GALGOTIAS UNIVERSITY

Syllabus of

Power System Engineering (M.Tech)

Name of School: School of Engineering

Department: Electrical, Electronics and Communication Engineering

Year: 2021-2023

Curriculum

Semester 1									
Sl. No	Course Code	Name of the Course					Assessment Pattern		
			L	T	P	C	IA	MTE	ETE
1	MATH5001	Advanced Numerical & Statistical Methods	3	0	0	3	20	30	50
2	MPED1501	Analysis of Power Electronics Circuits	3	0	0	3	20	30	50
3	MPSE1501	Power System Operation and Control	3	0	0	3	20	30	50
4	MPSE1502	Advanced Power System Analysis	3	0	0	3	20	30	50
5	MPED1503	Digital Control	3	0	0	3	20	30	50
6	MPED1505	FACTS and HVDC	3	0	0	3	20	30	50
7	MPSE1511	Power System lab-I	0	0	2	1	50	-	50
		Total				19			
Semester II									
Sl No	Course Code	Name of the Course					Assessment Pattern		
			L	T	P	C	IA	MTE	ETE
1	MPSE1601	Advanced Power System Protection	3	0	0	3	20	30	50
2	MPSE1603	Power System Transients	3	0	0	3	20	30	50
3	MPSE1606	Power Quality	3	0	0	3	20	30	50
4	MPSE1607	Power System Planning and Reliability	3	0	0	3	20	30	50
5	********	Program Elective-1	3	0	0	3	20	30	50
6	********	Program Elective-2	3	0	0	3	20	30	50
7	MPSE1611	Power System Lab-II	0	0	2	1	50	-	50
8	CENG5001	Professional and Communication Skills	0	0	4	2	50	-	50
		Total				21			
Semester III									
Sl No	Course Code	Name of the Course					Assessment Pattern		
			L	T	P	C	IA	MTE	ETE
1	MPSE2502	Power System Dynamics and Stability	3	0	0	3	20	30	50

2	MPSE2506	Electric and Hybrid Vehicles	3	0	0	3	20	30	50
3	MPSE2505	Smart Grid and Energy Management	3	0	0	3	20	30	50
4	MPSE2611	Power Quality Lab	0	0	2	1	50	-	50
5	MPSE9998	Capstone Design-I	0	0	10	5	50	-	50
		Total				15			
Semester IV									
Sl No	Course Code	Name of the Course					Assessment Pattern		
			L	T	P	C	IA	MTE	ETE
1	MPSE9999	Capstone Design-II	0	0	30	15	50	-	50
		Total				15			

List of Program Electives

Program Elective-1

Sl No	Course Code	Name of the Electives	L	T	P	C	Assessment Pattern IA	MTE	ETE
1	MPSE1608	Power System Planning in Deregulated Environment	3	0	0	3	20	30	50
2	MPSE1609	Demand side Energy Management	3	0	0	3	20	30	50
3	MPSE1503	Power System Reliability	3	0	0	3	20	30	50
4	MPSE1504	Reactive Power Compensation & Management	3	0	0	3	20	30	50
5	MPSE1604	Renewable Energy Sources	3	0	0	3	20	30	50

Program Elective-2

Sl No	Course Code	Name of the Elective	L	T	P	C	Assessment Pattern IA	MTE	ETE
1	MPED1610	Modelling, Simulation and Control of Power Electronics Systems	3	0	0	3	20	30	50
2	MPED1602	Power Electronics Applications in Renewable Energy Systems	3	0	0	3	20	30	50
3	MPED1606	System and Control Theory	3	0	0	3	20	30	50
4	MPED2504	Intelligent Control	3	0	0	3	20	30	50
5	MPED1604	Soft computing Techniques	3	0	0	3	20	30	50

Detailed Syllabus

MPED1501	ANALYSIS OF POWER ELECTRONICS CIRCUITS	3	0	0	3
Version No.	1.0				
Prerequisite	-				
Objectives:	To give in depth knowledge of the various power electronics circuits, analyze the behavior of the PE circuits along with their Dynamic modeling.				
Courses Outcome:	1.Learn the principles of operation of power electronic converters and its application in day to day modern life also Understand the problems associated with the PE circuits and design the circuits to overcome these problems. 2. Understand the operation of dc-dc power converters and its applications 3. Understanding the application and 1 phase and 3 phase inverters. 4. Advantages and disadvantages of voltage source and current source inverter also their selective usage. 5. Difference between cycloconverter and ac voltage converter. 6. Understand the ac voltage controller is more preferable over cycloconverter.				
Unit I	Review of power semiconductor devices and line commutated rectifiers				
Power Devices: Power Diode, BJT, MOSFET, IGBT & GTOs, IGCT – basic structure, operating characteristics .Controlled rectifiers – single-phase half converter and full converters – analysis with R & RL loads – DF, HF, input PF - 3-phase half-wave – full converters & semi converters – analysis with R & RL loads – continuous conduction & discontinuous conduction – inversion mode - effect of source inductance on 1-phase & 3-phase fully controlled converters – overlap angle - single-phase dual converters – circulating & non circulating current operation.					
Unit II	Choppers				
Operation of choppers, forced commutation principle, voltage and current commutated choppers Class A, B, C, D, E choppers. Steady state analysis of chopper circuit. Switch mode dc to dc converters-principle of buck and boost converters.					
Unit III	Voltage Source Inverters				
Inverters: Inverters – 1-phase half bridge and full bridge – HF, THD, DF – 3-phase inverter - 180º and 120º conduction – Analysis with R & RL load – PWM techniques – single pulse, multiple pulse & sinusoidal pulse width modulation – modulation index – voltage control of inverters .					
Unit IV	Current source inverters				
Single phase and three phase power circuit configuration and analysis. Load commutated inverters: principle of operation, modification of power circuit configuration for low frequency operation.					
Unit V	AC Voltage Controllers and Cycloconverters				
Introduction to bidirectional switches, principle of single phase and three phase ac voltage controller, R and RL load, output voltage control, input and output performance.					
Unit VI					
Cycloconverters: Principle of operation, single phase to three phase, three phase to three phase					

cyclocoverter, output voltage and frequency range.	
Text Books	
e 1. “Power Electronics”, M.H. Rashid, Prentice Hall, 2004. 2. “Power Electronics: Converters, Design and Applications”, Ned Mohan, Undeland, Robbins. John Wiley & Sons, 2004.	
References	
1 Reference papers from “Hand Book of Power Electronics”, Edited by Mohammed H. Rashid, Academic Press, 2001. 2.“Modern Power Electronics and AC drives”, B.K.Bose, Peasron Education Inc., 2002. 3.“Fundamentals of Power Electronics”, 2nd Edition, Robert W.Erickson, Dragan Maksimovic, Kulwer Academic Publishers, 2001	

