School of Engineering

Sri Satya Sai University of Technology and Medical Sciences, Sehore

Curriculum for

Postgraduate Degree Courses in Engineering & Technology

Master of Technology (Electrical Engineering)

Specialization: Electrical Power System

(01) Program Educational Objectives (PEO's)

PEO1: To strengthen the knowledge in the domain of power system its applications in power sectors and core Industries and enhance analytical skills to solve complex problems using Soft controllers appropriate to its solutions that are technically sound, economically feasible and socially acceptable

PEO2: To develop the graduate to identify and address current problems in the domain of power system engineering.

PEO3: Engage in research & development in cutting edge and sustainable technologies and to inculcate research and lifelong learning attitude among the graduates.

(02) Program Outcomes (PO's):

PO-01: Engineering Knowledge: Acquire in-depth knowledge in the domain of power systems.

PO-02: Problem Analysis: To design, analyze, test and evaluate the performance of the electrical machines and transformers and the Development of the design of a number of problems, relating to the constraints of fault levels and voltage regulation on power systems

PO-03: Design/Development of Solution: Design and choice of equipment are to ensure maximum security of supplies with operational flexibility at an acceptable cost.

PO-04: Investigation: Apply advanced concepts of electrical power engineering to analyze, design and develop electrical components, apparatus and systems and to put forward scientific findings at national and international levels.

PO-05: Modern Tool Usage: Ability to use advanced techniques like artificial intelligence, expert system, fuzzy concepts etc..skills and modern scientific and engineering tools like matlab, c++ for professional practice.

PO06: The Engineer and Society: An ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.

PO-07: Environment and Sustainability: Ability to design electrical and related system component, to meet desired needs and finding its solution within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

PO-08: Ethics: Understand the impact of Electrical Engineering solutions and implement the norms of professional societies like IEEE, IE (I) in ethical way.

PO-09: Individual and Team Work: Preparedness to lead a multidisciplinary scientific research team and communicate effectively.

PO-10: Communication: An ability to communicate effectively, orally as well as in writing, with society at large.

PO-11: Project Management: Demonstrate and apply knowledge and understanding of engineering principles for project management.

PO-12: Life-Long Learning: The in-depth research necessary to understand the impact of power system and its application and the advance recent trends, problems and their solutions in a global, economic, environmental and societal context.

(03) Programme Specific Outcomes (PSO's):

PSO1: Apply knowledge of power system configuration, electrical equipment and protection practices to the design and specification of electrical generation, transmission, distribution and utilization systems.

PSO2: Design advanced level power system, components, or processes to meet identified needs within economic, environmental and social constraints.

(04) Semester wise PO's and PSO's Mapping

Semester	Name of the Courses /POs(Basic, Core Electives, Projects, Internships etc.)	PO 1 Engineering Knowledge	PO 2 Problem Analysis	PO3 Design/ Development of Solution	PO4 Investigation	PO 5 Modern Tool Usage	PO 6 The Engineer and Society	PO7 Environment and Sustainability	PO 8 Ethics	PO9 Individual and Team Work	PO10 Communication	PO11 Project Management	PO 12 Life-Long Learning	PSO 1	PSO 2
Semester-Ist	Advanced Mathematics	*	*	*	*								*		
	Power System Analysis And Control	*	*		*								*		
	Advanced Power System Analysis	*	*	*	*	*			*		*		*		
	Advanced Electrical Machines	*	*	*	*	*								*	
	Advance Power System Protection Relays	*	*	*				*						*	
	Lab -1 : Power Electronics Lab	*	*	*	*	*			*	*	*		*	*	*
	Lab -2 : Power System Lab	*	*	*	*	*			*	*		*	*		
Semeste	Flexible AC Transmi	*	*	*	*								*	*	

r-IInd	ssion Systems (Facts)														
	Energy Conservation , Management and Auditing	*	*	*	*			*	*					*	
	Power Quality and Monitoring	*	*	*	*			*					*	*	
	Transient Over Voltages In Power Systems	*	*	*	*										*
	Power System Security and Deregulations	*	*	*	*	*		*	*			*			
	Lab - III:Advance Power System Lab	*	*	*	*	*								*	
	Lab -IV :Power Electronics Application to Power System Lab(Software Based)	*	*	*	*	*								*	*
Semester-IIIrd	Power Controller	*	*	*	*	*								*	*
	Power System Instrumentation	*	*	*	*	*								*	*
	Special Machines	*	*	*	*	*		*							

	Advanced Electrical Drives	*	*	*	*	*								*	*
	Seminar			*		*	*	*	*		*	*	*		
	Dissertation Part I	*	*	*	*			*		*					
Semester-IV	Dissertation Part- II	*	*	*	*	*	*	*		*			*	*	*

(05) Structure of Programme:

To fulfill the need of development of all the POs/ GAs, as per above mapping, the following semester wise programme structure are as under.

[L= Lecture, T = Tutorials, P = Practical's & C = Credits]

Total Credits*= 104

S. No.	Course Category	Credits of the EPS Curriculum
1.	Program Core Corse	64
2.	Program Elective Course	08
4.	Project	32
	Total	**104**

*Definition of Credit:

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit
1 Hr. Practical (P) per week	1Credit

(06) Scheme of Examination (Electrical Power System) Academic Year Semester -I

S.No.	Subject Code	Subject Name	Periods per week			Credits	Maximum marks (Theory Slot)			Maximum Marks (Practical Slot)		Total Marks
			L	T	P		End Sem. Exam.	Tests (Two)	Assignments/ Quiz	End Sem. Practical / Viva	Practical Record/ assignment/Quiz/Presentation	
1.	MEPS-101	Advanced Mathematics	3	1	-	4	70	20	10	-	-	100
2.	MEPS-102	Power System Analysis And Control	3	1	-	4	70	20	10	-	-	100
3.	MEPS-103	Advanced Power System Analysis	3	1	-	4	70	20	10	-	-	100
4.	MEPS-104	Advanced Electrical Machines	3	1	-	4	70	20	10	-	-	100
5.	MEPS-105	Advance Power System Protection Relays	3	1	-	4	70	20	10	-	-	100
6.	MEPS-106	Lab -1 : Power Electronics Lab	-	-	6	6	-	-	-	90	60	150
7.	MEPS-107	Lab -2 : Power System Lab	-	-	6	6	-	-	-	90	60	150
		Total	15	5	12	32	350	100	50	180	120	800

