

ACADEMIC REGULATIONS COURSE STRUCTURE AND DETAILED SYLLABUS

ELECTRICAL AND ELECTRONICS ENGINEERING
for

M.Tech. – Advanced Electrical Power System
(Applicable from 2023-2024 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 education for meeting the needs of academic, research and industry in the areas of Electrical & Electronics Engineering, and make the department a centre of academic excellence.

Mission:

1. To provide the requisite theoretical and practical knowledge by offering appropriate courses.
2. To promote research oriented innovation culture among the students.
3. To create social awareness and ethical values in the graduates for betterment of the society.
4. To help the students in building professional capabilities in Electrical & Electronics Engineering.

Program Educational Objectives (PEOs)

PEO1	To enable the students to learn the contemporary concepts of electrical power systems.
PEO2	To train the students with state-of-the-art concepts of power systems to carry out research and development activities.
PEO3	To impart knowledge for enabling the students to work in a collaborative and interdisciplinary environment.

Mapping of PEOs with Mission statements

	PEO1	PEO2	PEO3
M1	3	3	2
M2	2	3	3
M3	2	2	3
M4	3	2	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

Program Outcomes (POs)

PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Able to identify, analyze and solve critical power system problems
PO5	Able to use advanced tools and techniques in solving real-time power system issues
PO6	Able to develop models and analyze renewable energy integrated power systems

Mapping of Program Outcomes to PEOs

Program Outcomes (PO's)	Program Education Objectives (PEOs)		
	PEO1	PEO2	PEO3
PO1	3	3	2
PO2	2	3	2
PO3	3	3	2
PO4	3	3	2
PO5	3	3	3
PO6	2	2	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

M.Tech Program Course Structure & Syllabus

I-SEMESTER

S.No	Course Code	Courses	Category	L	T	P	C
1	MT-AEPS-1101	Advanced Power Systems Protection	PC	3	0	0	3
2	MT- AEPS-1102	Advanced Power System Operation & Control	PC	3	0	0	3
3	Program Elective-1:		PE	3	0	0	3
	MT- AEPS-1103	i.Real Time Control of Power Systems					
	MT- AEPS-1104	ii. Flexible AC Transmission Systems					
	MT- AEPS-1105	iii. Power System Reliability					
	MT- AEPS-1106	iv.Power Quality and Custom Power Devices					
4	Program Elective-2:		PE	3	0	0	3
	MT- AEPS-1107	i.Analysis of Power Electronic Converters					
	MT- AEPS-1108	ii. Generation & Measurement of High Voltages					
	MT- AEPS-1109	iii. Electrical Distribution Systems and Automation					
	MT- AEPS-1110	iv. AI applications in Power Systems					
5	MT- AEPS-1111	Research Methodology and IPR	CC	2	0	0	2
6	MT- AEPS-1112	Power Systems Laboratory	LB	0	0	3	1.5
7	MT- AEPS-1113	Power System Simulation Laboratory – I	LB	0	0	3	1.5
8	MT- AEPS-1114	Audit Course-1*	AC	2	0	0	0
Total Credits							17

**Student has to choose any one audit course listed below.*

II SEMESTER

S.No	Course Code	Courses	Category	L	T	P	C
1	MT- AEPS-1201	Renewable Energy Technologies	PC	3	0	0	3
2	MT- AEPS-1202	Power System Dynamics and Stability	PC	3	0	0	3
3	Program Elective-3:		PE	3	0	0	3
	MT- AEPS-1203	i. Smart Grid Technologies					
	MT-AEPS-1204	ii. HVDC Transmission					
	MT-AEPS-1205	iii. Power System Deregulation					
	MT-AEPS-1206	iv. EHVAC Transmission					
4	Program Elective-4:		PE	3	0	0	3
	MT-AEPS-1207	i.High Voltage Testing Techniques					
	MT-AEPS-1208	ii.Fundamentals of Electric Vehicles					
	MT-AEPS-1209	iii.Evolutionary Algorithms and Applications					
	MT-AEPS-1210	iv.Modern Control Theory					
5	MT- AEPS -1211	Renewable Energy Systems Laboratory	LB	0	0	3	1.5
6	MT- AEPS -1212	Power System Simulation Laboratory-II	LB	0	0	3	1.5
7	MT- AEPS-1213	Mini Project with Seminar	MP	2	0	0	2
8	MT- AEPS-1214	Audit Course-2 *	AC	2	0	0	0
Total Credits							17

Two months Mandatory Industrial Training/Internship during summer / semester break

**Student has to choose any one audit course listed below.*

Audit Course 1 & 2:

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|---------------------------------------|---|
| 1. English for Research Paper Writing | 5. Pedagogy Studies |
| 2. Disaster Management | 6. Stress Management by Yoga |
| 3. Sanskrit for Technical Knowledge | 7. Personality Development through |
| 4. Value Education | Life Enlightenment Skills |
| 5. Constitution of India | |

III-SEMESTER*

S.No	Course Code	Courses	Cate gory	L	T	P	C
1	Program Elective-5:		PE	3	0	0	3
	1. MOOCs (NPTEL)-12 Week Course recommended by the department						
	2. Courses offered by the department in the college						
	MT-AEPS-2101	i. Reactive Power Compensation & Management.					
	MT-AEPS-2102	ii. Energy Auditing, Conservation and Management.					
	MT-AEPS-2103	iii. Power System Reforms					
2	Open Elective:		OE	3	0	0	3
	1. MOOCs (NPTEL/SWAYAM)-Any 12 Week Course on Engineering/ Management/ Mathematics offered by other than parent department						
	2. Courses offered to other departments in the college*						
	MT-AEPS-2104	i. Fundamentals of Utilization of Electrical Energy.					
	MT-AEPS-2105	ii. Fundamentals of Electric Vehicles					
3	MT- AEPS-2106	Internship (Performed during summer / I year break)		-	-	-	2
4	MT- AEPS-2107	Dissertation-Part I/ Industrial Project partI #	PJ	0	0	20	10
Total Credits							18

#Students going for Industrial Project/Thesis will complete these courses through MOOCs

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

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

M. Tech. IV SEMESTER							
S.No	Course Code	Courses	Category	L	T	P	C
1	MT- AEPS-2201	Dissertation-Part II/ Industrial Project part II	PJ	0	0	32	16
Total Credits							16

