SYLLABUS

(With effect from 2015 - 16 Academic year)

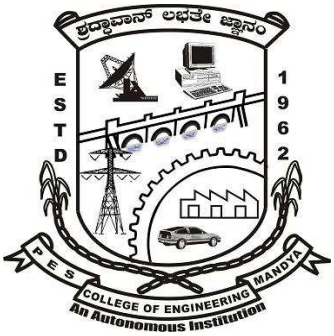
ಪಠ್ಯಕ್ರಮ

(ಶೈಕ್ಷಣಿಕವರ್ಷ 2015–16)

VII & VIII SEMESTER

Bachelor Degree
In
Electrical & Electronics Engineering

Out Come Based Education
With
Choice Based Credit System



P.E.S. COLLEGE OF ENGINEERING,

MANDYA - 571 401, KARNATAKA
(An Autonomous Institution Affiliated to VTU, Belagavi)
Grant -in- Aid Institution (Government of Karnataka)
Accredited by NBA, New Delhi & Approved by AICTE, New Delhi.

ಪಿ.ಇ.ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ
ಮಂಡ್ಯ–571 401, ಕರ್ನಾಟಕ
(ವಿ.ಟಿ.ಯು, ಬೆಳಗಾವಿ ಅಡಿಯಲ್ಲಿನ ಸ್ವಾಯತ್ತ ಸಂಸ್ಥೆ)

Ph : 08232- 220043, Fax : 08232 – 222075,Web : www.pescemandya.org

Preface

PES College of Engineering, Mandya, started in the year 1962, has become autonomous in the academic year 2008-09. Since, then it has been doing the academic and examination activities successfully. The college is running Eight undergraduate and Eight Postgraduate programs. It consists of Six M.Tech programs, which are affiliated to VTU. Other postgraduate programs are MBA and MCA.

India has recently become a Permanent Member by signing the Washington Accord. The accord was signed by the National Board of Accreditation (NBA) on behalf of India on 13th June 2014. It enables not only the mobility of our degree globally but also establishes equivalence to our degrees with that of the member nations such as Taiwan, Hong Kong, Ireland, Korea, Malaysia, New Zealand, Russia, Singapore, South Africa, Turkey, Australia, Canada and Japan. Among other signatories to the international agreement are the US and the UK. Implementation of Outcome Based Education (OBE) has been the core issue for enabling the equivalence and of Indian degrees and their mobility across the countries.

Our Higher Educational Institution has adopted the CBCS based semester structure with OBE scheme and grading system.

The credit based OBE semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching.

The OBE, emphasize setting clear standards for observable, measurable outcomes of programs in stages. There lies a shift in thinking, teaching and learning processes moving towards Students Centric from Teacher Centric education. OBE standards focus on mathematics, language, science, attitudes, social skills & moral values.

The key features which may be used to judge, if a system has implemented an outcome based education system is mainly Standard based assessments that determines whether students have achieved the stated standard. Assessments may take any form, so long as the process actually measure whether the student knows the required information or can perform the required task. Outcome based education is a commitment that all students of all groups will ultimately reach the same minimum standards. Outcome Based Education is a method or means which begins with the end in mind and constantly emphasizes continuous improvement.

Choice Based Credit System (CBCS) provides choice for students to select from the prescribed courses (core, Foundation, Foundation Elective, elective, open elective and minor or soft skill courses). The CBCS provides a 'cafeteria' type approach in which the students can Choose electives from a wide range of courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, adopt an interdisciplinary approach to learning which enables integration of concepts, theories, techniques, and, perspectives from two or more disciplines to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline. These greatly enhance the skill/employability of students.

In order to increase the Industry/Corporate readiness, many Soft Skills and Personality Development modules have been added to the existing curriculum of the academic year 2015-16. Industry Interactions have been made compulsory to enhance the field experience. In order to enhance creativity and innovation Mini Project and Industrial visit & Interaction are included in all undergraduate programs.

Dr. Umesh D.R.
Deputy Dean (Academic)
Associate Professor
Dept. of Computer Science &Engg.

Dr.P S Puttaswamy
Dean (Academic)
Professor
Dept. of Electrical & Electronics Engg

P.E.S.COLLEGE OF ENGINEERING, MANDYA-571 401
(An Autonomous Institution under VTU, Belagavi)

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Profile

Department of Electrical & Electronics Engineering Programme has been accredited by NBA for 6 Academic years(2017-18 to 2022-23).

The Department of Electrical and Electronics Engineering was established right from the inception of the institute in the year 1962. The various programs offered by the Department are B.E., M.Sc., (Engg.) by research and research leading Ph.D affiliated to Visvesvaraya Technological University (VTU), Belagavi. Also, Department is affiliated for Ph.D program with University of Mysore, Mysore and Kuvempu University, Shimoga. About 100 research papers have been published by the Department faculty members in various International & National journals and conferences.

The Department emphasizes towards imparting quality education, rigorous teaching-learning, hands-on expertise and helping students to shape their all-round personality. The Department with its strong pool of faculty, well-developed laboratories, latest software and hardware facilities, contributes to develop life-long learning skills to its students and producing worthy researchers by offering doctoral research program.

The academic programs are designed and updated keeping in view the constantly changing industrial needs, skills and challenges emerging out of new research. The academic programs are well received by the industry and academia. The department has always exerted the best of its effort to meet the objectives of achieving technical excellence in the areas of Electrical and Electronics Engineering such as High Voltage Engineering, Power Electronics & Drives, Control Systems, Power Systems, Energy Systems, Analog and Digital Electronics, Signal Processing, PLC & SCADA and Microcontrollers

The Department regularly organizes industrial visits, Technical lectures by experts from industries and institutes in contemporary areas to bridge the gap between syllabi and current developments.

VISION

The department of E & E would endeavour to create a pool of Engineers who would be technically competent, ethically strong also fulfil their obligation in terms of social responsibility.

MISSION

- Adopt the best pedagogical methods and provide the best facility, infrastructure and an ambience conducive to imbibe technical knowledge and practicing ethics.
- Group and individual exercises to inculcate habit of analytical and strategic thinking to help the students to develop creative thinking and in still team skills.
- MOUs and Sponsored projects with industry and R & D organizations for Collaborative learning
- Enabling and encouraging students for continuing Education and moulding them for life-long learning process

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Excel in professional career and/or higher education by acquiring knowledge in mathematical, computing and Electrical & Electronics engineering principles

PEO2: Analyze real life problems and Design Electrical & Electronics Engineering system with appropriate solutions that are technically sound, economically feasible and socially acceptable

PEO3: Exhibit professionalism, ethical attitude, communications kills, team work in their profession and adapt to current trends by engaging in lifelong learning.