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE1501	Power System Operation and Control	L 3	T 0	P 0	C 3
Version No.	1.0				
Prerequisite	Power System Engineering				
Objectives	1. To have an overview of power system operation and control. 2. To model power - frequency dynamics and to design power-frequency controllers. 3. To model reactive power - voltage interaction and the control actions to be implemented for maintaining voltage profile against varying system load.				
Course Outcome	• Identify various load driving parameters and review various forecasting methods for efficient power system operation. • Analyze the relationship between various power system variables in terms of mathematical modelling. • Model the steady state and dynamic performance of power system control. • Apply the knowledge of Unit Commitment and economic Dispatch to numerical problems based on real time situations. • Explain various functional aspects of SCADA/ECC along with various operating states of power system. • Analyse the power system performance using optimal power flow solutions, faults etc.				
Module I	Introduction				
System load – variation, load characteristics – load curves and load-duration curves, load factor, diversity factor, load forecasting, simple techniques of forecasting, basics of power system operation and control, reserve margin, load-frequency control, voltage control.					
Module II	Real Power - Frequency Control				
Speed governing mechanism and modelling, speed-load characteristics, load sharing, control area concept, LFC control of a single-area system, static and dynamic analysis, integration of economic dispatch control with LFC, two-area system – modelling – static analysis of uncontrolled case, tie line with frequency bias control of two-area system.					
Module III	Reactive Power – Voltage Control				
Reactive power control, excitation systems – modelling, static and dynamic analysis, stability compensation, generation and absorption of reactive power, relation between voltage, power and reactive power at a node, method of voltage control, tap changing transformers, tap setting of OLTC transformer and MVAR injection of switched capacitors.					
Module IV	Economic Load Dispatch				
Economic dispatch problem – cost of generation, incremental cost curve, co-ordination equations, solution by direct method and λ- iteration method, unit Commitment problem – constraints, solution methods – Priority-list methods – forward dynamic programming approach (Numerical problems only in priority-list method using full-load average production cost).					
Module V	Computer control of power systems				

Need of computer control of power systems, concept of energy control centre (or) load dispatch centre and the functions, system monitoring, data acquisition and control, system hardware configuration.		
Module VI		
SCADA and EMS functions, network topology, state estimation, security analysis and control, operating states (Normal, alert, emergency, in-extremis and restorative).		
Reference Books		

1. Allen. J. Wood and Bruce F. Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., 2003.
2. D.P. Kothari and I.J. Nagrath, „Modern Power System Analysis", Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
3. Chakrabarti & Halder, "Power System Analysis: Operation and Control", PHI, 2004 Edition.
4. L.L. Grigsby, „The Electric Power Engineering, Hand Book", CRC Press & IEEE Press, 2001.
5. Olle. I. Elgerd, "Electric Energy Systems theory: An introduction", Tata McGraw Hill Publishing Company Ltd. New Delhi, Second Edition 2003.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE1502	Advanced Power System Analysis	L 3	T 0	P 0	C 3
Version No.					
Prerequisite	Power System Analysis				
Objectives	1. To study the power flow using different load flow techniques. 2. To analyse different fault conditions.				
Course Outcome	1. Understand the impedance and admittance matrices, and its use in AC and DC power flow analysis and in optimal power flow solutions. 2. Identify the different types of faults and need of the state estimation in the power system. 3. Analyze the AC and DC power flow algorithms, optimal power flow solution techniques and different faults in the power system network. 4. Solve the power flow equations using different conventional and non-conventional algorithms with proper formulation of admittance and impedance matrices respectively. 5. Apply the knowledge in the power system planning and scheduling, reliability, security and its control. 6. Develop a optimal load flow solution.				
Unit I					
Load Flow - Network modeling – Conditioning of Y Matrix – Newton Raphson method- Decoupled – Fast decoupled Load flow -three-phase load flow.					
Unit II					
DC power flow – Single phase and three phase -AC-DC load flow - DC system model – Sequential Solution Techniques – Extension to Multiple and Multi-terminal DC systems – DC convergence tolerance – Test System and results.					
Unit III					
Fault Studies - Analysis of balanced and unbalanced three phase faults – fault calculations – Short circuit faults – open circuit faults.					
Unit IV					
System optimization - strategy for two generator systems – generalized strategies – effect of transmission losses - Sensitivity of the objective function- Formulation of optimal power flow-solution by Gradient method-Newton's method.					
Unit V					
State Estimation – method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation.					
Unit VI					
Application of optimal load flow, fault and state estimation in the power system with case studies.					