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1101	ADVANCED POWER SYSTEMS PROTECTION	CATEGORY PC	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Review the operating mechanisms of circuit breakers and relays.	2
CO2	Compare the equipment protection methods	4
CO3	Apply the static relay components to static over current relays	3
CO4	Illustrate the microprocessor and numerical relay protection	3
CO5	Practice the protection of HVDC systems	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	--	3	2	2	2
CO2	1	--	3	2	2	2
CO3	2	--	3	2	3	1
CO4	1	--	2	2	3	2
CO5	1	--	3	2	2	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	<p>Circuit breakers Miniature Circuit Breaker (MCB)–Elementary principles of arc interruption– Re-striking phenomenon – RRRV- Vacuum and SF6 circuit breakers– CB ratings and Specifications.</p> <p>Electromagnetic Relays Relay connection–Torque equation –Applications of relays: Over current and under voltage relays– Directional relays– Differential relays and percentage differential relays. Universal torque equation– Distance relays: Impedance– Reactance– Mho and offset mho relays– Characteristics of distance relays and comparison.</p>	
UNIT-2	<p>Generator Protection Protection of generators against stator faults– Rotor faults and abnormal conditions– restricted earth fault Numerical examples.</p> <p>Transformer Protection Percentage differential protection– Design of CT's ratio–Numerical examples. Transformer protection: issues, differential protection of auto transformers, two-winding, three-winding transformers.</p> <p>Bus bar protection: issues, bus configurations, protection zones, protection schemes</p>	

UNIT – 3	Static Relays classification and Tools: Components of static relays- Static over current (OC) relays – Instantaneous, Definite time, Inverse time OC Relays, static distance relays, static directional relays, static differential relays.	
UNIT – 4	Microprocessor based relays and Numerical Protection: Over current relays – impedance relay – directional relay – reactance relay. Numerical Protection: Numerical relay – numerical relaying algorithms – mann-morrison technique – Differential equation technique and discrete fourier transform technique – numerical over current protection – numerical distance protection.	
UNIT – 5	Overview of HVDC protection systems; Protection scheme for distributed generators (DGs); Special Protection Schemes (SPS); Power system protection testing; Common Format for Transient Data Exchange (COMTRADE), Communication architecture for substation automation; Basics of synchrophasor based Wide Area Monitoring Systems (WAMS)	
	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 Kimbark Vol-II, Willey.
4. Electrical Power System Protection –C.Christopoulos and A.Wright- Springer
5. Protection & Switchgear –Bhavesb Bhalaja, R.Pmaheshwari, Nilesh G.Chothani-Oxford publishers.
6. Distributed Generation (DG) Protection Overview Literature Review for ES 586b University of Western Ontario Andrew T. Moore, 250442203
<https://www.eng.uwo.ca/people/tsidhu/Documents/DG%20Protection%20V4.pdf>

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1102	ADVANCED POWER SYSTEM OPERATION & CONTROL	CATEGORY PC	L-T-P 3-0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Design the unit commitment problem and to understand the hydro thermal scheduling problem.	4
CO2	Explain the load frequency control of single area and two area systems with and without control.	2
CO3	Prioritize the concepts of generation with limited energy supply.	5
CO4	Categorize different production cost models	4
CO5	Analyze the interchange evaluation in interconnected power systems.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	--	3	3	2	1
CO2	2	--	3	3	2	2
CO3	2	--	2	2	1	1
CO4	1	--	2	2	1	1
CO5	2	--	2	2	1	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Unit commitment problem and optimal power flow solution: Unit commitment: 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. Hydrothermal coordination and hydrothermal scheduling problem.	
UNIT – 2	Single area Load Frequency Control: single area control, Concept of control area, block diagram representation, Steady State and dynamic - analysis -Uncontrolled and controlled case-PI control. Two area Load Frequency Control: Uncontrolled and controlled case, tie-line bias control, steady state representation. Optimal two-area LF control, Load frequency control and Economic dispatch control.	
UNIT – 3	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 – 4	Production cost models: introduction-uses and types of production cost programs. Production costing using load duration curves. Outages consideration. Probabilistic Production cost computations.	

UNIT – 5	Interchange Evaluation and Power Pools Economy Interchange: Economy interchange Evaluation, Interchange Evaluation with unit commitment, Multiple Interchange transactions, different types of Interchange, power pools, transmission effects and issues.	
	Total	48 Hrs

Text Books:

1. Power Generation, Operation, and Control, 3rd Edition Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé ISBN: 978-0-471-79055-6 November 2013
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.

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1103	REAL TIME CONTROL OF POWER SYSTEMS (PROGRAM ELECTIVE-1)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Illustrate different types of state estimations	3
CO2	Describe about security and contingency evaluation	2
CO3	Demonstrate the computer control of power systems	3
CO4	To classify and compare the voltage stability issues.	4
CO5	Describe the various conditions of deregulation	2

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	--	2	3	3	1
CO2	2	--	2	2	2	2
CO3	3	--	3	2	3	2
CO4	2	--	2	3	1	1
CO5	1	--	2	3	2	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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. Observability, Pseudo measurements, 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, Supervisory Control And Data Acquisition (SCADA) systems implementation considerations, energy control centers, 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. Allen J.Wood and Bruce F.Wollenberg: Power Generation operation and control, John Wiley & Sons, 1984.
2. John J.Grainger and William D.Stevenson, Jr.: Power System Analysis, McGraw-Hill, 1994, International Edition
3. PrabhaKundur : Power System Stability and Control -, McGraw Hill, 1994
4. Steven stoft : Power System Economics-Designing Markets for Electricity, IEEE Press and Wiley – interscienc -2002

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

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1104	FLEXIBLE AC TRANSMISSION SYSTEMS (PROGRAM ELECTIVE-1)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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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.	2
CO2	Demonstrate the effect of static shunt and series compensation.	3
CO3	Illustrate the use of SVC and STATCOM for Shunt Compensations	3
CO4	Determine an appropriate FACTS device for different types of applications.	4
CO5	Know the principle of operation and various controls of UPFC& IPFC	2

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	1	3	1	1
CO2	2	-	2	3	3	-
CO3	3	-	2	3	3	2
CO4	3	-	2	3	3	-
CO5	3	-	2	3	3	-

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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.Hand 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.

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1105	POWER SYSTEM RELIABILITY (PROGRAM ELECTIVE-1)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Illustrate the rules of basic probability theory	3
CO2	Explain the reliability analysis of different networks	2
CO3	Describe Markov Chains and application to power systems.	3
CO4	Illustrate reliability analysis of generation systems	3
CO5	Apply the decomposition techniques to power system.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	--	1	2	1	--
CO2	2	--	2	2	1	1
CO3	2	--	3	2	2	2
CO4	3	--	3	3	2	2
CO5	2	--	2	2	3	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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 modeling – 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

Text Books:

1. Reliability Evaluation of Engineering System – R.Billinton, R.N.Allan, Plenum Press, New York in 1982.
2. Reliability Modeling in Electric Power Systems – J. Endrenyi, John Wiley, 1978, New York.
3. An Introduction to Reliability and Maintainability Engineering. Charles E Ebeling, TATA McGraw Hill – Edition.