PROGRAMME OUTCOMES (POs)

PO-1: Graduates will apply the knowledge of mathematics, Physics, chemistry and allied engineering subjects to solve problems in Electrical and Electronics Engineering.

PO-2: Graduates will Identify, formulate and solve Electrical and Electronics Engineering problem.

PO-3: Graduates will design Electrical and Electronics systems meeting the given specifications for different problems taking safety and precautions into consideration.

PO-4: Graduates will design, conduct experiments, analyze and interpret data

PO-5: Graduates will use modern software tools to model and analyze problems, keeping in view their limitations.

PO-6: Graduates will understand the impact of local and global issues / happenings on Electrical Engineers.

PO-7: Graduates will provide sustainable solutions for problems related to Electrical and Electronics Engineering and also will understand their impact on environment.

PO-8: Graduates will have knowledge of professional ethics and code of conduct as applied to Electrical Engineers.

PO-9: Graduates will work effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.

PO-10: Graduates will communicate effectively in both verbal and written form.

PO-11: Graduates will plan, execute and complete projects

PO-12: Graduates will have the ability for self- education and lifelong learning

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1: To understand the concept in Electrical and Electronics Engineering and apply them to develop modules analyze assess the performance of various power system equipment, generation, transmission, utilization and protection mechanisms.

PSO2: Design, develop, analyze and test electrical and electronics system: Deploy control strategies for electrical dives, power system networks, power electronics, high voltage and other related applications.

Scheme of Teaching and Examination			VII Semester B.E. (Electrical & Electronics Engineering)					
Sl No.	Course Code	Course Title	Teaching Dept.	Hours Pattern L:T:P:H	Total Credit	Examination Marks		
						CIE	SEE	Total
1.	P15EE71	Computer Techniques in Power Systems	E & E E	4:0:0:4	4	50	50	100
2.	P15EE72	High Voltage Engineering	E & E E	4:0:0:4	4	50	50	100
3.	P15EE73	AC & DC Drives	E & E E	4:0:0:4	4	50	50	100
4.	P15EE74x	Elective-IV	E & E E	3:0:0:3	3	50	50	100
5.	P15EE75x	Open Elective-I	E & E E	3:0:0:3	3	50	50	100
6.	P15EEL76	Relay & High Voltage Lab	E & E E	0:0:3:3	1.5	50	50	100
7.	P15EEL77	Power System Simulation Lab	E & E E	0:0:3:3	1.5	50	50	100
8.	P15EE78	Project Work Phase - I	E & E E	0:0:4:2	2	--	50	50
				Total	23	350	400	750

	List of Electives				
	Elective – 4			Open Elective - 1	
Sl. No.	Course Code		Sl. No.	Course Code	Course title
1.	P15EE741	Flexible AC Transmission Systems	1.	P15EE751	Power Plant Engineering
2.	P15EE742	Electrical Distribution Systems	2.	P15EE752	Fuzzy Logic
3.	P15EE743	Testing & Commissioning of Electrical Equipments			
4.	P15EE744	Reliability Engineering Application to Power System			

Scheme of Teaching and Examination			VIII Semester B.E (Electrical & Electronics Engineering)					
Sl No.	Course Code	Course Title	Teaching Dept.	Hours Pattern L:T:P:H	Total Credit	Examination Marks		
						CIE	SEE	Total
1.	P15EE81	Renewable Energy Sources	E & E E	3:0:0:3	3	50	50	100
2.	P15EE82x	Elective-V	E & E E	3:0:0:3	3	50	50	100
3.	P15EE83x	Elective-VI	E & E E	3:0:0:3	3	50	50	100
4.	P15EE84	Open Elective-II	E & E E	3:0:0:3	3	50	50	100
5.	P15EE85	Project Work Phase – II	E & E E	0:0:16:16	8	50	100	150
6.	P15EE86	Internship	E & E E	0:0:2:2	2	50	--	50
				Total	22	300	300	600

List of Electives								
Elective – 5			Elective - 6			Open Elective - 2		
Sl. No.	Course Code	Course Title	Sl. No.	Course Code	Course title	Sl. No.	Course Code	Course title
1.	P15EE821	Energy Auditing & Demand Side Management	1.	P15EE831	HVDC Power Transmission	1.	P15EE841	Renewable Energy Sources
2.	P15EE822	Modern Power System Protection	2.	P15EE832	Computer Control of Electric Drives	2.	P15EE842	Utilization of Electrical Power
3.	P15EE823	Smart Grid	3.	P15EE833	Power System Operation and Control			
4.	P15EE824	Artificial Neural Network	4.	P15EE834	Insulation Engineering			

Course Title: Computer Techniques In Power Systems			
Course Code: P15EE71	**Semester: VII**	**L.T.P.H: 4-0-0-4**	**Credits: 4**
Contact Period: Lecture:52Hrs., Exam 3 Hrs		**Weightage: CIE:50%; SEE:50%**	

Prerequisites: The student should have undergone the course on Power system Analysis, transmission and distribution and A.C. machines

Course Learning Objectives (CLOs)

This course aims to:

1. Form the bus admittance matrix for the given power system network by singular transformation method (L3).
2. Develop general power flow equations (PFE) or Load flow analysis (LF) equations for an n-bus power system (L4).
3. Solve PFE (LFA) using algorithms such as Gauss-Seidel and Newton-Raphson methods (L4).
4. Analyze or Design a power system for a given operation conditions (L5).
5. To allocate the total demand of a power system by optimizing the overall operating costs (L4).
6. Determine the transient stability of a power system (L5).

Relevance of the Course

This course covers the analysis of large power systems by using computers. For large power system networks, it is not possible use conventional methods that employ manual calculations. Hence, it is necessary to go for the computer oriented techniques which are based on numerical methods. In this course students are thought how to do Load flow analysis, stability analysis of power system, and perform economic operation of power system.

Course Content

Unit-I.

Network Topology: Introduction, Elementary graph theory – oriented graph, tree, co-tree, basic cut sets, basic loops; Incidence matrices – Element-node, Bus incidence, Tree-branch path, Basic cut-set, Augmented cut-set, Basic loop and Augmented loop matrices; Primitive networks – impedance form and admittance form **10 Hrs**

Unit-II.

