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the basic static relay circuits using comparators, trigger circuits, and detectors.	K3
2.	**Illustrate** the performance characteristics of different amplitude and phase comparators.	K3
3.	**Analyze** the relay characteristics and protection schemes for power system protection.	K4
4.	**Explore** the different pilot relaying schemes in transmission line protection.	K3
5.	**Explore** the microprocessor relays and numerical relay algorithms.	K3

SYLLABUS

UNIT-I (10Hrs)	**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 – Thyristor and UJT Triggering Circuits. Phase sequence Filters – Speed and reliability of static relays.
UNIT-II (10 Hrs)	**Amplitude and Phase Comparators (2 Input):** 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:** Block Spike and phase Splitting Techniques – Transistor Integrating type, phase comparison, Rectifier Bridge Type Comparison – Vector product devices.
UNIT-III (10 Hrs)	**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.
UNIT-IV (10 Hrs)	**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.
UNIT-V (10 Hrs)	**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.

Textbooks:	
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 Kimbark Vol-II, Willey.
4.	Electrical Power System Protection –C.Christopoulos and A.Wright- Springer
5.	Protection & Switchgear –Bhavesh Bhalaja, R.PMaheshwari, Nilesh G.Chothani- Oxford publisher
e-Resources	
1.	https://onlinecourses.nptel.ac.in/noc20_ee73/preview

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25166A2	PE	3	--	--	3	40	60	3 Hrs.

ELECTRIC VEHICLES

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The fundamental components of conventional vehicles, propulsion loads, drive cycles, and terrains along with concepts of electric and hybrid vehicles.
2.	The hybridization techniques in automobiles, including the design and comparison of HEV, PHEV, and fuel cell vehicles.
3.	The motor control strategies, power electronic converters, and regenerative braking systems used in electric and hybrid electric vehicles.
4.	The role of power electronic converters and inverters in efficient energy management of Hybrid and Electric Vehicles
5.	The different energy storage systems such as batteries, ultra-capacitors, flywheels, and other advanced technologies for their suitability in electric and hybrid vehicles

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the key components of conventional vehicles and contrast them effectively with electric and hybrid vehicles.	K3
2.	**Explore** the hybrid vehicle architectures, motor control strategies and energy management systems to design or select appropriate EV's.	K3
3.	**Analyze** the functionality of motor controllers, power electronic devices, and regenerative braking to optimize electric vehicle performance.	K4
4.	**Illustrate** power electronic converters and inverters to analyze and control energy flow in Hybrid and Electric Vehicles.	K3
5.	**Explore** various energy storage technologies and their integration into electric and hybrid vehicles to improve overall system efficiency	K3

SYLLABUS

UNIT-I (10Hrs)	**Introduction:** Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept and classification of electric vehicle and hybrid electric vehicle; History of electric and hybrid vehicles, Comparison of conventional vehicle with electric and hybrid vehicles
UNIT-II (10 Hrs)	**Hybridization of Automobile:** Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; Plug-in

	hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell vehicles and its constituents.
UNIT-III (10 Hrs)	**Motor Control in Electric Vehicles:** Role of motors in Electric Vehicles, factors to choose motors for EV, Comparison of motors for EV power train, Motor Controller Unit (MCU)- need and components, Motor control units of two- and four –wheel EVs, Regenerative braking
UNIT-IV (10 Hrs)	**Power Electronics in HEVs:** Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.
UNIT-V (10 Hrs)	**Battery and Storage Systems:** Energy Storage Parameters; Lead–Acid Batteries; Ultra capacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource.
Textbooks:	
1.	Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
2.	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
Reference Books:	
1.	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2004.
2.	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3.	H. Partab: Modern Electric Traction – Dhanpat Rai & Co, 2007.
4.	Pistooa G., “Power Sources , Models, Sustanability, Infrastructure and the market”, Elsevier 2008.
5.	Mi Chris, Masrur A., and Gao D.W., “ Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives” 1995
e-Resources	
1.	https://nptel.ac.in/courses/108103009
2.	https://onlinecourses.nptel.ac.in/noc24_ee30/preview

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25166B0	**PE**	**3**	**--**	**--**	**3**	**40**	**60**	**3 Hrs.**

HVDC TRANSMISSION

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The various HVDC transmission schemes.
2.	The various converter topologies and their terminal equipment.
3.	The control Techniques for HVDC systems.
4.	The interaction between HVAC and HVDC system.
5.	The fault behaviour and various protection schemes in HVDC Systems.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the various HVDC transmission schemes.	K3
2.	**Illustrate** the various converter topologies and their terminal equipment.	K3
3.	**Explore** the different types of converter control techniques to calculate voltage & current harmonics and design of filters.	K3
4.	**Explore** the interaction between HVAC and HVDC system.	K3
5.	**Explore** the fault behaviour and various protection schemes in HVDC Systems.	K3

SYLLABUS

UNIT-I (10Hrs)	**Introduction:** Limitation of EHV AC Transmission, Advantages of HVDC, Technical economical and 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.
UNIT-II (10 Hrs)	**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 performance of diametrical connection with 6-pulse bridge circuit
UNIT-III (10 Hrs)	**Control of HVDC Converters and systems:** constant current, constant extinction angle and constant Ignition angle control. Individual phase control and equidistant firing angle 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.
UNIT-IV (10 Hrs)	Interaction between HV AC and DC systems – Voltage interaction, Harmonic instability 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.
UNIT-V (10 Hrs)	Transient over voltages in HV DC 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.

Textbooks:	
1.	S Kamakshaih and 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.
4.	Power Transmission by Direct Current – by E.Uhlmann, B.S.Publications
5.	EHVAC Transmission Engineering by R. D. Begamudre, New Age International (P) Ltd.
e-Resources	
1.	https://nptel.ac.in/courses/108104013
2.	https://nptel.ac.in/courses/108107114

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25166B1	**PE**	**3**	**--**	**--**	**3**	**40**	**60**	**3 Hrs.**

POWER ELECTRONIC CONVERTERS
(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The static and dynamic characteristics of power switching devices including MOSFET, IGBT, GTO, GaN devices, and their gate drive circuit requirements.
2.	The principle of operation of single and three phase-controlled rectifiers with different loads including power factor evaluation and harmonic analysis.
3	The various PWM inverter modulation schemes for single-phase and three-phase voltage and current source inverters, including sinusoidal, third harmonic, and space vector PWM.
4	The multilevel inverter topologies such as diode-clamped, cascaded H-bridge, and modular multilevel converters.
5.	Application of various PWM techniques for multilevel inverters.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the operation and characteristics for MOSFET, IGBT, GTO, GaN devices, and their gate drive circuit requirements.	K3
2.	**Analyze** the phase-controlled rectifiers with different loads including power factor evaluation and harmonic analysis.	K4
3.	**Explore** the PWM inverter modulation schemes for single-phase and three-phase voltage and current source inverters, including sinusoidal, third harmonic, and space vector PWM.	K3
4.	**Explore** multilevel inverter topologies such as diode-clamped, cascaded H-bridge, and modular multilevel converters.	K4
5.	**Explore** the application of various PWM techniques for multilevel inverters.	K3

SYLLABUS

UNIT-I (10Hrs)	**OVERVIEW OF SWITCHING DEVICES** Power MOSFET, IGBT, GTO, GaN devices-static and dynamic characteristics, gate drive circuits for switching devices.
UNIT-II (10 Hrs)	**AC-DC CONVERTERS** Single phase 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 control, Single-phase single stage boost power factor corrected rectifier. Three Phase AC-DC Converters, fully controlled converters feeding RL load with continuous and discontinuous load current, Evaluation of input power factor and harmonic factor-three phase dual converters.