M.Tech I-Semester

COURSE CODE – MT-AEPS-1106	POWER QUALITY AND CUSTOM POWER DEVICES (PROGRAM ELECTIVE-1)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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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.	2
CO2	Categorize short and long duration voltage variations in power systems.	3
CO3	Analyze the effects of harmonics and study of different mitigation techniques.	3
CO4	Illustrate the importance of custom power devices and their applications.	3
CO5	Compare different compensation techniques to minimize power quality disturbances.	4

Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	--	2	2	2	1
CO2	2	--	3	2	2	1
CO3	2	--	2	2	3	1
CO4	2	--	2	3	3	2
CO5	2	--	2	2	3	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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 Nostrand Reinhold, New York.
4. Power Quality c.shankaran, CRC Press, 2001

M.Tech I-Semester

COURSE CODE – MT-AEPS-1107	ANALYSIS OF POWER ELECTRONIC CONVERTERS (PROGRAM ELECTIVE-2)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Describe static characteristics and gate drive circuits of Switching devices.	2
CO2	Analyze the operation of non-isolated switch mode converters.	4
CO3	Analyze the operation of single-phase and three-phase inverters with PWM control and compare various PWM techniques.	4
CO4	Illustrate the operation of multilevel inverters and compare their features.	3
CO5	Investigate the PWM Control of CHB and diode clamped multilevel inverters.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	-	-	-
CO2	2	-	2	-	1	2
CO3	2	-	3	1	1	2
CO4	2	-	3	-	1	1
CO5	3	-	3	1	1	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT- 1	Overview of Switching Devices & AC-DC converters: Power MOSFET, IGBT, GTO, GaN devices-static and dynamic characteristics, gate drive circuits for switching devices.	
UNIT- 2	Non-Isolated DC-DC Converters: Control of DC-DC converters: Buck converters, Boost converters, Buck-Boost converter, CUK Converter, continuous and discontinuous operation, relation between input and output voltages, design of filter inductor and capacitors, Converter realization with non-ideal components.	
UNIT- 3	PWM Inverters: Voltage control of single-phase inverters employing phase displacement Control, Bipolar PWM, Unipolar PWM. Three-phase Voltage source inverters: Six stepped VSI operation-Voltage Control of Three-Phase Inverters employing Sinusoidal PWM, Third Harmonic PWM, Space Vector Modulation- Comparison of PWM Techniques- Three phase current source inverters.	
UNIT- 4	Multilevel Inverters: Introduction, Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter- Improved Diode Clamped Inverter-Cascaded H-bridge Multilevel Inverter, Principle of Operation, Features of Cascaded H-bridge	

	Inverter- Comparisons of DCMLI & CHB- Modular multilevel converters – principle of operation.	
UNIT– 5	PWM Multilevel Inverters: CHB Multilevel Inverter: Stair case modulation-SHE PWM- Phase shifted Multicarrier modulation-Level shifted PWM- Diode clamped Multilevel inverter: SHE PWM-Sinusoidal PWM- Space vector PWM-Capacitor voltage balancing.	
	Total	48 Hrs

Text Books

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008.
2. High-power converters and AC drives -Wu, Bin, and Mehdi Narimani-John Wiley & Sons, 2017.

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.
4. Power Electronics Daniel W. Hart - McGraw-Hill, 2011.

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1108	GENERATION & MEASUREMENT OF HIGH VOLTAGES (PROGRAM ELECTIVE-2)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Suggest suitable techniques for generation of high AC and DC voltages.	5
CO2	Suggest suitable techniques for generation of impulse voltages and currents.	5
CO3	Measure high DC and AC voltages.	4
CO4	Measure high AC peak voltages, impulse voltage and currents.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	1	1	2	2
CO2	1	-	2	1	2	2
CO3	2	-	2	3	3	2
CO4	2	-	3	3	3	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	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 – 2	Generation of Impulse Voltages: Impulse voltages: 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 – 3	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 – 4	Measurement of Peak and impulse Voltages: Measurement of Peak Voltages: Sphere gaps, uniform field gaps, rod gaps. Chubb-Fortescue 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.	
UNIT – 5	Measurement Impulse Currents:	

	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, McGraw-Hill Books Co., New Delhi, 2nd edition, 1995.

Reference Books:

1. High Voltage Engineering –by C.L.Wadhwa, New Age International (P) Limited, Publishers, Second Edition, New Delhi, 2007
2. High Voltage Measuring Techniques – A. Schwab MIT Press, Cambridge, USA, 1972.

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1109	ELECTRICAL DISTRIBUTION SYSTEMS AND AUTOMATION (PROGRAM ELECTIVE-2)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Describe the electrical distribution system networks.	2
CO2	Investigate the design aspects of distribution feeders	4
CO3	Analyze the coordination of the protection devices.	4
CO4	Examine the calculation of capacitive compensation.	4
CO5	Illustrate the distribution automation.	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	--	2	2	1	2
CO2	3	--	2	2	2	2
CO3	3	--	3	3	3	3
CO4	3	--	3	3	3	1
CO5	2	--	3	3	3	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	General : Introduction to Distribution systems-Load modeling and characteristics: definition of basic terms like demand factor, utilization factor, load factor, plant factor, diversity factor, coincidence factor, contribution factor and loss factor-Relationship between the load factor and loss factor – Classification of loads (Residential, Commercial, Agricultural and Industrial) and their characteristics.	
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 in distribution systems and procedure for fault calculation. Protective Devices: 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: an overview of the role of computers in distribution system planning, 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. Communication aided Distribution Automation using IEC 61850.	
	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, 4thedition, 1997.
2. Electrical Distribution V.Kamaraju-McGraw Hill
3. Handbook of Electrical Power Distribution – Gorti Ramamurthy-Universities press
4. For Communication aided Distribution Automation using IEC 61850: EPRI Tech. Report, “Guide to Implementing Distribution Automation Systems Using IEC 61850,” Dec. 2002.
5. ABB, Products – Distribution Control. [Online]. Available: <http://www.abb.com/product>
6. Schweitzer Engineering Laboratories, Inc., Products – Distribution Protection [Online]. Available: <http://www.selinc.com/>
7. GE Multilin, Products – Distribution Protection and Automation. [Online]. Available: <http://www.geindustrial.com/multilin/>