Network Matrices: Introduction, Formation of YBUS – by method of inspection, by method of singular transformation (YBUS = At[y]A); Formation of Bus Impedance Matrix (without mutual coupling elements). **10 Hrs**

Unit-III.

Load Flow Studies: Introduction, Power flow equations, Classification of buses, Operating constraints, Data for load flow, Gauss - Seidal Method – Algorithm and flow chart for PQ and PV buses (numerical problem for one iteration only), Acceleration of convergence; Newton Raphson Method – Algorithm and flow chart for NR method in polar coordinates (numerical problem for one iteration only), Comparison of Load Flow Methods. **11 Hrs**

Unit-IV

Economic Operation of Power System: Introduction, Performance curves, Economic Generation Scheduling neglecting losses and generator limits, Economic Generation Scheduling including generator limits and neglecting losses, Economic Dispatch including transmission losses – penalty factor, Derivation of transmission loss formula. **11 Hrs**

Unit-V

Transient Stability Studies: Numerical solution of Swing Equation – Point-by-point method, Modified Euler's method, Runge -Kutta method, Representation of power system for transient stability studies.

10 Hrs

Text Books:

1. "Computer Methods in Power System Analysis", by: Stagg, G.W, and EI-Abiad A.H McGraw Hill International Student Edition. 1988.
2. "Computer Techniques and Models in Power Systems", by: K.UmaRao,I.K (Interline) International publishing House Pvt. Ltd, 2015

Reference Books:

1. Modern Power System Analysis, by :Kothari, D. P., and Nagrath, I. J., TMH, 4th -Edition, 2014

Course Outcomes

After learning all the units of the course, the student is able to

CO1: Form the bus admittance matrix for the given power system network by singular transformation method

CO2: Develop general power flow equations (PFE) for an n-bus power system.

CO3: Determining the solution of PFE using algorithms such as Gauss-Seidel and Newton-Raphsonmethods.

CO4: Design a power system by optimizing the overall operating cost subject to pre-specified constraints.

CO5: Determine the transient stability of a power system

Course Assessment Matrix (CAM)

Course Outcome (CO)		Program Outcome													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Form the bus admittance matrix for the given power system network by singular transformation method.	L2	**2**	**2**	-	**1**	-	**1**	-	-	-	**2**	-	-		
Develop general power flow equations (PFE) for an n-bus power system.	L3	**3**	**2**	-	**2**	-	**1**	**1**	-	-	-	-	-		
Determining the solution of PFE using algorithms such as Gauss-Seidel and Newton-Raphson methods.	L4	**2**	**1**	**2**	**1**	-	-	**2**	-	-	**1**	-	-		
Design a power system by optimizing the overall operating cost subject to pre-specified constraints.	L4	**3**	**2**	**1**	**1**	-	-	-	-	-	**2**	-	-		
Determine the transient stability of a power system	L4	**2**	**1**	**2**	**1**	-	-	**2**	-	-	-	-	**1**		
1 – Low, 2 – Moderate and 3 – High															

Course Title: High Voltage Engineering			
Course Code: P15EE72	**Semester: VII**	**L-T-P-H: 4-0-0-4**	**Credits - 4**
Contact period : Lecture: 52Hrs, Exam 3 Hrs		**Weightage : CIE:50%: SEE:50%**	

Prerequisites: The student should have undergone the course on High Voltage Engineering

Course Learning Objectives

1. Students will understand the Breakdown phenomenon in gaseous, solids and liquid Dielectrics (L2)
2. Students will learn basic need to generate high voltages such as HVAC, HVDC, Impulse Voltages and Impulse Currents in the laboratory. (L3)
3. Students gain the fundamental knowledge of physical phenomena of breakdown ininsulating media and students will know the importance of insulating media and theirapplications in various fields (L3)
4. Students will learn how to measure the high voltages in the laboratory (L4)Students will know importance of testing and learn procedure of testing different insulating media for accessing their condition

Unit-1

Introduction: Introduction to HV technology, Need for generating high voltages in laboratory. Important applications of high voltage.

Breakdown phenomena: Classification of HV insulating media. Gaseous dielectrics: Ionizations, primary and secondary ionization processes. Criteria for gaseous insulation breakdown - Townsend's theory, limitations of Townsend's theory, Streamer's theory, Breakdown in non uniform fields, Corona discharges, Breakdown in electro-negative gases, Paschen's law and its significance, Time lags of Breakdown. Breakdown in solid dielectrics- Intrinsic breakdown, Avalanche breakdown, Thermal breakdown and Electro-mechanical breakdown. Breakdown of liquids dielectrics- Suspended particle theory, Electronic breakdown, Cavity breakdown (bubble's theory). **11Hrs**

Unit-2

Generation of HVAC and HVDC Voltages: HVAC - HV transformer; Need for cascade connection and working of transformer units connected in cascade, Series resonant circuit, Tesla coil. HVDC - Voltage doubler circuit, Cockcroft- Walton type high voltage DC set. Regulation, Ripple and Optimum number of stages. **10Hrs**

Unit-3

Generation of Impulse Voltage and Current: Introduction to standard lightning and switching impulse voltages. Analysis of single stage impulse generator-expression for output impulse voltage, Multistage impulse generator - working of Marx impulse generator, Rating of impulse generator, Components of multistage impulse generator, Triggering of impulse generator by three electrode gap arrangement and Trigatron gap, Generation of switching impulse voltage, Generation of high impulse current. **10Hrs**

Unit-4

Measurement of High Voltages: Electrostatic voltmeter - principle, construction and limitation; Chubb and Fortescue method for HVAC measurement, Generating voltmeter- Principle & Construction; Series resistance micro ammeter for HVDC measurements, Standard sphere gap measurements for HVAC, HVDC and Impulse voltages; Factors affecting the measurements: Potential dividers - Resistance dividers, Capacitance dividers , Mixed RC potential dividers; Surge current measurement - Klydanograph and Magnetic link. **11Hrs**

Unit-5

Non-destructive Insulation Testing Techniques: Dielectric loss and loss angle measurements using Schering Bridge, Transformer ratio arms bridge; Need for discharge detection, PD measurements – aspects, factors affecting the discharge detection; Discharge detection methods - Straight and Balanced methods.

