NARAYANA ENGINEERING COLLEGE::NELLORE

AUTONOMOUS

DEPARTMENT OF ELECTRICAL & ELETRONICS ENGINEERING

Course Structure for M.Tech (Electrical Power Systems) w.e f. AY:2020-21

SEMESTER I

Category	Course Title	Contact Periods per week				Credits
		L	T	P	Total	
PC	Power System Analysis	3	0	0	3	3
PC	Power System Dynamics-I	3	0	0	3	3
PE	Professional Elective I	3	0	0	3	3
PE	Professional Elective II	3	0	0	3	3
HS	Research Methodology and IPR	2	0	0	2	2
PC	Power System Steady State Analysis Lab	0	0	3	3	1.5
PC	Power System Dynamics Lab/	0	0	3	3	1.5
AC	Audit Course - I	2	0	0	2	0
SC	Value added course/Certificate course I	0	1	0	1	1
	Activity Point Programme	During the Semester				25 points
	Total	**16**	**1**	**6**	**23**	**18**

SEMESTER II

Category	Course Title	Contact Periods per week				Credits
		L	T	P	Total	
PC	Digital Protection of Power System	3	0	0	3	3
PC	Power System Dynamics-II	3	0	0	3	3
PE	Professional Elective III	3	0	0	3	3
PE	Professional Elective IV	3	0	0	3	3
PC	Power System Protection Lab	0	0	3	3	1.5
PC	Artificial Intelligence Lab	0	0	3	3	1.5
AC	Audit Course - II	2	0	0	2	0
EE	Mini Project	0	0	4	4	2
SC	Value added course/Certificate course II	0	1	0	1	1
	Activity Point Programme	During the Semester				25 points
	Total	**14**	**1**	**10**	**25**	**18**

SEMESTER III

Category	Course Title	Contact Periods per week				Credits
		L	T	P	Total	
PE	Professional Elective V	3	0	0	3	3
OE	Open Elective	3	0	0	3	3
EE	Teaching Assignment	-	-	-	-	**2**
PR	Project phase I	0	0	16	16	**8**
	Activity Point Programme	During the Semester				25 points
	Total	**6**	**0**	**16**	**22**	**16**

SEMESTER IV

Category	Course Title	Contact Periods per week				Credits
		L	T	P	Total	
PR	Project phase II	0	0	32	32	16
	Activity Point Programme	During the Semester				25 points
		0	**0**	**32**	**32**	**16**

Professional Electives

Professional Elective-1	Professional Elective-2	Professional Elective-3	Professional Elective-4	Professional Elective-5
Smart Grid Technology	Hybrid Electrical Vehicles	Restructured Power Systems	Power System Wide Area Monitoring & Control	Power System Transients
Advanced Power Converters	Advanced Control systems	Power Apparatus Design	State Estimation Techniques	Power System Optimization
Solar Energy Conversion Systems	Operation and Control of Power Systems	Reactive Power Compensation and Management	SCADA System and Applications	FACTS and Custom Power Devices
Modern Control Engineering & Principles of Optimal Control	HVDC & EHVAC Transmission Systems	Energy Audit &Demand side Management	Power Quality	Automotive Electrical Engineering
Renewable Energy Conversion Systems	Electrical Power Distribution System	Wind and Biomass Energy Systems	AI Techniques	Distributed Generation & Micro grid Control

Open Elective

Open Elective
1. Business Analytics
2. Industrial Safety
3. Operations Research
4. Cost Management of Engineering Projects
5. Composite Materials
6. Waste to Energy

Audit Courses

Audit Courses
1. English For Research Paper Writing
2. Sanskrit for Technical Knowledge
3. Disaster Management
4. Value Education
5. Constitution Of India
6. Pedagogical Studies
7. Stress Management By Yoga
8. Personality Development through Life and Enlightenment Skills

S NO	SUBJECT AREA	Credits Per Semester				Credits NECN
		I	II	III	IV	
1	HS	2	-			**2**
2	PC	9	9			**18**
3	PE	6	6	3		**15**
4	OE			3		**3**
5	PR			8	16	**24**
6	SC	1	1			**2**
7	EE		2	2		**4**
TOTAL		**18**	**18**	**16**	**16**	**68**

NARAYANA ENGINEERING COLLEGE::NELLORE

AUTONOMOUS

DEPARTMENT OF ELECTRICAL & ELETRONICS ENGINEERING

List of Subjects approved by BOS of EEE Department held on 09.01.2021 for M.Tech (EPS)

1. POWER SYSTEM ANALYSIS

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
I	3	0	0	48	3	40	60	100

MODULE – 1 POWER FLOW ANALYSIS 8 h

Representation of power Systems Elements, Per-Unit System of Representation. Per-Unit Equivalent Reactance Network of a Three Phase Power System. Necessity of Load Flow Studies – Data for Load Flow Studies – Derivation of Static Load Flow Equations – Load Flow Solutions using Gauss Seidel Method: Acceleration Factor, Load Flow Solution with and without P-V Buses, Algorithm and Flowchart. Numerical Load flow Solution for Simple Power Systems (Max. 3-Buses)

MODULE -2 LOAD FLOW STUDIES 8 h

Newton Raphson Method in Rectangular and Polar Co-Ordinates Form: Load Flow Solution with or without PV Buses- Derivation of Jacobian Elements, Algorithm and Flowchart. Decoupled and Fast Decoupled Methods- Comparison of Different Methods.

MODULE-3 SYMMETRICAL FAULT ANALYSIS 8 h

Symmetrical fault Analysis: Short Circuit current and MVA Calculations, Fault levels, Application of Series Reactors, Symmetrical Component Theory: Positive, Negative and Zero sequence components, Positive, Negative and Zero sequence Networks.

MODULE-4 UNSYMMETRICAL FAULT ANALYSIS 8 h

Unsymmetrical Fault Analysis: LG, LL, LLG faults with and without fault impedance, Numerical Problems.

MODULE-5 STABILITY ANALYSIS 8 h

Elementary concepts of Steady State, Dynamic and Transient Stabilities, Derivation of Swing Equation, Power Angle Curve and Determination of Steady State Stability.

MODULE-6 POWER SYSTEM STABILITY 8 h

Determination of Transient Stability by Equal Area Criterion, Application of Equal Area Criterion, Critical Clearing Angle Calculation, Numerical methods for solution of swing equation, Methods to improve stability, Voltage Stability.

Text Book(s):

1. Power Systems Analysis, Grainger and Stevenson, Tata Mc Graw-hill, 2005.
2. Modern Power system Analysis 2nd edition, I.J.Nagrath&D.P.Kothari: Tata McGraw- Hill Publishing Company, 2003.
3. Kundur, P., "Power System Stability and Control", Mc. Graw Hill inc. 1994.

Reference Book(s):

1. Computer Techniques in Power System Analysis 2nd Edition,, M A Pai, TMH, 2005.
2. Computer Techniques and Models in Power Systems, K. Uma Rao, I. K. International, 2007.
3. Electric Power Systems 1st Edition, S. A. Nasar, Schaum's Outline Series, TMH, 1997.
4. Computer Methods in Power System Analysis, E. I. Stagg and El-Abiad, Tata McGraw Hill,1969.
5. Kimbark, E.W., "Power System Stability, Vol. I : Elements of Stability Calculations", Johns Wiley & Sons, 1948.
6. Gainger John, J. and Steveson, W.D., Jr., "Power System Analysis", McGraw Hill, 1994

2. POWER SYSTEM DYNAMICS-I

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
I	3	0	0	48	3	40	60	100

MODULE – 1 BASICS OF SYSTEM DYNAMICS 8h

Power system stability states of operation and system security - system dynamics - problems system model analysis of steady State stability and transient stability - simplified representation of Excitation control.

MODULE -2 MODELING OF SYNCHRONOUS MACHINE 8h

Synchronous machine - park's Transformation-analysis of steady state performance per - unit quantities-Equivalent circuits of synchronous machine-determination of parameters of equivalent circuits.

MODULE-3 EXCITATION SYSTEM 8h

Excitation system modeling-excitation systems block Diagram - system representation by state equations-Dynamics of a synchronous generator connected to infinite bus - system model Synchronous machine model-stator equations rotor equations - Synchronous machine model with field circuit - one equivalent damper winding on q axis (model 1.1) - calculation of Initial conditions.

MODULE-4 ANALYSIS OF SINGLE MACHINE SYSTEM 8h

Small signal analysis with block diagram - Representation Characteristic equation and application of Routh Hurwitz criterion- synchronizing and damping torque analysis-small signal model - State equations.

MODULE-5 ANALYSIS OF MULTI MACHINE SYSTEM 8h

A Simplified System Model, Detailed Models: Case I and Case II, Inclusion of Load and SVC Dynamics, Modal Analysis of Large Power Systems, Case Studies.

MODULE-6 APPLICATION OF POWER SYSTEM STABILIZERS 8h

Basic concepts in applying PSS - Control signals - Structure and tuning of PSS - Washout circuit - Dynamic compensator analysis of single machine infinite bus system with and without PSS.

Text Book(s):

1. Power System Dynamics Stability and Control By K R Padiyar, B S Publications, 2nd Edition,2008.
2. Power System Stability & Control, By- P.Kundur, Tata Mcgraw hill, 2nd Edition,2003.
3. Power Systems Analysis By Vijay Vittal, Bergen , Pearson Education, 1st Edition, 1998.

