ACADEMIC REGULATIONS
COURSE STRUCTURE
AND
DETAILED SYLLABUS

ELECTRICAL AND ELECTRONICS ENGINEERING

for

M.Tech. – Advanced Electrical Power Systems

(Applicable from 2019-2020 Batches)

UNIVERSITY COLLEGE OF ENGINEERING KAKINADA *(Autonomous)*

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA

KAKINADA - 533 003, ANDHRA PRADESH, INDIA

Vision and Mission of the Institute:

Vision:

To be a premier institute of excellence developing highly talented holistic human capital that contributes to the nation through leadership in technology and innovation through engineering education.

Mission:

1. To impart Personnel Skills and Ethical Values for Sustainable Development of the Nation.
2. To create Research & Industry oriented centers of excellence in all engineering disciplines.
3. To be a renowned IPR generator and repository for innovative technologies.
4. To develop Research and Industry oriented technical talent.
5. To benchmark globally the academic & research output.

Vision and Mission of the Department:

Vision:

To be in the forefront in advanced research in emerging areas of Electrical & Electronics Engineering, be proactive with industry in technology development and mould the department into a centre of academic excellence.

Mission:

1. To produce high quality Electrical and Electronics Engineering graduates with the requisite theoretical and practical knowledge.

2. To undertake research & development and extension activities in the field of Electrical and Electronics Engineering in the area of relevance for immediate application as well as for establishing and strengthening the fundamental knowledge.

3. To create social awareness and ethical values in the graduates so as to contribute in the progress of the society.

Programme Education Objectives (PEOs):

PEO1:	To enable the students to learn primarily the concepts on electrical power transmission, utility, operation and control under the context of electrical power system engineering.
PEO2:	To enable the students to learn primarily the concepts on electrical power transmission, utility, operation and control under the context of electrical power system engineering.
PEO3:	To inculcate leadership and entrepreneur skills so as to enable the students to work in a collaborative and interdisciplinary environment.
PEO4:	To become socially and ethically responsible and pursue life-long learning.

Mapping of Mission statements to PEOs:

Mission of the Department	**Programme Education Objectives (PEOs)**			
	PEO1	**PEO2**	**PEO3**	**PEO4**
To produce high quality Electrical and Electronics Engineering graduates with the requisite theoretical and practical knowledge.				
To undertake research & development and extension activities in the field of Electrical and Electronics Engineering in the area of relevance for immediate application as well as for establishing and strengthening the fundamental knowledge.				
To create social awareness and ethical values in the graduates so as to contribute in the progress of the society.				

Rubrics:

L-Low**, M-**Medium**, H-**High

Programme Outcomes (POs):AEPS

PO1:	The graduate will be able to acquire in depth knowledge in the area of power system engineering.
PO2:	The graduate will attain the lateral thinking and problem solving capabilities in the area of power systems.
PO3:	The graduate will obtain the capabilities of critical thinking, analyzing real world problems and handling the complexities to arrive feasible and optimal solutions considering societal and environmental factors.
PO4:	The graduate will be able to extract information through literature survey and apply appropriate research methodologies, techniques and tools to solve power system problems.
PO5:	The graduate will be able to use the state-of-the-art tools for modelling, simulation and analysis of problems related to power systems.
PO6:	The graduate will be trained to assess social, health, safety, legal, cultural issues and She/he will also be trained on the consequent responsibilities relevant to the professional engineering practices.
PO7:	To sensitize the graduate about the impact of professional engineering solutions in social and environmental contents and demonstrates the knowledge of, and need for sustainable developments.
PO8:	The graduate will become socially responsible and follow ethical practices to contribute to the community for sustainable development of society.
PO9:	The graduate will be able to independently observe and examine critically the outcomes of his actions and reflect on to make corrective measures subsequently and move forward positively by learning through mistakes.
PO10:	The graduate will be able to communicate confidently, make effective presentations and write good reports to engineering community and society.
PO11:	The graduate will demonstrate knowledge and understanding of power system engineering and management principles and apply the same for efficiently carrying out projects with due consideration to economical and financial factors.
PO12:	The graduate will recognize the need for life-long learning and have the ability to do it independently.

Programme Specific Outcomes (PSOs):

PSO1:	Able to apply the knowledge during the course of the program from basic computing and social science in general and all electrical courses in particular to identify, formulate and solve real life problems faced in industries and/or during research work.
PSO2:	Development of environment-conscious, new technologies to enhance the quality of human life.

Mapping of POs, PSOs to PEOs

Programme Outcomes (PO's)	Programme Education Objectives (PEOs)			
	PEO1	PEO2	PEO3	PEO4
PO1				
PO2				
PO3				
PO4				
PO5				
PO6				
PO7				
PO8				
PO9				
PO10				
PO11				
PO12				

Programme Specific Outcomes (PSOs)	Programme Education Objectives (PEOs)			
	PEO1	PEO2	PEO3	PEO4
PSO1				
PSO2				

Rubrics:

L-Low**, M-**Medium**, H-**High

COURSE STRUCTURE

I Semester

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1	PC	Power System Operation & Control			3	0	0	3	100
2	PC	Renewable Energy Technologies			3	0	0	3	100
3	PE	Program Elective – I i. Electrical Distribution Automation ii. Analysis of Power Electronic Converters iii. Artificial Intelligent Techniques iv. Power Quality and Custom Power Devices			3	0	0	3	100
4	PE	Program Elective – II i. HVDC Transmission ii Generation & Measurement of High Voltages iii. Advanced Power Systems Protection iv. Power System Reliability			3	0	0	3	100
5		Research Methodology and IPR			2	0	0	2	100
6		Power System Simulation Laboratory – I			0	0	4	2	100
7		Power Systems Laboratory			0	0	4	2	100
8		Audit Course – I			2	0	0	0	100
				Total	16	0	8	18	800

II Semester

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1	PC	Power System Dynamics and Stability			3	0	0	3	100
2	PC	Real Time Control of Power Systems			3	0	0	3	100
3	PE	Program Elective – III i. Smart Grid Technologies ii. EHVAC Transmission iii. Flexible AC Transmission Systems iv. Hybrid Electric Vehicles			3	0	0	3	100
4	PE	Program Elective – IV i. Power System Deregulation ii. High Voltage Testing Techniques iii. Evolutionary Algorithms and Applications iv. Programmable Logic Controllers & Applications			3	0	0	3	100
5		Power System Simulation Laboratory – II			0	0	4	2	100
6		Renewable Energy Systems Laboratory			0	0	4	2	100
7		Mini Project with Seminar			0	0	4	2	100
8		Audit Course – II			2	0	0	0	100
				Total	14	0	12	18	800

III Semester*

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1	PE	Program Elective – V i. Reactive Power Compensation & Management. ii. Energy Auditing, Conservation and Management. iii. Power System Reforms iv. Swayam Courses			3	0	0	3	100
2		Open Elective ** i. Reactive Power Compensation & Management. ii. Utilization of Electrical Energy. iii. Swayam Courses			3	0	0	3	100
3		Dissertation Phase - I **(to be continued and evaluated next semester)**			0	0	20	10	---
				Total	6	0	20	16	200

* Students can complete these courses through MOOCs (Swayam).