UNIT-III (10 Hrs)	**PWM INVERTERS** Voltage control of single-phase inverters employing phase displacement Control, Bipolar PWM, Unipolar PWM. Three-phase Voltage source inverters: Six stepped VSI operation-Voltage Control of Three-Phase Inverters employing Sinusoidal PWM, Third Harmonic PWM, Space Vector Modulation- Comparison of PWM Techniques- Three phase current source inverters.
UNIT-IV (10 Hrs)	**MULTILEVEL INVERTERS** Introduction, Multilevel Concept, Types of Multilevel Inverters, Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode Clamped Inverter, Cascaded H-bridge Multilevel Inverter, Principle of Operation, Features of Cascaded H-bridge Inverter, Fault tolerant operation of CHB Inverter, Comparison of DCMLI & CHB, Modular multilevel converters, principle of operation.
UNIT-V (10 Hrs)	**PWM MULTILEVEL INVERTERS** CHB Multilevel Inverter: Stair case modulation-SHE PWM- Phase shifted Multicarrier Modulation-Level shifted PWM- Diode clamped Multilevel inverter: SHE PWM-Sinusoidal PWM- Space vector PWM-Capacitor voltage balancing.

Textbooks:

1.	Power Electronics: Converters, Applications, and Design- Ned Mohan, Tore M. Undeland, William P. Robbins, John Wiley& Sons, 2nd Edition, 2003.
2.	Power Electronics-Md.H. Rashid –Pearson Education Third Edition- First Indian Reprint- 2008.

Reference Books:

1.	Power Electronics Semiconductor Switches – Ram Shaw, 1993.. Power Electronics Daniel W. Hart - McGraw-Hill, 2011.
2.	Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014.
3.	Power Converter Circuits – William Shepherd & Li Zhang-Yes Dee CRC Press, 2004.
4	Thyristorised Power Controllers – G.K. Dubey, S.R Doradra, A. Joshi and R.M.K. Sinha, New Age international Pvt. Ltd. Publishers latest edition.
5	"Power Electronics": by P.S. Bimbhra, KHANNA PUBLISHERS,2022.

e-Resources

1.	https://nptel.ac.in/courses/108105066
2.	https://onlinecourses.nptel.ac.in/noc25_ee02/preview

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25166B2	PE	3	0	--	3	40	60	3 Hrs.

PROGRAMMABLE LOGIC CONTROLLERS & APPLICATIONS
(for Power Systems & Automation)

Course Objectives: Students will learn about

1	The fundamentals of PLC architecture, modules, and ladder diagrams.
2.	The PLC programming using logic instructions, Boolean algebra, and process control.
3	The PLC registers and functional instructions such as timers, counters, arithmetic, and comparison functions for automation applications.
4	The Data handling functions for sequence control and robotic applications.
5	The Implementation of analog operations and PID control for industrial automation.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the architecture, working principles, and interfacing of PLCs, I/O modules, CPU, and ladder diagram construction.	K3
2.	**Develop** the PLC programming using logic instructions and ladder diagrams for process control.	K3
3.	**Illustrate** the registers, timers, counters, arithmetic, and comparison functions in automation.	K3
4.	**Explore** data handling functions for robot control and sequence automation.	K3
5.	**Explore** the analog PLC operations and PID control for industrial process applications.	K3

SYLLABUS

UNIT-I (10Hrs)	**PLC Basics:** PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.
UNIT-II (10 Hrs)	**PLC Programming:** Input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill press operation. Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.
UNIT-III (10 Hrs)	**PLC Registers:** Characteristics of Registers, module addressing, holding registers, input registers, output registers. PLC Functions: Timer functions and Industrial applications, counters, counter function industrial applications, Arithmetic functions, Number comparison functions, number conversion functions.
UNIT-IV (10 Hrs)	**Data Handling functions:** SKIP, Master control Relay, Jump, Move, FIFO, FAL, ONS, CLR and Sweep functions and their applications. Bit Pattern and changing a bit shift register, sequence functions and

	applications, controlling of two axis and three axis Robots with PLC, Matrix functions.
UNIT-V (10 Hrs)	**Analog PLC operation:** Analog modules and systems, Analog signal processing, multi bit data processing, analog output application examples, PID principles, position indicator with PID control, PID modules, PID tuning, PID functions.
Textbooks:	
1.	Programmable Logic Controllers – Principle and Applications by John W. Webb and Ronald A. Reiss, Fifth Edition, PHI
2.	Programmable Logic Controllers – Programming Method and Applications by JR. Hackworth and F.D Hackworth Jr. – Pearson, 2004.
Reference Books:	
1.	Introduction to Programmable Logic Controllers- Gary Dunning-Cengage Learning.
2.	Programmable Logic Controllers –W.Bolton-Elsevier publisher.
e-Resources	
1.	https://onlinecourses.nptel.ac.in/noc21_me67/preview
2.	https://www.youtube.com/watch?v=MS3qJq2jvu0
3.	https://www.youtube.com/watch?v=zno8BYcdQzk&list=PLj_Alq7xw30mbL8RTojUTYt-nrfrGlDw0

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2516604	PC	--	1	2	2	40	60	3 Hrs.

POWER SYSTEM SIMULATION LABORATORY – I

(for Power Systems & Automation)

Course Objectives: Students will learn about

1	The formation of Y-Bus and Z-Bus matrices for power system network modeling.
2	The various load flow analysis methods including Gauss-Seidel, Newton-Raphson and Fast Decoupled techniques.
3	The symmetrical and unsymmetrical faults using Z-Bus and sequence components.
4	The Economic Load Dispatch with and without considering transmission losses.
5	The transient stability and load frequency control for Single and Two-area power systems.

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

S.No	Outcomes	Knowledge Level
1	**Distinguish** between different load flow methods.	K4
2	**Build** and **analyze** the Y-bus & Z-bus algorithms.	K4
3	**Analyze** the symmetrical & unsymmetrical faults.	K4
4	**Explore** the Load frequency control and Economic load dispatch.	K4
5	**Explore** the transient stability of the given power system.	K4

SYLLABUS

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 Decoupled Method
5	Load Flow Solution Using Fast Decoupled Method
6	Formation of Z-Bus by Z-bus building algorithm
7	Symmetrical Fault analysis using Z-bus
8	Unsymmetrical Fault analysis using Z-bus
9	Economic Load Dispatch with & without transmission losses
10	Transient Stability Analysis Using Point By Point Method
11	Load Frequency Control of Single Area Control with and without controllers.
12	Load Frequency Control of Two Area Control system with and without controllers.

Reference Books:

1	Power System Analysis by Hadi Saadat, McGraw Hill / PSA Publishing, 3rd Edition, 2010.

2	Modern Power System Analysis by D. P. Kothari & I. J. Nagrath**,** McGraw Hill Education, 4th Edition (2011)
3	Power System Analysis by J. J. Grainger & W. D. Stevenson, McGraw Hill Education, International Edition, 2003.

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2516605	PC	--	1	2	2	40	60	3 Hrs.

POWER SYSTEMS LABORATORY

(for Power Systems & Automation)

Course Objectives: Students will learn about

1	The sequence impedances of alternators and transformers through various experimental methods.
2	The power-angle characteristics of a synchronous machine.
3	The Poly-phase connection of three single phase transformers, measurement of phase displacement and equivalent circuit of 3-winding Transformer.
4	The performance and ABCD parameters of transmission lines.
5	The Ferranti effect and line compensation techniques to understand voltage regulation, power flow and stability.