Reference Book(s):

1. R. Ramanujam, "Power Systems Dynamics"- PHI Publications, 2nd Edition,2008.
2. Electric machinery and Drive Systems By P C Crause, Viley IEEE Press, 2nd Edition,2011.
3. Power system dynamics : analysis and simulation by Ramanujam. R, 2nd edition , 2013

4. DIGITAL PROTECTION OF POWER SYSTEMS

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
II	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION TO PROTECTIVE SYSTEMS 8 h

Need for Protective Systems-Nature and causes of faults-Types of faults & Effects-Fault Statistics-Zones of Protection-Primary and Back-up Protection-Essential Qualities of Protection-Automatic Reclosing-Current Transformers (CTs) for Protection-Voltage Transformers (VTs)

MODULE -2 POWER SWINGS 8h

Effect of power swings on the performance of Distance relays - Power swing analysis – Principle of out of step tripping and blocking relays – Effect of line length and source impedance on distance relays.

MODULE-3 INTRODUCTION TO STATIC RELAYS & COMPARATORS 8h

Introduction to static relays - Basic construction of static relays – Level detectors – Replica impedance mixing circuits-general equation for two input phase and amplitude comparators – Their types - Duality between amplitude and phase comparator. Conic section characteristics – Three input amplitude comparator – Hybrid comparator – Switched distance schemes – Polyphase distance schemes-Phase fault scheme – Three phase scheme – combined and ground fault scheme.

MODULE-4 STATIC RELAYS 8h

Introduction-Instantaneous over current relay – Time over current relays - Basic principles-Definite time and Inverse definite time over current relays. Static Differential Relays-Analysis of static differential relays – static relay schemes- Dual bias transformer differential protection – Harmonic restraint relay. Static Distance Relays- Static impedance –reactance - MHO and angle impedance relay sampling comparator – realization of reactance and MHO relay using a sampling comparator.

MODULE-5 MICROPROCESSOR BASED PROTECTIVE RELAYS 8h

Over current relays – Impedance relays – Directional relay – Reactance relay (Block diagram and flow chart approach only). Generalized mathematical expression for distance relays - Measurement of resistance and reactance – MHO and offset MHO relays – Realization of MHO characteristics – Realization of Offset MHO characteristics (Block diagram and flow chart approach only) Basic principle of Digital computer relaying.

MODULE-6 NUMERICAL RELAYS 8h

Advantages of Numerical Relays- Numerical network- Digital Signal processing – Estimation of Phasors – Full Cycle Fourier Algorithm – Half Cycle Fourier Algorithm- practical considerations for selection of Algorithm –Discrete Fourier Transform.

Text Book(s):

1. Power system Protection and Switchgear, Badri Ram and D.N.Vishwakarma, Tata McGraw Hill, First Edition -1995.
2. Power system Protection static relay, T.S.Madhava Rao, Tata McGraw Hill, 2nd Edition, 1989.

3. “ Power System Protection and Switchgear”, Bhuvanesh A Oza, Nirmal kumar C Nair et.al. Mc Graw Hill
4. TSM Rao, "Power System Protection - Static Relays", Tata McGraw Hill.
5. S.P Patra, S.K Bl,lsu and S. Choudhary, "Power System Protection", Oxford IBH Pub.

Reference Book(s):

1. S. Ravindernath and M. Chander, "Power System Protection and Switchgear", Wiley Eastern Ltd.
2. Switchgear and Protection, by Sunil S Rao, Khanna Publishers, 1992.
3. Electrical Power Systems, C.L.Wadhwa, New Age international (P) Limited, Publishers, 2012.
4. Transmission network Protection, Y.G. Paithankar ,Taylor and Francis,2009.
5. Digital power system protection by S.R.Bhide,PHI Learning Private Limited,2014

4. ADVANCED CONTROL SYSTEMS

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 STATE VARIABLE DESIGN 8 h

Introduction to state model: Effect of state feedback - Pole placement design: Necessary and sufficient condition for arbitrary pole placement, State regulator design - Design of state observers- Separation principle- Design of servo systems: State feedback with integral control

MODULE -2 PHASE PLANE ANALYSIS 8h

Features of linear and non-linear systems - Common physical non-linearities – Phase plane method: Basic concept, Singular points, Limit cycles, Phase trajectories - Construction of phase trajectories of linear and non-linear systems: Analytical method, Isocline method.

MODULE-3 DESCRIBING FUNCTION ANALYSIS 8h

Basic concepts, Derivation of describing functions for common non-linearities: Dead zone, Saturation, Relay, Hysteresis, Backlash – Describing function analysis of non-linear systems, Limit cycles, Stability of oscillations.

MODULE-4 OPTIMAL CONTROL 8h

Introduction: Classical control and optimization, formulation of optimal control problem, Typical optimal control performance measures - Optimal state regulator design: Lyapunov equation, Matrix Riccati equation - LQR steady state optimal control – Application examples.

MODULE-5 OPTIMAL ESTIMATION 8h

Introduction: Discrete systems - Optimal estimation: Kalman Filter, Kalman Bucy Filter, Solution by duality principle - Application examples.

MODULE-6 STABILITY ANALYSIS 8h

Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems. Direct method of Lypanov for the Linear and Nonlinear continuous time autonomous systems.

Text Book(s):

1. M.Gopal, "Digital Control and State Variable Methods", 4th edition, Mc Graw Hill India, 2012
2. K. Ogata, 'Modern Control Engineering', 5th Edition, Pearson, 2012
3. K. P. Mohandas, "Modern Control Engineering", Sanguine Technical Publishers, 2006.

Reference Book(s):

1. William S Levine, "Control System Fundamentals," The Control Handbook, CRC Press, Tayler and Francies Group, 2011.
2. M.Gopal, Modern Control System Theory, 3rd edition, New Age International Publishers, 2014

5. ADVANCED POWER CONVERTERS

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 SWITCHING VOLTAGE REGULATORS 8h

Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Half bridge, Full bridge configurations, Push-pull converter; Design criteria for SMPS; Multi-output switch mode regulator.

MODULE -2 RESONANT CONVERTERS 9h

Introduction, Need of resonant converters, Classification of resonant converters, Load resonant converters, Resonant switch converters, zero voltage switching dc-dc converters, zero current switching dc-dc converters, clamped voltage topologies.

MODULE-3 MULTI-LEVEL CONVERTERS 7h

Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, Flying capacitor and Cascaded H-bridge multilevel Converters configurations; Features and relative comparison of these configurations applications, Introduction to carrier based PWM technique for multi-level converters.

MODULE-4 MULTIPULSE CONVERTER 8h

Concept of multi-pulse, Configurations for m-pulse (m=12,18,24 ….) converters, Different phase shifting transformer (Y-Δ1, Y-Δ2, Y-Z1 and Y-Z2) configurations for multi-pulse converters, Applications.

MODULE-5 DC POWER SUPPLIES 8h

DC Power Supplies – Types – Switched Mode DC Power Supplies – Fly Back Converter –Forward Converter – Push-Pull Converter – Half Bridge Converter – Full Bridge Converter –Resonant DC Power Supplies – Bidirectional Power Supplies – Applications – Numerical Problems.

MODULE-6 AC POWER SUPPLIES 8h

AC Power Supplies – Types – Switched Mode Ac Power Supplies – Resonant AC Power Supplies – Bidirectional Ac Power Supplies – Multistage Conversions – Control Circuits – Power Line Disturbances – Power Conditioners – Uninterruptible Power Supplies – Applications – Numerical Problems.

Text Book(s):

1. Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics – Converters, Applications and Design”, John Willey & sons, Inc., 3rd ed., 2003.

2. Muhammad H. Rashid, “Power Electronics - Circuits, Devices and Applications”, Prentice Hall of India, 3rd ed., 2009.

3. Bin Wu, “High Power Converters and AC Drives”, John Willey & sons, Inc., 2006.

Reference Book(s):

1. Derek A. Paice “Power Electronic Converter Harmonics – Multipulse Methods for Clean Power”, IEEE Press, 1996.
2. Muhammad H. Rashid , “Power Electronics Handbook”, Elsevier, 3rd ed., 2011.
3. P.C.Sen, “Modern Power Electronics ”, S. Chand and Co. Ltd., New Delhi, 2000.
4. Vijay K. Sood, “HVDC and FACTS Controllers Applications of Static Converters in Power Systems”, Kluwer Academic Publishers, Boston, 2004.
5. L. Umanand, “Power Electronics Essentials and Applications”, Wiley India Ltd., 2009

6. AI TECHNIQUES

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 ARTIFICIAL NEURAL NETWORKS 8h

Introduction-Models of Neural Network - Architectures – Knowledge representation – Artificial Intelligence and Neural networks–Learning process – Error correction learning – Hebbian learning – Competitive learning –Boltzman learning –Supervised learning – Unsupervised learning – Reinforcement learning- learning tasks.

MODULE -2 ANN PARADIGMS 8h

Multi – layer perceptron using Back propagation Algorithm-Self – organizing Map – Radial Basis Function Network – Functional link, network – Hopfield Network

MODULE-3 FUZZY LOGIC 8h

Introduction, Comparison between Fuzzy and crisp logic, Fuzzy sets, Membership function, Basic fuzzy set operations, properties of Fuzzy set, fuzzy relations, Fuzzy interference system, Mamdani, Sugeno, Fuzzy rule based system, defuzzification methods

MODULE-4 GENETIC ALGORITHMS 8h

Introduction-Encoding –Fitness Function-Reproduction operators-Genetic Modeling –Genetic operators-Crossover-Single – site crossover-Two point crossover –Multi point crossover Uniform crossover – Matrix crossover-Crossover Rate-Inversion & Deletion –Mutation operator Mutation –Mutation Rate-Bit-wise operators-Generational cycle-convergence of Genetic Algorithm

MODULE-5 PPROACH TO ELECTRICAL LOAD FORECASTING 8h

ANN approach to Electrical Load forecasting – Load flow studies – Economic load dispatch – Load frequency control – Single area system and two area system – Small Signal Stability (Dynamic stability) Reactive power control – speed control of DC and AC Motor

MODULE-6 FUZZY LOGIC APPROACH TO AVR EXCITATION 8h

Fuzzy logic approach to AVR Excitation , IEEE 14 BUSBAR system, ANN for security assessment, Schedule Maintenance of Electrical Power Transmission Networks using Genetic Algorithm, Intelligent Systems for Demand Forecasting

Text Book(s):

1. Neural Networks, Fuzzy Logic & Genetic Algorithms, S.Rajasekaran and G.A.V.Pai, PHI, New Delhi, 2003

Reference Book(s):

1. Neural Computing Theory & Practice, P.D.Wasserman,Van Nostrand Reinhold, New York,1989.
2. Neural Network & Fuzzy System, Bart Kosko, Prentice Hall, 1992.