* Chairman in consultation with the local BoS members will float the list of allowed MOOC electives, each academic year.

* The student shall be encouraged to conduct the project in the industry.

** Open Elective subjects are offered to other branches by EEE Department (except for EEE Branch).

IV Semester

S.No	Course No	Course Name	P.Os	Category	L	T	P	Credits	Marks
1		Dissertation Phase-II **(continued from III semester)**			0	0	32	16	100
				Total	0	0	32	16	100

I-M.Tech. I-Semester

COURSE CODE –	POWER SYSTEM OPERATION & CONTROL	CATEGORY	L-T-P 3-0-0	CREDITS 3

Pre-requisite: Knowledge on Power Generation Engineering, Power Transmission Engineering.

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

		Knowledge Level (K)#
CO1	Determine the unit commitment problem for economic load dispatch.	
CO2	Get the knowledge of load frequency control of single area and two area systems with and without control.	
CO3	Get the knowledge of load frequency control of two area systems with and without control.	
CO4	Know the effect of generation with limited energy supply.	
CO5	Determine the interchange evaluation in interconnected power systems.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Unit commitment problem and optimal power flowsolution: Unitcommitment: Constraints in UCP,UC solution methods.Priority list method, introduction to Dynamic programming Approach. Optimal power flow: OPF without inequality constraints, inequality constraints on control variables and dependent variables.	
UNIT – 2	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 – 3	Two area Load Frequency Control: Load frequency control of 2-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.	
UNIT – 4	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 – 5	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.	
	Total	**48 Hrs**

Text Books:

1. Power Generation, Operation and Control - by A.J.Wood and F.Wollenberg,Johnwiley& sons Inc. 1984.
2. Modern Power System Analysis - by I.J.Nagrath & D.P.Kothari, Tata McGraw-Hill Publishing Company ltd, 2nd edition.

Reference Books:

1 Power system operation and control PSR Murthy B.S publication.
2 Electrical Energy Systems Theory - by O.I.Elgerd, Tata McGraw-Hill Publishing Company Ltd, 2nd edition.
3 Reactive Power Control in Electric Systems - by TJE Miller, John Wiley & sons.

I-M.Tech. I-Semester

COURSE CODE –	RENEWABLE ENERGY TECHNOLOGIES	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Understand various general aspects of renewable energy systems.	
CO2	Analyze and design induction generator for power generation from wind.	
CO3	Design MPPT controller for solar power utilization.	
CO4	Utilize fuel cell systems for power generation.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**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– 2	**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– 3	**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– 4	**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– 5	**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	
	Total	**48 Hrs**

Text Books:

1. Felix A. Farret, M. Godoy Simo` es, 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:

Gilbert M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004

I-M.Tech. I-Semester

COURSE CODE –	ELECTRICAL DISTRIBUTION AUTOMATION (ELECTIVE–I)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Knowledge on basics of distribution systems, Compensation in electrical distribution systems, Circuit Analysis, concept of load modelling.

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

		Knowledge Level (K)#
CO1	Analyse a distribution system.	
CO2	Design equipment for compensation of losses in the distribution system.	
CO3	Design protective systems and co-ordinate the devices.	
CO4	Understand of capacitive compensation.	
CO5	Understand of distribution automation..	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	General : Introduction to Distribution systems, 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 – 2	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 – 3	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 – 4	Capacitive compensation for power factor control: Different types of power capacitors, shunt and series capacitors, effect of shunt capacitors (Fixed and switched) power factor correction, capacitor location. Economic justification. Procedure to determine the best capacitor location. Voltage control: Equipment for voltage control, effect of series capacitors, effect of AVB/AVR, line drop compensation.	
UNIT – 5	Distribution automation functions: Electrical system automation, MS functional scope, DMS functional scope functionality of DMS: Steady state and dynamic performance improvement, Geographic information systems: AM/FM functions and Database management, communication options, supervisory control and data acquisition: SCADA functions and system architecture, Synchrophasors and its application in power systems: Definition & Application of PMUs.	
	Total	**48 Hrs**

Text Books:

1. "Electric Power Distribution System Engineering " byTuran Gonen, Mc.Graw-Hill Book Company,1986.
2. Distribution System Analysis and Automation, by Juan M. Gers, The Institution of Engineering and Technology, UK 2014.

Reference Books:

1. Electric Power Distribution-by A.S.Pabla, Tata McGraw-Hill Publishing Company, 4th edition, 1997.
2. Electrical Distribution V.Kamaraju-McGraw Hill
3. Handbook of Electrical Power Distribution – Gorti Ramamurthy-Universities press