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

S.No	Outcomes	Knowledge Level
1	**Calculate** the sequence impedances of synchronous machine and transformer	K4
2	**Draw** the power angle characteristics of a synchronous machine.	K4
3	**Explore** the Poly-phase connection of three single phase transformers, measurement of phase displacement and equivalent circuit of 3-winding Transformer.	K3
4	**Analyze** the performance and parameters of transmission lines.	K4
5	**Explore** the Ferranti effect and line compensation techniques.	K3

SYLLABUS

1	Determination of Sequence Impendence of an Alternator by direct method.
2	Determination of Sequence impedance of an Alternator by fault Analysis.
3	Measurement of sequence impedance of a three-phase transformer (a) by application of sequence voltage. (b) using fault analysis.
4	Power angle characteristics of a salient pole Synchronous Machine.
5	Poly-phase connection on three single phase transformers and measurement of phase displacement.
6	Determination of equivalent circuit of 3-winding Transformer.
7	Measurement of ABCD parameters on transmission line model.
8	Performance of long transmission line without compensation.
9	Study of Ferranti effect in long transmission line.
10	Performance of long transmission line with shunt compensation.

Reference Books:	
1	Modern Power System Analysis by I.J. Nagrath & D.P. Kothari, 5th Edition, Tata McGraw Hill publishers, 2010.
2	Power System Protection and Switchgear by Badri Ram & D.N. Vishwakarma,3rd edition, 2022.
3	Power System Analysis by Hadi Saadat, McGraw-Hill,3rd edition,1999

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2516606	**PR**	**--**	**--**	**2**	**1**	**100**	**--**	**3 Hrs.**

SEMINAR-I

A student under the supervision of a faculty member, shall collect the literature on a topic and critically review the literature and submit it to the department in a report form and shall make an oral presentation before the Project Review Committee consisting of Head of the Department, supervisor/mentor and two other senior faculty members of the department. For Seminar, there will be only internal evaluation of 100 marks. A candidate has to secure a minimum of 50% of marks to be declared successful.

Regulation: R25	I - M.Tech. II - Semester

POWER SYSTEMS & AUTOMATION

COURSE STRUCTURE
(With effect from 2025-26 admitted Batch onwards)

Course Code	Course Name	Category	L	T	P	Cr	C.I.E.	S.E.E.	Total Marks
D2526601	Real Time Control of Power Systems	PC	3	1	0	4	40	60	100
D2526602	Restructured Power Systems	PC	3	1	0	4	40	60	100
D2526603	Flexible AC Transmission Systems	PC	3	1	0	4	40	60	100
#PE-III	Program Elective-III	PE	3	0	0	3	40	60	100
#PE-IV	Program Elective-IV	PE	3	0	0	3	40	60	100
D2526604	Power System Simulation Laboratory – II	PC	0	1	2	2	40	60	100
D2526605	Renewable Energy Technologies Laboratory	PC	0	1	2	2	40	60	100
D2526606	Seminar – II	PR	0	0	2	1	100	--	100
		TOTAL	**15**	**5**	**6**	**23**	**380**	**420**	**800**

	Course Code	Course Name
#PE-III	D25266A0	Generation & Measurement of High Voltages
	D25266A1	Evolutionary Algorithms in Power Systems
	D25266A2	Energy Audit Conservation & Management
#PE-IV	D25266B0	Power Quality Enhancement Using Custom Power Devices
	D25266B1	Renewable Energy Technologies
	D25266B2	Battery Management systems and charging stations

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2526601	PC	3	1	--	4	40	60	3 Hrs.

REAL TIME CONTROL OF POWER SYSTEMS

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The principles of state estimation in power systems and the application of Weighted Least Squares (WLS) methods.
2.	The system security and perform contingency evaluations using various techniques.
3.	The need for real-time monitoring and control of power systems and understand the SCADA system structure and functionality.
4.	The voltage stability and voltage collapse phenomena using analytical tools and indices.
5.	The role and functionality of Phasor Measurement Units (PMUs) and their integration with communication systems and control centers.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** different types of state estimation techniques and handle bad data in measurements and assess system observability.	K3
2.	**Analyze** system security and perform contingency analysis for generator and line outages using iterative and fast decoupled power flow models.	K4
3.	**Illustrate** the operating states of power systems and the architecture and function of SCADA systems.	K3
4.	**Analyze** voltage stability using P-V & Q-V curves, long-term voltage stability and collapse scenarios.	K4
5.	**Explore** PMU structure, GPS synchronization, communication options for PMUs and DFT estimation for off-nominal frequency signals.	K3

SYLLABUS

UNIT-I (10Hrs)	**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.
UNIT-II (10 Hrs)	**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.
UNIT-III (10 Hrs)	**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.
UNIT-IV (10 Hrs)	**Voltage Stability:** Definitions of 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.
UNIT-V (10 Hrs)	**Synchro phasor Measurement units:** Introduction, Phasor representation of sinusoids, a generic PMU, GPS, Phasor measurement systems, Communication options for PMUs, Functional requirements of PMUs and PDCs, Phasors for nominal frequency signals, types of frequency excursions in power systems, DFT estimation at off nominal frequency with a nominal frequency clock.
Textbooks:	
1.	John J.Grainger and William D.Stevenson, Jr. : Power System Analysis, McGraw-Hill, 1994, International Edition
2.	Allen J.Wood and Bruce F.Wollenberg : Power Generation operation andcontrol, John Wiley & Sons, 1984.
3.	A.G.Phadka and J.S. Thorp, "Synchronized Phasor Measurements and Their Applications", Springer, 2008
Reference Books:	
1.	R.N.Dhar : Computer Aided Power Systems Operation and Analysis, Tata McGraw Hill, 1982
2.	L.P.Singh : Advanced Power System Analysis and Dynamics, WileyEastern Ltd. 1986
3.	PrabhaKundur : Power System Stability and Control -, McGraw Hill, 1994
4.	P.D.Wasserman : `Neural Computing : Theory and Practice' Van Nostrand -Feinhold, New York
e-Resources	
1.	https://nptel.ac.in/courses/108105133
2.	https://www.nrel.gov/grid/grid-technologies-systems

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2526602	PC	3	1	--	4	40	60	3 Hrs.

RESTRUCTURED POWER SYSTEMS

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The electricity market structures & architecture and evolution of electricity markets under different conditions & policy frameworks.
2.	The different electricity sector ownership and management models.
3.	The market mechanisms such as bilateral trading, power pools, LMP-based markets, and auction-based price formation methods.
4.	The role of transmission networks in deregulated environments and examine concepts like market power, power wheeling, congestion management, and marginal transmission costing.
5.	The ancillary services and system security in deregulated power markets & review of regulatory, technical and economic challenges.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the operation of deregulated electricity market systems	K3
2.	**Explore** the different structures and ownership model/management models in electricity markets	K3
3.	**Analyze** various types of electricity market operational and control issues using new mathematical models.	K4
4.	**Explore** the LMP's wheeling transactions and congestion management.	K3
5.	**Analyze** the impact of ancillary services.	K4

SYLLABUS

UNIT-I (10Hrs)	Need and conditions for deregulation: Introduction of Market structure, Market Architecture, Spot market, forward markets and settlements. Review of Concepts: marginal cost of generation, least-cost operation, incremental cost of generation. Power System Operation.
UNIT-II (10 Hrs)	Electricity sector structures and Ownership /management: the forms of Ownership and management. Different structure models like Monopoly model, Purchasing agency model, wholesale competition model, Retail competition model.
UNIT-III (10 Hrs)	Framework and methods for the analysis of Bilateral and pool markets, LMP based markets, auction models and price formation, price-based unit commitment, country practices.