3. Fuzzy sets,Uncertainty and Information, G.J.Klir and T.A.Folger, PHI, Pvt.Ltd,1994.
4. Genetic Algorithms, D.E.Goldberg, Addison Wesley 1999.

7. AUTOMOTIVE ELECTRICAL ENGINEERING

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 BATTERIES AND ACCESSORIES 8h

Principle and construction of lead acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on batteries, maintenance and charging.

MODULE -2 STARTING SYSTEM 8h

Condition at starting, behavior of starter during starting, series motor and its characteristics, principle and construction of starter motor, working of different starter drive units, care and maintenances of starter motor, starter switches.

MODULE-3 CHARGING SYSTEM 8h

Generation of direct current, shunt generator characteristics, armature reaction, third brush regulation, cutout. Voltage and current regulators, compensated voltage regulator, alternators principle and constructional aspects and bridge rectifiers, new developments.

MODULE-4 LIGHTING 8h

Lighting system: insulated and earth return system, details of head light and side light, LED lighting system, head light dazzling and preventive methods – Horn, wiper system and trafficator.

MODULE-5 FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS 8h

Current trends in automotive electronic engine management system, electromagnetic interference suppression, electromagnetic compatibility, electronic dashboard instruments, onboard diagnostic system, security and warning system.

MODULE-6 SENSORS AND ACTUATORS 8h

Types of sensors: sensor for speed, throttle position, exhaust oxygen level, manifold pressure, crankshaft position, coolant temperature, exhaust temperature, air mass flow for engine application. Solenoids, stepper motors, relay.

Text Book(s):

1. Tom Weather Jr and Cland C.Hunter, “Automotive Computers and Control system”, Prentice Hall Inc., New Jersey.
2. A. Bonnick, “Automotive Computer Controlled Systems”, 2011.
3. Young A. P & Griffiths L, “Automobile Electrical and Electronic Equipments” English Languages Book Society & New Press, 1990.

Reference Book(s):

1. Santini Al, “Automotive Electricity and Electronics”, Cengage Learning, 2012.
2. Tom Denton, “Automotive Electrical and Electronic System”, SAE International, 2004.
3. William B. Ribbens, “Understanding Automotive Electronics”, 6th Edition, Newnes, 2003.
4. BOSCH, “Automotive Handbook”, 8th Edition, BENTLEY ROBERT Incorporated, 2011.
5. Norm Chapman, “Principles of Electricity and electronics for the Automotive Technician”, Delmar Cengage Learning, 2008.
6. Judge A.W, “Modern Electrical Equipment of Automobiles”, Chapman & Hall, London, 1992.

8. DISTRIBUTED GENERATION & MICROGRID CONTROL

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION TO DG & MICROGRID 8h

Introduction to distributed generation - Active distribution network - Concept of Microgrid -Microgrid configuration - Interconnection of Microgrids - Technical and economical advantages of Microgrid - Challenges and limitations of Microgrid development - Management and operational issues of a Microgrid - Dynamic interactions of Microgrid with main grid – low voltage DC grid.

MODULE -2 DISTRIBUTED ENERGY RESOURCES 8h

Introduction - Combined heat and power (CHP) systems: Micro-CHP systems - Wind energy conversion systems (WECS): Wind turbine operating systems - Solar photovoltaic (PV) systems: Classification of PV cell - Small-scale hydroelectric power generation - Other renewable energy sources - Storage devices.

MODULE-3 MICROGRID & ACTIVE DISTRIBUTION 8h NETWORK MANAGEMENT SYSTEM

Introduction - Impact on heat utilisation - Impact on process optimisation - Impact on market - Impact on environment - Impact on distribution system - Impact on communication standards and protocols - Network management needs of Microgrid - Microsource controller - Central controller.

MODULE-4 SCADA 8h

Introduction - Existing DNO SCADA systems - Control of DNO SCADA systems - SCADA in Microgrids - Human–machine interface (HMI) - Hardware components - Communication trends in SCADA

MODULE-5 DISTRIBUTED CONTROL SYSTEM 8h

Distributed control system (DCS) - Sub-station communication standardization - SCADA communication and control architectures - Communication devices.

MODULE-6 IMPACT OF DG INTEGRATION ON POWER QUALITY 8h AND RELIABILITY

Introduction - Power quality disturbances - Power quality sensitive customers - Power quality improvement technologies - Impact of DG integration - Issues of premium power in DG integration

Text Book(s):

1. S. Chowdhury, S.P. Chowdhury and P. Crossley, “Microgrids and Active Distribution Networks”, The Institution of Engineering and Technology, 2009.

Reference Book(s):

1. H. H. Zeineldin ; E. F. El-saadany ; M. M. A. Salama, "Distributed Generation Micro-Grid Operation", 2006 Power Systems Conference.
2. Zeeshan Ahmad Arfeen, Azhar B. Khairuddin, Raja Masood Larik, Mohammad Salman Saeed "Control of distributed generation systems for microgrid applications" Electrical Energy Systems, 2019.

9. ELECTRICAL MACHINE DESIGN

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 PRINCIPLES OF ELECTRICAL MACHINE DESIGN 8h

Introduction, considerations for the design of electrical machines, limitations. Different types of materials and insulators used in electrical machines.

MODULE -2 DESIGN OF DC MACHINES 8h

Output equation, choice of specific loadings and choice of number of poles, design of Main dimensions of the DC machines, Design of armature slot dimensions, commutator and brushes, magnetic circuit - estimation of ampere turns, design of yoke and poles- main and inter poles, field windings – shunt, series and inter poles.

MODULE-3 DESIGN OF TRANSFORMERS 8h

Output Equations for single phase and three phase transformers, expression for volts/turn, Main Dimensions, Window space factor, Design of core and winding, Overall dimensions , expression for leakage reactance and voltage regulation, No load current , Temperature rise in Transformers ,Design of Tank, Methods of cooling of Transformers.

MODULE-4 DESIGN OF THREE PHASE INDUCTION MOTORS 8h

Output Equation, Choice of Specific Loadings, Main Dimensions of Stator. Design of stator slots and Winding, Choice of Length Air Gap, Estimation of Number of Slots for Squirrel Cage Rotor. Design of Rotor Bars and End Ring. Design of Slip Ring rotor. Estimation of No Load Current and Leakage Reactance.

MODULE-5 DESIGN OF SINGLE PHASE INDUCTION MOTOR 8h

Calculation of main dimensions of stator, complete design of stator with its punching details, design of main and auxiliary winding, design of rotor, performance calculation of designed rotor and performance by equivalent circuit approach.

MODULE-6 DESIGN OF THREE PHASE SYNCHRONOUS MACHINES 8h

Output Equation, Choice of Specific Loadings, Short Circuit Ratio, Main Dimensions of Stator. Design of stator slots and Winding. Design of Salient and non- salient Pole Rotors. Magnetic Circuit and Field Winding.

Text Book(s):

1. Sawhney, A.K., 'A Course in Electrical Machine Design', Dhanpat Rai & Sons, New Delhi, 1984.
2. M.V.Deshpande "Design and Testing of Electrical Machine Design" Wheeler Publications, 2010.

Reference Book(s):

1. A.Shanmuga Sundaram, G.Gangadharan, R.Palani 'Electrical Machine Design Data Book', New Age International Pvt. Ltd., Reprint, 2007.
2. R.K.Agarwal " Principles of Electrical Machine Design" Esskay Publications, Delhi, 2002.
3. Sen, S.K., 'Principles of Electrical Machine Designs with Computer Programmes', Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1987
4. Ramamoorthy M, "Computer Aided Design of Electrical Equipment", East-West Press.
5. M. N. O. Sadiku, " Numerical techniques in Electromagnetics", CRC Press Edition-2001.
6. M.V. Deshpande, "Design and Testing of Electrical Machines"PHI learning, New Delhi.

10. ENERGY AUDIT & DEMAND SIDE MANAGEMENT

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 BASIC PRINCIPLES OF ENERGY AUDIT 8h

Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams , load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential ,energy audit of process industry, thermal power station, building energy audit

MODULE -2 ENERGY MANAGEMENT-I 8h

Principles of energy management, organizing energy management program, initiating, planning , controlling, promoting, monitoring, reporting.

MODULE-3 ENERGY MANAGEMENT-II 8h

Energy manger, Qualities and functions , language ,Questionnaire - check list for top management

MODULE-4 ENERGY MANAGEMENT FOR LIGHTING& MOTORS 8h

Good Lighting System Design and Practice, Lighting Control, Lighting Energy Audit Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit

MODULE-5 INTRODUCTION TO DEMAND SIDE MANAGEMENT 8h

Introduction to DSM, Concept of DSM, Benefits of DSM, Different Techniques of DSM – Time of Day Pricing, Multi-Utility Power Exchange Model, Time of Day Models for Planning. Load Management, Load Priority Technique, Peak Clipping, Peak Shifting, Valley Filling, Strategic Conservation, Energy Efficient Equipment. Management and Organization of Energy Conservation Awareness Programs.