High Voltage Tests on Electrical Apparatus: Tests on Circuit breakers, Cables, Insulators and Transformers. **10Hrs**

Text Books:

1. High Voltage Engineering Fundamentals- E. Kuffel and W.S. Zaengl, Elsevier press, - 2nd Edition, 2005.

2. High Voltage Engineering- M.S.Naidu and Kamaraju, THM, - 3rd Edition ,2007.

Reference books:

1. High Voltage Engineering - C.L.Wadhwa, New Age International Private limited, 1995.

2. Extra High Voltage AC Transmission Engineering -Rakosh Das Begamudre, Wiley Eastern limited, 1987.

3.High Voltage Technology- L. L. Alston- BSB Publication, 1st Edition,2008.

Course Outcomes (CO)

After learning all the units of the course, The Students will be able to

CO1: Analyse Breakdown phenomenon in gaseous, solids and liquid Dielectrics

CO2: Understand generation of HVAC and HVDC in High Voltage Laboratory

CO3: Understand generation of Impulse Voltage and Current in High Voltage Laboratory

CO4: Understand and Analyse measurement principles for HVAC, HVDC and Impulse Voltages

CO5: Understand Non-Destructive and Destructive Techniques of various High Voltage Insulation and Electrical apparatus

Course Assessment Matrix (CAM)	Programme outcomes													
Course Outcome (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Analyse the concepts of High Voltage Engineering and Breakdown Phenomena in Gaseous Dielectrics	3	2	2	_	3	_	1	_	2	_	-			
Demonstrate the Generation of HVAC and HVDC Voltages	2	2	2	_	3	_	1	_	3	_	1			
Analyse the concepts of Generation of Impulse Voltage and Current	3	2	1	_	2	_	2	_	2	_	-			
Demonstrate the Measurement of High Voltages	3	3	2	_	1	_	1	_	2	_	1			
Analyze the concepts of Non-destructive Insulation Testing Techniques andHigh Voltage Tests on Electrical Apparatus .	3	2	1	_	3	_	2	_	1	_	_			
1 – Low, 2 – Moderate and 3 – High														

Course Title: AC and DC Drives			
Course Code: P15EE73	**Semester: VII**	**L-T-P-H: 4-0-0-4**	**Credits : 4**
Contact period : Lecture: 52Hrs, Exam 3 Hrs		**Weightage: CIE:50%; SEE:50%**	

Course Learning Objectives:

1. To study and understand the basics of drive system and their control with their operating regions.
2. To learn the operating principles of different types of drive systems and their speed control like dc shunt/separately excited motor drive system using single phase & three phase controlled rectifiers.
3. To learn the operating principle , performance characteristics and speed control of induction motor drive system, synchronous motor drive system.
4. To understand the principles of some energy recovery schemes for performance improvement of IM drive system.
5. To understand the various processes in manufacturing industries and the different types of motors used in different stages.
6. Design and analyze simple drive systems and also to carry out mini-project in teams for a given set of specifications.

Course Content

Unit – I

DC Drives Basic Concepts: Speed torque characteristics, starting, braking andspeed control techniques of dc shunt motor /separately excited dc motor

Rectifier controlled dc drives: Types of rectifiers- review, half wave, half &fully controlled rectifier fed dc drives, (separately &series dc motors) under continuous and discontinuous current mode, multi-quadrant operation of rectifier controlled dc drives**.** **10hr**

Unit – II

Converter fed Drives: Three phase half wave, half & fully controlled converter fed dc drives, dual converter fed drives.

Chopper Controlled dc drives*:* Types of choppers – review, chopper controlled dc drives – motoring and braking operation, multi-quadrant operation of chopper controlled dc drives**.** **10hr**

Unit – III

Closed loop control of DC Drives: Introduction, Open loop transfer function, closed loop transfer function, closed loop control, Phase locked loop, Microcomputer control of DC drives.

AC Drives: Introduction, IM drives, Performance, Speed and Torque control methods: Stator voltage control, rotor voltage control, Stator frequency control. **10hr**

Unit – IV

AC Drives: , Voltage and frequency control ,Current control, VSI fed IM drive, CSI fed IM drive, Static Kramer drive, Static Scherbius drive and braking of IM, closed loop IM drive **12hr**

Unit – V

Synchronous motor Drives: Introduction, Variable frequency control, Self-controlled synchronous motor employing load commutated thyristor inverter.

Industrial drives: Cement mill drives, Paper mill drives, and Textile mill drives, Rolling mill drives **10hr**

Text Books:

1. "Electric drives" by G.K Dubey, Narosa publishing house, second Edition 2011.
2. 2."A first course in Electric Drives", S K Pillai, Wiley Eastern ltd, 1990

Reference Books:

1. "Thyristor control of electric Drives",V.Subramanyam, Tata McGraw Hill, second Edition 2007.
2. "Power Semiconductor Drives", S.Sivanagaraju, PHI publications,1st Edition,2008
3. "Power electronics", M.H Rashid, PHI, third edition 2012.

4. Power Electronics: Principles and Applications, Joseph Vithayathil,Publisher(s):McGraw-Hill College,1995

Course Outcomes:

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

1. Explain the various types of electric drives speed torque characteristics, single phase converter fed dc drives with their operating characteristics to control their speed.
2. Describe the Three phase converter fed dc drives with their operating characteristics to control their speed and to analyze the various types of chopper fed drives to achieve different quadrant operation.
3. Describe the basic concepts & requirements of closed loop drives and to derive the closed loop transfer functions.
4. Explain and analyze the different methods of speed control used for Induction motor drives for variable speed applicationsanalyze the braking operation of Induction motor.
5. Describe the principle operation of synchronous motor drives that are generally used and to describe and analyze the various stages of process involved in some manufacturing industries also analyze thetypes of motors used in various processes involved

Course Assessment Matrix (CAM)