Semester -II

S.No.	Subject Code	Subject Name	Periods /week			Total Credits	Maximum Marks Allotted					Total Marks
							Theory Slot			Practical Slot		
			L	T	P		End Sem. Exam.	Tests (Two)	Assignments /Quiz	End Sem. Practical / Viva	Practical Record/ assignment/ Quiz/Presentation	
1.	MEPS-201	Flexible AC Transmission Systems (Facts)	3	1	-	4	70	20	10	-	-	100
2.	MEPS-202	Energy Conservation , Management and Auditing	3	1	-	4	70	20	10	-	-	100
3.	MEPS-203	Power Quality and Monitoring	3	1	-	4	70	20	10	-	-	100
4.	MEPS-204	Transient Over Voltages In Power Systems	3	1	-	4	70	20	10	-	-	100
5.	MEPS-205	Power System Security and Deregulations	3	1	-	4	70	20	10	-	-	100
6.	MEPS-206	Lab -III:Advance Power System Lab	-	-	6	6	-	-	-	90	60	150
7.	MEPS-207	Lab -IV :Power Electronics Application to Power System Lab(Software Based)	-	-	6	6	-	-	-	90	60	150
		Total	15	5	12	32	350	100	50	180	120	800

Semester -III

S.No.	Subject Code	Subject Name	Periods per week			Credits	Maximum marks (Theory Slot)			Maximum Marks (Practical Slot)		Total Marks
			L	T	P		End Sem. Exam.	Tests (Two)	Assignments/ Quiz	End Sem. Practical / Viva	Practical Record/ assignment/Quiz/ Presentation	
1.	MEPS-301	Elective 1	3	1	-	4	70	20	10	-	-	100
2.	MEPS-302	Elective 2	3	1	-	4	70	20	10	-	-	100
3.	MEPS-303	Seminar			4	4				-	100	100
4.	MEPS-404	Dissertation Part I			8	8				120	80	200
		Total	6	2	12	20	140	40	20	120	180	500

Elective 1

MEPS – 301(A) Power Controller

MEPS – 301(B) Special Machines

Elective 2

MEPS – 302(A) Power System Instrumentation

MEPS – 302(B) Advanced Electrical Drives

Semester –IV

S.No.	Subject Code	Subject Name	Credits Allotted Subject wise/ Period per week			Credits	Maximum marks (Theory Slot)			Maximum Marks (Practical Slot)		Total Marks
			L	T	P		End Sem. Exam.	Tests (Two)	Assignments/ Quiz	End Sem. Practical / Viva	Practical Record/ assignment/Quiz/ Presentation	
1.	MEPS 401	Dissertation Part- II	-	-	20	20	-	-	-	300	200	500
		Total	-	--	20	20	-	-	-	300	200	500

(07) Course Content

Semester I

MEPS – 101 Advanced Mathematics

MEPS – 101	Advanced Mathematics	3L:1T:0P	4 credits	4 Hrs/Week

Preamble:

To make students aware of Elementary Partial Differential Equation, Matrices, Reliability and fuzzy lozgic.

Outcomes:

At the end the students will be able to

- Apply the fundamental concepts of Partial Differential Equation and their solution
- Operations of fuzzy sets
- Apply the concepts Reliability
- Solve Matrices And Linear System Of Equations

Unit I : Partial Differential Equation (6Hrs)
Solution of Partial Differential Equation (PDE) by separation of variable method, Numerical solution of PDE (Laplace, Poisson's, Parabola) using finite difference Methods.

Unit II : Matrices And Linear System Of Equations (8Hrs)
Solution of linear simultaneous equations by Gaussian elimination and its modification, Crout's triangularization method, Iterative methods-Jacobins method, Gauss-Seidal method, Determination of Eigen values by iteration.

Unit III : Calculus Of Variations (10Hrs)
Euler-Lagrange's differential equation, The Brachistochrone problems and other applications. Isoperi-metric problem, Hamilton's Principle and Lagrange's Equation, Rayleigh-Ritz method, Galerkin method.

Unit IV : Fuzzy Logic (10Hrs)
Operations of fuzzy sets, fuzzy arithmetic & relations, fuzzy relation equations, fuzzy logics. MATLAB introduction, programming in MATLAB scripts, functions and their application.

Unit V : Reliability (10Hrs)
Introduction and definition of reliability, derivation of reliability functions, Failure rate, Hazard rate, mean time t future & their relations, concepts of fault tolerant analysis.