MODULE-6 ECONOMICS & COST EFFECTIVENESS TESTS OF DSM PROGRAMS 8h

Basic payback calculations, Depreciation, Net present value calculations. Taxes and Tax Credit – Numerical Problems. Importance of evaluation, measurement and verification of demand side management programs. Cost effectiveness test for demand side management programs - Ratepayer Impact Measure Test, Total Resource Cost, Participant Cost Test, Program Administrator Cost Test

Text Book(s):

1.Industrial Energy Management Systems, Arry C. White, Philip S. Schmidt, David R. Brown, Hemisphere Publishing Corporation, New York, 1994.

2.Fundamentals of Energy Engineering - Albert Thumann, Prentice Hall Inc, Englewood Cliffs, New Jersey, 1984.

Reference Book(s):

1. Energy management by W.R. Murphy & G. Mckay Butter worth, Heinemann publications.
2. Energy management by Paul o‟ Callaghan, Mc-graw Hill Book company-1/e,1998
3. Energy efficient electric motors by John C. Andreas, Marcel Dekker Inc Ltd-2/e, 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

11. HVDC & EHVAC TRANSMISSION SYSTEMS

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION & APPLICATIONS OF HVDC 8h

Introduction: Introduction of DC power transmission technology, comparison of AC and DC transmission, limitation of HVDC transmission, reliability of HVDC systems.

Applications of HVDC : application of transmission, description of DC transmission system, planning for HVDC transmission, modern trends in DC transmissions

MODULE -2 ANALYSIS OF HVDC CONVERTERS 8h

Analysis of HVDC converters:: Choice of converter configuration, simplified analysis of Graetz circuit, converter bridge characteristics, Detailed analysis of converters: Characteristics of a twelve pulse converter, detailed analysis of converters.

MODULE-3 CONTROL OF HVDC CONVERTER AND SYSTEMS 8h

Control of HVDC converter and systems:: Necessity of control of a DC link, rectifier control, compounding of rectifiers, power reversal of DC link, voltage dependent current order limit(VDCOL) characteristics of the converter::inverter extinction angle control, pulse phase control, starting and stopping of DC link, constant power control, control scheme of HVDC converters

MODULE-4 INTRODUCTION TO EHV AC TRANSMISSION 8h

Necessity of EHV AC transmission - advantages and problems-power handling capacity and line losses. Mechanical considerations - resistance of conductors - properties of bundled conductors – bundle spacing and bundle radius- Examples.

MODULE-5 LINE AND GROUND REACTIVE PARAMETERS 8h

Line inductance and capacitances – sequence inductances and capacitances – modes of propagation – ground return – Examples.

MODULE-6 VOLTAGE GRADIENTS OF CONDUCTORS 8h

Voltage gradients of conductors: Electrostatics – field of sphere gap – field of line changes and properties – charge – potential relations for multi-conductors – surface voltage gradient on conductors – distribution of voltage gradient on sub conductors of bundle – Examples.

Text Book(s):

1. HVDC Transmission, S. Kamakshaiah & V. Kamaraju, Tata McGraw hill education
2. HVDC Power transmission system, K.R.Padiyar, Wiley Eastern Limited
3. High Voltage Direct Current Transmission, J. Arrillaga, Peter Pregrinu
4.Extra High Voltage AC Transmission Engineering – Rokosh Das Begamudre, Wiley Eastern Ltd., New Delhi – 1987.
5. EHV Transmission line reference Books – Edison Electric Institution (GEC 1968).

Reference Book(s):

1. "Direct current Transmission"-EW Kimbark.
2. "Power system stability and control"- Prabha Kundur, TMH, 9th reprint, 2007.
3. Power System Analysis: Operation and Control, AbhijitChakrabarti and SunitaHalder, PHI Learning Pvt. Ltd.
4. BegamudreR.D , "Extra High Voltage AC Transmission Engineering", Wiley EasternLtd., Second edition. 5. K.R, Padiyar, HDVC Power Transmission System, Wiley Eastern Ltd.
6. E.W. Kimbark, Direct Current Transmission, Vol:1 Wiley Interscience.
7. D. Chakrabarti, D.P.Kothari, A.K. Mukhopdadhyay ,"Performance, Operation & Controlof EHV Power Transmission System ", Wheeler publications.

12. HYBRID ELECTRICAL VEHICLES

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION TO ELECTRIC VEHICLES 8h

: Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

MODULE -2 HYBRID ELECTRIC DRIVE-TRAINS 8h

: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis

MODULE-3 ELECTRIC PROPULSION UNIT 8h

Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives

MODULE-4 ENERGY STORAGE SYSTEMS 8h

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery, Fuel Cell, Super Capacitor based energy storage and its analysis.

MODULE-5 ENERGY MANAGEMENT STRATEGIES 8h

:Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

MODULE-6 HYBRID VEHICLE CONTROL STRATEGY 8h

HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode - series parallel mode.

Text Book(s):

1. C. Mi, M. A. Masrur and D. W. Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.
3.Electric Vehicle Technology Explained-James Larminie, John Lowry-John Wiley & Sons Ltd,-2003
4.Electric & Hybrid Vehicles-Design Fundamentals-Iqbal Hussain, Second Edition, CRCPress,2011

Reference Book(s):

1. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
2. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016.

3. Iqbal Husain, "Electric and Hybrid Electric Vehicles", CRC Press, 2011.
4. Wei Liu, "Hybrid Electric Vehicle System Modeling and Control", Second Edition, WILEY, 2017

13. POWER APPARATUS DESIGN

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 TRANSMISSION LINE DESIGN 8h

Types of Insulator, String Efficiency, Improvement of voltage distribution, Improvement of String Efficiency, Line Supports, Types of Steel Towers, Cross Arms, Equivalent span, Conductor configurations.

MODULE -2 OVERHEAD LINE DESIGN 8h

Spacing & Clearance, Sag & Tension calculations, Erection conditions, Factors affecting Sag, Sag Template, Catenary, Vibration of conductors & prevention, Selection of conductor size, Cross arm, No. Of circuits, Selection of ground wire.

MODULE-3 ELECTRICAL SUBSTATION & EARTHING 8h

Types of Substation, Layout and Bus Bar schemes, Voltage level, Substation equipments Protection & Control, Substation Earthing, Tolerance limits of body currents, Soil resistivity, Earth resistance, Tolerable & Actual Step, & Touch Voltages, Design of Earthing Grid, Tower Footing Resistance, Measurement of soil & earth resistivity.

MODULE-4 POWER SYSTEM EARTHING 8h

Ground versus isolated neutral, Solidly and effectively grounded system Resistance and Impedance Grounding, Resonant Grounding, Reactance Grounding, Voltage Transformer Grounding, Zigzag Transformer Grounding, Grounding practice, Effect of grounding on system over voltages & protection over voltage and over voltage phenomenon in isolated and grounded neutral system.

MODULE-5 SURGE PROTECTION& INSULATION CO-ORDINATION 8h

External and Internal over voltages mechanism of lighting discharge, wave shapes of stroke current line design based on direct stroke, over voltage protection, earth wire Rod gap T.F.R., Expulsion tube, surge diverter. General idea, Selection of B.I.L., International recommendation, Selection of arrester rating, Co-ordination of protector devices with apparatus insulation.

MODULE-6 RELIABILITY OF TRANSMISSION & DISTRIBUTION SYSTEMS 8h

Definition, Outage, Bath Tub Curve, Two State Model, Failure & Repair Rate, Probability Density Function, Probabilities of Survival & Failure, Mean Time to Failure, Mean Down Time, Reliability of Series & Parallel Systems, Two-State Fluctuating Environment, Approximate Method, Reliability Planning, Preparation of Reliability Models.

Text Book(s):

1. Power System Analysis & Design by B.R. Gupta –S.Chand
2. Sub Station Design and Equipment – Gupta & Satnam (Dhanpat Rai & Sons)

Reference Book(s):

1. Transmission & Distribution – Westinghouse
2. A Course in Electrical Power – J.B. Gupta, Kataria

14. POWER QUALITY

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION 8h

Power quality-voltage quality, power quality evaluation procedures term and definitions general classes of power quality problems, transients, long duration voltage variation, short duration voltage variations, voltage imbalance, waveform distortion, and power quality terms.

MODULE -2 VOLTAGE SAGS AND INTERRUPTIONS 8h

Sources of sags and interruptions, estimating voltage sag performance, fundamental principles of protection, motor starting sags.

MODULE-3 HARMONICS 8h

Definition of Harmonics - Odd and Even Order Harmonics - Harmonic Phase Rotation and Phase Angle – Causes of Voltage and Current Harmonics – Individual and Total Harmonic Distortion - Harmonic Signatures - Effect of Harmonics on Power System Devices - Guidelines for Harmonic Voltage and Current Limitation - Harmonic Current Mitigation

MODULE-4 POWER QUALITY MONITORING 8h

Monitoring considerations, power quality measurement equipments, assessment of power quality measurement data, application of intelligent systems, power quality monitoring standards.

MODULE-5 POWER QUALITY PROBLEMS 8h

Introduction to Power Quality Measurements - Power Quality Measurement Devices - Power Quality Measurements - Test Locations - Test Duration - Instrument Setup - Instrument Guidelines

MODULE-6 POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES 8h

Introduction to Custom Power Devices-Network Reconfiguring Type: Solid State Current Limiter (SSCL)-Solid State Breaker (SSB) -Solid State Transfer Switch (SSTS) - Compensating Type: Dynamic Voltage Restorer (DVR)-Unified Power Quality Conditioner(UPQC)-Principle of Operation Only.