	Course Outcome – CO		Program Outcome													
			PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
1	Explain and understand the various types of electric drives speed torque characteristics, single phase converter fed dc drives with their operating characteristics to control their speed.	L2	1	2	3	_	1	_	_	_		_	_	1		
2	Describe the Three phase converter fed dc drives with their operating characteristics to control their speed and to analyse the various types of chopper fed drives to achieve different quadrant operation	L2	1	2	3	_	1		_	_	_	_	_	1		
3	Describe the basic concepts & requirements of closed loop drives and to derive the closed loop transfer functions and analyse the braking operation of Induction motor.	L3	2	2	1	2	1	_	_	_		_	_	2		
4	Explain and analyze the different methods of speed control used for Induction motor drives for variable speed applications	L3	2	2	3	_	2	_	_	_		_	_	1		
5	Describe the principle operation of synchronous motor drives that are generally used and to describe and analyse the various stages of process involved in some manufacturing industries also analyse the types of motors used in various processes involved.	L3	2	2	1	_	3	_		_		_	_	2		
1-Low, 2-Moderate, 3-High																

Course Title: Flexible AC Transmission Systems (FACTS)			
Course Code: P15EE741	**Semester: VII**	**L-T-P-H: 3-0-0-3**	**Credits - 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50; SEE:50**	

Course Content

Unit – I

FACTS Concepts and General System Configuration: Transmission interconnection, Power flow in AC system, Power flow and dynamic stability consideration of a transmission interconnection, relative importance of controllable parameters, Basic types and Brief Description of FACTS Controller.

8Hrs

Unit – II

Applications of Voltage sourced converters: Basic concepts, single phase full wave bridge converter operation, single phase-Leg operation, Square wave voltage harmonics for a single phase bridge, Three phase full wave bridge converter, Self Transformer connections for 12, 24 and 48-Pulse operation.

8Hrs

Unit – III

Applications of Current Source Converter: Basic concepts, Self and Line Commutated Inverters,3-phase full wave diode rectifier, Thyristor based converter, Current sourced converter with turn-off devices, Current source versus voltage source converters. **8Hrs**

Unit – IV

Static Shunt Compensator SVC and STATCOM: Objective of shunt compensation, Methods of controllable Var generation, Static Var compensator, SVC and STATCOM. **8Hrs**

Unit – V

Static Series Compensators GCSC, TSSC, TCSC and SSSC: Objectives of series compensation, Variable impedance type of series compensation, Switching converter type series compensation, External control for series reactive compensators. **8Hrs**

Text Book:

1.Narain G. Hingorani and Laszlo Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press, Standard Publishers Distributors, Delhi, Publication.2013, ISBN 81-86308-79-2.

Reference Books:

1.R.Mohan Mathur, Static Controllers for Electrical Transmission Systems, IEEE Press and John Wiley & Sons, Inc.,2002.

2.R.Mohan Mathur and Rajiv K. Varma, Thyristor-Based FACTS Controllers for Electrical Transmission Systems, IEEE Press and John Wiley & Sons, Inc. 2010-I

Course Title: Electrical Distribution Systems			
Course Code: P15EE742	**Semester: VII**	**L-T-P-H: 3-0-0-3**	**Credits - 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50; SEE:50**	

Course Content

Unit-I

DISTRIBUTION SYSTEM PLANNING AND AUTOMATION: Introduction,factors affecting system planning, present planning techniques, future trends in planning, Role of computers in distribution planning, planning models, SCADA, Local energy control centre, typical control applications, systems approach, distribution automation. **8Hrs**

Unit -II

DISTRIBUTION SUBSTATION: Introduction, Basic Definition ,Load characteristics, relation between load and load factor, load growth, substation location, rating of a distribution substation, substation service area with 'n' primary feeders, derivation of K constant, substation application curves, present voltage drop formula. **8Hrs**

Unit-III

SYSTEM PLANNING: Planning Process, Planning Criteria, System Development, Introduction to distributed generation and control, Types of distributed energy resources (DER), Integration with grid and microgrid, communication in DER systems.Voltage stability analysis of distributed generation, distribution System Economics and Finance, Mapping, Modeling, System Calculations, Load Flow, Automated Planning. **8Hrs**

Unit-IV

DESIGN AND OPERATION: Engineering Design, Operation Criteria, Sub-transmission Sub-station and Feeder, Voltage Control, Harmonics, Load Variations, System Losses, Energy Management, Model Distribution System 8**Hrs**

Unit-V

OPTIMIZATION: Introduction, Costing of Schemes, Typical Network Configurations, Planning Terms, Network Cost Modeling, Synthesis of Optimum Line Network, Economic Loading of Distribution Transformers, Worst Case Loading of Distribution Transformers. **8Hrs**

TEXT BOOKS:

1. "Electric power distribution"-A S. Pabla, TMH, 5th edition, 2004.

Reference Books:

1. "Electric power distribution system engineering", T. Gonen, McGrawHill, 1986.
2. "Electrical power distribution systems", V. Kamaraju. TMH New Dehli.

Course Title: Testing and commissioning of Electrical Equipments			
Course Code : P15EE743	Semester : IV	L-T-P-H: 3-0-0-3	Credits – 3
Contact Period: Lecture: 40 Hr. Exam 3 Hr		Weightage : CIE:50: SEE:50	

Course Content

Unit-I

TRANSFORMERS: Specifications: Power and distribution transformers as per BIS standards.

Installation: Location, site, selection, foundation details (like bolts size, their number, etc), code of practice for terminal plates, polarity & phase sequence, oil tanks, drying of windings and general inspection.

Commissioning tests: Following tests as per national & International Standards, volt ratio test, earth resistance, oil strength, Bucholz& other relays, tap changing gear, fans & pumps, insulation test, impulse test, polarizing index, load & temperature rise test.

Specific Tests: Determination of performance curves like efficiency, regulation etc, and determination of mechanical stress under normal &abnormal conditions **8Hrs**

Unit-II

SYNCHRONOUS MACHINES: Specifications: As per BIS standards.

Installation: Physical inspection, foundation details, alignments, excitation systems, cooling and control gear, drying out.

Commissioning Tests: Insulation, Resistance measurement of armature & field windings,

Performance tests: Various tests to estimate the performance of generator operations, slip test, maximum lagging current, maximum reluctance power tests, sudden short circuit tests, transient & sub transient parameters, measurements of sequence impedances, capacitive reactance,separation of losses, temperature rise test, retardation tests,Various abnormal conditions and the respective Protection. **8Hrs**

Unit-III

Induction Motors: Specifications for different types of motors, Duty, I.P. protection.

Installation: Location of the motors (including the foundation details) & its control apparatus, shaft & alignment for various coupling, fitting of pulleys & coupling, drying of windings.

Commissioning Test: Mechanical tests for alignment, air gap symmetry, tests for bearings, vibrations & balancing.