UNIT-IV (10 Hrs)	Transmission network and market power: Power wheeling transactions and marginal costing, transmission costing. Congestion management methods- market splitting, countertrading; Effect of congestion on LMPs- country practices.
UNIT-V (10 Hrs)	Ancillary Services and System Security in Deregulation: Classifications and definitions, AS management in various markets- country practices. Technical, economic, & regulatory issues involved in the deregulation of the power industry.
Textbooks:	
1.	Power System Economics: Designing markets for electricity - S. Stoft, wiley.
2.	Operation of restructured power systems - K. Bhattacharya, M.H.J. Bollen and J.E. Daalder, Springer.
Reference Books:	
1.	Market operations in electric power systems - M. Shahidehpour, H. Yaminand Z. Li,Wiley.
2.	Fundamentals of power system economics - S. Kirschen and G. Strbac, Wiley.
3.	Optimization principles: Practical Applications to the Operation and Marketsof the Electric
4.	Power Industry - N. S. Rau, IEEE Press series on Power Engineeirng
5.	Competition and Choice in Electricity - Sally Hunt and Graham Shuttleworth
e-Resources	
1.	https://www.youtube.com/watch?v=DGqlq3D_IMY
2.	https://www.youtube.com/watch?v=0j0krEi-4ko

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2526603	**PC**	**3**	**1**	**--**	**4**	**40**	**60**	**3 Hrs.**

FLEXIBLE AC TRANSMISSION SYSTEMS
(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The need for FACTS devices in modern power systems to enhance transmission capability and stability.
2.	The different types of FACTS controllers and their functionality.
3.	The operating principles of shunt and series compensators and their impact on power system operation.
4.	The role of voltage source and current source converters in FACTS applications.
5.	The advanced FACTS devices like UPFC and IPFC for comprehensive control of power flow.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the concept of FACTS and their importance in enhancing power system performance and stability.	K3
2.	**Compare** voltage source converters (VSCs) and current source converters (CSCs) and describe their role in shunt compensation.	K3
3.	**Analyze** the working principles and control strategies of shunt compensators like SVC and STATCOM.	K4
4.	**Explore** the operation of series compensators such as TCSC, TSSC, and GSC in improving power transfer and system stability.	K3
5.	**Illustrate** the operation of UPFC and IPFC and their role in real and reactive power flow control in transmission systems.	K3

SYLLABUS

UNIT-I (10Hrs)	**Introduction**: FACTS concepts, Transmission interconnections, power flow in an AC System, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, benefits from FACTS controllers.
UNIT-II (10 Hrs)	Basic concept of voltage and current source converters, comparison of current source converters with voltage source converters. **Static shunt compensation :** 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 generation, switching converter type VAr generation, hybrid VAr generation.

UNIT-III (10 Hrs)	**SVC and STATCOM:** The regulation slope, transfer function and dynamic performance, transient stability enhancement and power oscillation damping, operating point control and summary of compensation control.
UNIT-IV (10 Hrs)	**Static series compensators:** Concept of series capacitive compensation, improvement of transient 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.
UNIT-V (10 Hrs)	**Unified Power Flow Controller:** Basic operating principle, conventional transmission control capabilities, independent real and reactive power flow control, comparison of the UPFC to series compensators and phase angle regulators. Introduction to Inter line Power Flow Controller (IPFC).
Textbooks:	
1.	Understanding FACTS Devices" N.G.Hingorani and L.Guygi, IEEE Press. Indian Edition is available:--Standard Publications.
Reference Books:	
1.	Sang.Y.HandJohn.A.T, "Flexible AC Transmission systems" IEEE Press (2006).
2.	HVDC & FACTS Controllers: applications of static converters in power systems- Vijay K.Sood- Springer publishers
e-Resources	
1.	https://nptel.ac.in/courses/108107114

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25266A0	PE	3	--	--	3	40	60	3 Hrs.

GENERATION AND MEASUREMENT OF HIGH VOLTAGES

(For Power Systems & Automation)

Course Objectives: Students will learn about

1.	The numerical methods for analyzing electrostatic field problems.
2.	The generation of high DC and AC voltages.
3.	The generation of impulse voltages & currents.
4.	The different methods for measurement of High DC & AC Voltages.
5.	The different methods for measurement of peak voltages, impulse voltages and currents.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the numerical computation techniques for electrostatic problems.	K3
2.	**Illustrate** different methods of generating high DC and AC voltages using electrostatic generators, voltage multipliers, cascaded transformers, and resonant circuits.	K3
3.	**Explore** the principles of impulse voltage and current generation for impulse generators, switching impulses, and high current pulse generation systems.	K3
4.	**Measure** high DC and AC voltages in high voltage systems.	K3
5.	**Explore** different methods and instruments such as sphere gaps, voltage dividers, current transformers, and impulse oscilloscopes to measure peak, impulse voltages, and impulse currents.	K3

SYLLABUS

UNIT-I (10Hrs)	**Electrostatic fields and field stress control**: Electric fields in homogeneous Isotropic materials and in multi dielectric media-Simple configurations-field stress control. Methods of computing electrostatic fields-conductive analogues-Impedance networks Numerical techniques-finite difference method-finite element method and charge simulation method.
UNIT-II (10 Hrs)	**Generation of High AC & DC Voltages:** **DC Voltages:** AC to DC conversion methods, electrostatic generators, Cascaded Voltage Multipliers. **AC Voltages:** Cascading transformers-Resonant circuits and their applications, Tesla coil.
UNIT-III (10 Hrs)	**Generation of Impulse Voltages:** Impulse voltage specifications-Impulse generation circuits-Operation, construction and design of Impulse generators-Generation of switching and long duration impulses.

	Impulse Currents: Generation of high impulse currents and high current pulses.
UNIT-IV (10 Hrs)	**Measurement of High DC & AC Voltages :** Measurement of High D.C. Voltages: Series resistance meters, voltage dividers and generating voltmeters. Measurement of High A.C. Voltages: Series impedance meters electrostatic voltmeters potential transformers and CVTS-voltage dividers and their applications.
UNIT-V (10 Hrs)	**Measurement of Peak Voltages :** Sphere gaps, uniform field gaps, rod gaps. Chubb-Fortesque method, passive and active rectifier circuits for voltage dividers. Measurement of Impulse Voltages: Voltage dividers and impulse measuring systems-generalized voltage measuring circuits-transfer characteristics of measuring circuits-L.V. Arms for voltage dividers-compensated dividers. Measurement of Impulse Currents: Resistive shunts-current transformers-Hall Generators and Faraday generators and their applications-Impulse Oscilloscopes.

Textbooks:	
1.	High Voltage Engineering – by E.Kuffel and W.S.Zaengl. Pergaman press Oxford, 1984.
2.	High Voltage Engineering – by M.S.Naidu and V.Kamaraju, Mc.Graw-Hill Books Co., New Delhi, 2nd edition, 1995.
Reference Books:	
1.	High Voltage Technology – LL Alston, Oxford University Press 1968.
2.	High Voltage Measuring Techniques – A. Schwab MIT Press, Cambridge, USA, 1972.
3.	Relevant I.S. and IEC Specifications.
e-Resources	
1.	https://nptel.ac.in/courses/108108099

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25266A1	PE	3	--	--	3	40	60	3 Hrs.