Text Book(s):

1.Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, 'Electrical Power Systems Quality' McGraw Hill,2003.

2.Eswald.F.Fudis and M.A.S.Masoum, "Power Quality in Power System and Electrical Machines," Elseviar Academic Press, 2013.

3.J. Arrillaga, N.R. Watson, S. Chen, 'Power System Quality Assessment', Wiley, 2011

Reference Book(s):

1.Heydt G.T., "Electric Power Quality", Stars in a Circle Publications, 1994

2.M.H.J Bollen, 'Understanding Power Quality Problems: Voltage Sags and Interruptions', (New York: IEEE Press, 1999).

3.G.J.Wakileh, "Power Systems Harmonics – Fundamentals, Analysis and Filter Design," Springer 2007.

4.E.Aeha and M.Madrigal, "Power System Harmonics, Computer Modelling and Analysis, " Wiley India, 2012.

5.R.S.Vedam, M.S.Sarma, "Power Quality – VAR Compensation in Power Systems," CRC Press 2013.

6.C. Sankaran, 'Power Quality', CRC press, Taylor & Francis group, 2002

7. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002.

15. POWER SYSTEM OPTIMIZATION

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 FUNDAMENTALS OF PARTICLE SWARM OPTIMIZATION (PSO) TECHNIQUES 8h

Introduction – Basics of Particle Swarm Optimization – Background of PSO, Original PSO, Variation of PSO – Discrete PSO,PSO for MINLPs, Constriction Factor Approach (CFA), Hybrid PSO (HPSO), Lbest Model, Adaptive PSO (APSO) Evolutionary PSO (EPSO) – Applications.

MODULE -2 FUNDAMENTALS OF ANT COLONY SEARCH ALGORITHMS 8h

Introduction – Ant Colony Search Algorithm – Behaviour of Real Ants – Ant Colony Algorithms, The Ant System, The Ant Colony System, The Max-Min Ant System – Major Characteristics of Ant Colony Search Algorithm, Distributed Computation: Avoid Premature Convergence, Positive Feedback: Rapid Discovery of Good Solution, Use of Greedy Search and Constructive Heuristic Information: Find Acceptable Solutions in the Early Stage of the Process

MODULE-3 FUNDAMENTALS OF TABU SEARCH 8h

Introduction – Overview of the Tabu Search Approach, Problem Formulation, Coding and Representation, Neighborhood Structure, Characterization of the Neighborhood – Functions and Strategies in Tabu Search, Recency- Based Tabu Search

MODULE-4 TABU SEARCH STRATEGIES 8h

Basic Tabu Search Algorithm, Candidate List Strategies, Tabu tenure, Aspiration Criteria – The Use of Long Term Memory in Tabu Search, Frequency-Based Memory, Intensification, Diversification - Other TS Strategies, Path Relinking, Strategic Oscillation – Applications of Tabu Search

MODULE-5 APPLICATION TO POWER SYSTEMS 8h

Introduction to power system applications, model identifications—Dynamic load modeling, short term load forecasting, Distribution system applications—Network reconfiguration for loss reduction, optimal protection and switching devices placements—examples.

MODULE-6 POWER SYSTEM CONTROLS 8h

Introduction, power system controls: Particle Swarm Technique—problem formulation of VVC, state variables, problem formulation – Expansion of PSO for MINLP, voltage security assessment, VVC using PSO—treatment of state variables, VVC algorithm using PSO, Numerical Examples—IEEE 14 Bus system

Text Book(s):

1. Kwang Y. Lee and Mohamed A. EI- Sharkawi "Modern Heuristic Optimization Techniques Theory and Applications to Power Systems" A John Wiley & Sons. INC.Publication
2. D. P. Kothari and J. S. Dhillon, "Power System Optimization", Second Edition-PHI Learning

Private Limited- 2011.

Reference Book(s):

1. Jizhong Zhu , ‘’ Optimization of power system operation ’’ Second Edition –Wiley-Blackwell publishers.
2. Joshua adam Taylor,“Convex optimization of power systems’’ Cambridge University Press

16. RESEARCH METHODOLOGY AND IPR

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 FUNDAMENTALS OF RESEARCH PROBLEMS 8h

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

MODULE – 2 LITERATURE STUDIES 8h

Effective literature studies approaches, analysis Plagiarism, Research ethics,

MODULE – 3 TECHNICAL WRITING 8h

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

MODULE – 4 INTELLECTUAL PROPERTY 8h

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

MODULE – 5 PATENT RIGHTS 8h

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

MODULE – 6 NEW DEVELOPMENTS IN IPR 8h

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Text Book(s):

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”

Reference Book(s):

1. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.
5. Asimov, “Introduction to Design”, Prentice Hall, 1962.

6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
7. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

17. POWER SYSTEM WIDE AREA MONITORING AND CONTROL

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 COMPUTER CONTROL OF POWER SYSTEMS 8h

Need for real - time and computer control of power systems, operating states of a power system -3 state & 5 states operation of power system - Supervisory Control and Data Acquisition system (SCADA), implementation considerations, energy control centers.

MODULE -2 WIDE AREA MEASUREMENT SYSTEM 8h

Architecture, Components of WAMS, GUI (Graphical User Interface), Applications: Voltage Stability Assessment, Frequency stability Assessment, Power Oscillation Assessment, Communication needs of WAMS, WAMPAC (Wide Area Monitoring Protection & Control), RAS (Remedial Action Scheme).

MODULE-3 STATE ESTIMATION IN POWER SYSTEMS 8h

Introduction, Power system state estimation, Maximum likelihood, Weighted least Square estimation, Weighted least square estimation. State Estimation of AC Networks: Types of measurements, Linear weighted least square (WLS) estimation theory, DC Load flow based WLS state estimation, Linearised model of WLS state estimation of Non - Linear AC power systems, sequential and non - Sequential methods to process measurements, Typical results of state estimation on an Ac network.

MODULE-4 TYPES OF STATE ESTIMATION & NETWORK OBSERVABILITY 8h

State estimation by conventional WLS (normal equations), Orthogonal decomposition and its algorithm, hybrid method. Tracking of state estimation, Dynamic state estimation, Detection and identification of bad measurements, estimation of quantities not being measured. Network observability and pseudo-measurements, observability by graphical technique and triangularisation approach, Optimal meter placement, Application of power system state estimation.

MODULE-5 POWER SYSTEM SECURITY ANALYSIS 8h

Concept of security, Security analysis and monitoring, factors affecting power system security, detection of network problems, an overview of security analysis. Contingency analysis for generator and line outages by Interactive Linear Power Flow (ILPF) method, Fast decoupled inverse Lemma based approach, network sensitivity factors, Contingency selection, concentric relaxation and bounding.

MODULE-6 VOLTAGE STABILITY 8h

Basic concepts, Voltage collapse – general characterization, classification, Voltage stability analysis – modeling, dynamic analysis, static analysis, shortest distance to instability, continuation power flow analysis, prevention of voltage collapse – design measures, operating measures.

Text Book(s):

1. Allen J. Wood and Bruce Woolenberg, Power System Generation, Operation and Control, John Wiley and Sons, 1996.
2. John J. Grainger and William D Stevenson Jr, Power System Analysis, McGraw Hill ISE, 1994.
3. P. Kundur, Power System Stability and Control, McGraw Hill.
4. Fahd Hashiesh, M. M. Mansour , Hossam E. Mostafa Fahd Hashiesh , M. M. Mansour , Hossam E. Mostafa, Wide Area Monitoring, Protection and Control: The Gateway to Smart Grids, Lambert Academic Publishing.

Reference Book(s):

1. E. Handschin, Real-time Control of Electrical Power Systems, Elsevier Publications & Co, 1988.
2. Special Issue on Computer Control of Power Systems, IEEE Proc, July 1974

18. REACTIVE POWER COMPENSATION AND MANAGEMENT

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 LOAD COMPENSATION 8h

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.

MODULE -2 STEADY–STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM 8h

Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples

MODULE-3 TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS 8h

Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers – examples

MODULE-4 REACTIVE POWER COORDINATION 8h

Objective – Mathematical modelling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences.

MODULE-5 DEMAND SIDE MANAGEMENT 8h

Load patterns, basic methods load shaping, power tariffs, KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels - System losses, loss reduction methods - examples

MODULE-6 REACTIVE POWER MANAGEMENT IN INDUSTRIAL SECTORS 8h

Typical layout of traction systems – Reactive power control requirements – Distribution transformers - Electric arc furnaces – Furnaces transformer – Filter requirements – Remedial measures – Power factor of an arc furnace.

Text Book(s):

1. T.J.E.Miller, Reactive power control in Electric power systems, John Wiley and Sons, 1982.
2. D.M. Tagare, Reactive power Management, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004

Reference Book(s):

1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just, Reactive power compensation: A Practical Guide, Willey, April, 2012.

19. RENEWABLE ENERGY CONVERSION SYSTEMS

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 ELECTRIC ENERGY CONVERSION SYSTEM 8h

Generation of electricity using different sources, Transmission and distribution losses, AC to DC and DC to AC conversions, Electric motors: Types, losses, efficiency, Lightning systems, Diesel generating systems.

MODULE -2 SOLAR THERMAL CONVERSION SYSTEM 8h

Relevance of solar thermal power generation; Components of solar thermal power plant, Design and performance, characteristics of different solar concentrator types suitable for thermal power generation

MODULE-3 SOLAR THERMAL CONVERSION SYSTEM FOR HIGH TEMPERATURE APPLICATIONS 8h

Types of solar thermal conversion system used in high temperature application, Tracking of solar concentrators; performance characterization of solar concentrators both line focus and point focus, Comparative analysis of the both mode focus system.