I-M.Tech I-Semester

COURSE CODE –	ANALYSIS OF POWER ELECTRONICS CONVERTERS (ELECTIVE–I)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Describe and analyze the operation of AC-DC, DC-AC and AC-AC power converters.	
CO2	Analyze the operation of power factor correction converters.	
CO3	Analyze the operation of three phase inverters with PWM control.	
CO4	Study the principles of operation of multi level inverters and their applications.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Overview of Switching Devices:** Power MOSFET, IGBT, GTO, GaN devices-static and dynamic characteristics, gate drive circuits for switching devices.	
UNIT– 2	**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. Three Phase AC-DC Converters, fully controlled Converters with RL load, Evaluation of input power factor and harmonic factor, Continuous and Discontinuous load current-three phase dual converters.	
UNIT– 3	**Power Factor Correction Converters:** Single-phase single stage boost power factor corrected rectifier, power circuit principle of operation, and steady state-analysis, three phase boost PFC converter	
UNIT– 4	**PWM Inverters:** Principle of operation-Voltage control of single phase inverters - sinusoidal PWM – modified PWM – phase displacement Control – Trapezoidal, staircase, stepped, harmonic injection and delta modulation. Voltage Control of Three-Phase Inverters- Sinusoidal PWM- 60^0 PWM- Third Harmonic PWM-Space Vector Modulation- Comparison of PWM Techniques- Three phase current source inverters-Variable dc link inverter.	
UNIT– 5	**Multi level inverters:** Introduction, Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter- Principle of Operation, Features of Flying- Capacitors Inverter- Cascaded Multilevel Inverter- Principle of Operation- Features of Cascaded Inverter- Switching Device Currents-DC-Link Capacitor Voltage Balancing- Features of Multilevel Inverters- Comparisons of Multilevel Converters.	
	Total	**48 Hrs**

Text Books

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008.
2. Power Electronics Daniel W. Hart - McGraw-Hill,2011.

Reference Books:

1. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014.
2. Power Electronics: Converters, Applications, and Design- Ned Mohan, Tore M. Undeland, William P. Robbins, John Wiley& Sons, 2nd Edition, 2003.
3. Power Converter Circuits – William Shepherd & Li Zhang-Yes Dee CRC Press, 2004.

I-M.Tech. I-Semester

COURSE CODE –	ARTIFICIAL INTELLIGENT TECHNIQUES (ELECTIVE–I)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Differentiate between Algorithmic based methods and knowledge based methods.	
CO2	Use the soft computing techniques for power system problems.	
CO3	Use appropriate AI framework for solving power system problems.	
CO4	Apply GA to power system optimization problems.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction** Artificial Neural Networks (ANN) – definition and fundamental concepts – Biological neural networks – Artificial neuron – activation functions – setting of weights – typical architectures – biases and thresholds – learning/training laws and algorithms. Perceptron – architectures, ADALINE and MADLINE – linear separability- XOR function.	
UNIT– 2	**ANN Paradigms** ADALINE – feed forward networks – Back Propagation algorithm- number of hidden layers – gradient decent algorithm – Radial Basis Function (RBF) network. Kohonen’s self organizing map (SOM), Learning Vector Quantization (LVQ) and its types – Functional Link Networks (FLN) – Bidirectional Associative Memory (BAM) – Hopfield Neural Network.	
UNIT– 3	**Classical and Fuzzy Sets** Introduction to classical sets- properties, Operations and relations; Fuzzy sets, Membership, Operations, Properties, Fuzzy relations, Cardinalities, Membership functions.	
UNIT– 4	**FUZZY LOGIC CONTROLLER (FLC)** Fuzzy logic system components: Fuzzification, Inference engine (development of rule base and decision making system), Defuzzification to crisp sets- Defuzzification methods.	
UNIT– 5	**Application of AI Techniques** Speed control of DC motors using fuzzy logic –load flow studies using back propagation algorithm, single area and two area load frequency control using fuzzy logic.	
	Total	**48 Hrs**

Text Books:

1. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.
2. Fuzzy logic with Fuzzy Applications – T.J Ross – Mc Graw Hill Inc, 1997.

Reference Books:

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by RajasekharanandPai – PHI Publication.
2. Modern power Electronics and AC Drives – B.K.Bose -Prentice Hall, 2002
3. Genetic Algorithms- David E Goldberg. Pearson publications.
5. Introduction to Neural Networks using MATLAB 6.0 by S N Sivanandam,SSumathi,S N Deepa TMGH
6. Introduction to Fuzzy Logic using MATLAB by S N Sivanandam,SSumathi,S N Deepa Springer, 2007.

I-M.Tech I-Semester

COURSE CODE –	POWER QUALITY AND CUSTOM POWER DEVICES (ELECTIVE–I)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Identify the issues related to power quality in power systems.	
CO2	Address the problems of transient and long duration voltage variations in power systems.	
CO3	Analyze the effects of harmonics and study of different mitigation techniques.	
CO4	Identify the importance of custom power devices and their applications.	
CO5	Acquire knowledge on different compensation techniques to minimize power quality disturbances.	

 # Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**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– 2	**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– 3	**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– 4	**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– 5	**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 – Interline Power Flow Controller (IPFC): Operation and control of Unified Power Quality Conditioner (UPQC); Generalized power quality conditioner	
	Total	**48 Hrs**

Text Books:

1. Electrical Power Systems Quality, Dugan R C, McGranaghan M F, Santoso S, and Beaty H W, Second Edition, McGraw-Hill, 2002.
2. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J, First Edition, IEEE Press; 2000.
3. Guidebook on Custom Power Devices, Technical Report, Published by EPRI, Nov 2000
4. Power Quality Enhancement Using Custom Power Devices – Power Electronics and Power Systems, Gerard Ledwich, Arindam Ghosh, Kluwer Academic Publishers, 2002.

Reference Books:

1. Power Quality Primer, Kennedy B W, First Edition, McGraw-Hill, 2000.
2. Power System Harmonics, Arrillaga J and Watson N R, Second Edition, John Wiley & Sons, 2003.
3. Electric Power Quality control Techniques, W. E. Kazibwe and M. H. Sendaula, Van Nostrad Reinhold, New York.
4. Power Quality c.shankaran, CRC Press, 2001
5. Harmonics and Power Systems –Francisco C.DE LA Rosa-CRC Press (Taylor & Francis).
6. Power Quality in Power systems and Electrical Machines-EwaldF.fuchs, Mohammad A.S. Masoum-Elsevier
7. Power Quality, C. Shankaran, CRC Press, 2001
8. Instantaneous Power Theory and Application to Power Conditioning, H. Akagiet.al., IEEE Press, 2007.
9. Custom Power Devices - An Introduction, Arindam Ghosh and Gerard Ledwich, Springer, 2002
10. A Review of Compensating Type Custom Power Devices for Power Quality Improvement, Yash Pal et.al., Joint International Conference on Power System Technology and IEEE Power India Conference, 2008. POWERCON 2008.

I-M.Tech. I-Semester

COURSE CODE –	HVDC TRANSMISSION (ELECTIVE–II)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Knowledge on Power Electronics, Power Systems and High Voltage Engineering.