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1110	AI APPLICATIONS IN POWER SYSTEMS (PROGRAM ELECTIVE-2)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Analyse different models of artificial neuron & Use learning methods of ANN.	4
CO2	Evaluate different paradigms of ANN.	5
CO3	Classify between classical and fuzzy sets.	4
CO4	Illustrate different modules of Fuzzy logic controller.	3
CO5	Apply Neural Networks and fuzzy logic for real-time applications.	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	-	2	2	2
CO2	2	-	-	2	2	2
CO3	2	-	-	2	2	2
CO4	2	-	-	2	2	2
CO5	2	-	-	2	3	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT- 1	Introduction Artificial Neural Networks (ANN) – Humans and computers – Biological neural networks – ANN Terminology – Models of Artificial neuron – activation functions –typical architectures – biases and thresholds – learning strategy(supervised, unsupervised and reinforced) learning rules,perceptron training andclassification using Discrete and Continuous perceptron algorithms, ADALINE and MADLINE – linear separability and non-separability with examples.	
UNIT- 2	ANN Paradigms Generalized delta rule – Back Propagation algorithm- Radial Basis Function (RBF) network. Kohonen’s self-organizing feature map (KSOFM), Learning Vector Quantization (LVQ) – 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, Uncertainty, 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	

	Load forecasting using back propagation algorithm –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. Zurada, Jaico Publishing House, 1997.
2. Fuzzy logic with Fuzzy Applications – T.J Ross – McGraw Hill Inc, 1997.

Reference Books:

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by RajasekharanandPai – PHI Publication.
2. Introduction to Neural Networks using MATLAB 6.0 by S N Sivanandam,SSumathi,S N Deepa TMGH
3. Introduction to Fuzzy Logic using MATLAB by S N Sivanandam,SSumathi,S N Deepa Springer, 2007.

I-M.Tech. I-Semester

COURSE CODE – MT-AEPS-1111	RESEARCH METHODOLOGY AND IPR	CATEGORY CC	L-T-P 2-0-0	CREDITS 2
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate the research problem and research process	3
CO2	Illustrate functions of the literature review and research ethics	3
CO3	Prepare a well-structured research paper and scientific presentations	3
CO4	Explore on various IPR components and process of filing	3
CO5	Adapt the adequate knowledge on patent and rights	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2				
CO2	3	3				
CO3	3	2				
CO4	3	2				
CO5	3	3				

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT– 1	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	
UNIT– 2	Effective literature studies approaches, analysis Plagiarism, Research ethics	
UNIT– 3	Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	
UNIT– 4	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	
UNIT– 5	Patent Rights: Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications. New Developments in IPR: Administration of Patent System, New	

	developments in IPR; IPR of Biological Systems, Computer Software etc., Traditional knowledge Case Studies, IPR and IITs.	
	Total	48 Hrs

Text Books:

1. “Research Methodology: An introduction for science engineering students”, Stuart Melville and Wayne Goddard
2. “Research Methodology: An Introduction”, Wayne Goddard and Stuart Melville
3. “Research Methodology: A Step by Step Guide for beginners”, Ranjit Kumar, 2nd Edition
4. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007

Reference Books:

1. “Industrial Design”, Mayall, McGraw Hill, 1992
2. “Product Design”, Niebel, McGraw Hill, 1974
3. Intellectual Property in New Technological Age”, Robert P. Merges, Peter S. Menell, Mark A. Lemley, 2016.

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1112	POWER SYSTEMS LABORATORY	CATEGORY LB	L-T-P 0-0-3	CREDITS 1.5
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Calculate the sequence impedances of synchronous machine.	3
CO2	Calculate the sequence impedances and explain the connections of transformer.	3
CO3	Describe the Ferranti effect and compensation in transmission lines.	2
CO4	Analyze performance and importance of transmission line parameters.	4
CO5	Analyze the operation of various protection relays.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	2	1
CO2	3	2	2	1	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	3	1
CO5	2	3	2	2	2	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

List of Experiments

Any 10 of the following experiments are to be conducted

S.No.	CONTENTS
1	Determination of Sequence Impedences 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	Poly-phase connection on three single phase transformers and measurement of phase angle.
5	Determination of equivalent circuit of 3-winding Transformer.
6	Study of Ferranti effect in long transmission line.
7	Measurement of ABCD parameters on transmission line.
8	Performance of long transmission line without compensation.
9	To determine and verify the reactor compensation of 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.

M.Tech. I-Semester

COURSE CODE – MT-AEPS-1113	POWER SYSTEM SIMULATION LABORATORY – 1	CATEGORY LB	L-T-P 0-0-3	CREDITS 1.5
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Distinguish between different load flow methods.	4
CO2	Building and analyzing Y-bus & Z-bus algorithms.	4
CO3	Practice and analyze the symmetrical & unsymmetrical faults.	3
CO4	Recognize the importance of Load flow control and Economic load dispatch.	2
CO5	Recognize the importance of Economic load dispatch and transient stability analysis.	2

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	2	2	3
CO2	3	3	2	2	2	3
CO3	3	3	3	3	3	2
CO4	2	2	2	2	2	2
CO5	2	3	2	2	2	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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.

M.Tech. I-Semester

COURSE CODE – MT-AEPS- 1114	AUDIT COURSE – 1	CATEGORY AC	L-T-P 2 -0-0	CREDITS 0
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		
CO5		

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1						
CO2						
CO3						
CO4						
CO5						

(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

M.Tech. II-Semester

COURSE CODE – MT-AEPS-1201	RENEWABLE ENERGY TECHNOLOGIES	CATEGORY PC	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	List out various economic and managerial aspects of renewable energy systems.	2
CO2	Analyze the operation of induction generator for wind power generation.	4
CO3	Illustrate various functional components of wind power plants.	3
CO4	Design various MPPT controllers for solar power generation.	2
CO5	Analyze the operation and determine equivalent circuit parameters of fuel cells	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	1	2	2	3
CO2	-	-	-	2	2	3
CO3	-	-	1	2	2	3
CO4	1	-	-	2	2	3
CO5	-	-	-	2	2	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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. MPPT for wind power plants.	
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. Integration of Photovoltaic power plant into the grid.	
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 Simões, Integration of Alternative Sources of Energy, John Wiley & Sons, 2006.
2. Remus Teodorescu, Marco Liserre, Pedro Rodríguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.