MODULE-4 THERMAL ENERGY CONVERSION & BIO-ENERGY CONVERSION SYSTEMS 8h

Thermo-electric generator, Concepts and design considerations of MHD generators, Cycle analysis of MHD systems, Thermionic power conversion and plasma diodes, Thermo chemical Conversion. Bio-energy conversion, bio methanation technology.

MODULE-5 WIND ENERGY CONVERSION SYSTEM (WECS) 8h

Rotor Selection, Annual Energy Output, HAWT, VAWT, Rotor Design Considerations-Number of Blades, Blade Profile -2/3 Blades and Teetering, Coning- Upwind/Downwind, Power Regulation, Yaw System- Tower, Synchronous and Asynchronous Generators and Loads, Integration of Wind Energy Converters to Electrical Networks, Inverters.

MODULE-6 FUEL CELL TECHNOLOGY 8h

Overview of fuel cells, Fuel cell thermodynamics, fuel cell efficiency, Fuel cell characterization, Fuel cell modelling and system integration, Balance of plant, Hydrogen production from renewable sources and storage, life cycle analysis of fuel cells

Text Book(s):

1. S. S. L. Chang, Energy Conversion, Prentice Hall, 1963
2. R. J. Rosa, Magneto hydrodynamic Energy Conversion, Springer, 1987.
3. V. S. Bagotsky, Fuel Cell Problems and Solutions, John Wiley & Sons, 2009

Reference Book(s):

1. Kettani, M.A., Direct energy conversion, Addison-Wesley, Reading, Mass, 1970
2. Hand book Batteries and Fuel Cells. Linden, McGraw Hill, 1984

20. RESTRUCTURED POWER SYSTEM

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY 8h

Introduction about deregulation – Structure of restructured electric utility – Different entities – Deregulation situation around the world (Qualitative treatment) – Benefits from competitive electricity market – After effects of deregulation. Role of Load Managers

MODULE -2 POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT 8h

Role of ISO – Comparison of two different market structures – Operational planning activities of ISO – ISO in bilateral markets – Operational planning activities of GENCO – GENCO in pool and bilateral markets – Market participation issues – Competitive bidding.

MODULE-3 TRANSMISSION OPEN ACCESS AND PRICING ISSUES 8h

Power wheeling – Types of transmission services in open access – Cost components in transmission – Pricing of power transactions – Pricing mechanisms in various countries

MODULE-4 ANCILLARY SERVICES MANAGEMENT 8h

General description of some ancillary services – Ancillary service management in various countries – Reactive power as an ancillary service – Synchronous generators as ancillary service providers

MODULE-5 AVAILABLE TRANSFER CAPABILITY 8h

Total Transfer Capability – Limitations - Margins – Available transfer capability (ATC) – Procedure - Methods to compute ATC – Static and Dynamic ATC –Concept of Congestion Management – Bid, Zonal and Node Congestion Principles - Generation Rescheduling.

MODULE-6 AVAILABILITY BASED TARIFF 8h

Necessity – Working Mechanism – Beneficiaries – Day Scheduling Process – Deviation from Schedule – Unscheduled Interchange Rate – 24*4 block – System Marginal Rate – Trading Surplus Generation – Applications

Text Book(s):

1. “Understand Electric Utilities and Deregulation” by LorrinPhilipson and H Lee willis,CRC PRESS, 2005 2. “Restructured Electrical Power System operation, Trading and Volatility” by Mohammad 3. “Shahideh pour and MuwaffaqAlomoush‖, Marcel Dekker Inc, New Delhi.

3.Fundamentals of Power System economics Daniel Kirschen and Goran Strbac, John Wiley & Sons Ltd, 2004.

4. Loi Lei Lai, “Power system Restructuring and Regulation”, John Wiley sons, 2001.

Reference Book(s):

1. “Power system Restructuring and deregulation”, edited by Loi Lei lai John Wiley & Sons Ltd.
2. “Power System Restructuring Engineering and Economics”, by Marijallic, Francisco Galiana and Lestor Fink, Kluwer Academic Publisher, USA, 2000
3.Making competition work in electricity Sally Hunt, John Wiley & Sons, Inc., 2002.
4. Operation of restructured power systems Kankar Bhattacharya, Jaap E. Daadler, Math H.J Bollen, Kluwer Academic Pub., 2001
5.Steven Stoft,” Power system economics: designing markets for electricity”, John Wiley & Sons, 2002.
6.Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, “Restructured electrical power systems: operation, trading and volatility” Pub., 2001

21. SMART GRID TECHNOLOGY

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION TO SMART GRID 8h

Introduction - Evolution of Electric Grid, Smart Grid Concept - Definitions and Need for Smart Grid – Functions – Opportunities – Benefits and challenges, Difference between conventional & Smart Grid, Technology Drivers

MODULE -2 SMART GRID TO EVOLVE A PERFECT POWER SYSTEM 8h

Introduction- Overview of the perfect power system configurations- Device level power system Building integrated power systems- Distributed power systems- Fully integrated power system-Nodes of innovation.

MODULE-3 SMART ELECTRIC GRID 8h

Generation Distributed energy resources: Renewable energy, energy storage, solar energy, wind energy, biomass, hydro power, geothermal and fuel cell, effect of electric vehicles(EV‟s), transmission, distribution, and end-user; Basic concepts of power, load models, load flow analysis.

MODULE-4 MEASUREMENT TECHNOLOGIES 8h

Wide area monitoring system (WAMS), advanced metering infrastructure (AMI), phasor measurement units.

MODULE-5 COMMUNICATION NETWORKING 8h

Communication & networking technology: Architectures, standards and adaptation of power line communication (PLC), zigbee, GSM, and more; machine to-machine communication models for the smart grid; Home area networks (HAN) and neighborhood area networks (NAN).

MODULE-6 ENERGY MANAGEMENT SYSTEM 8h

Energy Management System (EMS) - Smart substations - Substation Automation - Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit – Wide area monitoring protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage

Text Book(s):

1.“The smart grid: Enabling energy efficiency and demand response”, by Clark W. Gellings, - CRC Press.

2.“Smart grid: technology and applications”, by Janaka Ekanayake, N. Jenkins, K. Liyanage, J. Wu, Akihiko Yokoyama - Wiley.

Reference Book(s):

1.Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015

2.Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, ‘Communication Networks for Smart Grids’, Springer, 2014.

22. SOLAR ENERGY CONVERSION SYSTEM

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 SOLAR POWER GENERATION 8h

Introduction, solar radiation, calculation of solar radiation on horizontal and inclined surfaces , Measurement of solar radiation, Atmospheric phenomena, Solar Cell Fundamentals, Solar Cell Characteristics, Solar Cell Classification, Maximizing the Solar PV Output and Load Matching. Maximum Power Point Tracker, Solar PV Systems, Solar PV Applications.

MODULE -2 SOLAR THERMAL SYSTEMS 7h

Solar Thermal Systems: Introduction, Solar Collectors, Solar Water Heater, Solar Passive Space Heating and Cooling Systems, Solar Industrial Heating Systems, Solar Refrigeration and Air Conditioning Systems, Solar Cookers.

Solar Energy: Measurement of Solar Radiation, Solar Radiation Data, Blackbody radiation, Planck's Law, Solar Time, Solar Radiation Geometry, Solar Day Length, Extraterrestrial Radiation on Horizontal Surface, Empirical Equations for Estimating Terrestrial Solar Radiation on Horizontal Surface, Solar Radiation on Inclined Plane Surface .

MODULE-3 SOLAR PHOTOVOLTAIC 10h

Solar cell, Current-voltage characteristics of Solar Cell, Efficiency Variation of solar cell, Performance variation of solar photo cell at different light intensities,; Determination of power produced by a solar photo voltaic system, Performance Evaluation of a Solar Photo voltaic lighting system and its components: inverter, charge controller and battery, Performance evaluation of a solar photovoltaic water pump. Current trends in worldwide applications of PV systems, economic considerations

MODULE-4 TYPES OF SOLAR CELLS AND CONCENTRATORS 9h

Types of solar cells: Amorphous silicon (a-Si) solar cells, Cadmium Telluride (Cd-Te) Solar cells, Dye-sensitized solar cells, Organic and polymer solar cells. Types of solar energy concentrators, Review of concentrated Solar Power (CSP) and Concentrated Photovoltaic (CPV) systems, Fresnel lenses and Fresnel reflectors, operating solar cells at high incident energy for maximum power output.

MODULE-5 SOLAR RADIATION DATA MONITORING AND ANALYSIS 6h

Sunshine hour duration, Direct Solar Radiation, Global Solar Radiation, Diffuse Solar Radiation, Net radiation [W/m2], Outgoing radiation [W/m2] , Infra red radiation, Diffuse radiation from global and direct radiation at a given zenith angle

MODULE-6 SOLAR ENERGY UTILIZATION 10h

Solar radiation and modeling, solar collectors and types: flat plate, concentrating solar collectors, advanced collectors and solar concentrators, selective coatings, solar water heating, solar cooking, solar drying, solar distillation and solar refrigeration, Active and passive heating and cooling of buildings, solar thermal power generation, solar cells, home lighting systems, solar lanterns, solar PV pumps, solar energy storage options, industrial process heat systems, solar thermal power generation, and sterling engine.

Text Book(s):

1. James Vignola, Frank, Michalsky, Joseph, Stoffel, Thomas, "Solar And Infrared Radiation Measurements, Second Edition", by Crc Press, 2019.
2. "Renewable Energy Resources" by John Twidell and Tony Weir, 2nd edition, Fspon & Co
3. "Energy conversion systems" by Rakosh das Begamudre, New age international publishers, New Delhi - 2000.