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

		Knowledge Level (K)#
CO1	Understand the various schemes of HVDC transmission.	
CO2	Understand the basic HVDC transmission equipment.	
CO3	Understand the control of HVDC systems.	
CO4	Understand the interaction between HVAC and HVDC system.	
CO5	Understand the various protection schemes of HVDC engineering.	
CO6	Understand the various schemes of HVDC transmission.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	Limitation of EHV AC Transmission, Advantages of HVDC Technical economical reliability aspects. HVDC Transmission: General considerations, Power Handling Capabilities of HVDC Lines, Basic Conversion principles, static converter configuration. Types of HVDC links-Apparatus and its purpose	
UNIT – 2	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 – 3	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 – 4	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 – 5	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.	
	Total	**48 Hrs**

Text Books:

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.

I-M.Tech. I-Semester

COURSE CODE –	GENERATION & MEASUREMENT OF HIGH VOLTAGES (ELECTIVE–II)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basics of Electrical circuits, Electronics and measurements for testing purpose.

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

		Knowledge Level (K)#
CO1	Understand numerical computation of electrostatic problems.	
CO2	Understand the techniques of generation of high AC, DC and transient voltages.	
CO3	Measure high AC, DC and transient voltages.	
CO4	Measure high AC, DC and transient currents.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	**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 – 2	**Generation of High AC & DC Voltages**: Direct Voltages : AC to DC conversion methods electrostatic generators-Cascaded Voltage Multipliers. Alternating Voltages : Testing transformers-Resonant circuits and their applications, Tesla coil.	
UNIT – 3	**Generation of Impulse Voltages** : Impulse voltage specifications-Impulse generations 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 – 4	**Measurement of High AC & DC 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 – 5	**Measurement of Peak Voltages :** Sphere gaps, uniform field gaps, rod gaps.Chubb-Fortesque methods. 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.	
	Total	**48 Hrs**

Text Books:

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.

I-M.Tech. I-Semester

COURSE CODE –	ADVANCED POWER SYSTEMS PROTECTION (ELECTIVE–II)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Concepts of Power Electronics, Electronic circuits, STLD and basics of Relays and protection.

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

		Knowledge Level (K)#
CO1	Know the classifications and applications of static relays.	
CO2	Understand the application of comparators.	
CO3	Understand the static version of different types of relays.	
CO4	Understand the numerical protection techniques.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	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 – 2	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 – 3	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 – 4	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 – 5	Microprocessor based relays andNumerical 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.	
	Total	**48 Hrs**

Text Books:

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

Reference Books:

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

I-M.Tech. I-Semester

COURSE CODE –	POWER SYSTEM RELIABILITY (ELECTIVE–II)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Probability theory, power systems.

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

		Knowledge Level (K)#
CO1	Understand reliability analysis applied to power systems.	
CO2	Understand Markov Chains and application to power systems.	
CO3	Perform stability analysis of generation systems.	
CO4	Understand decomposition techniques applied to power system.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	Basic probability theory – rules for combining probabilities of events – Bernoulli`s trials – probability density and distribution functions – binomial- distributions – expected value and standard deviation of binomial distribution.	
UNIT – 2	Network Modeling and Reliability Analysis of Series, Parallel, Series-Parallel networks – complex networks – decomposition method Reliability functions F(t), R(t), h(t) and their relationship – exponential distributions – Expected value and standard deviation of exponential distribution – Bath tub curve – reliability analysis of series parallel networks using exponential distribution – reliability measures MTTF, MTTR, MTBF	
UNIT – 3	Markov chains – concept of stochastic transitional probability Matrix, Evaluation of limiting state Probabilities – Markov processes one component repairable system – time dependent probability evaluation using Laplace transform approach – evaluation of limiting state probabilities using STPM – two component repairable models – Frequency and duration concept – Evaluation of frequency of encountering state, mean cycle time, for one, two component repairable models – evaluation of cumulative probability and cumulative frequency of encountering merged states	
UNIT – 4	Generation system reliability analysis – reliability model of a generation system – recursive relation for unit addition and removal – load modelling – merging of generation load model – evaluation of transition rates for	

	merged state model – cumulative Probability, cumulative frequency of failure evaluation – LOLP, LOLE.	
UNIT – 5	Composite system reliability analysis decomposition method – distribution system reliability analysis – radial networks – weather effects on transmission lines – Evaluation of load and energy indices.	
	Total	**48 Hrs**

Reference Books :

1. Reliability Evaluation of Engg. System – R.Billinton, R.N.Allan, Plenum Press, New York.
2. Reliability Modeling in Electric Power Systems - J. Endrenyi, John Wiley, 1978, Neewyork.
3. An Introduction to Realiability and Maintainability Engineering. Sharies E Ebeling, TATA McGraw Hill – Edition.

I-M.Tech. I-Semester

COURSE CODE –	RESEARCH METHODOLOGY AND IPR	CATEGORY	L-T-P	CREDITS 2

Pre-requisite:

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

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		
CO5		
CO6		

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1		
UNIT – 2		
UNIT – 3		
UNIT – 4		
UNIT – 5		
	Total	**48 Hrs**

I-M.Tech. I-Semester

COURSE CODE –	**POWER SYSTEM SIMULATION LABORATORY – I**	**CATEGORY**	**L-T-P 0-0-4**	**CREDITS 2**

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

		Knowledge Level (K)#
CO1	Distinguish between different load flow methods.	
CO2	Analyze Y-bus & Z-bus algorithm.	
CO3	Analyze symmetrical & unsymmetrical faults.	
CO4	Understand importance of Load flow control	
CO5	Understand importance of Economic load dispatch and transient stability analysis.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

S.No.	CONTENTS
1	Formation of Y- Bus by Direct-Inspection Method.
2	Load Flow Solution Using Gauss Siedel Method
3	Load Flow Solution Using Newton Raphson Method
4	Load Flow Solution Using Fast Decoupled Method
5	Formation of Z-Bus by Z-bus building algorithm
6	Symmetrical Fault analysis using Z-bus
7	Unsymmetrical Fault analysis using Z-bus
8	Economic Load Dispatch with & without transmission losses
9	Transient Stability Analysis Using Point By Point Method
10	Load Frequency Control of Single Area Control & Two Area Control system with and without controllers.