EVOLUTIONARY ALGORITHMS IN POWER SYSTEMS

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	Conventional optimization algorithms and evolutionary optimization algorithms.
2.	Genetic algorithm and particle swarm optimization algorithm to power system.
3.	Ant colony optimization algorithm and artificial Bee colony algorithm to optimize the control parameters of power system.
4.	Shuffled frog leaping algorithm and bat optimization algorithm to power system.
5.	Multi-objective optimization algorithm to power system

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

S.No	Outcomes	Knowledge Level
1.	Classify and formulate different types of optimization problems and identify suitable soft computing techniques to solve them.	K4
2.	Explore Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) for solving Economic Load Dispatch (ELD), harmonic elimination and controller tuning.	K4
3.	Apply and analyze Ant Colony Optimization (ACO) and Artificial Bee Colony (ABC) algorithms in real-time optimization scenarios.	K4
4.	Evaluate and compare the performance of Bat Algorithm (BA) and Shuffled Frog-Leaping Algorithm (SFLA) for control and optimization applications.	K4
5.	Solve multi-objective problems using Pareto optimality concepts and the NSGA-II algorithm to derive trade-off solutions among conflicting objectives.	K4

SYLLABUS

UNIT-I (10Hrs)	**Fundamentals of Soft Computing Techniques** Definition-Classification of optimization problems- Unconstrained and Constrained Optimization, Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Single solution based and population based algorithms – Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.
UNIT-II (10 Hrs)	**Genetic Algorithm and Particle Swarm Optimization** Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of

	crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters – GA and PSO algorithms for solving ELD problem without loss, Selective Harmonic Elimination in inverters and PI controller tuning
UNIT-III (10 Hrs)	**Ant Colony Optimization and Artificial Bee Colony Algorithms** Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating- local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system-max min ant system - Concept of Elitist Ants-Task partitioning in honeybees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms – ACO and ABC algorithms for solving Economic Dispatch without loss and PI controller tuning.
UNIT-IV (10 Hrs)	**Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm** Bat Algorithm- Echolocation of bats- Behaviour of microbats- Acoustics of Echolocation- Movement of Virtual Bats- Loudness and Pulse Emission- Shuffled frog algorithm-virtual population of frogs comparison of memes and genes -memeplex formation- memeplex updation- BA and SFLA algorithms for solving ELD without loss and PI controller tuning.
UNIT-V (10 Hrs)	**Multi Objective Optimization** Multi-Objective optimization Introduction- Concept of Pareto optimality - Non-dominant sorting technique- Pareto fronts-best compromise solution-min-max method-NSGA-II algorithm and application to general two objective optimization problem.

Textbooks:	
1.	Xin-She Yang, „Recent Advances in Swarm Intelligence and Evolutionary Computation‟, Springer International Publishing, Switzerland, 2015.
2.	Kalyanmoy Deb „Multi-Objective Optimization using Evolutionary Algorithms‟, John Wiley & Sons, 2001.
3.	James Kennedy and Russel E Eberheart, „Swarm Intelligence‟, The Morgan Kaufmann Series in Evolutionary Computation, 2001.
Reference Books:	
1.	Eric Bonabeau, Marco Dorigo and Guy Theraulaz, „Swarm Intelligence-From natural to Artificial Systems‟, Oxford university Press, 1999.
2.	David Goldberg, „Genetic Algorithms in Search, Optimization and Machine Learning‟, Pearson Education, 2007.
3.	Konstantinos E. Parsopoulos and Michael N. Vrahatis, „Particle Swarm Optimization and Intelligence: Advances and Applications‟, InformatIonscIence reference, IGI Global, , 2010.
4.	N P Padhy, „Artificial Intelligence and Intelligent Systems‟, Oxford University Press, 2005.
e-Resources	
1.	"Shuffled frog-leaping algorithm: a memetic meta-heuristic for discrete optimization" by Muzaffareusuff, Kevin lansey and Fayzul pasha, Engineering Optimization, Taylor & Francis,

	Vol. 38, No. pp.129–154, March 2006.
2.	“A New Metaheuristic Bat-Inspired Algorithm” by Xin-She Yang, Nature Inspired Cooperative Strategies for Optimization (NISCO 2010) (Eds. J. R. Gonzalez et al.), Studies in Computational Intelligence, Springer Berlin, 284, Springer, 65-74 (2010).
3.	“Firefly Algorithms for Multimodal Optimization” Xin-She Yang, O. Watanabe and T. Zeugmann (Eds.), Springer-Verlag Berlin Heidelberg, pp. 169–178, 2009.
4.	https://nptel.ac.in/courses/112103301

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25266A2	PE	3	--	--	3	40	60	3 Hrs.

ENERGY AUDIT CONSERVATION & MANAGEMENT
(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The basics of energy audit and energy conservation schemes.
2.	The principles of energy management
3.	The need of energy efficient motors and lighting design practices.
4.	The power factor improvement techniques and energy instruments.
5.	The economic aspects of energy equipment.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the principle of energy audit and their economic aspects.	K3
2.	**Explore** the principles of energy management	K3
3.	**Illustrate** energy efficient motors and design good lighting system.	K3
4.	**Illustrate** the advantages of improving the power factor in an electrical system.	K3
5.	**Apply** different methods of depreciation and the time value of money to evaluate engineering economics problems.	K3

SYLLABUS

UNIT-I (10Hrs)	**Basic Principles of Energy Audit** Energy audit- definitions, concept , types of audit, energy index, cost index, pie charts, Sankey diagrams and load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.
UNIT-II (10 Hrs)	**Energy Management** Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting. Energy manager, qualities and functions, language, Questionnaire – check list for top management.
UNIT-III (10 Hrs)	**Energy Efficient Motors and Lighting** Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics – variable speed , variable duty cycle systems, RMS - voltage variation-voltage unbalance-over motoring-motor energy audit. lighting system design and practice, lighting control, lighting energy audit.

UNIT-IV (10 Hrs)	**Power Factor Improvement and energy instruments** Power factor – methods of improvement, location of capacitors, Power factor with non-linear loads, effect of harmonics on p.f, p.f motor controllers – Energy Instruments- watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's.
UNIT-V (10 Hrs)	**Economic Aspects and their computation** Economics Analysis depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, lifecycle costing analysis – Energy efficient motors. Calculation of simple payback method, net present value method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment.

Textbooks:

1.	Energy management by W.R.Murphy &G.Mckay Butter worth, Heinemann publications, 1982.
2.	Energy management hand book by W.CTurner, John Wiley and sons, 1982.

Reference Books:

1.	Energy efficient electric motors by John.C.Andreas, Marcel Dekker Inc Ltd-2nd edition,1995
2.	Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
3.	Energy management and good lighting practice : fuel efficiency- booklet12-EEO

e-Resources

1.	https://nptel.ac.in/courses/112105221

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25266B0	PE	3	--	--	3	40	60	3 Hrs.

POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The significance of power quality and power quality parameters.
2.	The types of transient over voltages and protection of transient voltages.
3.	The harmonics, their effects, harmonic indices and harmonic minimization techniques.
4.	The importance of custom power devices and their applications.
5.	The different compensation techniques to minimize power quality disturbances.