Reference Book(s):

1. Mcmordie, Robert K., Brown, Mitchel C., Stoughton, Robert S.," Solar Energy Fundamentals", by Fairmont Press, 2012
2. "The Electrical Energy Storage" by IEC Market Strategy Board.
3. Jim Eyer, Garth Corey, "Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report", Press, Feb 2010.

23. STATE ESTIMATION TECHNIQUES

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION TO STATE ESTIMATION IN POWER SYSTEMS 8h

Introduction, Power system state estimation, Maximum likelihood, Weighted least Square estimation, Weighted least square estimation, State Estimation of AC Networks**:** Types of measurements, Linear weighted least square (WLS) estimation theory, DC Load flow based WLS state estimation, Linearised model of WLS state estimation of Non - Linear AC power systems, sequential and non - Sequential methods to process measurements, Typical results of state estimation on an Ac network.

MODULE -2 TYPES OF STATE ESTIMATION 8h

State estimation by conventional WLS (normal equations), Orthogonal decomposition and its algorithm, hybrid method. Tracking of state estimation, Dynamic state estimation. Detection and identification of bad measurements, estimation of quantities not being measured.

MODULE-3 NETWORK OBSERVABILITY 8h

Network observability and pseudo- measurements, observability by graphical technique and triangularisation approach, Optimal meter placement, Application of power system state estimation

MODULE-4 INTRODUCTION TO POWER SYSTEM SECURITY 8h

Concept of security, Security analysis and monitoring, factors affecting power system security, detection of network problems, an overview of security analysis.

MODULE-5 POWER SYSTEM SECURITY ANALYSIS 8h

Contingency analysis for generator and line outages by Interactive Linear Power Flow (ILPF) method, Fast decoupled inverse Lemma based approach, network sensitivity factors, Contingency selection, concentric relaxation and bounding.

MODULE-6 COMPUTER CONTROL OF POWER SYSTEMS 8h

Need for real - time and computer control of power systems, operating states of a power system - 3 state & 5 states operation of power system - Supervisory Control and Data Acquisition system (SCADA), implementation considerations, energy control centers.

Text Book(s):

1. Allen J. Wood and Bruce Woolenberg, Power System Generation, Operation and Control, John Wiley and Sons, 1996.
2. John J. Grainger and William D Stevenson Jr, Power System Analysis, McGraw Hill ISE, 1994.

Reference Book(s):

3. E. Handschin, Real-time Control of Electrical Power Systems, Elsevier Publications & Co, 1988.
4. Special Issue on Computer Control of Power Systems, IEEE Proc, July 1974.

24. WIND & BIOMASS ENERGY SYSTEM

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 WIND POWER GENERATION 8h

Introduction – Basic principles of wind energy conversion power in the wind-Forces on blades and thrust on turbines – Wind energy conversion – site selection Considerations -Basic components of WECS – Classification- Advantages and disadvantages – Power, torque and speed characteristics.

MODULE -2 WECS DESIGN 8h

Design of wind turbine :Wind turbine design considerations; Methodology; Theoretical simulation of wind turbine characteristics; Test methods. Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and combine theory; Rotor characteristics; Maximum power coefficient; Prandlt's tip loss Correction.

MODULE-3 WIND ENERGY APPLICATIONS & MEASUREMENTS 8h

Wind energy measurements: Wind speed, Wind direction, Data measurement and analysis, Performance evaluation of Wind energy system, Wind potential assessment

Wind energy application Wind pumps: Performance analysis, design concept and testing; Principle of WEG; Stand alone, grid connected and hybrid applications of WECS; Economics of wind energy. Utilization; Wind energy in India; Case studies.

MODULE-4 BIOMASS CONVERSION TECHNOLOGIES 8h

Bio Energy: Introduction – Biomass conversion technologies – Bio gas generation – Factors affecting bio digestion or generation of gas – Classification of bio gas plants – advantages and disadvantages – Materials used for biogas plant – selection of site for biogas plant Thermo-chemical conversions: Direct Combustion, Technology of Biomass gasification, Pyrolysis and Liquefaction, Bio- Chemical Conversion: anaerobic digestion, alcohol production from biomass, Chemical conversion process: hydrolysis and hydrogenation

MODULE-5 BIOMASS GASIFIERS 8h

History, Principle, Design of Biomass Gasifiers, updraft gasifier, down draft gasifier, zero carbon biomass gasification plants, Gasification of plastic-rich waste, applications for cooking, electricity generation, Gasifier Engines, Operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol and biogas, Biomass integrated gasification/combined cycles systems.

MODULE-6 BIO-ENERGY SYSTEMS WITH EFFICIENT APPLICATIONS 8h

Traditional Stoves, Energy Efficient Cooking and Space heating Stoves, Metal Stoves Improved Gasifier Stoves, Pollution due to smoke emissions, Biogas Systems : Technology of Bio-gas production, Biogas Plants , Digester types, Digester design, Chemical kinetics and mathematical modeling of bio-methanation process, Dung, Vegetable Waste, Night Soil and Municipal Waste based Bio-gas plants, Bio gas as fuel for transportation, Lighting, Running Dual Fuel Engines, Electricity generation, Bio gas Bottling Plant Technology, Application of Bio gas slurry in agriculture , Design of Biogas for cold

climates.

Text Book(s):

1. S.N.Bhadra,D.Kastha, S.Banerjee, " wind electrical systems" Oxford University Press
2. S.Rao & B.B.Parulekar, "Energy Technology", 4th edition, Khanna publishers, 2005.
3. "Energy conversion systems" by Rakosh das Begamudre, New age international publishers, New Delhi - 2000.

Reference Book(s):

1. "Renewable Energy sources & Conversion Technology" by N.K.Bansal, Manfred Kleemann, Michael Meliss. Tata Mcgraw Hill Publishers.
2. "The Electrical Energy Storage" by IEC Market Strategy Board.
3. Jim Eyer, Garth Corey, "Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report", Press, Feb 2010.

25. FACTS AND CUSTOM POWER DEVICES

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 BASICS OF TRANSMISSION SYSTEM & FACTS CONTROLLERS 8h

Reactive power flow control in Power Systems – Control of dynamic power un-balances in Power System. Power flow control - Constraints of maximum transmission line loading – Benefits of FACTS Transmission line compensation.- Uncompensated line -Shunt compensation - Series compensation – Phase angle control. Reactive power compensation.- Shunt and Series compensation principles – Reactive compensation at transmission and distribution level.

MODULE -2 SVC AND STATCOM 8h

Static versus passive VAR compensator, Static shunt compensators: SVC and STATCOM - Operation and control of TSC, TCR and STATCOM -Compensator control. Comparison between SVC and STATCOM.

MODULE-3 STATIC SERIES COMPENSATION 8h

TSSC, SSSC -Static Voltage and phase angle regulators – TCVR and TCPAR Operation and Control – Applications, Static series compensation – GCSC, TSSC, TCSC and their Control.

MODULE-4 UNIFIED POWER FLOW CONTROLLER 8h

SSR and its damping Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC. Basic Principle of P and Q control- Independent real and reactive power flow control- Applications.

MODULE-5 INTERLINE POWER FLOW CONTROLLER 8h

Introduction to interline power flow controller. Modeling and analysis of FACTS Controllers – Simulation of FACTS controllers Power quality problems in distribution systems, harmonics. Loads that create harmonics, modeling, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filtering– shunt, series and hybrid and their control.

MODULE-6 POWER QUALITY ISSUES 8h

Voltage swells, sags, flicker, unbalance and mitigation of these problems by power line conditioners- IEEE standards on power quality.

Text Book(s):

1. K R Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International Publishers, 2007. (Unit-I, II&V)

2. N.G. Hingorani, L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001. (Unit-II,III,IV)

Reference Book(s):

1. X P Zhang, C Rehtanz, B Pal, “Flexible AC Transmission Systems- ModellingandControl”, Springer Verlag, Berlin, 2006.
2. K.S.Suresh Kumar, S.Ashok, “FACTS Controllers & Applications”, E-book edition, Nalanda Digital Library, NIT Calicut, 2003.
3. G. THeydt, “Power Quality”, McGraw-Hill Professional, 2007.
4. T. J. E. Miller, “Static Reactive Power Compensation”, John Wiley and Sons, Newyork, 1982.

26. POWER SYSTEM DYNAMICS-II

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 BASICS OF DYNAMIC SYSTEMS 8h

Basic Concepts of Dynamic Systems and Stability Definition, Small Signal Stability (Low Frequency Oscillations) of Unregulated and Regulated System

MODULE -2 EFFECT OF AVR 8h

Effect of Damper, Flux Linkage Variation and AVR

MODULE-3 STABILITY ASSESSMENT 8h

Large Signal Rotor Angle Stability, Dynamic Equivalents And Coherency, Direct Method of Stability Assessment, Stability Enhancing Techniques, Mitigation Using Power System Stabilizer.

MODULE-4 MULTI-MACHINE STABILITY 8h

Asynchronous Operation and Resynchronization, Multi-Machine Stability.