Reference Books:
1. Higher Engineering Mathematics - by Dr. B.S. Grewal; Khanna Publishers
2. Calculus of Variations - by Elsgole; Addison Wesley.
3. Applied Numerical Methods with MATLAB by Steven C Chapra, TMH.
4. Introductory Methods of Numerical Analysis by S.S. Shastry,
5. Calculus of Variations - by Galfand & Fomin; Prentice Hall.
6. Higher Engineering Mathematics by B.V. Ramana, Tata Mc Hill.
7. Advance Engineering Mathematics by Ervin Kreszig, Wiley Easten Edd.
8. Numerical Solution of Differential Equation by M. K. Jain
9. Numerical Mathematical Analysis By James B. Scarborogh
10. Fuzzy Logic in Engineering by T. J. Ross
11. Fuzzy Sets Theory & its Applications by H. J. Zimmersoms

MEPS – 102 Power System Analysis And Control

MEPS – 102	**Power System Analysis And Control**	**3L:1T:0P**	**4 credits**	**4 Hrs/Week**

Preamble:

- To provide students the knowledge of power system stability, modeling of synchronous machine and prime mover controllers.
- To provide the knowledge of transient stability, transformation and signal analysis with block diagram representation

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

- Analyse power system stability problem and their mitigation.
- Analysis of steady state performance per unit equivalent circuits of synchronous machine
- Field implementation and transient analysis of a synchronous machine.
- Block diagram representation of small signal

UNIT 1 Introduction to power system stability problem: Basic concepts definitions and types: Rotor angle stability, voltage stability and voltage collapse, Mid term and long-term stability, Classification of stability, states of operation, system security, system dynamic problems.
Review of classical method: System model, some mathematical analysis of steady state stability, analysis of transient stability, simplified representation of excitation control.

UNIT 2 Modeling of synchronous machine: Introduction, synchronous machine, parks transformation, analysis of steady state performance per unit equivalent circuits of synchronous machine, determination of parameters of equivalent circuits, measurements for obtaining data, saturation models, transient analysis of a synchronous machine.

UNIT 3 Excitation and prime mover controllers: Excitation system Modeling, system representation by state evasions, prime move control systems.

UNIT 4 Transmission line, svc and loads: D-Q transformation using L-B variables, static var compensators, loads Dynamics of a synchronous generator connected to estimate bus: system model, synchronous machine model, calculation of initial conditions, inclusion of SVC Model, Analysis of single machine system, Small signal analysis with block diagram representation, synchronizing and damping torque analysis, small signal model, nonlinear oscillators.

UNIT 5 Application of power system stabilizers: Basic concepts, control signals, structure and tuning of PSS, field implementation and operating experience 24 Hours.

Reference Books:
1. K.R. Padiyar, Power system dynamics, stability and control, BS Pub. Hydbid
2. P Kunder, Power system stability and control, TMH.
3. P. W. Sauer & M A Pai: Power system dynamics and stability: Pearson.

MEPS-103 Advanced Power System Analysis

MEPS – 103	**Advanced Power System Analysis**	**3L:1T:0P**	**4 credits**	**4 Hrs/Week**

Preamble:

To provide students the knowledge of incidence and network matrices, unbalanced fault and load flow studies.

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

- Design Algorithm for formation of single phase Bus Impedance Matrix.
- Contingency Analysis for power systems
- state estimation of line power flow

UNIT I (**6Hrs)**Incidence and network matrices,
formation of network matrices by singular and non-singular transformation.

UNITII. (**8Hrs)** Algorithm for formation of single phase Bus Impedance Matrix.

UNIT III. (**10Hrs)**Three- phase balanced network elements, Transformation matrices , Three phase unbalanced network elements , Algorithm for formation of three phase Bus Impedance Matrix.

UNIT IV. (**10Hrs)**Short circuit calculations using Z-BUS for balanced and unbalanced three phase networks, symmetrical components, sequence impedances, sequence networks,Unbalanced fault analysis for three phase to ground fault, LG fault, LL Fault, LLG Fault.

UNIT V. (**10Hrs)**Load flow studies using Y-BUS, Gauss-Seidel method ,Newton Raphson method, Fast Decoupled load flow method , representation of transformers, Sparsity technique. Contingency Analysis for power systems using Brown's method, State estimation from on line measurements, The line power flow state estimation.

Books:-

1. G.N. Stagg and A. H.EI- Abiad , Computer Methods in Power System Analysis, McGraw –Hill ,International Edition .
2. George L .Kusic, Computer Aided Power Systems Analysis ,Prentice Hall.
3. J. Arrillaga, C.P. Arnold and S.J. Harker, Computer Modelling of Electrical Power Systems, John Willey and Sons.
4. O.I. Elgerd Electric Energy Systems -An Introduction, Tata McGraw Hill.
5. M.A. Pai, Computer Techniques in Power Systems Analysis ,Tata McGraw Hill.
6. P.M. Anderson, Analysis of Faulted Power System, IEEE Press Book.

7. Related IEEE/IEE Publication.

MEPS-104 Advanced Electrical Machines

MEPS – 103	**Advanced Electrical Machines**	**3L:1T:0P**	**4 credits**	**4 Hrs/Week**

Preamble:

- To make students aware of machine parameters, its transient and steady state analysis.
- To provide knowledge of machine dynamics and excitation in transformer.

Outcomes:

- At the end of the course content the students will be able to
- Do mathematical modelling of synchronous machine
- Analysis linear and non-linear concept of synchronous machine
- Unbalanced operation of transformers methods to remove harmonics

Unit I Mathematical Modelling: (8 Hrs)
Basic Synchronous machine parameters, Voltage, Flux linkage and inductance relations, Park's transformation - its physical concept, equations of performance.
Balanced Steady State Analysis:
Phasor equations and phasor diagrams, Power-angle characteristics, cylindrical rotor and Salient pole machines, Short
circuit ratio.

Unit II Transient Analysis: (10Hrs)
Three phase short circuit Armature and field transients, Transient torque, Sudden reactive loading and Unloading. Transient Analysis -a qualitative approach, Reactances and time , constants from equivalent circuit .Measurement of Reactances, Transient Power angle characteristics.

Unit III Synchronous - machine Dynamics: (8Hrs)
The basic electromechanical equation, Linearized Analysis, Large Angular/oscillation, Non-linear analysis.

Unit IV Multi-Circuit Transformers: (10Hrs)
General theory, Equivalent circuits, Three winding transformer as a multi-circuit transformers, Determination of parameters.
Excitation phenomena in Transformers: Harmonics in Single – phase transformers, Harmonics in three-phase transformers, Disadvantages of harmonics, Suppression of harmonics.