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

S.No	Outcomes	Knowledge Level
1.	**Identify** the issues related to power quality in power systems.	K3
2.	**Explore** the problems of transient and long duration voltage variations in power systems.	K3
3.	**Analyze** the effects of harmonics and study of different mitigation techniques.	K4
4.	**Illustrate** the importance of custom power devices and their applications.	K3
5.	**Illustrate** the different compensation techniques to minimize power quality disturbances.	K3

SYLLABUS

UNIT-I (10Hrs)	**Introduction to power quality:** Overview of Power Quality, Concern about the Power Quality, General Classes of Power Quality Problems, Voltage Unbalance, Waveform Distortion, Voltage fluctuation, Power Frequency Variations, Power Quality Terms, Voltage Sags, swells, flicker and Interruptions - Sources of voltage and current interruptions, Nonlinear loads.
UNIT-II (10 Hrs)	**Transient and Long Duration Voltage Variations:** Source of Transient Over Voltages - Principles of Over Voltage Protection, Devices for Over Voltage Protection, Utility Capacitor Switching Transients, Utility Lightning Protection, Load Switching Transient Problems. 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 generation
UNIT-III (10 Hrs)	**Harmonic Distortion and solutions:** Voltage vs. Current Distortion, Harmonics vs. Transients - Power System Quantities under Non-sinusoidal Conditions, Harmonic

	Indices, Sources of harmonics, Locating Sources of Harmonics, System Response Characteristics, Effects of Harmonic Distortion, Inter harmonics, Harmonic Solutions Harmonic Distortion Evaluation, Devices for Controlling Harmonic Distortion, Harmonic Filter Design, Standards on Harmonics
UNIT-IV (10 Hrs)	**Custom Power Devices:** Custom power and custom power devices, voltage source inverters, reactive power and harmonic compensation devices, compensation of voltage interruptions and current interruptions, static series and shunt compensators, compensation in distribution systems, interaction with distribution equipment, installation considerations.
UNIT-V (10 Hrs)	**Application of custom power devices in power systems:** Static and hybrid Source Transfer Switches, Solid state current limiter - Solid state breaker. P-Q theory – Control of P and Q, Dynamic Voltage Restorer (DVR), Operation and control of Interline Power Flow Controller (IPFC), Operation and control of Unified Power Quality Conditioner (UPQC), Generalized power quality conditioner.
Textbooks:	
1.	Power Quality Enhancement Using Custom Power Devices – Power Electronics and Power Systems, Gerard Ledwich, Arindam Ghosh, Kluwer Academic Publishers, 2002.
2.	Guidebook on Custom Power Devices, Technical Report, Published by EPRI, Nov 2000.
Reference Books:	
1.	Power System Harmonics, Arrillaga J and Watson N R, Second Edition, John Wiley & Sons, 2003.
2.	Electric Power Quality Control Techniques, W. E. Kazibwe and M. H. Sendaula, Van Nostrad Reinhold, New York.
3.	Custom Power Devices - An Introduction, Arindam Ghosh and Gerard Ledwich, Springer, 2002.
e-Resources	
1.	https://onlinecourses.nptel.ac.in/noc21_ee103/preview
2.	https://onlinecourses.nptel.ac.in/noc24_ee34/preview

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25266B1	**PE**	**3**	**--**	**--**	**3**	**40**	**60**	**3 Hrs.**

RENEWABLE ENERGY TECHNOLOGIES

(for Power Systems & Automation)

Course Objectives: Students will learn about

1.	The economic aspects, demand & supply- side management strategies and control of renewable energy Systems.
2.	The induction generator operation and analyze their performance under steady-state, self-excited, interconnected and stand-alone modes.
3.	The site selection criteria of wind power plant, classification of wind turbines, control methods and analysis of wind energy conversion system.
4.	The principles of photovoltaic (PV) energy conversion, modeling, Maximum Power Point Tracking (MPPT) control & economic aspects.
5.	The principle & performance of different types of fuel cells, manufacturing issues and hydrogen storage aspects.

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

S.No	Outcomes	Knowledge Level
1.	**Apply** cost analysis methods and **analyze** demand-side, supply-side & control strategies for renewable energy–based power systems.	K4
2.	**Illustrate** the induction generator operation and **analyze** their excitation process, power characteristics & control strategies in different operating modes.	K4
3.	**Explore** site selection criteria of wind power plant, classification of wind turbines, control methods and analysis of wind energy conversion system.	K4
4.	**Apply** MPPT schemes in solar power generation and **analyze** the effects of temperature, irradiance, partial shading on photovoltaic power plant performance & its applications and economic factors.	K4
5.	**Illustrate** fuel cell operation, equivalent circuit modeling & parameter estimation and hydrogen storage aspects.	K3

SYLLABUS

UNIT-I (10Hrs)	**Introduction:** Renewable Sources of Energy; Distributed Generation; Renewable Energy Economics - Calculation of Electricity Generation Costs; Demand-Side Management Options; Supply-Side Management Options; Control of renewable energy-based power Systems.
UNIT-II (10 Hrs)	**Induction Generators:** Principles of Operation; Representation of Steady-State Operation; Power and Losses Generated; Self-Excited Induction Generator; Magnetizing Curves and Self-Excitation; Mathematical Description of the Self-Excitation Process; Interconnected and Stand-alone operation; Speed and Voltage Control.

UNIT-III (10 Hrs)	**Wind Power Plants:** Site Selection - Evaluation of Wind Intensity, Topography, Purpose of the Energy Generation; General Classification of Wind Turbines - Rotor Turbines, Multiple-Blade Turbines, Drag Turbines, Lifting Turbines; Generators and Speed Control Used in Wind Power Energy; Analysis of Small wind energy conversion system.
UNIT-IV (10 Hrs)	**Photovoltaic Power Plants:** Solar Energy; Generation of Electricity by Photovoltaic Effect; Dependence of a PV Cell on Temperature and irradiance; input-output Characteristics; Equivalent Models and Parameters for Photovoltaic Panels; MPPT schemes: P&O, INC; effect of partial shaded condition. Applications of Photovoltaic Solar Energy; Economical Analysis of Solar Energy.
UNIT-V (10 Hrs)	**Fuel Cells:** The Fuel Cell; Low and High Temperature Fuel Cells; Commercial and Manufacturing Issues; Constructional Features of Proton Exchange Membrane Fuel Cells; Reformers, Electrolyzer Systems; Advantages and Disadvantages of Fuel Cells; Fuel Cell Equivalent Circuit; Practical Determination of the Equivalent Model Parameters; Aspects of Hydrogen for storage.
Textbooks:	
1.	Felix A. Farret, M. Godoy Simoes, Integration of Alternative Sources of Energy, John Wiley & Sons, 2006.
2.	Remus Teodorescu, Marco Liserre, Pedro Rodríguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.
Reference Books:	
1.	Gilbert M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004.
e-Resources	
1.	nptel.ac.in/courses/121106014
2.	nptel.ac.in/courses/112106318

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D25266B2	PE	3	--	--	3	40	60	3 Hrs.

BATTERY MANAGEMENT SYSTEMS AND CHARGING STATIONS

(for Power Systems & Automation)

Course Objectives: Students Will learn about

1.	The fundamental types, characteristics, and chemistry of various EV batteries including lead-acid, nickel-based, sodium-based, and lithium-ion batteries.
2.	The diverse battery charging algorithms and balancing techniques to safely and efficiently manage battery pack charging under different operational conditions
3.	The diverse Charging Infrastructures for domestic and public EV charging.
4	The design and functional requirements of battery management systems, sensing, control elements and communication techniques.
5	The General approach to modelling batteries and simulation model of Li-ion & NiCd batteries with their Parameterization.