Reference Books:

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

M.Tech. II-Semester

COURSE CODE – MT-AEPS-1202	POWER SYSTEM DYNAMICS AND STABILITY	CATEGORY PC	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Describe the models of synchronous machines	2
CO2	Summarize stability studies of synchronous machines.	2
CO3	Evaluate the solution methods of transient stability.	5
CO4	Examine the effect of governor action on the power system stability	4
CO5	Implement different excitation systems to power systems.	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	--	3	2	1	2
CO2	2	--	3	2	1	1
CO3	3	--	3	3	2	2
CO4	2	--	2	2	2	1
CO5	2	--	2	2	2	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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 Eigen value 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.Vadhera Khanna Publishers

M.Tech. II-Semester

COURSE CODE – MT-AEPS-1203	SMART GRID TECHNOLOGIES (PROGRAM ELECTIVE-3)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Describe smart grids and explain the smart grid policies and developments in smart grids.	2
CO2	Demonstrate the concepts of smart grid technologies for home and electrical applications.	3
CO3	Illustrate the usage of GIS, IED, SMES, WAMS, and PMU etc. for smart grids.	3
CO4	Demonstrate the integration of Distributed energy resources with micro grids	3
CO5	Analyze the effect of power quality in smart grid and understand latest developments in ICT for smart grid.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	--	2	2	2	3
CO2	2	--	2	2	2	3
CO3	3	--	2	2	3	3
CO4	2	--	3	2	3	2
CO5	2	--	3	3	3	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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 Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.	
UNIT – 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, NouredineHadsaïd, “Smart Grids”, Wiley Blackwell
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

M.Tech. II-Semester

COURSE CODE – MT-AEPS-1204	HVDC TRANSMISSION (PROGRAM ELECTIVE-3)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Discuss about advantages, power handling capabilities of HVDC links and understand the components of HVDC converter station	2
CO2	Illustrate the operation of 6-pulse and 12-pulse bridge converters	3
CO3	Demonstrate various control schemes of HVDC converters and systems	3
CO4	Examine the interaction between HVAC and HVDC systems and compare Multiterminal DC system	4
CO5	Analyze various converter faults and protection schemes of HVDC systems	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	1	-	-	-
CO2	2	-	2	2	1	-
CO3	2	-	2	2	1	-
CO4	2	-	2	3	2	-
CO5	2	-	2	3	2	-

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Typical layout of HVDC transmission system and role of equipment involved, Comparison of AC and DC transmission: Economics of transmission, technical performance. Limitations of EHV AC Transmission, Advantages and limitations of HVDC transmission, Reliability of HVDC systems, Types of HVDC links	
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. Voltage and current harmonics in HVDC. Harmonic elimination using Filters.	
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 HVDC systems: Over voltages due to	

	disturbances on DC side, over voltages due to DC and AC side line faults. Converter faults and protection in HVDC Systems: Converter faults, over current protection – valve group, and DC line protection, circuit breakers. Over voltage protection of converters, surge arresters. VSC based HVDC converter principal and operation, components of VSC	
	Total	48 Hrs

Text Books:

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

Reference Books:

1. E.W. Kimbark: Direct current Transmission, Wiley Inter Science – New York.
2. J.Arillaga : H.V.D.C. Transmission Peter Peregrinus ltd., London UK 1983
3. Vijay K Sood: HVDC and FACTS controllers: Applications of static converters in power systems by, Kluwer Academic Press.
4. Dragan Jovcic, Khaled Ahmed, High voltage direct current transmission: converters, systems and DC Grids, Wiley publications 2015.

M.Tech. II-Semester

COURSE CODE – MT-AEPS-1205	POWER SYSTEM DEREGULATION (PROGRAM ELECTIVE-3)	CATEGORY PE	L-T-P 3-0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Illustrate the operation of deregulated electricity market systems	3
CO2	Explain typical issues in electricity markets	2
CO3	Analyze various types of electricity market operational and control issues using new mathematical models.	4
CO4	Summarize LMP's wheeling transactions and congestion management.	2
CO5	Analyze impact of ancillary services.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	--	2	3	3	2
CO2	2	--	2	3	3	2
CO3	3	--	1	2	3	2
CO4	2	--	2	3	2	1
CO5	1	--	2	3	3	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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, 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. Yamin and 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 Engineering.
5. Competition and Choice in Electricity – Sally Hunt and Graham Shuttleworth

M.Tech. II-Semester

COURSE CODE – MT-AEPS-1206	EHVAC TRANSMISSION (PROGRAM ELECTIVE-3)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Calculate the transmission line parameters.	3
CO2	Calculate the field effects on EHV and UHV AC lines.	3
CO3	Explain the corona, RI and audible noise in EHV and UHV lines.	2
CO4	Discuss the power frequency voltage control	2
CO5	Compare different reactive power compensation devices	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	--	3	2	1	1
CO2	3	--	3	2	1	1
CO3	2	--	2	3	1	-
CO4	2	--	3	3	2	1
CO5	2	--	3	2	3	1

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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 in the space – 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 –exact loss formula using charge voltage diagram, 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. Ultra-high Voltage AC/DC power transmission – Hao Zhou et al., Springer publishers - 2018

M.Tech. II-Semester

COURSE CODE – MT-AEPS-1207	HIGH VOLTAGE TESTING TECHNIQUES (PROGRAM ELECTIVE-4)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Identify the suitable non-destructive testing technique for high voltage and high current applications	2
CO2	Analyze the electrical, mechanical, and pollution performances of the dielectric materials and high-voltage apparatus by conducting suitable tests as per standards.	4
CO3	Demonstrate various high-voltage AC testing methods and differentiate between laboratory testing and in-service performances.	3
CO4	Evaluate the performance of the various high voltage power equipment with their suitable impulse testing procedures.	5
CO5	Calibrate the PD detectors and Analyze the performance of the power apparatus by choosing a suitable partial discharge measurement method.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	2	2	1
CO2	3	-	3	2	2	1
CO3	1	-	2	2	2	3
CO4	3	-	3	3	3	3
CO5	1	-	2	3	3	3

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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 - Measurement of String Efficiency	
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.
3. High Voltage Engineering – by C.L.Wadhwa, New Age International Pvt Ltd Publishers -3rd edition.
4. Outdoor insulators – by Ravi S. Gorur, Edward A.Cherney, Jeffrey T. Burnham, “Outdoor Insulators”, Ravi S. Gorur, Inc., Phoenix, Arizona85044,USA,1999.