Unit V Transformer Transients: (10Hrs)
Inrush current phenomena, Qualitative approach, Analytical approach, Inrush current in 3-phase transformers.
Unbalanced Operation of three-phase Transformers: Single phase load on three-phase transformers, Single - Phasing in 3-phase transformers, Effect of using tertiary winding.
Recommended Text Book:
Generalized theory of Electrical Machines by Dr. P.S. Bimbhra (Khanna Publishers.)

Reference Books:
1. Generalized theory of electrical Machines by B. Edkins.
2. Synchronous machines by Concordia.
3. Power System Stability Vol. III by E.W, Kimbark.
4. Electrical Machinery by Fitzegerald, Kingsley.
5. Electrical Machines by A. Draper.
6. Magnetic Circuits and Transformer MIT Staff.

MEPS – 105 Advance Power System Protection Relays

MEPS – 105	**Advance Power System Protection Relays**	**3L:1T:0P**	**4 credits**	**4 Hrs/Week**

Preamble:
To provide the fundamentals of Digital Relaying, Advanced Protection of Transmission Line and Modern trends in power system protection
Outcomes:

At the end the students will be able to :
- determine the various techniqus used in the Protection of Transmission Line
- importance of digital and computer aided relays,
- design Algorithms for transmission line, transformer & bus bar protection

Unit-I Digital Relaying (6Hrs)
Advantages of Digital Relaying systems, Block diagram of Digital Relay, Anti aliasing filters, Data window, Facilities in commercial digital relays, Different relay algorithms such as least square error method, Walsh algorithm, Man and Morrison algorithm, Discrete Full Cycle and Half Cycle Algorithm, communication protocol (IEC 61850), Time Synchronization with Wide Area Measurements

Unit - 2 Advanced Protection of Transmission Line (10Hrs)

Coordination of over current relays in an interconnected system, LINKNET structure, Concept of Sympathy Trips, Coordination of Distance Relays, Protection of Series Compensated Lines: Problems & Solutions, Teed Line,Carrier Current Protection, Phase Comparison Carrier, Carrier Aided Distance Protection,Blocking Carrier, Carrier Intercropping and Carrier Acceleration, Philosophy of Adaptive Relaying

Unit 3 Generator and transformer protection: (8Hrs)
Protective devices for system. Protective devices for stator, rotor, and prime mover of generator, percentage differential relays protection, three winding transformer protection, earth fault protection,generator transformer unit protection.

UNIT 4 Bus bar and transmission line protection: (10Hrs)
Distance protective schemes,directional wave detection relay. Phase compensation carrier protection. High impedance differential scheme, supervisory and check relay, Some features of 500 KV relaying protection.

Unit 5 Modern trends in power system protection: (10Hrs)
Different types of digital and computer aided relays, Microprocessor based relays, auto-reclosing, frequency relays, under and over frequency relays, di/dt relays. Algorithms for transmission line, transformer & bus bar protection; out-of-step relaying Introduction to adaptive relaying & wide area measurements

Reference Books:

1. Power System Protection and Switchgear, B.Ram – Tata Mc-Graw Hill Pub.
2. Switchgear and Protection, M.V.Deshpande - Tata Mc-Graw Hill Pub.
3. Power System Protection & Switchgear, Ravindra Nath, M.Chander, Willy P

MEPS 106 - LAB 1 Power Electronics Lab

MEPS 106	**Power Electronics Lab**	**0L:0T:6P**	**6credits**	**6Hrs/Week**

Preamble: To provide knowledge about the tools and software's used in power system and different techniques to do programming as well as find solution based on experimental study

Outcomes: The students will be able to verify different characteristics and application of various converters, rectifiers used in power system analysis.

List of experiments

1 To study the Step –up chopper.
2 To study the Jone's Chopper.
3 To study the working of Cycloconverter.

4 To study the half wave, full wave & fully controlled bridge rectifier using SCR's.
5 To study various type of forced Commutation techniques.
6 To study the SCR triggering circuit.
7 To study the Characteristics and Applications of the following Devices:Silicon Controlled Rectifier (SCR) ,Diac,Triac
8 To study the Conversion of DC to AC by using Single-phase Inverter Circuit using Power MOSFET in Bridge configuration

MEPS 107- LAB 2 Power System Lab

MEPS 107	**Power System Lab**	**0L:0T:6P**	**6credits**	**6Hrs/Week**

Preamble: To provide knowledge about the tools and software's used in power system and different techniques to do programming and design algorithms and perform simulations.

Outcomes: The students will be able to simulate various transformations, design algorithms based on data available and inbuilt data in the software's and verify the results based on characteristics curves and graphs.

List of experiments:

1 Formation of Ybus using Singular Transformation
2 Solution of power flow using Gauss siedal method
3 Solution of power flow using Newton Raphson method
4 Economic load dispatch using MATLAB considering loss less transmission line
5 Economic load dispatch using MATLAB considering loss less transmission line

MEPS 201 Flexible AC Transmission Systems (FACTS)

MEPS 201	**Flexible AC Transmission Systems (FACTS)**	**3L:1T:0P**	**4 credits**	**4Hrs/Week**

Preambles:
The students will
1. Understand the FACTS devices ,operation and controlling
2. Understand model of power systems installed with FACTS based Stabilizers

Outcomes:
At the end the students will be able to :
Install Linearized model of power systems with FACTS based Stabilizers
Design of FACTS based stabilizers:
operation and control of Power flow Controller

Unit-1: Introduction: (**8Hrs)**
Facts basic concepts and general system considerations, power flow in ac system, definitions on facts, basic types of facts controllers, benefits from facts Technology, static var compensator (SVC): principle of operation and control strategy, Thyristor controlled phase angle regulator (TCPAR): principle of operation and control strategy.