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

<table>
<tr><td>MPED1503</td><td>DIGITAL CONTROL</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Version No.</td><td colspan="5">1.0</td></tr>
<tr><td>Prerequisite</td><td colspan="5">-</td></tr>
<tr><td>Objectives:</td><td colspan="5">To provide an advanced level course on systems concepts and digital control strategy.</td></tr>
<tr><td>Course Outcome:</td><td colspan="5">1. Analyze and design SISO systems through Z-transform.
2. Analyze and design of MIMO systems through state space analysis.
3. Analyze systems stability.
4. Introduction to Microprocessor and DSP based control.
5. Discuss the quantization effect on the digital control system.
6. Design the digital regulator system for a system.</td></tr>
<tr><td>Unit I</td><td colspan="4">Introduction</td><td></td></tr>
<tr><td colspan="6">Overview of design approaches, continuous versus digital control, sampling process, effect of sampling rate. Calculus of difference equations. Z-transform. Signal flow graphs.</td></tr>
<tr><td>Unit II</td><td colspan="4">Design of State space systems</td><td></td></tr>
<tr><td colspan="6">Controllability, Observability, Discretization of continuous transfer functions; Digital filter properties. Controller design using transformation techniques: Z-plane specifications. Design in the w domain. PID controller., deadbeat controller. Root Locus design.</td></tr>
<tr><td>Unit III</td><td colspan="4">State space methods</td><td></td></tr>
<tr><td colspan="6">Pole placement design, stabilization and all stabilizing controllers. Observer design. Infinite time optimal regulator, Stability and tracking in SD systems,</td></tr>
<tr><td>Unit IV</td><td colspan="4">Quantization effects:</td><td></td></tr>
<tr><td colspan="6">Limit cycles and dither. Sample rate reduction. Multi-rate sampled data system and stability studies. Design of digital controller using fast output sampling.</td></tr>
<tr><td>Unit V</td><td colspan="4">Microprocessor and DSP control:</td><td></td></tr>
<tr><td colspan="6">Mechanization of control algorithms. Iterative computation via parallel, direct, canonical, cascade realization; Effects of computing time. Systems with time delay.</td></tr>
<tr><td>Unit VI</td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td colspan="6">Application of digital controller and observer in the power system with case studies.</td></tr>
<tr><td colspan="2">Text Books</td><td colspan="4"></td></tr>
<tr><td colspan="6">1. K. Ogata, “Discrete-time control sytems”, PHI, 2005.
2. B.C. Kuo, “Digital Control System”, Oxford University press, 1995</td></tr>
<tr><td colspan="2">References</td><td colspan="4"></td></tr>
<tr><td colspan="6">1. Norman S. Nise," Control systems Engineering", John Wiley and Sons, 4th Edition, 2004.
2. G. F. Franklin, J. David Powell and Micheal Workman,“Digital Control of Dynamic Systems“, Pearson Education, 3rd Edition,2003.
3. M.Gopal, “Digital Control Engineering”, New Age Publishers, 2008.</td></tr>
<tr><td colspan="2">Mode of Evaluation</td><td colspan="4">Quiz/Assignment/ Seminar/Written Examination</td></tr>
</table>

MPED1505	FACTS AND HVDC	3	0	0	3
Version No.	1.0				
Prerequisite	-				
Objectives:	The course aims to impart in-depth knowledge of reactive power control, system compensation, application of FACTS controllers and power electronics applications in HVDC transients.				
Expected Outcome:	After taking this course, the student should be able to: 1. Explain steady state and dynamic problems in AC system. 2. Identify significance of DC over AC transmission system, types and application of HVDC links in practical power systems 3. Apply the concept of reactive power control to AC power system. 4. Design and implement various FACTS controllers 5. Power quality improvement using custom power devices. 6. Analyze the control of HVDC transmission and different solid state excitation systems.				
Unit I	Introduction				
Steady state and dynamic problems in AC systems- Theory of Load compensation- Power factor correction- Voltage regulation and Phase balancing. Theory of Reactive Power Control in Transmission systems.					
Unit II	Facts Devices				
Principles of series and shunt compensation. Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC).					
Unit III					
Control strategies to improve system stability. Active & Passive Filters					
Unit IV	Power Quality improvement using custom power devices				
Modeling of harmonics creating loads, harmonic propagation, harmonic power flow, Mitigation of harmonics through filters. Mitigation of power quality problems using power electronic conditioners. IEEE standards.					
Unit V	HVDC Transmission				
Comparison AC and DC Transmission, Introduction to HVDC Transmission systems, HVDC Systems Control, HVDC systems in India					
Unit VI	Static Excitation Systems				
Different types of Solid State excitation systems, their effects on Power System stability					
Text Books					
1.Narain Hingorani & Lazzlo Gyugi -Understanding FACTS. Concepts & Technology of FACTS. (Standard publishers & distributors, Delhi-110 006) 2. Yong Hua Song and Allan T Johns - Flexible AC Transmission Systems (FACTS) (IEE Press, London, UK)					
References					
1. T.J.E Miller -Reactive Power Control in Electric system (John Wiley & Sons, NY) 2. Edward Wilson Kimbark, ‘Direct Current Transmission (volume I)’, John Wiley & Sons 3. K.R.Padiyar,"HVDC Power Transmission Systems – Technology & System Interaction", 2005.					

4. Arindam Ghosh, “Enchancing Power Quality using custom power devices”

5. Prabha Kundur, “Power system stability and control” McGraw Hill.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

<table>
<tr><td>MPSE1601</td><td>Advanced Power System Protection</td><td>L
3</td><td>T
0</td><td>P
0</td><td>C
3</td></tr>
<tr><td>Version No.</td><td colspan="5">1.0</td></tr>
<tr><td>Prerequisite</td><td colspan="5">Power System Engineering</td></tr>
<tr><td>Objectives</td><td colspan="5">1. To know the various static relays and comparators that is used for protection.

2. To study various protective techniques/approaches in fault rectification of transmission system and machines.</td></tr>
<tr><td>Expected Outcome</td><td colspan="5">Students will be able to:

1. Identify static protective components used in power system protection for electrical apparatus and transmission line.
2. Understand the principle of static relays, protection scheme and protection systems.
3. Select different types of relays for power system faults.
4. Apply the knowledge of static relays, microprocessor based relays for protection of electrical apparatus and transmission lines.
5. Analyze the power system protection problem/application using principle of statics relays, protection scheme and microprocessor based relays.
6. Design the effective protection scheme needed for power system equipments and verify them through MATLAB simulations.</td></tr>
<tr><td>Unit I</td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">Classification Of Static Relays: Basic construction of static relays, Classification of protective schemes, Comparison of Static relays with electromagnetic relays, Amplitude comparator, Phase comparator, Principle of Duality.Amplitude And Phase Comparators (2-Input): Rectifier bridge circulating and opposed Voltage type- Averaging -phase splitting type -Sampling type of amplitude Comparison. Block spike type-Phase splitting type- Transistor integrating type-Rectifier bridge type-Vector product type Phase comparison.</td></tr>
<tr><td>Unit II</td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">Static Over Current Relays: Instantaneous- Definite time – Inverse time- Directional- IDMT- Very inverse Time-Extremely inverse time over current relays. Time current characteristics of Over current relays-applications. Protection Against Over Voltages: Protection of transmission lines, stations, and substations against direct lightning strokes-protection against travelling waves-Insulation coordination.</td></tr>
<tr><td>Unit III</td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">Distance Protection: Impedance Relay: operating principle- relay Characteristic-Protective Schemes-Static Impedance Relay- Static reactance relay- static MHO relay-effect of arc resistance, effect of power surges, effect of line length and source impedance on performance of distance relays-Quadrilateral relay – Elliptical relay - selection of distance relays</td></tr>
<tr><td>Unit IV</td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">Pilot Relaying Schemes: Wire pilot protection: circulating current scheme- balanced voltage scheme-translay scheme-half wave comparison scheme- Carrier current protection: phase comparison type-</td></tr>
</table>

carrier aided distance protection-operational comparison of transfer trip and bloking schemes-optical fibre channels

Unit V		

AC Machines and Bus Zone Protection: Protection of Alternators: stator protection-rotor protection-over voltage protection-over speed protection-Transformer protection: earth faults in transformers-percentage differential protection-protection against magnetic inrush current-generator and transformer unit protection-Bus zone protection: differential current protection-high impedance relay scheme-frame leakage protection.