Reference Books:

1. Discharge Detection in H.V. Equipment – by KREUGER, F.H. Haywood London – 1964.
2. Ryan H.M. and Whiskand: design and operation perspective of British UHV Lab IEE pre 133 H.V. Testing Techniques Halfly
3. The practical guide to outdoor high voltage insulators – by W L Vosloo et al, crown publications – 2004.
4. Insulators for high voltages by J.S.T. Looms by IET power and energy series

M.Tech II-Semester

COURSE CODE – MT-AEPS-1208	FUNDAMENTALS OF ELECTRIC VEHICLES (PROGRAM ELECTIVE-4)	CATEGORY PE	L-T-P 3-0-0	CREDITS 3
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Course Outcomes: After the completion of the course the student should be able to:

		Knowledge Level (K)#
CO1	Describe different types of electric vehicles.	2
CO2	Illustrate the components of Electric vehicles	3
CO3	Differentiate among series, parallel and complex Electric vehicles	3
CO4	Present the need and merits of V2G and G2V Technologies	3
CO5	Demonstrate the battery management system for Electric vehicle system	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	-	-
CO2	2	-	2	-	-	-
CO3	2	-	3	-	-	-
CO4	3	-	2	3	3	1
CO5	2	-	2	-	--	--

(Please fill the above with Levels of Correlation - viz. - L-1 - M-2 - H-3)

UNIT	CONTENTS	Contact Hours
UNIT - 1	Introduction Fundamentals of vehicles - Components of conventional vehicles - drawbacks of conventional vehicles – Need for electric vehicles - History of Electric Vehicles – Types of Electric Vehicles – Advantages and applications of Electric Vehicles.	
UNIT - 2	Components of Electric Vehicles (EVs) Main components of Electric Vehicles – Power Converters - Controller and Electric Traction Motor – Rectifiers used in EVs – Bidirectional DC–DC Converters – Voltage Source Inverters.	
UNIT - 3	Hybrid Electric Vehicles Evolution of Hybrid Electric Vehicles – Advantages and Applications of Hybrid Electric Vehicles – Architecture of HEVs - Series and Parallel HEVs – Complex HEVs – Range extended HEVs – Examples - Merits and Demerits.	
UNIT - 4	V2G and G2V Technologies Energy scenario in India, Electricity consumption by EVs and all other loads, End of life batteries for grid support, EV charging schemes, types of EV chargers, Vehicle-to-grid (V2G) and Grid-to-Vehicle (G2V) technologies, Energy trading with EVs.	
UNIT - 5	Energy Sources for Electric Vehicles Batteries - Types of Batteries – Lithium-ion - Nickel-metal hydride - Lead-acid – Comparison of Batteries - Battery Management System – Ultra	

	capacitors – Flywheels – Fuel Cell – it's working.	
	Total	

Text Books

1. Iqbal Hussein - Electric and Hybrid Vehicles: Design Fundamentals - CRC Press - 2021.
2. Denton - Tom. Electric and hybrid vehicles. Routledge - 2020.

Reference Books:

1. Kumar - L. Ashok - and S. Albert Alexander. Power Converters for Electric Vehicles. CRC Press - 2020.
2. Chau - Kwok Tong. Electric vehicle machines and drives: design - analysis and application. John Wiley & Sons - 2015.
3. Berg - Helena. Batteries for electric vehicles: materials and electrochemistry. Cambridge university press - 2015.

M.Tech II-Semester

COURSE CODE – MT-AEPS-1209	EVOLUTIONARY ALGORITHMS AND APPLICATIONS (PROGRAM ELECTIVE-4)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Classify optimization problems and describe their properties, formulate mathematical model for optimization problem and explain the features of soft computing algorithms	2
CO2	Demonstrate the usage of GA and PSO algorithms to solve single-objective optimization problems such as ELD, Selective Harmonic Elimination in inverters and PI controller tuning.	3
CO3	Demonstrate the application of ABC and Bat algorithms to solve ELD and PI controller tuning problems.	3
CO4	Illustrate the steps of HSA & TLBO optimization algorithms and use them solve ELD and PI controller tuning problems.	3
CO5	Describe Pareto optimality concept, Non-dominant sorting technique, crowding distance operator and demonstrate the usage of NSGA-II algorithm to solve two-objective optimization problems	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		2	-	1	1
CO2	3		3	2	1	2
CO3	3		3	2	1	2
CO4	3		3	2	1	2
CO5	3		3	2	1	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT- 1	Fundamentals of Soft Computing Techniques Introduction to real world optimization problems-Properties of practical optimization problems-Mathematical formulation of single-objective and multi-objective optimization problems-Classification of optimization problems-Classification of conventional optimization methods – Steepest descent method-drawbacks of conventional optimization methods- Classification of computational intelligent techniques-Evolutionary algorithms- Single solution based and population based algorithms – Exploitation and exploration in population based algorithms – Advantages of Evolutionary algorithms over conventional optimization methods	
UNIT- 2	Genetic Algorithm and Particle Swarm Optimization Genetic algorithms- Generalized framework -introduction to binary-coded GA -	

	Real-coded GA: initialization of population- selection operator- crossover and mutation operators. PSO: Bird flocking and Fish Schooling –swarm initialization- swarm evaluation- velocity and position updation - control parameters – GA and PSO algorithms for solving ELD problem without loss, Selective Harmonic Elimination in inverters and PI controller tuning.	
UNIT– 3	Artificial Bee Colony Algorithm and Bat optimization Algorithm Bat optimization algorithm-Echolocation of bats- Behaviour of microbats- Acoustics of Echolocation- Movement of Virtual Bats- Loudness and Pulse Emission- Artificial bee colony (ABC) algorithms- Foraging Behaviour of Honey Bees-Initialization phase-Employee bee phase – Onlooker bee phase - Scout bee phase -Applications of Bat and ABC optimization algorithms for solving Economic Dispatch without loss and PI controller tuning.	
UNIT– 4	Harmony search Algorithm (HSA) and Teacher learning based optimization Algorithm (TLBO) HSA: Initialize harmony memory- Improvise a new harmony from the harmony memory- Update harmony memory- Improved harmony search algorithm. Teacher learning based optimization Algorithm -Teacher phase-Learner phase- Demonstration of working of TLBO on unconstrained and constrained optimization problems- HSA and TLBO 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 (editor), “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.

Reference Books:

1. David Goldberg, “Genetic Algorithms in Search, Optimization and Machine Learning”, Pearson Education, 2007.
2. Konstantinos E. Parsopoulos and Michael N. Vrahatis, “Particle Swarm Optimization and Intelligence: Advances and Applications”, Information science reference, IGI Global, , 2010.
3. Rao, R.V. (2016). Teaching-Learning-Based Optimization Algorithm. In: Teaching Learning Based Optimization Algorithm. Springer, Cham. https://doi.org/10.1007/978-3-319-22732-0_2

Reference Papers:

1. K. Nekooei, M. M. Farsangi, H. Nezamabadi-Pour and K. Y. Lee, "An Improved Multi-Objective Harmony Search for Optimal Placement of DGs in Distribution Systems," in IEEE Transactions on Smart Grid, vol. 4, no. 1, pp. 557-567, March 2013, doi: 10.1109/TSG.2012.2237420.
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).