Unit-2: Transient Stability Analysis: (**6Hrs)**
Analysis of Power systems installed with FACTS devices.
Control with FACTS: Power Transmission Control using UPFC, Power Transmission Control using Phase Shifting Transformer (PST), Power Transmission Control using SSSC.

Unit-3: **Oscillation Stability Analysis and Control with FACTS**: (**10Hrs)**
Linearised model of power systems installed with FACTS based Stabilizers, Heffron-Phillips model of a SMIB system installed with SVC, TCSC and TCPS, Heffron-Phillips model of a SMIB system with UPFC, Heffron-Phillips model of a Multi-machine system installed with SVC, TCSC and TCPS.

Unit-4: **Design of FACTS based stabilizers**: (**10Hrs)**
Analysis of damping torque contribution by FACTS based stabilizers installed in SMIB systems, Selection of installing locations and feedback signal for FACTS based stabilizers, Dynamic Voltage restorer.

Unit-5: Power flow Controller: (**10Hrs)**
Unified Power Flow Controller (UPFC): Principle of operation, configuration and control, Simulation of UPFC, Steady state model of UPFC, Interline Power Flow Controller (IPFC): Principle of operation, configuration and control, Static compensator (STATCOM): principle of operation and control, Application for mitigation of ssr.

References:
1. "Understanding FACTS Devices" N.G. Hingorani and L. Guygi. IEEE Press Publications 2000.
2. Flexible AC Transmission System: Y.H.Song and A.T.Jhons, IEE, 1996(A Book)
3. Dr Ashok S & K S Suresh Kumar "FACTS Controllers and applications" course book for STTP, 2003.
4. Ned Mohan et.al, Power Electronics, John Wiley and Sons.
5. K. R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International, First Edition.

MEPS 202 Energy Conservation, Management and Auditing

MEPS 202	**Energy Conservation, Management and Auditing**	**3L:1T:0P**	**4 credits**	**4Hrs/Week**

Preambles:
Students will be able to:
1. To learn various renewable energy sources
2. To gain understanding of integrated operation of renewable energy sources
3. To understand Power Electronics Interface with the Grid

Outcomes:
Students will be able to:
1. Knowledge about renewable energy
2. Understand the working of distributed generation system in autonomous/grid connected modes
3. Know the Impact of Distributed Generation on Power System
4. Know the Principles of energy management, auditing and conversion
5. Use of energy efficient controller in power system

Unit-1: Energy auditing: (6Hrs)
Concepts of Energy audit, types of audit, energy index, cost index, pie charts, Sankey diagrams, load profiles, Energy audit of industries- process industry, thermal power station, building energy audit, Thermal energy audit in heating, ventilation and air conditioning, Energy monitoring, Energy accounting and analysis, targeting, Loss of energy in material flow, Maximizing system efficiency, Energy auditing instruments.

Unit-2:Energy Conservation- (10Hrs)
Thermodynamics of Energy Conservation, Basic principle, Irreversibility and second law, Energy storage for power systems (Mechanical, Thermal, Electrical & Magnetic) Energy conservation task before industry, Energy conservation equipments, Co-Generation, Energy conservation in Sugar, Textiles, Cement, process industry, Electrical Energy Conservation in building, heating, lighting, domestic gadgets, Energy Conservation in transportation system especially in electric vehicle, Primary energy sources, optimum use of prime-movers, energy efficient housekeeping, energy recovery in thermal systems, waste heat recovery techniques.

Unit3-:Energy Management- (8Hrs)
Principles of energy management, energy management program, initiating, planning, controlling, promoting, monitoring, reporting, Energy manager, qualities and function of energy managers, Language of an energy manager.

Unit-4: Economic Analysis -(10Hrs) Economics Analysis-Depreciation Methods, time value of money, rate of return , return on investment ,replacement analysis, life cycle costing analysis-calculation of simple payback method, Payback period, net present worth method, , lighting ,Applications of life cycle costing analysis, Load curve analysis, load management DSM,

Restructuring of electric tariff from energy conservation consideration, Energy economics, Cost Benefit Risk analysis.

Unit-5: Energy Efficient Motor, Instrument & Pf Improvement: (10Hrs)

Power factor improvement methods, location of capacitors, Pf with non linear loads, effect of harmonics on power factor, power factor motor controllers

Energy instruments- wattmeter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's.

Energy efficient motors-Energy efficient electric drives, factors affecting efficiency, loss distribution.

References:

1. Energy management by W.R. Murphy AND G. Mckay Butter worth, Heinemann publications.
2. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
3. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition,1995
4. Energy management hand book by W.C.Turner, John wiley and sons
5. Energy management and good lighting practice: fuel efficiency- booklet12-EEO
6. Elect, Energy Utilization & Conservation. Dr. Tripathi S.C.,
7. Energy Management – W.R. Murphy & G. Mckey Butler worths.
8. Energy Management Head Book- W.C. Turner, John Wiley
9. Energy conservation & Management: JB GUPTA

MEPS 203 Power Quality and monitoring

MEPS 203	**Power Quality and monitoring**	**3L:1T:0P**	**4 credits**	**4Hrs/Week**

Preambles:

Students will be able to understand and analyse the Causes and effects of power quality disturbances and transients.

Outcomes:

At the end students will learn Remedies to improve power quality, the controlling of EMI
And use of PWM converters and power quality conditioners.

Unit-1: Introduction: (6Hrs)

Power quality basics, types of power quality disturbances, power quality indices, Causes and effects of power quality disturbances , Voltage, Sag, Swell, Surges, over voltages, spikes, Voltage fluctuations, , Interruption, Remedies to improve power quality.

Unit -2: Transients: (10Hrs)

Origin and classifications, capacitor switching transient, lightning-load switching , impact on users ,protection, mitigation, causes and effects of harmonics, converter configuration and their contribution to supply harmonics, other sources of harmonics.