Unit VI		

Microprocessor Based Protective Relays: Introduction-over current relays-Impedance relay-Directional relay-Reactance relay.

Reference Books	

1. Power system protection - by TSM Rao.2.Power system protection and switch gear - by Badri Ram& DN Vishwakarma. 3.Switch gear and protection - by MV Deshpande. 4.Protective relaying vol-2 - by Warrington. 5Power system protection and switch gear - by Ravindranath & Chandan

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE1603	Power System Transients	L 3	T 0	P 0	C 3
Version No.	1.0				
Prerequisite					
Objectives	1. Study the different cases of transient and its occurrence. 2. To learn the transients due to current chopping, lightning, grounding and their effects				
Expected Outcome	Students will be able to: 1. Understand the wave technology in the power system. 2. Understand the circuit breaker operation. 3. Analyze and clear the fault in the network using different methodologies. 4. Analyse the transient control scheme in the power network. 5. Develop Impulse generator, Impulse-testing technique, Power frequency HV Transformers for the industrial applications. 6. Demonstrate the important of grounding.				
Unit I					
Wave terminology, Development of wave equations, Terminal problems, Lattice diagrams, Origin and nature of power system transient and surges, Surge parameters of plants, Equivalent circuit representations, Lumped and distributed circuit transients, Line energisation and de-energisation, Earth and earth wire effect.					
Unit II					
Current chopping in circuit breakers, Short line fault condition and its relation to circuit breaker duty, Trapped charge effect, Effect of source and source representation in short line fault studies.					
Unit III					
Control of transients, Lightening phenomenon, Influence of tower footing resistance and earth resistance, Traveling waves in distributed parameters multi-conductor lines, Parameters as a function of frequency.					
Unit IV					
Method of neutral grounding and their effect on system behavior, Insulation coordination, Over voltage limiting devices, Dielectric properties, Requirement in surge protection of lines and equipments.					
Unit V					
Impulse generator development, Impulse-testing technique, Power frequency HV Transformers, Cascade connection, HVDC Generators, Tests with power frequency and DC voltage.					
Unit VI					
Large current generating and measurement techniques, Partial discharge testing, High voltage and high current testing of power equipment.					
Reference Books	C.S. Indulkar, D.P.Kothari, K. Ramalingam,” Power System Transients “ PHI. Allen Greenwood, “Electrical transients in power systems “ Wiley Interscience				

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE1606	POWER QUALITY	3	0	0	3
Version No.	1.0				
Prerequisite	-				
Objectives:	1. To understand the necessity of power quality and its importance in the power system. 2. Effects of harmonics, sag/swell and interruptions in the power system and its elimination.				
Expected Outcome:	1. To understand the necessity of power quality and its importance in the power system. 2. To Understand Effects of harmonics, sag/swell in Power Syatem. 3. Understand the interruptions in the power system and its elimination. 4. To understand transients, long and short duration Voltage variations. 5. To understand Harmonic distortion, Voltage versus Current distortion, Harmonic				
Unit I					
Power and Voltage Quality: General, classes of Power Quality Problems, Power quality terms, Power frequency variations, the power quality evaluation procedure.					
Unit II					
Voltage quality: Transients, long and short duration Voltage variations, Voltage imbalance, waveform distortion, Voltage Flicker.					
Unit III					
Voltage sags and Interruptions: Sources of sags and Interruptions, Estimating Voltage sag performance. Fundamental Principles of Protection, Solutions at the end-user level, Evaluating Ride-through Alternatives, Motor-Starting Sags.					
Unit IV					
Fundamentals of Harmonics: Harmonic distortion, Voltage versus Current distortion, Harmonic indexes, Harmonic sources from commercial loads, Harmonic sources from industrial loads, Locating Harmonic sources, System response characteristics, Effects of Harmonic Distortion.					
Unit V					
Distributed Generation and Power Quality: Resurgence of DG, DG Technologies, Interface to the Utility System, Power Quality Issues, Operating Conflicts, DG on distribution Networks, Sitting DG distributed Generation, Interconnection standards.					
Unit VI					
Wiring and Grounding: Recourses, Definitions, Reasons for Grounding, Typical wiring and grounding problems, Solution to wiring and grounding problems. Power Quality Monitoring: Monitoring Consideration. Historical Perspective of power quality measurement equipment, Assessment of Power Quality.					
References					
1. Electrical Power Systems Quality: By ROGER C. DUGAN, Electrotek Concepts Inc. (second edition)					

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE1607	Power System Planning And Reliability	L 3	T 0	P 0	C 3
Version No.	1.0				
Prerequisite					
Objectives	1. To have an overview of planning and reliability of the system. 2. To understand different techniques to check reliability of the system.				
Expected Outcome	1. Identify different techniques to check reliability of the system. 2. Plan long and short term load and energy forecasting. 3. Apply different techniques to check reliability of the system. 4. Understand the importance of the reliability. 5. Understand the role of the forecasting process in power system. 6. Analyse the stability of the power network during loss of prime mover.				
Unit I					
Objectives of planning – Long and short term planning .Load forecasting – characteristics of loads – methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting – annual and monthly peak demand forecasting.					
Unit II					
Reliability concepts – exponential distributions – meantime to failure – series and parallel system – MARKOV process – recursive technique.					
Unit III					
Generator system reliability analysis – probability models for generators unit and loads – reliability analysis of isolated and interconnected system – generator system cost analysis – corporate model – energy transfer and off peak loading.					
Unit IV					
Transmission system reliability model analysis –average interruption rate-LOLP method-frequency and duration method.					
Unit V					
Two plant single load system-two plant two load system-load forecasting uncertainly interconnections benefits.					
Unit VI					
Introduction to system modes of failure – the loss of load approach – frequency & duration approach – spare value assessment – multiple bridge equivalents.					
Reference Books					
1. Sullivan, R.L., „Power System Planning‟, Heber Hill, 1987. 2. Roy Billington, „Power System Reliability Evaluation‟, Gordan & Breach Scain Publishers, 1990. 3. Endreni, J., „Reliability modelling in Electric Power System‟ John Wiley, 1980.					