I-M.Tech. I-Semester

COURSE CODE –	POWER SYSTEMS LABORATORY	CATEGORY	L-T-P 0 -0-4	CREDITS 2

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

		Knowledge Level (K)#
CO1	Distinguish between sequence impedances of alternator and transformer.	
CO2	Understand the Ferranti effect.	
CO3	Analyze performance and importance of transmission line parameters.	
CO4	Understand the operation of various protection relays.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

List of Experiments

Any 10 of the following experiments are to be conducted

S.No.	CONTENTS
1	Determination of Sequence Impendences of an Alternator by direct method.
2	Determination of Sequence impedances 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.
11	To study the differential and percentage bias integrated relay operations.
12	Performance characteristics of Over current relay
13	To study the protection of generator and transformer.

I-M.Tech. I-Semester

COURSE CODE –	AUDIT COURSE – I	CATEGORY	L-T-P 2 -0-0	CREDITS 0

Pre-requisite:

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

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		
CO5		
CO6		

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1		
UNIT – 2		
UNIT – 3		
UNIT – 4		
UNIT – 5		
	Total	**48 Hrs**

I-M.Tech. II-Semester

COURSE CODE –	POWER SYSTEM DYNAMICS AND STABILITY	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Knowledge of synchronous machine, Power System Analysis

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

		Knowledge Level (K)#
CO1	Determine the model of synchronous machines.	
CO2	Know the stability studies of synchronous machines.	
CO3	Get the knowledge of solution methods of transient stability.	
CO4	Know the effect of different excitation systems in power systems.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	System Dynamics: Synchronous machine model in state space from computer representation for excitation and governor system –modeling of loads and induction machines.	
UNIT – 2	Steady state stability – steady state stability limit – Dynamics Stability limit – Dynamic stability analysis – State space representation of synchronous machine connected to infinite bus-time response – Stability by eighvalue approach.	
UNIT – 3	Digital Simulation of Transient Stability: Swing equation machine equations – Representation of loads – Alternate cycle solution method – Direct method of solution – Solution Techniques : Modified Euler method – RungeKutta method – Concept of multi machine stability.	
UNIT – 4	Effect of governor action and excite on power system stability effect of saturation, saliency & automatic voltage regulators on stability.	
UNIT – 5	Excitation Systems : Rotating Self-excited Exciter with direct acting Rheostatic type voltage regulator – Rotating main and Pilot Exciters with Indirect Acting Rheostatic Type Voltage Regulator – Rotating Main Exciter, Rotating Amplifier and Static Voltage Regulator – Static excitation scheme – Brushless excitation system.	
	Total	**48 Hrs**

Text Books:

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

Reference Books:

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

I-M.Tech. II-Semester

COURSE CODE –	REAL TIME CONTROL OF POWER SYSTEMS	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Power system operation and control.

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

		Knowledge Level (K)#
CO1	Understand state estimation, security and contingency evaluation.	
CO2	Understand about Supervisory control and data acquisition.	
CO3	Real time software application to state estimation.	
CO4	Understand application of AI in power system.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	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 – 2	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 – 3	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 – 4	Voltage Stability, voltage collapse, and voltage security, relation of voltage stability to rotor angle stability. Voltage stability analysis Introduction to voltage stability analysis `P-V' curves and `Q-V' curves, voltage stability in mature power systems, long-term voltage stability, power flow analysis for voltage stability, voltage stability static indices and Research Areas.	
UNIT – 5	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.	
	Total	**48 Hrs**

Text Books:

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 and control, John Wiley & Sons, 1984.

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, Wiley Eastern 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.

COURSE CODE –	SMART GRID TECHNOLOGIES (ELECTIVE–III)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basic knowledge on smart concept communication protocols, renewable energy systems and electronic circuits.

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

		Knowledge Level (K)#
CO1	Understand smart grids and analyze the smart grid policies and developments in smart grids.	
CO2	Develop concepts of smart grid technologies in hybrid electrical vehicles etc.	
CO3	Understand smart substations, feeder automation, GIS etc.	
CO4	Analyze micro grids and distributed generation systems.	
CO5	Analyze the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**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 – 2	**Smart Grid Technologies: Part 1:** Introduction to Smart Meters, Real Time Prizing, 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 – 3	**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, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).	
UNIT – 4	**Microgrids and Distributed Energy Resources:** Concept of micro grid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators,	

	fuelcells, microturbines, Captive power plants, Integration of renewable energy sources.	
UNIT – 5	**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. **Information and Communication Technology for Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN).	
	Total	**48 Hrs**

Text Books:

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, Akihiko Yokoyama,"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
6. Andres Carvallo, John Cooper, "The Advanced Smart Grid: Edge Power Driving Sustainability: 1", Artech House Publishers July 2011

COURSE CODE –	EHVAC TRANSMISSION (ELECTIVE–III)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Transmission line parameters and properties, Corona etc.

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

		Knowledge Level (K)#
CO1	Calculate the transmission line parameters.	
CO2	Calculate the field effects on EHV and UHV AC lines.	
CO3	Determine the corona, RI and audible noise in EHV and UHV lines.	
CO4	Analyze voltage control and compensation problems in EHV and UHV transmission systems.	
CO5	Understand reactive power compensation using SVC and TCR	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	E.H.V. A.C. Transmission, line trends and preliminary aspects ,standard transmission voltages – power handling capacities and line losses – mechanical aspects. Calculation of line resistance and inductance: resistance of conductors, temperature rise of conductor and current carrying capacity. Properties of bundled conductors and geometric mean radius of bundle, inductance of two conductor lines and multi conductor lines, Maxwell's coefficient matrix. Line capacitance calculation.capacitance of two conductor line, and capacitance of multi conductor lines, potential coefficients for bundled conductor lines, sequence inductances and capacitances and diagonalization.	
UNIT – 2	Calculation of electro static field of AC lines - Effect of high electrostatic field on biological organisms and human beings. Surface voltage Gradient on conductors, surface gradient on two conductor bundle and cosine law, maximum surface voltage gradient of bundle with more than 3 sub conductors, Mangolt formula.	
UNIT – 3	Corona : Corona in EHV lines – corona loss formulae – attenuation of traveling waves due to corona – Audio noise due to corona, its generation, characteristics and limits, measurement of audio noise.	
UNIT – 4	Power Frequency voltage control : Problems at power frequency, generalized constants, No load voltage conditions and charging currents, voltage control using synchronous condenser, cascade connection of	

	components : Shunt and series compensation, sub synchronous resonance in series – capacitor compensated lines	
UNIT – 5	Reactive power compensating systems : Introduction, SVC schemes, Harmonics injected into network by TCR, design of filters for suppressing harmonics injected into the system.	
	Total	**48 Hrs**

Text Books :

1. Extra High Voltage AC Transmission Engineering – Rakesh Das Begamudre, Wiley Eastern ltd., New Delhi – 1987.
2. EHV Transmission line reference book – Edison Electric Institute (GEC) 1986.