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

S.No	Outcomes	Knowledge Level
1.	**Explore** the types, characteristics, and performance parameters of various EV batteries including lead-acid, nickel-based, sodium-based, and lithium-ion systems.	K3
2.	**Explore** diverse battery charging algorithms and balancing techniques to safely and efficiently manage battery pack charging under different operational conditions.	K3
3.	**Illustrate** domestic and public EV charging infrastructures, including normal, fast, and battery swapping stations, for practical deployment in electric mobility systems.	K3
4.	**Explore** the functional requirements of battery management systems with emphasis on sensing, control, protection, communication, and diagnostics to ensure reliable battery operation.	K3
5.	**Develop** the battery simulation models for Li-ion and NiCd batteries to predict performance metrics such as SOC, SOH, and power capability.	K3

SYLLABUS

UNIT-I (10Hrs)	EV Batteries: Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel. Lead Acid Batteries: Lead acid battery basics, special characteristics of lead acid batteries, battery life and maintenance, Li-ion batteries. Nickel-based Batteries: Nickel cadmium, Nickel metal hydride batteries. Sodium-Based Batteries: Introduction, sodium sulphur batteries, sodium metal chloride (Zebra) batteries. Lithium Batteries: Introduction, the lithium polymer battery, lithium ion battery.

UNIT-II (10 Hrs)	**Battery charging strategies:** Charging algorithms for a single battery: Basic terms for charging performance evaluation and characterization, CC charging for NiCd/NiMH batteries, CV charging for lead acid batteries, CC/CV charging for lead acid and Li-ion batteries, MSCC charging for lead acid, NiMH and Li- ion batteries, TSCC/CV charging for Li-ion batteries, CVCC/CV charging for Li-ion batteries, Pulse charging for lead acid, NiCd/NiMH and Li-ion batteries, Charging termination techniques, Comparisons of charging algorithms and new development; Balancing methods for battery pack charging: Battery sorting Overcharge for balancing, Passive balancing, Active balancing.
UNIT-III (10 Hrs)	**Charging Infrastructure:** Domestic Charging Infrastructure, Public charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.
UNIT-IV (10 Hrs)	**Battery-Management-System Requirements:** Battery-pack topology, BMS design requirements, Voltage sense, Temperature sense, Current sense, Contactor control, Isolation sense, Thermal control, Protection, Charger control, Communication via CAN bus, Log book, SOC estimation, Energy estimation, Power estimation, Diagnostics .
UNIT-V (10 Hrs)	**Battery Modelling:** General approach to modelling batteries, simulation model of rechargeable Li-ion battery, simulation model of a rechargeable NiCd battery, Parameterization of NiCd battery model, Simulation examples.
Textbooks:	
1.	Electric Vehicles Technology Explained by James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., Uk. (Unit-1).
2.	Energy Systems for Electric and Hybrid Vehicles by K.T. Chau, IET Publications, First edition, 2016. (Unit-2).
Reference Books:	
1.	Modern Electric Vehicles Technology by C.C.Chan, K.T Chau, Oxford University Press Inc., New york , 2001. (Unit-3).
2.	Battery Management Systems Vol. – II Equivalent Circuits and Methods, by Gregory L.Plett, Artech House publisher, First edition 2016. (Unit-4).
3.	Battery Management Systems: Design by Modelling by Henk Jan Bergveld, Wanda S. Kruijt, Springer Science & Business Media, 2002. (Unit-5).
e-Resources	
1.	https://onlinecourses.nptel.ac.in/noc25_ee134/preview?
2.	https://onlinecourses.nptel.ac.in/noc20_ee99/preview
3	https://nptel.ac.in/courses/108106170?

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2526604	PC	--	1	2	2	40	60	3 Hrs.

POWER SYSTEM SIMULATION LABORATORY-II
(for Power Systems & Automation)

Course Objectives: Students will learn about

1	The advanced analytical and computational approaches to evaluate and enhance the stability of multi-machine power systems.
2	The optimal power flow techniques to improve system efficiency and analyze unit commitment strategies for cost-effective power generation.
3	The load flow studies and assess contingency scenarios to ensure the reliability and resilience of power systems.
4	The state estimation techniques and power quality improvement strategies to maintain system reliability and performance.
5	The stability of Single Machine Infinite Bus (SMIB) systems under different conditions, with and without controllers, to improve system dynamics.

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

S.No	Outcomes	Knowledge Level
1	**Analyze** the multi machine stability by advanced approaches.	K4
2	**Calculate** optimal power flows and analyze unit commitment by optimal methods.	K4
3	**Analyze** the load flow and contingency cases of power systems	K4
4	**Analyze** the state estimations and power quality improvements	K4
5	**Analyze** the stability of SMIB with and without controllers	K4

SYLLABUS

1	Multi Machine Transient stability using modified Euler's method.
2	Multi Machine Transient stability using R-K 2nd order method.
3	Optimal Power Flow using Newton's method.
4	Unit Commitment using dynamic programming.
5	Optimal Power Flow using Genetic Algorithm.
6	Distribution system load flow solution using Forward-Backward sweep Method.
7	Contingency analysis of a Power System
8	State estimation of a power system using Weighted Least Squares Error Method
9	Stability Analysis of SMIB using State space approach without PSS controller
10	Stability Analysis of SMIB using State space approach with PSS controller
11	Power Quality improvement using D-STATCOM

Reference Books:	
1	Power System Dynamics: Stability and Control by K. R. Padiyar, BS Publications, 2nd Edition, 2008.
2	Power System Analysis and Design J. Duncan Glover, Thomas J. Overbye & Mulukutla S. Sarma, Cengage Learning, 6th Edition, 2017.
3	Power System Analysis by Hadi Saadat, McGraw Hill / PSA Publishing, 3rd Edition, 2010.

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2526605	**PC**	**--**	**1**	**2**	**2**	**40**	**60**	**3 Hrs.**

RENEWABLE ENERGY TECHNOLOGIES LABORATORY

(for Power Systems & Automation)

Course Objectives: Students will learn about

1	The Solar energy extraction, Photovoltaic (PV) panels and connections through simulation and experiments.
2	The characteristics of PV Modules through simulation and experiments.
3	The Partial shading effect on PV Array and maximum power extraction through simulation and experiments.
4	The Performance characteristics of wind energy systems through simulation and experiments.
5	The Wind energy systems and observe real-time operational effects.

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

S.No	Outcomes	Knowledge Level
1	**Illustrate** PV Panel specifications and modelling of solar power systems.	K4
2	**Analyze** the performance Characteristics of a PV Modules through simulation and experiments.	K4
3	**Illustrate** partial shading effect on PV Modules, maximum power extraction algorithms through simulation and experiments.	K4
4	**Analyze** performance characteristics of wind energy systems through simulation and experiments.	K4
5	**Analyze** the model of Uninterrupted Power Supply and wind turbine real time operational effects.	K4

SYLLABUS

	PART A
1	Simulate the Mathematical Model of a PV cell using Single Diode model and Two Diode model equivalent circuits.
2	Simulate the performance curves (I-V & P-V) of a Solar cell and their variation with change in temperature and irradiation.
3	Simulate the performance curves (I-V & P-V) for PV modules connect in series and their variation with temperature and irradiation.
4	Simulate the performance curves (I-V & P-V) for PV modules connect in parallel and their variation with temperature and irradiation.
5	Simulate the performance curves (I-V & P-V) for the effect of varying the series resistance on the fill factor of the PV cell.
6	Simulate the Buck-Boost Converter with Closed Loop control.