Unit -3:**Controlling**: (**10Hrs)**Active wave shaping of input line current, constant frequency control, constant tolerance band control, variable tolerance band control, discontinuous current control, Electromagnetic interference(EMI), EMI generation ,EMI standards, and elimination.

Unit- 4: **Filters** : (**10Hrs)**
Radio interference, supply standards, suppression of harmonics, passive input filters, design of harmonic filters, Improved power quality converter topologies,(single and three phase), transformer connections, reduction of harmonics using active power filters – topologies, and their control methods, PWM converter as a voltage source active filter, current source active filter.

Unit- 5: **Power Quality conditioners**: (**6Hrs)**
Shunt and series compensators, DStatcom-Dynamic voltage restorer, unified power quality conditioners, case studies.

References:
1. Power Quality – by R.C. Duggan
2. Power system harmonics – by A.J. Arrillga
3. Power electronic converter harmonics – by Derek A. Paice
4. Power Electronics –Mohan,Undeland,Robbins
5. Heydt, G.T., „Electric Power Quality", Stars in a Circle Publications, Indiana,2nd edition 1994.
6 .Bollen, M.H.J., „Understanding Power Quality Problems: Voltage sags and interruptions", IEEE Press, New York, 2000.
7. Arrillaga, J, Watson, N.R., Chen, S., „Power System Quality Assessment", Wiley, New York, 2000.

MEPS 204 Transient Over Voltages In Power Systems

MEPS 204	Transient Over Voltages In Power Systems	3L:1T:0P	4 credits	4Hrs/Week

Preambles:
Students will be able to understand Transients and Generation of high AC and DC-impulse voltages in electric power systems.

Outcomes:
At the end students will learn Protection system used in and industrial drive systems.
And removal of abnormal switching transients in power system.

Unit-1: Transients in electric power systems – (**10Hrs)**Internal and external causes of over voltages-– Lightning strokes – Mathematical model to represent lightning, Travelling waves in

transmission lines – Circuits with distributed constants – Wave equations – Reflection and refraction of travelling waves – Travelling waves at different line terminations.

Unit- 2: Switching transients –**(6Hrs)**
double frequency transients – abnormal switching transients – Transients in switching a three phase reactor- three phase capacitor.

Unit-3: voltage distribution in transformer winding – **(10Hrs)**
voltage surges-transformers – generators and motors, Transient parameter values for transformers,reactors,generators and transmission lines.

Unit-4: Basic ideas about protection –**(10Hrs)**
surge diverters-surge absorbers-protection of lines and stations Modern lighting arrestors,Insulation coordination,Protection of alternators and industrial drive systems.

Unit- 5 AC and DC-impulse voltages(6Hrs)
Generation of high AC and DC-impulse voltages,currents-measurement using sphere gaps-peak voltmeters-potential dividers and CRO.

References:
1. Allen Greenwood, „Electrical transients in power systems", Wiley Interscience, 1991.
2. Bewley, L.W., „Travelling waves and transmission systems", Dover publications, New York, 1963
3. Gallaghar, P.J. and Pearmain, A.J., 'High voltage measurement, Testing and Design', John Wiley and sons, New York, 2001. EE615G – ANALYSIS AND DESIGN OF ART

MEPS 205 Power System Securities and Deregulation

MEPS 205	**Power System Securities and Deregulation**	**3L:1T:0P**	**4 credits**	**4Hrs/Week**

Preambles:
Students will be able to understand the Power system stability, Securities and Deregulation and pricing system used in power system domain.

Outcomes:
At the end the students will be able to
1. Analyse system monitoring
2. restructuring of power systems and Power system security assessment
3. Detection of network problems
4. Methods of determination of ATC

Unit-1: Basic Concepts(6Hrs)

Power system stability, security, observability, reliability, deregulation, decomposition and multilevel approach, state estimation, system monitoring, static and dynamic – online and offline, security enhancement.

Unit-2: Power System Deregulation: (6Hrs)
Introduction, motivation for restructuring of power systems, Electricity market entities model benefits of deregulation, deregulation in Indian power sector, Operations in power Markets, power pools, transmission networks and electricity markets.

Unit-3: Power System Security: (10Hrs)
Introduction, Factors affecting power system security, Contingency analysis, Detection of network problems, linear sensitivity analysis, AC power flow methods, contingency selection, Bounding area method.

Unit-4: Power system security assessment: (10Hrs)
Network sensitivity factors, performance indices, security constrained optimization, SCOPF, basis of evolutionary optimization techniques, preventive, emergency and restorative controls though non- linear programming (NLP) and linear programming (LP) methods.

Unit-5: Available Transfer Capability: (10Hrs)
Methods of determination of ATC, ATC calculation considering the effect of contingency analysis, Transmission open access and pricing-cost components of transmission system, transmission pricing methods, Incremental cost based transmission pricing.

References:
1. A.J.Wood & B.F.Woollenberg- John Wiley Power Generation, "Operation and Control"-2nd edition.
2. P.Venkatesh. B.V.Manikandan, S.Charles Raja- A.Srinivasan, "Electrical power systems:Analysis, security, Deregulation"– PHI2012.
3.K.Bhattacharya, M.H.J Bollen and J.E. Daaider, "Operation of restructured power system" Kluwer Power Electronics and Power System series (2001)
4.N.S.Rau,"Optimization Principles: Practical Applications to the operation and Markets of the Electric Power Industry".
5.Sally Hunt, "Making competition work in Electricity", John Wiley, 2002

MEPS 206-Lab –III Advance Power System Lab

MEPS 206	**Lab –III Advance Power System Lab**	**0L:0T:6P**	**6credits**	**6Hrs/Week**

Preamble: To make students understand the concept of advance power system experiments based on simulation.