Electrical Tests: Insulation test, earth resistance, high voltage test, starting up, failure to speed up to take the load, type of test, routine test, factory test and site test (in accordance with ISI code. **8Hrs**

Unit-IV

SWITCH GEAR & PROTECTIVE DEVICES: Standards, types, specification, installation, commissioning tests, maintenance schedule, type & routine tests.

Current transformer and Voltage transformer: Specifications, procurement , testing of CT, Specifications, procurement , testing of PT, Specifications and testing of cable , Classification of Cables, Sizing and Selection of cables, Different types of Lighting arrestor& Its applications. **8Hrs**

Unit-V

Safety Management: Objectives of safety management, seven principles of safety management, work permit system , safety clearance and creepages, Safety procedures in eclectic plant, First aid, Electric shock, touch potential and step potential, recommended safety precautions against electric shock in small buildings, shops, and small LV installations Live line working (Hot line Maintenance), safety management during O and M. **8Hrs**

TEXT BOOKS:

1. Testing & Commissioning Of Electrical Equipment -S.S. Rao,TMH,1st Edition,1990
2. Testing & Commissioning Of Electrical Equipment -Ramesh L. Chakrasali, Elite Publication.

REFERENCE BOOKS:

1. Relevant Bureau of Indian Standards
2. "A Handbook on Operation and Maintenance of Transformers"-H. N. S. Gowda, Transformer & Switch GearHandbook-Transformers-BHEL, J &P, J & P

Course Title: Reliability Engineering Application to Power System			
Course Code: P15EE744	**Semester: VII**	**L-T-P-H: 3-0-0-3**	**Credits – 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50; SEE:50**	

Course Content

Unit – I

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. **8Hrs**

Unit – II

Network Modelling and Reliability Analysis &Reliability functions: Analysis of Series, Parallel, Series-Parallel networks – complex networks – decomposition method, Reliability functions f(t), F(t), R(t), h(t) and their relationships – exponential distribution. **8Hrs**

Unit – III

Markov Modelling: 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. **8Hrs**

Unit – IV

Frequency Duration Techniques & Generation System Reliability Analysis: 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, 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. **8Hrs**

Unit – V

Composite Systems Reliability Analysis, Distribution System and Reliability Analysis: Decompositions method – Reliability Indices – Weather Effects on Transmission Lines,Basic Concepts – Evaluation of Basic and performance reliability indices of radial networks. **8Hrs**

Text Book:

1. Reliability Evaluation of Engg. System – R. Billinton, R.N.Allan, Plenum Press, New York, reprinted in India by B.S.Publications, 2007.
2. Reliability Evaluation of Power systems – R. Billinton, R.N.Allan, Pitman Advance Publishing Program, New York, reprinted in India by B.S.Publications, 2007.

Reference Books:

1. Power System Planning - R.L. Sullivan, Tata McGraw Hill Publishing Company Ltd.
2. Modern Power System Planning – X. Wang & J.R. McDonald, McGraw Hill Book Company
3. Electrical Power Distribution Engineering - T. Gönen, McGraw Hill Book Company

Course Title: Power Plant Engineering			
Course Code : P15EE751	**Semester : IV**	**L-T-P –H(Hrs)3-0-0-3**	**Cridits-3**
Contact Period: Lecture: 40Hr. Exam 3 Hr		**Weightage: CIE:50: SEE:50**	

Unit- I

a) Hydro Electric Power Generation: Selection of site, Classification of site, General arrangement and operation. Power station structure & control.

b)Thermal Power Generation: Introduction, Main parts, Working, Plant layout, Coal handling system, Ash disposal schemes **8Hrs**

Unit- II

a) Nuclear Power Station: Introduction, Selection of site, Cost, Components, Reactors, Description of fuel sources, Adverse effects, Safety of nuclear power station, Disposal schemes of nuclear waste.

b) Diesel Electric Station: Introduction, Types of plants, Components, Plant layout and maintenance, Choice and characteristics 8**Hrs**

Unit- III

a) Generation Using Non-Conventional Energy Sources: Solar, Wind, Tidal and Gas Power Plant.

b) Co-Generation: Mini, Micro and Bio fuel Generation, Distributed generation **8 Hrs**

Unit-IV

Economic Aspects: Introduction, Terms commonly used in system operations: Diversity factor, Load factor, Plant capacity factor, Plant use factor, Plant utilization factor, Loss factor. Load duration curve and different Tariffs 8**Hrs**

Unit-V

Grounding Systems: Introduction, Resistance grounding system, Neutral grounding, Ungrounded system, Resonant grounding, Solid grounding, Reactance grounding, Earthing transformer, Neutral grounding transformer. , Power factor: Advantages of power factor cause of power factor improvement of power factor **8Hrs**

TEXT BOOKS:

1. S. M. Singh, "Electrical power generation, transmission and distribution"-Prentice hall of India, New Delhi, 2nd 2008.
2. Chakrabarti, M-L Soni, P.V. Gupta, U.S. Bhatnagar, "Power system Engineering", DhanpatRai& Co., 2001.

REFERENCE BOOKS:

1.M.V. Deshapande, "Electrical Power System Design" T.M.H., 1993.
2. C.L. Wadwa, "Electrical Power System", Wiley Stern

Course Title: : Fuzzy Logic			
Course Code : P15EE752	**Semester : VII**	**L-T-P-H: 3-0-0-3**	**Credits: 3**
Contact Period: Lecture: 40 Hr. Exam 3 Hr		**Weightage: CIE:50%: SEE:50%**	

Unit-I

Classical / Crisp Sets and Fuzzy Sets: Introduction, Background – Uncertainty, Imprecision, Uncertainty inInformation. Fuzzy Systems, Fuzzy Set and its Membership values.

Classical Sets, Operations on Classical Sets, Properties of Classical (Crisp) Sets, Mapping of Classical Sets to Functions, Membership functions of fuzzy sets, Fuzzy Set Operations.Properties of Fuzzy Sets. Alternative Fuzzy Set Operations. **8 hrs**

Unit-II

Classical Relations and Fuzzy Relations: Cartesian product,Crisp Relations, Cardinality of Crisp Relations, Operations on Crisp Relations, Properties of Crisp Relations, Composition. Fuzzy Relations - Cardinality of Fuzzy Relations, Operations on Fuzzy Relations, Properties of Fuzzy Relations, Fuzzy Cartesian product and Composition. Tolerance and Equivalence Relations.Crisp Equivalence Relation, Crisp Tolerance Relation, Fuzzy Tolerance and Equivalence Relations. **8 hrs**

Unit-III

Properties of Membership FunctionsandFuzzyfication

Membership functions: Features of the Membership Function- Various Forms.Development of Membership Functions: Fuzzyfication-Membership Value Assignments - Intuition, Inference, Rank Ordering, Angular fuzzy sets,Neural Networks, Genetic Algorithms, andInductive Reasoning.