I-M.Tech. II-Semester

COURSE CODE –	FLEXIBLE AC TRANSMISSION SYSTEMS (ELECTIVE–III)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Concepts on Power Electronics and Power Systems

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

		Knowledge Level (K)#
CO1	Know the performance improvement of transmission system with FACTS.	
CO2	Get the knowledge of effect of static shunt and series compensation.	
CO3	Know the principle of operation and various controls of UPFC	
CO4	Determine an appropriate FACTS device for different types of applications.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	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 – 2	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 – 3	**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 – 4	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 – 5	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)	
	Total	**48 Hrs**

Text Books:

1. "Understanding FACTS Devices" N.G.Hingorani and L.Guygi, IEEE Press.
   Indian Edition is available:--Standard Publications

Reference Books:

1. Sang.Y.H and John.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

I-M.Tech. II-Semester

COURSE CODE –	HYBRID ELECTRIC VEHICLES (ELECTIVE–III)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Know the concept of electric vehicles and hybrid electric vehicles.	
CO2	Familiar with different motors used for hybrid electric vehicles.	
CO3	Understand the power converters used in hybrid electric vehicles	
CO4	Know different batteries and other energy storage systems.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Introduction:** History of hybrid vehicles, architectures of HEVs, series and parallel HEVs, complex HEVs.	
UNIT– 2	**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– 3	**Plug-in Hybrid Electric Vehicle:** PHEVs and EREVs blended PHEVs, PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging.	
UNIT– 4	**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– 5	**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	
	Total	**48 Hrs**

Text Books

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, YimiGao, 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 - DhanpatRai& Co, 2007.

ResearchBooks:

1. Pistooa G., “Power Sources , Models, Sustanability, Infrstructure and the market”, Elsevier 2008
2. Mi Chris, Masrur A., and Gao D.W., “ Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives” 1995.

COURSE CODE –	POWER SYSTEM DEREGULATION (ELECTIVE–IV)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Knowledge on power systems.

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

		Knowledge Level (K)#
CO1	Understand of operation of deregulated electricity market systems	
CO2	Typical issues in electricity markets	
CO3	Analyze various types of electricity market operational and control issues using new mathematical models.	
CO4	Understand LMP's wheeling transactions and congestion management.	
CO5	Analyze impact of ancillary services.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1	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 – 2	Electricity sector structures and Ownership /management, the forms of Ownership and management. Different structure model like Monopoly model, Purchasing agency model, wholesale competition model, Retail competition model.	
UNIT – 3	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 – 4	Transmission network and market power. Power wheeling transactions and marginal costing, transmission costing. Congestion management methods- market splitting, counter-trading; Effect of congestion on LMPs- country practices	
UNIT – 5	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.	
	Total	**48 Hrs**

Text Books:

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. Power generation, operation and control, -J. Wood and B. F. Wollenberg, Wiley.
2. Market operations in electric power systems - M. Shahidehpour, H. Yaminand Z. Li,Wiley.
3. Fundamentals of power system economics - S. Kirschen and G. Strbac, Wiley.
4. Optimization principles: Practical Applications to the Operation and Markets of the Electric Power Industry - N. S. Rau, IEEE Press series on Power Engineeirng.
5. Competition and Choice in Electricity - Sally Hunt and Graham Shuttleworth

I-M.Tech. II-Semester

COURSE CODE –	HIGH VOLTAGE TESTING TECHNIQUES (ELECTIVE–IV)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

Pre-requisite: Basics of high voltage engineering.

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

		Knowledge Level (K)#
CO1	Understand non-destructive testing techniques	
CO2	Analyse HV testing of apparatus	
CO3	Understand HVAC testing methods.	
CO4	Analyse impulse testing electrical equipment's.	
CO5	Learn partial discharge measurement techniques.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Non Destructive Testing Techniques : Measurement of DC Resistivity – Dielectric loss and dielectric constant of insulating materials – Schering bridge method – Transformer ratio arm bridge for high voltage and high current applications – null detectors.	
UNIT – 2	High Voltage Testing of Power Apparatus: Need for testing standards – Standards for porcelain/Glass insulators-Classification of porcelain/glass insulator tests – Tests for cap and pin porcelain/Glass insulators.	
UNIT – 3	High voltage AC testing methods-Power frequency tests-Over voltage tests on insulators, Isolators, Circuit Breakers and power cables. Artificial Contamination Tests : Contamination flashover phenomena-Contamination Severity-Artificial contamination tests-Laboratory Testing versus in-Service Performance-Case study.	
UNIT – 4	Impulse Testing: Impulse testing of transformers, insulators, Surge diverters, Bushings, cables, circuit breakers.	
UNIT – 5	Partial Discharge Measurement: PD equivalent model-PD currents-PD measuring circuits-Straight and balanced detectors-Location and estimation of PD in power apparatus-PD measurement by non-electrical methods-Calibration of PD detectors. RIV Measurements : Radio Interference – RIV – Measurement of RI and RIV in laboratories and in field. Different test arrangements and their limitations.	
	Total	**48 Hrs**

Text Books:

1. High Voltage Engineering – by E.KUFFEL and W.S.ZAENGL, Pergamon press, Oxford 1984.
2. High Voltage Engineering – by M.S.Naidu and V.Kamaraju, Tata McGraw Hill Publishing Company Limited, New Delhi – 2001.