Outcomes:

The students will learn to simulate power system devices with power electronics and machine using simulant tools and their application for solving related problems

List of experiments:

1 To simulate single phase half controlled rectifier with R and RL Load
2 To simulate single phase half controlled rectifier with R and RL lOAD
3 To simulate three phase full controlled rectifier with R and RL lOAD
4 To study ac voltage regulator
5 Characterization of dc motor
6 To simulate dc motor speed control

Lab -IV : Power Electronics Application to Power System Lab

MEPS 207	**Lab –IV Power Electronics Application to Power System Lab**	**0L:0T:6P**	**6credits**	**6Hrs/Week**

Preamble: To make students understand the use and application of power electronics devices in power system based on simulation.

Outcomes: The students will learn to simulate power electronic devices in power system using simulation tools.

List of Experiments:

1. Single phase half controlled converter using R and RL load using MATLAB / SIMULINK
2. Single phase fully controlled converter using R and RL load using MATLAB / SIMULINK
3. Three phase fully controlled converter using R and RL load using MATLAB / SIMULINK
4. Single phase AC voltage regulator using MATLAB / SIMULINK
5. Formation of Y bus matrix by inspection / analytical method using MATLAB Software
6. Formation of Z bus using building algorithm using MATLAB Software
7. Gauss Seidal load flow analysis using MATLAB Software
8. Newton Raphson method of load flow analysis using MATLAB Software
9. Fast decoupled load flow analysis using MATLAB Software
10. Fault analysis using MATLAB Software
11. Economic dispatch using MATLAB Software

III Semester

MEPS – 301(A) Power Controller

MEPS – 301(A)	**Power Controller**	**3L:1T:0P**	**4 credits**	**4Hrs/Week**

Preamble: To provide the fundamentals of Various power semiconductor devices, commutation and effects of harmonics.

Outcomes: At the end the students will be able to

- Design of firing circuit for converters, choppers & inverters
- Analyse harmonics in supply and their mitigation
- Design various inverter commutation circuits

UNIT I (6Hrs)
Various power semiconductor devices i.e. SCR, GTO, MOSFET, BJT, IGBT & MCT's & their protection, series-parallel operation, Heat sink calculations, Design of firing circuit for converters, choppers & inverters.

UNIT II (6Hrs)
Analysis & design of 1-φ bridge converter, 3-φ bridge converter with and without freewheeling diode, effect of source impudence, power factor improvement techniques, and pulse width modulated converters, Dual converters, converter for HVDC application & DC drives.

UNIT III (10Hrs)
Analysis & design of voltage commutated, current commutated and load commutated choppers, multiquadrant choppers, chopper for traction application. Resonant choppers, SMPS.

UNIT IV (10Hrs)
Detailed analysis of 1-φ VSI, 3-φ VSI (180° mode, 150° mode & 120° mode of conduction), various inverter commutation circuits, harmonic reduction techniques, PWM inverters, Inverters for HVDC application & AC drives. Advantages & limitation of current source inverters over VSI, 1-phase and 3-phase CSI. Resonant inverters.

UNIT V(10Hrs)
1-φ to 1-φ, 3-φ to 3-φ cycloconverter circuits, circulating current scheme, non-circulating current operation, Mean output voltage, harmonics in supply current waveform & input-power factor. Concept of power quality
Reference Books :
1. Thyristorised Power Controllers - G.K.Dubey, Doradla, Joshi, Sinha
2. Power Electronics - C.W.Lander
3. Power Electronics - Rashid
4. Thyristorised power controlled converters & cycloconverters - B.R.Pelly
5. Power Electronics - N.Mohan
6. Power Electronics Application - Vithyathil.

MEPS – 301(B) Special Machines

MEPS – 301(B)	**Special Machines**	**3L:1T:0P**	**4 credits**	**4Hrs/Week**

Preambles:

To provide knowledge about the fundamentals of special machines used in electrical drive system and other power system operation and control and their application.

Outcomes:

Upon completing of the course student shall be

1. Able to understand the principle of operation and power converter for switched reluctance motor and stepper motor
2. Able to understand construction, principle of operation, theory of torque production in brushless DC motor
3. Able to understand construction, principle of operation of linear induction drive for electric traction and permanent magnet motors
4. Able to explain the control aspect of special electrical machines.
5. Able to understand the features of electric motors for traction applications.

UNIT 1 (6Hrs)

Square wave permanent magnet brushless dc motor, magnetic circuit analysis on open circuit torque & emf equations, torque speed characteristics, efficiency, commutation, winding inductances, armature reaction and controllers.

UNIT 2 (6Hrs)

Sine wave permanent magnet brushless dc motor, torque & emf equation, Inductance of phase winding, synchronous reactance, phasor diagram, torque-speed characteristics.

UNIT 3 (8Hrs)

Switched reluctance motor, static torque production, partition of energy and the effects of saturation, Dynamic torque production, torque speed characteristics, shaft position sensing, solid rotors.

UNIT 4 (10Hrs)

Linear Induction Motors, construction, performance, thrust-speed characteristic, application, end effect.

UNIT 5 (10Hrs)

Stepper motor – variable reluctance stepper motor, single stack stepper motor multistack stepper motor, permanent magnet stepper motor, Important features of stepper motor, torque v/s stepping rate characteristics, Drive circuits, unipolar drive circuits, Bipolar drive circuits.

Reference Books:

1.Brushless Permanent Magnet & Reluctance Motor Drives – T.J.E.Miller
2.Principles of Electric Machines & Power Electronics – P.C.Sen
3.Electric Drives – G.K.Dubey

MEPS – 302(A) Power System Instrumentation

MEPS – 302(A)	**Power System Instrumentation**	**3L:1T:0P**	**4 credits**	**4Hrs/Week**

Preambles:

To provide knowledge about the display instruments Transducers, sensors, actuators etc used in power system fault analysis and control.
Outcomes:
The students will be able to

- Demonstrate industrial instrumentation and pollution monitoring devices.
- Signal conditioning of inputs and supervisory control
- Analyze factor effecting measuring devices performance

UNIT I (6Hrs)
Introduction to instrumentation and control of energy systems, display instruments, recorders.