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE2502	Power System Dynamics And Stability	L 3	T 0	P 0	C 3
Version No.	1.0				
Prerequisite					
Objectives	1. To have an overview of system dynamics and stability. 2. To understand the concepts of Multi-machines and its stability. 3. To know the effect of governor and exciter system.				
Expected Outcome	Students will be able to: 1. Understand the power network dynamics and its important. 2. Analyze small and large system stability. 3. Identify and solve stability problems using different approaches. 4. Understand the multimachine stability analysis and its convergence. 5. Demonstrate the governor and its control. 6. Understand the application of excitor in the power system.				
Unit I					
System Dynamics: Synchronous machine model in state space form, computer representation for excitation and governor systems – modelling of loads and induction machines. State space representation of synchronous machine connected to infinite bus, Time response – Stability by Eigen value approach.					
Unit II					
Stability – steady state stability limit – Dynamic Stability limit – Dynamic stability analysis. Digital Simulation of Transient Stability: Swing equation, Machine equations.					
Unit III					
Concept of Multimachine Stability, Multimachine Transient Stability Under Different Faulted Conditions.					
Unit IV					
Rotating Main Exciter, Rotating Amplifier and Static Voltage Regulator – Static excitation scheme – Brushless excitation system.					
Unit V					
Effect of governor action and exciter on power system stability. Effect of saturation, saliency & automatic voltage regulators on stability.					
Unit VI					
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.					
Reference Books					

1. Power System Stability by Kimbark Vol. I&II, III – 1968, Dover Publication Inc, New York 1968.
2. Power System control and stability by Anderson and Fund, Vol – I, P.M.Arolerson & A.A.fouad, Galgotia Publications 3B/12, Uttari marg Rajunder Nagar, New Delhi – 110060, 1981, 1 st edition.
3. Power System Dynamics Stability and Control by K.R.Padiyar, Second edition B.S.Publications 2002.
4. Computer Applications to Power Systems–Glenn.W.Stagg & Ahmed. H.El.Abiad
5. Power Systems Analysis & Stability – S.S.Vadhera Khanna Publishers.
6. Power System Analysis by "Hadi Saadat" – Tata McGraw Hill Publications
7. Power System Analysis by John J.Graniger William D.Stevenson. JR. – Tata McGraw Hill Publications.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

Name of The Course	Electrical and Hybrid vehicle				
Course Code	MPSE2506				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the electrical vehicle
2. To understand the hybrid vehicle

Course Outcomes

CO1 Understand basics of battery technology.

CO2 Understand scheme of HEV and full electric vehicle.

CO3 Analyse need of different motor drives for electric vehicle.

CO4 Apply new topologies to electric vehicle.

CO5 Evaluate performance parameters of electric vehicle.

CO6 Understand recent industrial power electronic applications for electric vehicle.

Text Books:

1. Sandeep Dharmeja, Electric Vehicle Battery Systems, 1st Edition, Newnes, 2001

2. K.T.Chau, Zheng Wang, Chaos in Electrical Drive Systems: Analysis, Control & Applications, 1st Edition, John Wiley and Sons, 2011

Reference Books:

1. Chung Chow Chan, K.T.Chau, Modern Electric Vehicle Technology, 1st Edition, Oxford University Press, 2001

2. Springer Books, Electrical Vehicle Integration into Modern Power Networks

3. A.T.P.So George C.Barney waterstones.com, International Journal of Elevator Engineering, United Kingdom

4. John Lowry, John Wiley and Sons, Electrical Vehicle Technology Explained-James Larminie, 1st Edition, 2003

Unit I: Introduction to Electric Vehicles

Electric vehicles (EV) development, past, present and future, comparison with IC engine driven vehicles.
Unit II: Storage Units
Batteries, fuel cells, ultracapacitors. Power converters in EV. Different types of motors used in EV and their torque-speed characteristics, motor control techniques,
Unit III: Vehicle Control 10 lecture hours
High performance and efficiency-optimized control, sensorless control. Electric vehicles modeling and their Characteristics.
Unit IV : Electric drive-trains
Basic concept of electric traction - introduction to various electric drive-train topologies - power flow control in electric drive-train topologies - fuel efficiency analysis
Unit V: Hybrid Electric Vehicle
Fuel cell Vehicles, Hybrid Electric Vehicles (HEV), series, parallel and series-parallel (split) systems,
Unit VI: Recent Technologies
Recent industrial power electronic applications. Advanced topic on the subject

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Smart Grid and Energy Management				
Course Code	MPSE2505				
Prerequisite	Power System Analysis and Power Electronics				
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives:

A smart grid is an electrical grid which includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources. Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid.

1. To make use of the Smart grid with the coming future.
2. To analyze the global policies about the smart grid.
3. To develop and design the Advanced Metering infrastructure (AMI).
4. To estimate the Power Quality issues of Grid connected Renewable Energy Sources.
5. To understand the different fault detection schemes.
6. To understand the communication network for a smart grid.

Text/ Reference Books:

1. A. S boyer, SCADA:supervisory Control and Data Acquisition, The Instrumentation system and Automation Society,4 th Edition 2009.
2. Vehbi C. Güngör, Dilan Sahin, TaskinKocak, SalihErgüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke: Smart Grid Technologies- Communication Technologies and Standards IEEE Transactions on Industrial Informatics, Vol. 7, No. 4, November 2011.
3. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang: Smart Grid – The New and Improved Power Grid- A Survey, IEEE Transaction on Smart Grids.
4. Stuart Borlase: Smart Grid-Infrastructure, Technology and Solutions, CRC Press.
5. B.G. Liptac Instrument Engineering Handbook,Volume 3:process Software and Digital Networks,CRC Press, 4 th Edition 2011.