MODULE-5 VOLTAGE STABILITY 8h

Dynamic Analysis of Voltage Stability , Voltage Collapse

MODULE-6 FREQUENCY STABILITY 8h

Frequency Stability, Automatic Generation Control , Primary and Secondary Control, Sub-Synchronous Resonance and Counter Measures

Text Book(s):

1. P. Kundur, “Power System Stability and Control”, McGraw Hill Inc, 1994
2. J. Machowski, Bialek, Bumby, “Power System Dynamics and Stability”, John Wiley & Sons,1997

Reference Book(s):

1. L. Leonard Grigsby (Ed.); “Power System Stability and Control”, Second edition, CRC Press, 2007
2. V. Ajjarapu, “Computational Techniques for voltage stability assessment & control”; Springer,2006

27. POWER SYSTEM STEADY STATE ANALYSIS LAB

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	0	0	3	48	1.5	40	60	100

TASK 1 - COMPUTATION OF PARAMETERS AND MODELLINGOF TRANSMISSION LINES

TASK 2 - SOLUTION OF POWER FLOW USING GAUSS-SEIDEL METHOD

TASK 3 -SOLUTION OF POWER FLOW USING NEWTON-RAPHSON METHOD

TASK 4 - SHORT CIRCUIT ANALYSIS

TASK 5 - LOAD – FREQUENCY DYNAMICS OF SINGLE AREA POWER SYSTEMS

TASK 6 - LOAD – FREQUENCY DYNAMICS OF TWO AREA POWER SYSTEMS

TASK 7 - TRANSIENT AND SMALL SIGNAL STABILITY ANALYSIS

TASK 8 - SINGLE MACHINE INFINITE BUS SYSTEM

TASK 9 - ECONOMIC DISPATCH IN POWER SYSTEMS

TASK 10 - SIMULATION OF IGBT INVERTERS.

TASK 11 - SIMULATION OF THYRISTOR CONVERTERS

TASK 12 - LOAD FORECASTING AND UNIT COMMITMENT

28. POWER SYSTEM DYNAMICS LAB

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	0	0	3	48	1.5	40	60	100

TASK 1 - DETERMINATION OF SUB TRANSIENT REACTANCE OF A SALIENT POLE SYNCHRONOUS MACHINE

TASK 2 - DETERMINATION OF SEQUENCE IMPEDANCES OF A CYLINDRICAL ROTOR SYNCHRONOUS MACHINE

TASK 3 - POWER ANGLE CHARACTERISTICS OF A SALIENT POLE SYNCHRONOUS MACHINE

TASK 4 - . FAULT ANALYSIS-I
I) LG FAULT
II) LL FAULT

TASK 5 - FAULT ANALYSIS-II
I) LLG FAULT
II) LLLG FAULT

TASK 6 - CALCULATION OF STRING EFFICIENCY

TASK 7 - DESIGN OF BUCK CONVERTER FOR POWER SYSTEM APPLICATIONS

TASK 8 - STUDY OF FERRANTI EFFECT AND VOLTAGE DISTRIBUTION HV LONG TRANSMISSION LINE USING TRANSMISSION LINE MODEL

TASK 9 - TRANSIENT STABILITY ANALYSIS USING RANGE-KUTTA METHOD

TASK 10 - SHORT CIRCUIT FAULTS AND OVERLOADING OF TRANSMISSION LINES

TASK 11 - POLARITY, RATIO AND MAGNATISATION CHARACTERISTICS TEST OF CT & PT

29. ARTIFICIAL INTELLIGENCE LAB

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
II	0	0	3	48	1.5	40	60	100

TASK 1 - SPEED CONTROL OF DC MOTOR USING FUZZY LOGIC

TASK -2 LOAD FLOW STUDIES USING BACK PROPAGATION ALGORITHM

TASK -3 SINGLE AREA AND TWO AREA LOAD FREQUENCY CONTROL USING FUZZY LOGIC

TASK-4 SPEED CONTROL OF INDUCTION MOTOR USING FUZZY LOGIC CONTROLLER

TASK-5 ECONOMIC LOAD DISPATCH USING AI TECHNIQUE

TASK-6 STATE ESTIMATIONS USING NEURAL NETWORK

TASK-7 CONTINGENCY ANALYSIS USING NEURAL NETWORK

TASK-8 FUZZY LOGIC BASED SMALL SIGNAL STABILITY ANALYSIS

TASK-9 MATLAB/SIMULINK IMPLEMENTATION AND ANALYSIS OF THREE PULSE-WIDTH-MODULATION (PWM) TECHNIQUES USING MATLAB

TASK -10 POWER LOAD BALANCING USING FUZZY LOGIC USING MATLAB

TASK-11 BATTERY MANAGEMENT SYSTEM USING FUZZY LOGIC CONTROL APPROACH

TASK -12 BLDC MOTOR SPEED CONTROL USING FUZZY CONTROLLER

30. POWER SYSTEM PROTECTION LAB

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	0	0	3	48	1.5	40	60	100

TASK -1 Study on (i) on load Time Delay Relay (ii) off load Time Delay Relay

TASK -2 Testing on (i) Under Voltage Relay and (ii) Earth Fault Relay

TASK -3 Characteristics of microprocessor based over voltage relay

TASK-4 Characteristics of IDMT over current relay

TASK-5 Characteristics of static negative sequence relay

TASK-6 Characteristics of electromagnetic-over voltage relay

TASK-7 Characteristics of percentage biased differential relay

TASK-8 Study of Transformer Protection by Simulation

TASK-9 Study of Generator Protection by Simulation

TASK -10 . Study of Motor Protection by Micon Relay

TASK-11 Study of Different Characteristics of Over Current Relay

TASK -12 To study the micro-controller based over voltage relay

OPEN ELECTIVES

1. Business Analytics
2. Industrial Safety
3. Operations Research
4. Cost Management of Engineering Projects
5. Composite Materials
6. Waste to Energy

1. BUSINESS ANALYTICS

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 BUSINESS ANALYTICS 8h

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modeling, sampling and estimation methods overview.

MODULE -2 TRENDINESS AND REGRESSION ANALYSIS 8h

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology

MODULE -3 ORGANIZATION STRUCTURES OF BUSINESS ANALYTI 8h

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

MODULE -4 FORECASTING TECHNIQUES 8h

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

MODULE -5 DECISION ANALYSIS 8h

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

MODULE-6 RECENT TRENDS IN BUSINESS ANALYTICS 8h

Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism

Text Book(s):

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

2. INDUSTRIAL SAFETY

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INDUSTRIAL SAFETY 8h

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

MODULE -2 FUNDAMENTALS OF MAINTENANCE ENGINEERING 8h

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

MODULE-3 WEAR AND CORROSION AND THEIR PREVENTION 8h

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

MODULE-4 FAULT TRACING 8h

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

MODULE-5 PERIODIC AND PREVENTIVE MAINTENANCE 8h

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance

MODULE-6 PROCEDURE FOR PERIODIC AND PREVENTIVE MAINTENANCE 8h

Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Text Book(s):

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.

Reference Book(s):

1. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
2. Foundation Engineering Handbok, Winterkorn, Hans, Chapman & Hall London

3. INDUSTRIAL SAFETY

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 OPTIMIZATION TECHNIQUES 8h

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

MODULE -2 LINEAR PROGRAMMING 8h

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

MODULE -3 CLASSICAL OPTIMIZATION METHODS 8h

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

MODULE -4 SCHEDULING AND SEQUENCING 8h

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

MODULE -5 GAMES THEORY 8h

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

MODULE-6 EVOLUTIONARY ALGORITHMS 8h

An overview of evolutionary algorithms, Simulated annealing algorithm, Genetic algorithm, Particle swarm optimization

Text Book(s):

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008

Reference Book(s):

1. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
2. Pannerselvam, Operations Research: Prentice Hall of India 2010
3. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

4. COST MANAGEMENT OF ENGINEERING PROJECTS

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION 8h

Introduction and Overview of the Strategic Cost Management Process

MODULE -2 COST CONCEPTS 8h

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

MODULE -3 PROJECT MANAGEMENT 8h

Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

MODULE -4 COST BEHAVIOR 8h

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.

MODULE -5 PRICING STRATEGIES 8h

Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

MODULE-6 QUANTITATIVE TECHNIQUES 8h

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory

Text Book(s):

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting

Reference Book(s):

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
2. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd

5. COMPOSITE MATERIALS

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE 1 INTRODUCTION 8h

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance

MODULE 2 REINFORCEMENTS 8h

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

MODULE 3 MANUFACTURING OF METAL MATRIX COMPOSITES 8h

Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications..

MODULE 4 MANUFACTURING OF POLYMER MATRIX COMPOSITES 8h

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

MODULE 5 STRENGTH OF COMPOSITE MATERIALS 8h

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

MODULE 6 METAL MATRIX COMPOSITES 8h

Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement - volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process - diffusion bonding– stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface measurement of interface properties- applications of MMC in aerospace, automotive industries

Text Book(s):

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007. 5th Edition, New Delhi, 2015.

Reference Book(s):

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi

6. WASTE TO ENERGY

Semester	Hours / Week			Total	Credit	Max Marks		
	L	T	P	**hrs**	C	CIE	SEE	TOTAL
	3	0	0	48	3	40	60	100

MODULE – 1 INTRODUCTION TO ENERGY FROM WASTE 8h

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

MODULE – 2 WASTE TO ENERGY OPTIONS 8h

Waste to energy options: combustion (unprocessed and processed fuel), gasification, aerobic digestion, anaerobic digestion, fermentation

MODULE – 3 BIOMASS PYROLYSIS 8h

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

MODULE – 4 BIOMASS GASIFICATION 8h

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation

MODULE – 5 BIOMASS COMBUSTION 8h

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

MODULE – 6 BIOGAS 8h

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Text Book(s):

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.

Reference Book(s):

1. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

AUDIT COURSES

1. English For Research Paper Writing
2. Sanskrit for Technical Knowledge
3. Disaster Management
4. Value Education
5. Constitution Of India
6. Pedagogical Studies
7. Stress Management By Yoga
8. Personality Development through Life and Enlightenment Skills