Online resources:

1. <https://nptel.ac.in/courses/103103164>
2. <https://nptel.ac.in/courses/112103301>

M.Tech II-Semester

COURSE CODE – MT-AEPS-1210	MODERN CONTROL THEORY (PROGRAM ELECTIVE-4)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Solve the state equations of dynamic systems, analyze controllability and observability.	4
CO2	Design a state feedback controller and observer.	3
CO3	Analyze various types of nonlinearities and construction of trajectories using describing functions and phase plane analysis.	4
CO4	Determine the stability of a given system and generate a Lyapunov function.	5
CO5	Examine minimization of functional and optimal control performance measures	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	-	1	2	2
CO2	2	-	-	1	2	2
CO3	2	-	-	2	2	2
CO4	2	-	-	2	2	2
CO5	2	-	-	1	2	2

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

UNIT	CONTENTS	Contact Hours
UNIT- 1	State Variable Analysis The concept of state – State Equations for dynamic systems– Solution of Linear Time Invariant Continuous Time State Equations, State transition matrix and it's properties. Controllability and Observability of state model in Jordan Canonical form - Controllability and Observability Canonical forms of State model.	
UNIT- 2	Design using state variable technique Design of state feedback controller through pole placement technique-Necessary and sufficient condition- Ackermann's formula. Concept of observer-Design of full order state observer-reduced order observer.	
UNIT- 3	Non Linear Systems Classification of Nonlinearities- common physical nonlinearities– Characteristics of nonlinear systems - Singular Points –Linearization of nonlinear systems– Describing function – describing function analysis of nonlinear systems- Stability analysis of Nonlinear systems through describing functions, Introduction to phase plane analysis, Method of Isoclines for Constructing Trajectories.	
UNIT- 4	Stability Analysis Stability in the sense of Lyapunov, Lyapunov's stability and Lyapunov's instability theorems – Stability Analysis of Linear Continuous time invariant systems by Lyapunov method – Generation of Lyapunov functions – Variable gradient method – Krasovskii's method.	
UNIT- 5	Introduction to Optimal Control Minimization of functional of single function – Constrained minimization –	

	Minimum principle – Control variable inequality constraints – Control and state variable inequality constraints – Euler lagrangine equation. Typical optimal control performance measures-optimal control based on Quadratic performance measures- Quadratic optimal regulator systems- State regulator problems –Output regulator problems.	
	Total	48 Hrs

Text Books:

1. Modern Control Engineering – by K. Ogata, Prentice Hall of India, 3rd edition, 1998.
2. Automatic Control Systems by B.C. Kuo, Prentice Hall Publication.

Reference Books:

1. Modern Control System Theory – by M. Gopal, New Age International Publishers, 2nd edition, 1996
2. Control Systems Engineering by I.J. Nagarath and M.Gopal, New Age International (P) Ltd.
3. Digital Control and State Variable Methods – by M. Gopal, Tata McGraw–Hill Companies, 1997.
4. Systems and Control by Stainslaw H. Zak, Oxford Press, 2003.
5. Optimal control theory: an Introduction by Donald E.Kirk by Dover publications.
6. Modern control systems, Richard C. Dorf and Robert H. Bishop, 11th Edition, Pearson Edu, India, 2009

M.Tech. II-Semester

COURSE CODE – MT-AEPS-1211	RENEWABLE ENERGY SYSTEMS LABORATORY	CATEGORY LB	L-T-P 0-0-3	CREDITS 1.5
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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.	4
CO2	Demonstrate the effect of series and parallel combination of PV cells by I-V and P-V curves.	3
CO3	Analyze the effect of suitable power electronic converters for PV system.	4
CO4	Demonstrate the significance of various MPPT algorithms on PV System.	3
CO5	Demonstrate wind power generation and wind turbine curves.	3
CO6	Analyze the model of Uninterrupted Power Supply.	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	-	2	2	3
CO2	1	1	-	2	2	3
CO3	1	1	-	-	-	3
CO4	1	1	-	2	1	3
CO5	1	1	-	2	2	3
CO6	1	1	-	1	2	3

(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.	

M.Tech. II-Semester

COURSE CODE – MT-AEPS-1212	POWER SYSTEM SIMULATION LABORATORY – II	CATEGORY LB	L-T-P 0-0-3	CREDITS 1.5
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Analyze the multi machine stability by advanced approaches.	4
CO2	Calculate optimal power flows and analyze unit commitment by optimal methods.	3
CO3	Analyze the load flow and contingency cases of power systems	4
CO4	Illustrate the state estimations and power quality improvements	3
CO5	Analyze the stability of SMIB with and without controllers	4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	2	--
CO2	2	2	3	2	3	1
CO3	3	3	3	2	2	2
CO4	2	3	2	2	2	1
CO5	3	2	2	3	2	--

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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 2 nd 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

I-M.Tech. II-Semester

COURSE CODE – MT-AEPS-1213	MINI PROJECT WITH SEMINAR	CATEGORY MP	L-T-P 2-0-0	CREDITS 2
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Identify various problems in his/her specialization domain.	
CO2	Know suitable simulation tools to develop/test simulation models.	
CO3	Prepare effective technical report and present his/her work.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		2			
CO2	2		2			
CO3		3	2			

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)

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.

M.Tech. II-Semester

COURSE CODE – MT-AEPS- 1214	AUDIT COURSE – 2	CATEGORY AC	L-T-P 2-0-0	CREDITS 0
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Pre-requisite:

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

		Knowledge Level (K)#
CO1		
CO2		
CO3		
CO4		
CO5		

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1						
CO2						
CO3						
CO4						
CO5						

(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

M.Tech III-Semester

COURSE CODE – MT-AEPS-2101	REACTIVE POWER COMPENSATION & MANAGEMENT (PROGRAM ELECTIVE-5)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Learn and describe various load compensations.	2
CO2	Determine the reactive power compensation in transmission systems	5
CO3	Demonstrate the mathematical model of reactive power compensating devices.	3
CO4	Compare the distribution side and load side reactive power management	4
CO5	Get application of reactive power compensation in electrical traction & arc furnaces.	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	--	2	3	2	1
CO2	3	--	3	3	2	1
CO3	2	--	2	2	2	1
CO4	3	--	2	3	3	1
CO5	2	--	2	2	2	1

(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 arc furnaces: Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace.	
	Total	48 Hrs

Text Books:

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

M.Tech III-Semester

COURSE CODE – MT-AEPS-2102	ENERGY AUDITING, CONSERVATION AND MANAGEMENT (PROGRAM ELECTIVE-5)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Discuss the principle of energy audit and their economic aspects.	2
CO2	Report the energy management planning and reporting	2
CO3	Recommend energy efficient motors and design good lighting system.	5
CO4	Summarize the power factor improvement methods and energy instruments	2
CO5	Evaluate the depreciation of equipment.	5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	--	2	2	2	2
CO2	1	--	3	3	2	1
CO3	2	--	3	1	3	1
CO4	3	--	2	3	2	1
CO5	2	--	2	2	2	2