Unit-I	Introduction to Smart Grid	8 Hours
Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits Difference between conventional & Smart Grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.		
Unit II		
Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).		
Unit-III	Smart Grid Technologies	8 Hours
Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation , Wide area monitoring, Protection and Control, Distribution Systems: DMS, Volt/Var control.		
Unit-IV	Smart Meters and Advanced Metering Infrastructure	8 Hours

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.		
Unit-V	Power Quality Management in Smart Grid	8 Hours
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..		
Unit-VI	High Performance Computing for Smart Grid Applications	8 Hours
Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broad band over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.		

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

Program Elective-1

MPSE1608	Power System Planning in Deregulated Environment	L 3	T 0	P 0	C 3
Version No.	1.0				
Prerequisite					
Objectives	To have an overview of planning and regulatory structure of power system				
Expected Outcome	Students will be able to: 1. Understand the importance of the power markets 2. Analysis of the generation cost and its important. 3. Analyze market structure in case restructuring of power system. 4. Understand of unit price commitment, power flow and money flow concept. 5. Reduce the congestion in network line and reduce cost of power flow. 6. Analyse of the deregulation needs and its important in power market.				
Unit I					
Need and conditions for deregulation. Introduction of Market structure, Market Architecture, Spot market, forward markets and settlements.					
Unit II					
Review of Concepts marginal cost of generation, least-cost operation, incremental cost of generation. Power System Operation: Old vs. New					
Unit III					
Electricity sector structures and Ownership /management, the forms of Ownership and management. Different structure model like Monopoly model, Purchasing agency model, wholesale competition model, Retail competition model.					
Unit IV					
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 V					
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 VI					
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.					

Reference Books	

1. Power System Economics: Designing markets for electricity – S. Stoft
2. Power generation, operation and control, -J. Wood and B. F. Wollenberg
3. Operation of restructured power systems – K. Bhattacharya, M.H.J. Bollen and J.E. Daalder
4. Market operations in electric power systems – M. Shahidehpour, H. Yamin and Z. Li
5. Fundamentals of power system economics – S. Kirschen and G. Strbac
6. Optimization principles: Practical Applications to the Operation and Markets of the Electric Power Industry – N. S. Rau
7. Competition and Choice in Electricity – Sally Hunt and Graham Shuttleworth

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

<table>
<tr><td>MPSE1503</td><td>Power System Reliability</td><td>L
3</td><td>T
0</td><td>P
0</td><td>C
3</td></tr>
<tr><td>Version No.</td><td colspan="5">1.0</td></tr>
<tr><td>Prerequisite</td><td colspan="5"></td></tr>
<tr><td>Objectives</td><td colspan="5">1. To understand the basic probability theory, Reliability functions and analysis of complex networks.
2. To understand Markov Modeling, Frequency & Duration Techniques and System Reliability Analysis.</td></tr>
<tr><td>Expected Outcome:</td><td colspan="5">Student will be able to:

• Evaluate Reliability of Engineering Systems.
• Understand the different stochastic solutions in the field of system reliability.
• Understand the frequency and time duration techniques.
• Analyze and design of Reliability model of a generation and other complex systems.
• Analyze the power generation system reliability.
• Analyze the power distribution system reliability.</td></tr>
<tr><td>Unit I</td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">Basics of Probability theory & Distribution: Basic probability theory – rules for combining probabilities of events – Bernoulli's trials – probabilities density and distribution functions – binomial distribution – expected value and standard deviation of binomial distribution.

Network Modeling and Reliability Analysis: Analysis of Series, Parallel, Series-Parallel networks – complex networks – decomposition method.</td></tr>
<tr><td>Unit II</td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">Reliability functions: Reliability functions f(t), F(t), R(t), h(t) and their relationships – exponential distribution – 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.</td></tr>
<tr><td>Unit III</td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">Markov Modeling: 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.</td></tr>
<tr><td>Unit IV</td><td colspan="4"></td><td></td></tr>
<tr><td colspan="6">Frequency & Duration Techniques: 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 of merged states.</td></tr>
<tr><td>Unit V</td><td colspan="4"></td><td></td></tr>
</table>

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. Composite Systems Reliability Analysis: Decompositions method – Reliability Indices – Weather Effects on Transmission Lines.

Unit VI		

Distribution System and Reliability Analysis: Basic Concepts – Evaluation of Basic and performance reliability indices of radial networks.

Reference Books	

1. Reliability Evaluation of Engg. System – R. Billinton, R.N.Allan, Plenum Press, New York.
2. Reliability Evaluation of Power systems – R. Billinton, R.N.Allan, Pitman Advance Publishing Program, New York.
3. An Introduction to Reliability and Maintainability Engineering. Charles E. Ebeling, TATA Mc Graw - Hill – Edition.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE1609	Demand Side Energy Management	3	0	0	3
Version No.	1.0				
Prerequisite	-				
Objectives:	1. To understand the Energy Audit, Energy Economics, Cost benefit risk analysis and Energy Conservation in Electric utilities and industry. 2. To understand the Co-generation, pumped hydro schemes and superconducting magnetic energy storage (SMES).				
Expected Outcome:	Students will be able to: • Apply understand Energy audit, energy and electrical load management. • Analyse Electric Lighting, Air-Conditioning (HVAC), Water. • Heating and Heating of buildings and Energy conservation methods. • Apply the knowledge in the proper selection of electrical equipment. • Analyze electrical machine efficiency and its performance.				
Unit I					
Energy Audit: Definitions-Need-concepts-Types of energy audit; Energy index – cost index – pieharts – Sankey diagrams. Energy Economics: Introduction-Cost benefit risk analysis-Payback period-Straight line depreciation-Sinking fund depreciation—Reducing balance depreciation-Net present value method-Internal rate of return method-Profitability index for benefit cost ratio.					
Unit II					
Energy Conservation in Electric utilities and Industry: Electrical load management: Energy and load management devices-Conservation strategies; conservation in electric utilities and industry: Introduction-Energy conservation in utilities by improving load factor-Utility voltage regulation-Energy conservation in Industries-Power factor improvement.					
Unit III					
Electric Lighting: Introduction-Need for an energy management program-Building analysis-Modification of existing systems-Replacement of existing systems-priorities: Illumination requirement: Task lighting requirements-lighting levels-system modifications-non illumination modifications-lighting for non task areas-reflectance's-space geometry; System elements. Light sources – characteristics of families of lamps-lamp substitution in existing systems-selection of Higher efficiency lamps for a new system-Luminaries-ballasts-energy conservation in lighting. White light LED and conducting Polymers.					
Unit IV					
Energy–efficient electric motors (EEMs) : Energy efficient motors-construction and technical features-case studies of EEMs with respect to cost effectiveness-performance characteristics; Economics of EEMs and system life cycle-direct savings and payback analysis-efficiency factor or efficiency evaluation factor					
Unit V					
Space Heating, Ventilation, Air-Conditioning (HVAC) and Water Heating: Introduction-Heating of buildings-Transfer of Heat-Space heating methods-Ventilation and air-conditioning-Insulation-Cooling load-Electric water heating systems-Energy conservation methods.					
Unit VI					
Co-generation and storage: Combined cycle cogeneration-energy storage: pumped hydro schemes – compressed air energy storage (CAES) – storage batteries – superconducting magnetic energy storage (SMES).					
References					