Reference Books:

1. Discharge Detection in H.V. Equipment – by KREUGER, F.H. Haywood London – 1964.
2. Hyltencavallius. N. High voltage laboratory planning EnileHaefely&Co. Ltd. Based Switzerland 1988.
3. Ryan H.M. and Whiskand: design and operation perspective of British UHV Lab IEE pre 133 H.V. Testing Techniques Halfly

I-M.Tech. II-Semester

COURSE CODE –	**Evolutionary Algorithms and Applications (Elective-IV)**	**PE**	**3-0-0**	**3**

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

		Knowledge Level (K)#
CO1	State and formulate the optimization problem, without and with constraints, by using design variables from an engineering design problem.	
CO2	Apply classical optimization techniques to minimize or maximize a multi-variable objective function, without or with constraints, and arrive at an optimal solution.	
CO3	Formulate a mathematical model and apply linear programming technique by using Simplex method. Also extend the concept of dual Simplex method for optimal solutions.	
CO4	Apply gradient and non-gradient methods to nonlinear optimization problems and use interior or exterior penalty functions for the constraints to derive the optimal solutions.	
CO5	Apply Genetic algorithms for simple electrical problems and able to solve practical problems using PSO.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	**CONTENTS**	**Contact Hours**
UNIT– 1	**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– 2	**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– 3	**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 elistic ants-Task partitioning in honey bees - 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– 4	**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 frogscomparison of memes and genes - memeplex formation- memeplex updation- BA and SFLA algorithms for solving ELD without loss and PI controller tuning.	
UNIT– 5	**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.	
	Total	**48 Hrs**

Text Books

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‟, InformatIon scIence reference, IGI Global, , 2010.
4. N P Padhy, „Artificial Intelligence and Intelligent Systems‟, Oxford University Press, 2005.

Reference Papers:

1. “Shuffled frog-leaping algorithm: a memetic meta-heuristic for discrete optimization” by Muzaffar eusuff, 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).

“Firefly Algorithms for Multimodal Optimization” Xin-She Yang, O. Watanabe and T. Zeugmann (Eds.), Springer-Verlag Berlin Heidelberg, pp. 169–178, 2009.

I-M.Tech. II-Semester

COURSE CODE –	PROGRAMMABLE LOGIC CONTROLLERS & APPLICATIONS (ELECTIVE–IV)	CATEGORY	L-T-P 4 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Understand the PLCs and their I/O modules.	
CO2	Develop control algorithms to PLC using ladder logic etc.	
CO3	Manage PLC registers for effective utilization in different applications.	
CO4	Handle data functions and control of two axis and their axis robots with PLC.	
CO5	Design PID controller with PLC.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**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– 2	**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– 3	**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– 4	**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– 5	**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.	
	Total	**48 Hrs**

Text Books:

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.
   Programmable Logic Controllers –W.Bolton-Elsevier publisher.

I-M.Tech. II-Semester

COURSE CODE –	POWER SYSTEM SIMULATION LABORATORY – II	CATEGORY	L-T-P 0-0-4	CREDITS 2

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

		Knowledge Level (K)#
CO1	Analyze the stability of SMIB and Multi machine systems by using advanced approaches	
CO2	Understand the optimal power flows by Newton's method.	
CO3	Analyze the unit commitment and economic load dispatch applications	
CO4	Understand the contingency and state estimations	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

Any 10 of the following experiments are to be conducted

S.No.	CONTENTS
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

COURSE CODE –	RENEWABLE ENERGY SYSTEMS LABORATORY	CATEGORY	L-T-P 0-0-4	CREDITS 2

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

		Knowledge Level (K)#
CO1	Analyze the mathematical model and understand its solar PV cell characteristics.	
CO2	Demonstrate the effect of series and parallel combination of PV cells by I-V and P-V curves.	
CO3	Analyze the effect of suitable power electronic converters for PV system.	
CO4	Demonstrate the significance of various MPPT algorithms on PV System.	
CO5	Demonstrate wind power generation and wind turbine curves.	
CO6	Analyze the model of Uninterrupted Power Supply.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

Any 10 of the following experiments are to be conducted.

S.NO	CONTENTS	**Contact Hours**
	Software Based List of Experiments:	
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.	

Hardware Based list of Experiments		
Using Solar PV Training System:		
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.	
Using Wind Energy Training System:		
16.	Evaluation of cut-in speed of wind turbine.	
17.	Evaluation of Tip Speed Ratio (TSR) at different wind speeds.	
18.	Evaluation of Coefficient of performance of wind turbine.	
19.	Characteristics of turbine (power variation) with wind speed.	
20.	Power curve of turbine with respect to the rotational speed of rotor at fix wind speeds.	
21.	Power analysis at turbine output with AC load for a Wind Energy System.	

I-M.Tech. II-Semester

COURSE CODE –	MINI PROJECT WITH SEMINAR	CATEGORY	L-T-P 0-0-4	CREDITS 2

Mini Project with Seminar

Syllabus Contents:

Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.

End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution.

Continuous assessment of Mini Project at Mid Sem and End Sem will be monitored by the departmental committee.

I-M.Tech. II-Semester

COURSE CODE –	AUDIT COURSE – II	CATEGORY	L-T-P 2-0-0	CREDITS 0

Pre-requisite:

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

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		
CO5		
CO6		

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	**Contact Hours**
UNIT – 1		
UNIT – 2		
UNIT – 3		
UNIT – 4		
UNIT – 5		
	Total	**48 Hrs**

II M.Tech I-Semester

COURSE CODE –	REACTIVE POWER COMPENSATION & MANAGEMENT (ELECTIVE-V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Learn various load compensations.	
CO2	Know the reactive power compensation in transmission systems	
CO3	Obtain the mathematical model of reactive power compensating devices.	
CO4	Get application of reactive power compensation in electrical traction & arc furnaces.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

- **(Please fill the above with Levels of Correlation, viz., L, M, H)**

UNIT	CONTENTS	Contact Hours
UNIT– 1	**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– 2	**Reactive power compensation in transmission system:** Steady state - Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples Transient state - Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers – examples	
UNIT– 3	**Reactive power coordination:** Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences.	
UNIT– 4	**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– 5	**Reactive power management in electric traction systems and are 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.	
	Total	**48 Hrs**

Reference Books:

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

II M.Tech I-Semester

COURSE CODE –	ENERGY AUDITING, CONSERVATION AND MANAGEMENT (ELECTIVE-V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Understand the principle of energy audit and their economic aspects.	
CO2	Recommend energy efficient motors and design good lighting system.	
CO3	Understand advantages to improve the power factor.	
CO4	Evaluate the depreciation of equipment.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**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– 2	**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– 3	**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– 4	**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– 5	**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.	
	Total	**48 Hrs**

Text Books:

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

II M.Tech I-Semester

COURSE CODE –	POWER SYSTEM REFORMS (ELECTIVE-V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Understand the importance of power system deregulation and restructuring.	
CO2	Compute the Access Time Information System (ATC).	
CO3	Understand the transmission congestion management.	
CO4	Compute the electricity pricing in deregulated environment.	
CO5	Understand the power system operation in deregulated environment and the importance of ancillary services.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Over view of key issues in electric utilities** Introduction – Restructuring models – Independent system operator (ISO) – Power Exchange – Market operations – Market Power – Standard cost – Transmission Pricing – Congestion Pricing – Management of Inter zonal/Intra zonal Congestion.	
UNIT– 2	**OASIS: Open Access Same–time Information System** Structure of OASIS – Processing of Information – Transfer capability on OASIS – Definitions Transfer Capability Issues – ATC – TTC – TRM – CBM calculations – Methodologies to calculate ATC.	
UNIT– 3	**Congestion Management** Introduction to congestion management, Effect of congestion, importance of congestion management in the deregulated environment -desired features of congestion management-phases of network access with respect to congestion- Methods to relieve congestion using FACTS controller.	
UNIT– 4	**Electricity Pricing:** Introduction – Electricity price volatility electricity price indexes – Challenges to electricity pricing – Construction of forward price curves – Short–time price forecasting.	
UNIT– 5	**Power system operation in competitive environment:** Introduction – Operational planning activities of ISO – The ISO in pool markets – The ISO in bilateral markets – Operational planning activities of a Genco. **Ancillary Services Management:** Introduction – Reactive power as an ancillary service – A review – Synchronous generators as ancillary service providers.	
	Total	**48 Hrs**

Text Books:

1. Mohammad Shahidehpour, and Muwaffaq alomoush, – “Restructured electrical Power systems” Marcel Dekker, Inc. 2001
2. Kankar Bhattacharya, Math H.J. Boller, Jaap E.Daalder, ‘Operation of Restructured Power System’ Klum,er Academic Publisher – 2001
3. Loi Lei Lai; “Power system Restructuring and Deregulation”, Jhon Wiley & Sons Ltd., England.
4. Electrical Power Distribution Case studies from Distribution reform, upgrades and Management (DRUM) Program, by USAID/India, TMH

II M.Tech I-Semester

COURSE CODE –	REACTIVE POWER COMPENSATION & MANAGEMENT (Open Elective-V)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Learn various load compensations.	
CO2	Obtain the mathematical model of reactive power compensating devices.	
CO3	Know the applications of Reactive power Management	
CO4	Get application of reactive power compensation in electrical traction & arc furnaces.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

- **(Please fill the above with Levels of Correlation, viz., L, M, H)**

UNIT	CONTENTS	Contact Hours
UNIT– 1	**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– 2	**Reactive power coordination:** Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences.	
UNIT– 3	**Distribution side Reactive power Management:** System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks.	
UNIT– 4	**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– 5	**Reactive power management in electric traction systems and are 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.	
	Total	**48 Hrs**

Reference Books:

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

II M.Tech I-Semester

COURSE CODE –	UTILIZATION OF ELECTRICAL ENERGY (Open Elective)	CATEGORY	L-T-P 3 -0-0	CREDITS 3

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

		Knowledge Level (K)#
CO1	Understand various level of illuminosity produced by different illuminating sources.	
CO2	Estimate the illumination levels produced by various sources and recommend the most efficient illuminating sources and design different lighting systems by taking inputs and constraints in view.	
CO3	Identify most appropriate heating or welding techniques for suitable applications.	
CO4	Identify a suitable motor for electric drives and industrial applications and also determine the speed/time characteristics of different types of traction motors.	
CO5	Know the necessity and usage of different energy storage schemes for different applications.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

- **(Please fill the above with Levels of Correlation, viz., L, M, H)**

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Illumination fundamentals** Introduction, terms used in illumination–Laws of illumination–Polar curves–Integrating sphere–Lux meter–Sources of light. **Various Illumination Methods** Discharge lamps, MV and SV lamps – Comparison between tungsten filament lamps and fluorescent tubes–Basic principles of light control–Types and design of lighting and flood lighting–LED lighting, Energy conservation.	
UNIT– 2	**Selection of Motors** Choice of motor, type of electric drives, starting and running characteristics–Speed control–Temperature rise–Applications of electric drives–Types of industrial loads–continuous–Intermittent and variable loads–Load equalization, Introduction to energy efficient motors.	
UNIT– 3	**Electric Heating** Advantages and methods of electric heating–Resistance heating induction heating and dielectric heating. **Electric Welding** Electric welding–Resistance and arc welding–Electric welding equipment–Comparison between AC and DC Welding	

UNIT– 4	**Electric Traction** System of electric traction and track electrification– Review of existing electric traction systems in India– Special features of traction motor–Mechanics of train movement–Speed–time curves for different services – Trapezoidal and quadrilateral speed time curves. Calculations of tractive effort– power –Specific energy consumption for given run–Effect of varying acceleration and braking retardation–Adhesive weight and braking retardation adhesive weight and coefficient of adhesion-Numerical problems.	
UNIT– 5	**Introduction to energy storage systems** Need for energy storage, Types of energy storage-Thermal, electrical, magnetic and chemical storage systems, Comparison of energy storage technologies-Applications.	
	Total	**48 Hrs**

Text Books:

1. Utilization of Electric Energy – by E. Openshaw Taylor, Orient Longman.
2. Art & Science of Utilization of electrical Energy – by Partab, Dhanpat Rai& Sons.
3. “Thermal energy storage systems and applications”-by Ibrahim Dincer and Mark A.Rosen. John Wiley and Sons 2002.

Reference Books:

1. Utilization of Electrical Power including Electric drives and Electric traction – by N.V.Suryanarayana, New Age International (P) Limited, Publishers, 1996.
2. Generation, Distribution and Utilization of electrical Energy – by C.L. Wadhwa, New Age International (P) Limited, Publishers,1997.