7	Simulate the Maximum Power Point tracking of PV module using INC Algorithm.
8	Simulate the Maximum Power Point tracking of PV module using P & O Algorithm.
9	Simulate the Wind Power Plant model.
10	Simulate the Uninterrupted Power Supply model.
	PART B
11	Single PV module I-V and P-V characteristics with radiation and temperature changing effect.
12	I-V and P-V characteristics with series and parallel combination of modules.
13	Effect of shading on PV Module.
14	Effect of tilt angle on PV Module.
15	Demonstration of bypass and blocking diode on a PV Module.
16	Evaluation of Tip Speed Ratio (TSR) at different wind speeds.
17	Evaluation of Coefficient of performance of wind turbine.
18	Characteristics of turbine (power variation) with wind speed.
19	Power curve of turbine with respect to the rotational speed of rotor at fix wind speeds.
20	Power analysis at turbine output with AC load for a Wind Energy System.
Reference Books:	
1	Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications" PHI Publication, 3rd edition.
2	G. D. Rai, "Non-Conventional Energy Sources", 5th edition, Khanna Publishers, 2015.
3	Mukund R Patel "Wind and Solar Power Systems: Design, Analysis, and Operation ", 3rd Edition

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2526606	**PR**	**--**	**--**	**2**	**1**	**100**	**--**	**3 Hrs.**

SEMINAR-II

A student under the supervision of a faculty member, shall collect the literature on a topic and critically review the literature and submit it to the department in a report form and shall make an oral presentation before the Project Review Committee consisting of Head of the Department, supervisor/mentor and two other senior faculty members of the department. For Seminar, there will be only internal evaluation of 100 marks. A candidate has to secure a minimum of 50% of marks to be declared successful

Regulation: R25	II - M.Tech. I - Semester								
POWER SYSTEMS & AUTOMATION									
COURSE STRUCTURE (With effect from 2025-26 admitted Batch onwards)									
Course Code	**Course Name**	**Category**	**L**	**T**	**P**	**Cr**	**C.I.E.**	**S.E.E.**	**Total Marks**
D2536601	Research Methodology and IPR / Swayam 12 week MOOC course – RM&IPR		3	0	0	3	40	60	100
D2536602	Summer Internship/ Industrial Training (8-10 weeks)*	PR	--	--	--	3	100	--	100
D2536603	Comprehensive Viva#	PR	--	--	--	2	100	--	100
D2536604	Dissertation Part – A$	PR	--	--	20	10	100	--	100
		TOTAL	**3**	**-**	**20**	**18**	**340**	**60**	**400**

* Student attended during summer / year break and assessment will be done in 3rd Sem.

Comprehensive viva can be conducted courses completed upto second sem.

$ Dissertation – Part A, internal assessment

Course Code	Category	L	T	P	C	CIE	SEE	Exam
D2536601	**PC**	**3**	**--**	**--**	**3**	**40**	**60**	**3 Hrs.**

RESEARCH METHODOLOGY AND IPR
(for Power Systems & Automation)

Course Objectives:

1.	To bring awareness on Research Methodology and research ethics.
2.	Familiarize the concepts of IPR.

Course Outcomes:

S.No	Course Outcome	Knowledge Level
1.	Identify the research problem through effective literature review and data analysis	**K3**
2.	Develop a technical paper with essential sections	**K3**
3.	Choose the patents, trade, and copyrights for protecting intellectual creations	**K3**
4.	Identify patents rights and transfer of technology	**K3**
5.	Identify appropriate IPR mechanism for protecting various types of intellectual creations.	**K3**

SYLLABUS

UNIT-I (10Hrs)	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations
UNIT-II (12Hrs)	Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee
UNIT-III (12Hrs)	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.
UNIT-IV (12Hrs)	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.
UNIT-V (12Hrs)	New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies,

	IPR and IITs.
Textbooks:	
1.	Stuart Melville and Wayne Goddard, —Research methodology: an introduction for science & engineering students'
2.	Wayne Goddard and Stuart Melville, —Research Methodology: An Introduction
3.	Ranjit Kumar, 2nd Edition, —Research Methodology: A Step by Step Guide for beginners
Reference Books:	
1.	Halbert, —Resisting Intellectual Property‖, Taylor & Francis Ltd, 2007.
2.	Mayall, —Industrial Design‖, McGraw Hill, 1992.
3.	Niebel, —Product Design‖, McGraw Hill, 1974.
4.	Asimov, —Introduction to Design‖, Prentice Hall, 1962
5.	Robert P. Merges, Peter S. Menell, Mark A. Lemley, — Intellectual Property in New Technological Age, 2016.
6.	T. Ramappa, —Intellectual Property Rights Under WTO‖, S. Chand, 2008

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2536602	PR	--	--	--	3	100	--	3 Hrs.
Summer Internship/ Industrial Training (8-10 weeks)*								
Students shall undergo mandatory summer internship / industrial training for a minimum of eight weeks duration at the end of second semester of the Programme/Summer Break. A student will be required to submit a summer internship/industrial training report to the concerned department and appear for an oral presentation before the committee. The Committee comprises of a Professor of the department and two faculty. The report and the oral presentation shall carry 40% and 60% weightages respectively. For summer internship / industrial training, there will be only internal evaluation of 100 marks. A candidate has to secure a minimum of 50% of marks to be declared successful.								

Student attended during summer / year break and assessment will be done in 3rd Sem

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2536603	PR	--	--	--	2	100	--	3 Hrs.
Comprehensive Viva								
The objective of comprehensive viva-voce is to assess the overall knowledge of the student in the relevant field of Engineering/Specialization in the PG program. Viva will be conducted in 3rd semester. The duration of the viva will be around 30 min. The examination committee will be constituted by the HoD and consist of Professor of the department and two faculty. For comprehensive viva-voce, there will be only internal evaluation of 100 marks. A candidate has to secure a minimum of 50% of marks to be declared successful.								

Comprehensive viva can be conducted courses completed up to second sem.

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2536604	**PR**	**--**	**--**	**20**	**10**	**100**	**--**	**3 Hrs.**

Dissertation Part – A

The Student has to register for Dissertation-I / Industrial project in III semester. Student has to submit, in consultation with his project supervisor, the title, objective and plan of action of his project work for approval. The student can initiate the Project work, only after obtaining the approval from the Project Review Committee (PRC).

Continuous assessment of Dissertation-I during the III-Semester will be monitored by the PRC.

Dissertation-Part A will be only internal evaluation by PRC for 100 marks. A candidate has to secure a minimum of 50% of marks to be declared successful.

The candidate shall submit a status report to the PRC in two stages, each accompanied by an oral presentation, with a minimum interval of three months between the two

Dissertation – Part A, internal assessment

Regulation: R25	II - M.Tech. II - Semester								
POWER SYSTEMS & AUTOMATION									
COURSE STRUCTURE (With effect from 2025-26 admitted Batch onwards)									
Course Code	**Course Name**	**Category**	**L**	**T**	**P**	**Cr**	**C.I.E.**	**S.E.E.**	**Total Marks**
D2546601	Dissertation Part – B%	PR	--	--	32	16	--	100	100
		TOTAL	**--**	**--**	**32**	**16**	**--**	**100**	**100**

% External Assessment

Course Code	Category	L	T	P	C	C.I.E.	S.E.E.	Exam
D2546601	PR	--	--	32	16	--	100	3 Hrs.

Dissertation Part – B

The student has to continue his/her work from Dissertation Part-A to complete Dissertation Part-B in IV semester.

Continuous assessment of Dissertation Part-B during IV-Semester will be monitored by the PRC.

Dissertation Part-B is evaluated for 100 external marks based on Review and Viva Voce.

Review and Viva-Voce examination shall be conducted by a board consisting of the Supervisor, Head of the Department and the examiner who adjudicated the Thesis. The Board shall jointly report the candidate's work for 100 marks.

If the report of the Viva-Voce is unsatisfactory (ie, < 50 marks), the candidate shall retake the Viva-Voce examination only after three months. If he fails to get a satisfactory report at the second Viva-Voce examination, the candidate has to reregister for the project and complete the project within the stipulated time after taking the approval from the College.