1. Energy management Hand book by Wayne C.Turner,John wiley and sons publications
2. Electric Energy Utilization and Conservation by S C Tripathy, Tata McGraw hill publiching company ltd.New Delhi.
3. Energy efficient electric motors selection and application by John C.Andreas
4. Hand book on Energy Audit and Management by Amit kumar Tyagi, published by TERI (Tata energy research Institute).
5. Energy management by Paul W.O' Callaghan McGraw hill book company
6. Energy conversion systems by Rakosh Das Begamudre New age international publishers.
7. Energy Management – by W.R.Murphy & G.Mckey Butterworths.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE1504	Reactive Power Compensation and Management	L 3	T 0	P 0	C 3
Version No.	1.0				
Prerequisite					
Objectives	1. Steady and Transients state reactive power compensation. 2. Study of reactive power coordination, management and application.				
Expected Outcome	Students will be able to: 1. Understand the basic fundamental and necessity of reactive power. 2. Apply the requirement compensation of reactive power in the transmission lines. 3. Calculate load compensation, voltage regulation and power factor correction of unsymmetrical is most important in industrial aspects. 4. Apply the reactive power compensation in distribution side. 5. Design of typical traction systems layout using reactive power e.g. railways. 6. Demonstrate and management of reactive power in traction system.				
Unit I					
Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.					
Unit II					
Steady state reactive power compensation in transmission system: Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples. Transient state reactive power compensation in transmission systems: Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation – compensation using synchronous condensers – examples					
Unit III					
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.					
Unit IV					
Harmonics, radio frequency and electromagnetic interferences, Demand side management: Load patterns – basic methods load shaping – power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels					
Unit V					
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 VI		
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		
Reference Books		
1. Power control in Electric power systems by T.J.E. Miller, John Wiley and sons, 1982 (Units I to IV) 2. Reactive power Management by D.M.Tagare,Tata McGraw Hill,2004.(Units V toVIII)		

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE1604	Renewable Energy Sources	L 3	T 0	P 0	C 3
Version No.	1.0				
Prerequisite					
Objectives	1. To have an overview of non-conventional energy sources. 2. To understand the need of alternate sources of energy.				
Expected Outcome	Students will be able to: 1. Understand the different types of non-conventional energy resources and their utilities. 2. Outline the principle of operation and analyze the models solar energy conversion systems. 3. Demonstrate the principle of operation of geothermal energy conversion system and its role in future energy generation. 4. Outline the principle of operation and analyze the models Wind energy conversion systems. 5. Evaluate the availability of other nonconventional energy resources and understand the techniques to utilize them effectively. 6. Design models for generating energy through alternate energy sources (with the help of additional learning).				
Unit I					
Energy Scenario :Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns. Worldwide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts. Global environmental concern, Kyoto Protocol, Concept of Clean Development Mechanism (CDM) and Prototype Carbon Funds (PCF). Factors favoring and against renewable energy sources, IRP					
Unit II					
Solar Energy : Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, - solar cells , cell technologies,characteristics of PV systems, equivalent circuit, array design , building integrated PV system, its components , sizing and economics. Peak power operation. Standalone and grid interactive systems.					
Unit III					
Wind Energy : wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Turbine rating, Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation.					
Unit IV					
Other energy sources : Biomass – various resources, energy contents, technological advancements, conversion of biomass in other form of energy – solid, liquid and gases. Gasifiers, Biomass fired boilers, Cofiring, Generation from municipal solid waste, Issues in harnessing these sources.					
Unit V					
Hydro energy – feasibility of small, mini and micro hydel plants scheme layout economics.Tidal and wave energy ,Geothermal and Ocean-thermal energy conversion. (OTEC) systems – schemes,					

feasibility and viability.		
Unit VI		
Energy storage and hybrid system configurations :Energy storage: Battery – types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Fly wheel-energy relations, components, benefits over battery. Fuel Cell energy storage systems. Ultra Capacitors.		
Reference Books		
1. Renewable energy technologies – R. Ramesh, Narosa Publication 2. Non-conventional Energy Systems – Mittal, Wheelers Publication. 3. John F Walker & Jekins. N, Wind Energy Technology., John Wiley and Sons, chichester, UK, 1997. 4. Van Overstra , Mertens, R.P, Physics, Technology and use of Photovoltaics, Adam Hilger, Bristol, 1996.		