UNIT II (6Hrs)
Transducers, sensors, actuators such as pressure, temperature, velocity, speed, volume, torque and solar flux measuring devices, current, voltage and power factor.

UNIT III (10Hrs)
Gas analysers, power plants and industrial instrumentation and pollution monitoring devices.

UNIT IV (10Hrs)
Signal conditioning of inputs, single channel and multichannel data acquisition system, D/A and A/D converters, data loggers, supervisory control.

UNIT V (10Hrs)
Data transmission systems, Advantage and disadvantage of digital transmission over anolog. Time division multiplexing, pulse modulation, digital modulation.

Reference Books:

1.Transducers & Instrumentation by D.V.S. Murty – PHI Prentice Hall
2.Electronic Instrumentation by H.S.Kalsi – Tata McGraw Hill
3.Electrical and Electronics Measurement and Instr., A.K.Sawhney, Dhanpat Rai

4. Instrumentation devices and systems by C.S.Rangan and G.R. Sharma, TMH

302(B) Advanced Electrical Drives

302(B)	Advanced Electrical Drives	3L:1T:0P	4 credits	4Hrs/Week

Preambles:

To give unified treatment of advance electrical drive systems with power electronic converters, including the mechanical parts, electrical machines, and power converters and control.

Outcomes:

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

1. Understand the operation of power electronic converters and their control strategies.

2. Understand the vector control strategies for ac motor drives

3. Understand the implementation of the control strategies using digital signal processors.

UNIT I Electrical Drives (6Hrs)

Introduction, Choice of Electrical Drives, Dynamics of Electrical Drives, Concept ofMulti-quadrant operation, Components of load torques. Selection of motor power rating.

UNIT II D.C.Drive, (6Hrs)
speed torque, speed control. Starting, Breaking. Controlled rectified fed DC drive, chopper controlled dc drives. Close loop control of d.c. drive. Introduction of transient analysis.

UNIT III Induction Motor Drives : (10Hrs)
Three phase I.M., analysis and performance. Operation with unbalanced source voltages and single phasing, analysis of I.M. fed from Non-sinusoidal voltage supply. Starting, Breaking, Introduction of transient analysis. Speed control methods, single phase I.M. Close loop control of I.M. Drives.

UNIT IV Synchronous Motor Drives(10Hrs)
cylindrical rotor wound field motor, salient pole wound field motor, synchronous reluctance motor, Hysterisis synchronous motor, operation from fixed frequency
supply, starting, breaking, synchronous motor variable speed drives, starting large synchronous machines.

UNIT V SPECIAL MOTORS(10Hrs)
Introduction of Brushless dc motor, stepper motor and switch reluctance motor drives, solar and battery powered drives, Traction Drives, Energy conservation in Electrical Drives.

Reference Books:
1.Power semi conductor controlled drives by G.K.Dubey
2.Fundamentals of Electrical Drives by G.K.Dubey
3.Electrical Machine & Power Electronics by P.C.Sen

MEPS 303 - Seminar

MEPS 303	**Seminar**	**0L:0T:4P**	**4 credits**	**4Hrs/Week**

Preamble: To prepare students demonstrate effectively with better representation skill as per electrical industry requirements

Outcomes:

- Ability to convey ideas on electrical power system concepts and technology clearly and effectively in both written and spoken forms. In addition, ability to work collaboratively as part of a team undertaking a range of different team roles
- Lectures, group assignments, individual assignments, individual research projects, Computer laboratory works

- Oral presentations, written assignments, computer laboratory reports, project report, Peer Assessment

Semester III

MEPS 304 Dissertation Part I

MEPS304	**Dissertation Part I**	**0L:0T:8P**	**8 credits**	**8Hrs/Week**

Preamble:

To provide the understanding of synopsis work in terms of

1 Think of topics that interest you. Discuss your topics with adviser before choosing the most interesting and practical one.

2 to search for more information first in order to understand what has been studied about the subject or your topic of interest.

3 Define a research problem on the basis of literature reviewed

Outcomes:

The outcomes will be in the form of a short brief summary report of the work to be carried on in context to electrical power system and its sub division as a qualitative approach for the betterment of industry using latest technology both in hard and soft or individually.

Semester IV

MEPS 401-Dissertation Part- II

MEPS304	**Dissertation Part I**	**0L:0T:20P**	**20 credits**	**8Hrs/Week**

Preamble

The course requires students to work alone with minimal supervision to assist students to develop the organisational skills to work alone on a major research project.

Outcomes:

1 Deeper knowledge of methods in the subject or topic or work

2 Capability to critically and systematically integrate knowledge.

3 Plan, manage and execute a substantial research project utilizing speacialised electrical soft computing techniques such as ANN ,Fuzzy or recent industry requirements

4 Explain the significance of the project in the context of the power system and its controlling or transient behavior in context to recent industrial problem and implication of simulation techniques within the limit of industry,

5 Analyse and interpret the results of the project.

6 Communicate the project objectives, process and results to practising field engineers and scientists in written and verbal form.

7 The ethics of self copy right work

(08) Assessment

PO/Course Assesment Tools Types	PO/Course Assesment Tools	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO9	PO10	PO11	PO12
		Engineering Knowledge	Problem Analysis	Design/Development of Solution	Investigation	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Project Management	Life-Long Learning
Direct Tools	Test	✓	✓	✓	✓				✓		✓	✓	
	Assignments	✓	✓			✓				✓			
	lab /seminar/industrial training/projects(Rubrics)	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓
Indirect Tools	Course end survey	✓				✓		✓					
	Exit survey	✓	✓										✓
	Faculty Survey		✓	✓	✓			✓					
	Alumni Survey	✓			✓		✓		✓	✓	✓		✓
	Program Statistics	✓			✓				✓			✓	