8 hrs

Unit-IV

Defuzzyfication: Fuzzy to Crisp conversions. Lambda (λ) -Cuts (or alpha – cuts) for Fuzzy sets and Fuzzy Relations, Defuzzification to Scalars. Defuzzyfication methods – Max-membership principle, Centroid method, Weighted Average Method, Mean-Max membership, Center of Sums, and Center of Largest area, First (and/or) Last of Maxima.Extension principle.

8 hrs

Unit-V

Fuzzy Logic and Fuzzy Systems:

Part-I Logic:

ClassicalLogic or Predicate logic: Tautologies, Contradictions, Equivalence, XOR and XNOR, logical proofs deductive inferences.

Fuzzy logic: ApproximateReasoning.Fuzzy Tautologies, Contradictions, Equivalence, and Logical proofs. Other forms of Implification operations.

Part- II Fuzzy Systems:

Natural Language, Linguistic Hedges, Fuzzy / Rule-Based Systems, Graphical Techniques of Inference. **8 hrs**

Text Books:

"Fuzzy Logic With Engineering Applications"- by: TimothyJ,Ross, McGraw Hill publications or John Wiley, Fourth Edition, 2016.

Reference: "Principles of Soft Computing", - by S.N.Shivanandam, S.N.Deepa, Wiley India (pvt) Ltd publications, second edition 2010.

Course Title : Relay and High Voltage Laboratory			
Course Code : P15EEL76	**Semester : VII**	**L- T- P -H: 0 - 0 - 1.5**	**Credits-3**
Contact Period: Lecture: 36 Hr, Exam: 3 Hr	**Weightage: CIE:50; SEE:50**		

Course Learning Objectives (CLOs)

This course aims

Toconduct practical experiments on Relay and High voltage equipments; IDMT directional/non-directional relay, differential relay, over voltage relay, feeder protection, Spark over characteristics of air (HVAC/HVDC), impulse generator & Partial Discharge analysis for different insulation at different pressure.

List of Experiments

A. RELAY LAB

1. Over current relay**:**
   (a) IDMT non-directional characteristics
   (b) Directional features
   (c) IDMT directional characteristics
2. DMT Characteristics of over voltage or under voltage relay.
3. Generator protection –Merz-Price- protection scheme.
4. Feeder protection scheme-fault studies.
5. Motor protection scheme-fault studies.

B. HIGH VOLTAGE LAB

1. Spark over characteristics of air insulation subjected to HVAC & HVDC for uniform and non uniform fields
2. Measurement of HVAC and HVDC using standard spheres.
3. To determine 50% probability flashover voltage using impulse generator
4. Partial Discharge characteristics at low pressures using vacuum system and high pressure chamber.
5. Breakdown characteristics of gaseous/liquid insulation using power/high frequency voltage generator.

C. Self-study experiment

Course Outcomes

Student will be able to

1. Conduct experiments on over voltage & over current relay
2. Analyze the fault between phase to phase, phase to neutral & phase to earth in merz price & feeder protection scheme.
3. Understand spark over characteristics of air insulation subjected to HVAC & HVDC for uniform and non uniform fields
4. Determine 50% probability flashover voltage using impulse generator
5. Conduct Partial Discharge experiments for different insulation at different pressure

Topic learning objective:

1. IDMT directional &non directional characteristics of over current relay
2. DMT Characteristics of over voltage or under voltage relay
3. Merz-Price- protection scheme
4. Feeder protection for different faults
5. Motor protection scheme-fault studies
6. Spark over characteristics of air in HVAC for uniform &non uniform fields
7. Spark over characteristics of air in HVDCfor uniform &non uniform fields
8. Measurement of HVAC
9. Measurement of HVDC

10. 50% probability flashover voltage using impulse generator
11. Partial Discharge characteristics at low & high pressure using vacuum system chamber.
12. Breakdown characteristics of gaseous/liquid insulation using power/high frequency

Course Assessment Matrix (CAM)															
Course Outcome (CO)		**Program Outcome**													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Conduct experiments on over voltage & over current relay		**1**	**3**	**2**	**1**	**1**	**1**	**-**	**-**	**1**	**1**	**1**			
Analyze the fault between phase to phase, phase to neutral & phase to earth in merz price & feeder protection scheme		**1**	**3**	**1**	**-**	**1**	**2**	**2**	**1**	**2**	**1**	**1**			
Understand spark over characteristics of air insulation subjected to HVAC & HVDC for uniform and non uniform fields		**1**	**3**	**2**	**1**	**1**	**2**	**2**	**2**	**2**	**-**	**1**			
Determine 50% probability flashover voltage using impulse generator		**1**	**3**	**-**	**-**	**1**	**1**	**1**	**1**	**1**	**-**	**-**			
Conduct Partial Discharge experiments for different insulation at different pressure		**1**	**3**	**-**	**1**	**1**	**2**	**2**	**2**	**3**	**1**	**2**			
1 – Low, 2 – Moderate and 3 – High															

Course Title : Power System Simulation Lab			
Course Code : P15EEL77	**Semester : VII**	**L - T – P-H 0-0-1.5-3**	**Credits : 1.5**
Contact Period: Lecture: 36 Hr, Exam: 3 Hr			**Weightage: CIE:50; SEE:50**

Course Learning Objectives (CLOs)

This course aims

To simulate the experiments to form formation of Y bus by inspection method and singular transformation method, find the bus currents bus voltages, and line flow of the specified system. Find the different faults of a transmission line and study the load flow analysis.

List of Experiments

1. **C**alculation of ABCD parameters for medium and long transmission line systems. Verification of AD-BC=1. Determination of efficiency and regulation.
2. (i)Y-Bus formation for power systems by inspection method.(ii) Determination of bus currents, bus power and line flows for a specified system with given bus voltage profile.