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

Program Elective-2

MPED1606	System and Control Theory	3	0	0	3
Version No.					
Prerequisite	Knowledge of complex variables, differential equations and Laplace transform is required.				
Objectives:	To provide an advanced level course in the field of systems and control.				
Expected Outcome:	Student will be able to 1. Understand the SISO and MIMO system in state space domain. 2. Analyze and design SISO continuous-time systems. 3. Analyze and design of MIMO systems through state space analysis. 4. Analyze systems stability in time domain, frequency domains and state space. 5. Apply control theory techniques such as root-locus, Bode, and Nyquist plots. 6. Demonstrate the closed loop system stability of any system.				
Unit I	Introduction to Control Systems				
Open loop & closed control, Mathematical modelling of dynamic systems (Laplace transforms, transfer functions), Block diagram algebra, Signal flow graph, Mason's gain formula, sensitivity, Reduction of effect of parameter variation and disturbance by using negative feedback.					
Unit II	Time domain analysis				
Standard test signals, time response of first and second order systems, time response specifications(delay time, rise time, overshoot ,settling time etc.), steady state error, final value theorem and error constants, P,PI,PD and PID control actions, performance indices					
Unit III	Stability analysis				
Concept of stability and necessary conditions, Routh-Hurwitz criteria, Root locus concepts, construction of root loci and BIBO stability.					
Unit IV	Frequency domain analysis				
Frequency response, frequency response performance specifications (gain margin, phase margin, band width), correlation between time and frequency responses, polar plot, Bode plots. Stability in Frequency Domain: Nyquist stability criterion, relative stability: gain margin and phase margin.					
Unit V	State space analysis				
Introduction, conversion of state variable model to transfer function model and vice-versa, diagonalization, Controllability and observability, Kalman's Test for Controllability and observability.					

Unit VI	Control System Design	
The design problem, lead, lag and lead-lag networks, design of closed loop systems using compensation techniques in time domain and frequency domain.		
Text Books		
1. K. Ogata, “Modern Control Engineering”, Prentice Hall of India. 2. B.C. Kuo & Farid Golnaraghi, “Automatic Control System” Wiley India Ltd, 2008.		
References		
1. Norman S. Nise,” Control systems Engineering”, John Wiley and Sons, 4th Edition, 2004. 2. . R.T. Stefani, B.Shahian, C.J.Savant and G.H. Hostetter, “Design of Feedback Control Systems”Oxford University Press. 3. M.Gopal, “Digital Control Engineering”, New Age Publishers, 2008.		

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPED1604	Soft Computing Techniques	L 3	T 0	P 0	C 3
Version No.	1.0				
Prerequisite	NIL				
Objectives:	Introduce to the field of soft computing which is used for design of hybrid intelligent systems, which is in contrast to classical hard computing technique.				
Expected Outcome:	Student will be able to • Implement a neural network for an application of your choice using an available tool. • Apply probabilistic discriminative and generative algorithms for an application of your choice and analyze the results. • Use a tool to implement typical clustering algorithms for different types of applications. • Design and implement an HMM for a sequence model type of application. • Identify applications suitable for different types of generic algorithm with suitable justification. • Develop scientific and commercial applications.				
Module I					
Neural Networks: History, overview of biological Neuro-system, Mathematical Models of Neurons,ANN architecture, Learning rules, Learning Paradigms-Supervised, Unsupervised and reinforcement Learning, ANN training Algorithms-perceptions, Training rules, Delta, Back Propagation Algorithm, Multilayer Perceptron Model, Hopfield Networks, Associative Memories, Applications of Artificial Neural Networks.					
Module II					
Fuzzy Logic: Introduction to Fuzzy Logic, Classical and Fuzzy Sets: Overview of Classical Sets, Membership Function, Fuzzy rule generation.Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations.					
Module III					
Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations.Fuzzy Logic: Classical Logic, Multivalued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges.Uncertainty based Information: Information & Uncertainty, Nonspecificity of Fuzzy & Crisp Sets,Fuzziness of Fuzzy Sets.					
Module IV					
Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks.Application of Fuzzy Logic: Medicine, Economics etc.Genetic Algorithm: An Overview, GA in problem solving, Implementation of GA					
Module V					
Genetic algorithm : Fundamentals, basic concepts, working principle, encoding, fitness function, reproduction, Genetic modeling: Inheritance operator, cross over, inversion & deletion, mutation operator, Bitwise operator, Generational Cycle, Convergence of GA.					
Unit VI					

Applications & advances in GA, Differences & similarities between GA & other traditional method.	
Reference Books	
1. Anderson J.A, “An Introduction to Neural Networks”,PHI, 1999. 2. Hertz J. Krogh, R.G. Palmer, “Introduction to the Theory of Neural Computation”, Addison-Wesley, California, 1991. 3. G.J. Klir & B. Yuan, “Fuzzy Sets & Fuzzy Logic”, PHI, 1995. 4. Melanie Mitchell, “An Introduction to Genetic Algorithm”, PHI, 1998. 5. Davis E.Goldberg, “Genetic Algorithms: Search, Optimization and Machine Learning”, Addison Wesley, N.Y., 1989	

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100

MPSE2504	Intelligent Control	3	0	0	3
Version No.	1.0				
Prerequisite	-				
Objectives:	To inculcate the basic concepts of neural networks, fuzzy systems and AI methods. To provide the foundation for solving application-oriented problems like optimization, a non-linear controller for electric drives etc. using AI techniques.				
Expected Outcome:	On completion of this course, the students should be able to: • Identify and describe Fuzzy Logic and Artificial Neural Network techniques in building intelligent machines. • Apply Artificial Neural Network, Fuzzy Logic models to handle uncertainty. • Develop fuzzy relation rules, and aggregations. • Understand concept of classical and fuzzy sets, fuzzification and				
Unit I	Introduction and motivation				
Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.					
Unit II	Concept of Artificial Neural Networks				
Basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network.					
Unit III	Data Processing				
Scaling, Fourier transformation, principal-component analysis and wavelet transformations.					
Unit IV	Networks				
Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller. Stability analysis of Neural-Network interconnection systems					
Unit V	Case studies				
Identification and control of linear and nonlinear dynamic systems using Matlab -Neural Network toolbox.					
Unit VI	Fuzzy sets and fuzzy relations				
Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control. Fuzzy logic control for nonlinear time-delay system. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox. Stability analysis of fuzzy control systems.					
Text Books					
1. Introduction to Artificial Neural Systems, Jack M. Zurada, Jaico Publishing House, 2003.					
References					
1. Neuro-Fuzzy soft computing", JSR JANG, CT Sun, E.Mizutani, Pearson Education, 2004 2. Fundamentals of Neural Networks- Architectures, Algorithms and Applications, Laurence Fausett, Pearson Education, 2004 3. Fuzzy Logic with Engineering Applications, Timothy J.Ross, McGrw Hill International Editions, 2004					

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Test (MTE)	End Term Test (ETE)	Total Marks
20	30	50	100