(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

M.Tech III-Semester

COURSE CODE – MT-AEPS-2103	POWER SYSTEM REFORMS (PROGRAM ELECTIVE-5)	CATEGORY PE	L-T-P 3 -0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Summarize the methods of power system restructuring.	2
CO2	Calculate the Access Time Information System calculations.	4
CO3	Describe the transmission congestion management.	2
CO4	Compute the electricity pricing in deregulated environment.	3
CO5	Illustrate the power system operation in competitive environment and the importance of ancillary services.	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	--	2	2	2	2
CO2	2	--	2	1	1	1
CO3	2	--	1	1	2	2
CO4	3	--	2	2	3	2
CO5	2	--	1	1	2	2

(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 Muwaffaqalomoush, – “Restructured electrical Power systems” Marcel Dekker, Inc. 2001
2. Kankar Bhattacharya, Math H.J. Boller, JaapE.Daalder, ‘Operation of Restructured Power System’ Klumer 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

M.Tech III-Semester

COURSE CODE – MT-AEPS-2104	FUNDAMENTALS OF UTILIZATION OF ELECTRICAL ENERGY (OPEN ELECTIVE)	CATEGORY OE	L-T-P 3-0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Describe the concepts of illumination and various illumination methods.	2
CO2	Explain various heating methods.	2
CO3	Compare various welding process.	4
CO4	Analyze the characteristics of various traction systems and applications.	4
CO5	Summarize various energy storage systems	2

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	--	1	-	1	1
CO2	1	--	1	-	1	1
CO3	1	--	1	-	1	1
CO4	2	--	1	-	1	1
CO5	1	--	1	-	1	1

(Please fill the above with Levels of Correlation - viz. - L-1 - M-2 - H-3)

UNIT	CONTENTS	Contact Hours
UNIT - 1	Illumination fundamentals Introduction - terms used in illumination–Laws of illumination–Lux meter–Sources of light. Various Illumination Methods Tungsten filament lamps and fluorescent lamps - Comparison –Basic principles of light control– Types and design of lighting and flood lighting–LED lighting - Energy conservation.	
UNIT - 2	Electric Heating Advantages and methods of electric heating–Resistance heating induction heating and dielectric heating.	
UNIT - 3	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.	
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	

Text Books:

1. Electrical Power Systems (Generation - Transmission - Distribution- Protection and Utilization of Electrical Energy) – Dr. S.L.Uppal and Prof. Sunil S.Rao – Khanna Publisher - 15th edition - 1987.
2. Electric Power Distribution – A. S. Pabla – McGrawHill - 5th edition - 2004.

Reference Books:

1. Generation Distribution and Utilization of Electrical Energy – C.L.Wadhwa- New Age International Publishers- revised 3rd edition.

M.Tech III-Semester

COURSE CODE – MT-AEPS-2105	FUNDAMENTALS OF ELECTRIC VEHICLES (OPEN ELECTIVE)	CATEGORY OE	L-T-P 3-0-0	CREDITS 3
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Describe different types of electric vehicles.	2
CO2	Illustrate the components of Electric vehicles	3
CO3	Differentiate among series, parallel and complex Electric vehicles	3
CO4	Present the need and merits of V2G and G2V Technologies	3
CO5	Demonstrate the battery management system for Electric vehicle system	3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	-	-	-
CO2	2	-	2	-	-	-
CO3	2	-	3	-	-	-
CO4	3	-	2	-	-	-
CO5	2	-	2	-	-	-

(Please fill the above with Levels of Correlation - viz. - L-1 - M-2 - H-3)

UNIT	CONTENTS	Contact Hours
UNIT - 1	Introduction Fundamentals of vehicles - Components of conventional vehicles - drawbacks of conventional vehicles – Need for electric vehicles - History of Electric Vehicles – Types of Electric Vehicles – Advantages and applications of Electric Vehicles.	
UNIT - 2	Components of Electric Vehicles (EVs) Main components of Electric Vehicles – Power Converters - Controller and Electric Traction Motor – Rectifiers used in EVs – Bidirectional DC–DC Converters – Voltage Source Inverters.	
UNIT - 3	Hybrid Electric Vehicles Evolution of Hybrid Electric Vehicles – Advantages and Applications of Hybrid Electric Vehicles – Architecture of HEVs - Series and Parallel HEVs – Complex HEVs – Range extended HEVs – Examples - Merits and Demerits.	
UNIT - 4	V2G and G2V Technologies Energy scenario in India, Electricity consumption by EVs and all other loads, End of life batteries for grid support, EV charging schemes, types of EV chargers, Vehicle-to-grid (V2G) and Grid-to-Vehicle (G2V) technologies, Energy trading with EVs.	
UNIT - 5	Energy Sources for Electric Vehicles Batteries - Types of Batteries – Lithium-ion - Nickel-metal hydride - Lead-	

	acid – Comparison of Batteries - Battery Management System – Ultra capacitors – Flywheels – Fuel Cell – it's working.	
	Total	

Text Books

1. Iqbal Hussein - Electric and Hybrid Vehicles: Design Fundamentals - CRC Press - 2021.
2. Denton - Tom. Electric and hybrid vehicles. Routledge - 2020.

Reference Books:

1. Kumar - L. Ashok - and S. Albert Alexander. Power Converters for Electric Vehicles. CRC Press - 2020.
2. Chau - Kwok Tong. Electric vehicle machines and drives: design - analysis and application. John Wiley & Sons - 2015.
3. Berg - Helena. Batteries for electric vehicles: materials and electrochemistry. Cambridge university press - 2015.

M.Tech. III-Semester

COURSE CODE – MT-AEPS- 2106	INTERNSHIP	CATEGORY	L-T-P	CREDITS 2
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M.Tech. III & IV - Semester

COURSE CODE – MT-AEPS- 2107	DISSERTATION-PART I & II INDUSTRIAL PROJECT PART I & II	CATEGORY PJ	L-T-P 0-0-52	CREDITS 26
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Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate various problems in the industries/society in his/her specialization domain.	
CO2	Recommend appropriate solution to the identified problem and develop prototype/simulation model to arrive suitable conclusions.	
CO3	Prepare effective technical report and present his/her work.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3			
CO2	3		3			
CO3		3	3			

(Please fill the above with Levels of Correlation, viz., 3: Strong, 2: Moderate, 1: Weak)