3. Bus admittance matrix (Y – Bus) formation for power systems with and without mutualCoupling, by singular transformation.
4. To determine fault currents and voltages in a single transmission line system with a Specified location for SLG fault, LL fault, and LLG (DLG) fault.
5. Determination of power angle diagram of salient and non-salient pole synchronous machines. Calculation of reluctance power & regulation.
6. To determine I) Swing curve II) Critical clearing time for a single machine connected to Infinite bus through a pair of identical transmission lines.
7. Determination of optimal generator scheduling for thermal plants.
8. Load flow analysis using (i) Gauss Siedel method, (ii) Newton Raphson method, and (iii) Fast decoupled flow method for both PQ and PV buses using software package.
9. Self Study experiment viz. Analysis of typical power system (problems) by using software package or MATLAB programs.
10. Self-study experiment / simulation

Course Outcomes

Student will be able to

1. Simulate experiments for formation of Y bus, by inspection method and singular transformation method and Analyze the bus currents, bus power and line flows for a given bus .
2. Determine the fault currents and voltages in a single line transmission line for SLG, LL,DLG fault
3. Determine power angle diagram of salient and non salient pole synchronous machine
4. Determine Swing curve critical clearing time for a single bus machine connected to infinite bus
5. Analyze the load flow studies by different methods.

Course Assessment Matrix (CAM)															
Course Outcome (CO)		**Program Outcome**													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Simulate experiments for formation of Y bus, by inspection method and singular transformation method and Analyze the bus currents, bus power and line flows for a given bus		**3**	**3**	**2**	**1**	**3**	**1**	**l-**				**2**			
Determine the fault currents and voltages in a single line transmission line for SLG, LL,DLG fault		**3**	**3**	**2**	**1**	**3**	**2**	**2**				**2**			
Determine power angle diagram of salient and non salient pole synchronous machine		**3**	**3**	**2**	**1**	**3**	**2**	**2**				**2**			
Determine Swing curve critical clearing time for a single bus machine connected to infinite bus		**3**	**3**	**2**	**1**	**3**	**1**	**1**				**2**			
Analyzethe load flow studies by different methods.		**3**	**3**	**2**	**1**	**3**	**2**	**2**				**2**			
1-Low, 2-Moderate, 3-High.															

Course Title: Renewable Energy Sources			
Course Code: P15EE81	**Semester: VIII**	**L-T-P-H: 3-0-0-3**	**Credits – 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50%; SEE:50%**	

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Course Learning Objectives

After going through the course, the students should be able to:

1. Appreciate the importance of various types of energy sources and understand the need for studying renewable energy sources.
2. Understand the various types of conversion methods of solar radiations into heat and know the various types of solar collectors and applications.
3. Know the significance of wind energy and understand the basic principles and its applications.
4. Understand the need for biomass energy and to know the various types of biomass conversion technologies.
5. Understand the relevance of various types of ocean and tidal energy conversion systems and to know the different types of arrangements and application.

UNIT-1

Energy Sources: Introduction, Importance of energy consumption as measure of prosperity, per capita energy consumption ,Classification of energy resources; Conventional energy resources-availability and their limitations, non-conventional energy resources-Classifications, advantage ,limitations;comparison of conventional and non-conventional energy resources; world energy scenario; Indian energy Scenario.

04Hrs

Solar Energy Basics: Introduction, Solar constant, Basic sun-Earth angle-definition & their representation, solar radiation geometry(Numerical Problems) Estimation of solar radiation of horizontal and tidal surface(Numerical Problems) Measurement of Solar Radiation data-pyranometer & pyrheliometer. **04 Hrs**

UNIT-2

Solar Thermal System: Principle of conversion of solar radiation into heat, solar water heater(Flat plat collectors)solar cookers-boxtype, concentrating dish type,solar driers,still furnaces, green houses.

Solar Electric System: Solar thermal electric power generation-solar pond & concentrating solar collector(Parabolic trough, parabolic dish central collector)advantages and disadvantages; Solar Photovoltaic-solar cell fundamentals,characteristic,classification,construction of module,panel & array.Solar PV systems-stand-alone/grid connected;applications-street lightning,domestic lightning & solar water pumping systems. **8Hrs**

UNIT-3

Wind Energy: Introduction, wind & its property, history of wind energy,scenario-world&India.Basic principle of Wind energy conversion system(WECS),classifications of WECS,part of aWECS. Derivation of power in the wind,electrical power output & capacity factor of WECS ,wind site selection consideration, advantages & disadvantages of WECS

8 Hrs

UNIT-4

Biomass Energy: Introduction photosynthesis process , biomass fuel, biomass conversion technologies urban waste to energy conversion, Biomass gasification, biomass to ethanol production, Biogas

production from the waste biomass, factors affecting Biogas generation, types of Biogas plants – KVIC &Janata Model; Biomass programme in India. **8 Hrs**

UNIT-5

Energy From Ocean: Tidal energy-principle of tidal power, components of tidal power plant(TPP) classification of tidal power plant estimation of energy-single Basin & Double Basin type TTP(no derivation, simple numerical problems),Advantages & Limitation ofTTP.Ocean thermal Energy Conversion(OTEC) principle of OTEC System, method of OTEC power generation-open cycle(Claude Cycle),Closed cycle(Anderson cycle) &Hybrid cycle(Block diagram description of OTEC).

8Hrs

TextBook

1) Rai,GD,Non-conventional sources of energy,4th Edition ,Khannapublishers,New Delhi,2007.

Reference Books:

1.KhanBH,Non-conventional energy resources,TMH,New Delhi,2006.
2.Mukherjee,D&ChakrabortiS,Fundamentals of Renewable Energy Systems,New Age International Publishers,2005.

Course outcomes

After completion of this course students shall be well versed with the following information:

CO1: Need for knowing importance of the electrical energy the various factors contributing for the demand and supply of electrical energy.
CO2: Conversion principles, potential of the solar energy, various types of solar energy working with solar energy.
CO3: Scenario of the wind energy. Wind energy conversion systems different types of assemblies, applications.
CO4: Photosynthesis process, biomass conversion technologies. Solid waste conversion and management systems.
CO5: Basic energy conversion principle of tidal and ocean energy. Different types of tidal power plant, ocean thermal energy conversion systems, applications.

Course Title: Energy Auditing & Demand Side Management			
Course Code: P15EE821	**Semester: VIII**	**L-T-P-H: 3-0-0-3**	**Credits – 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50%; SEE:50%**	

Course Content

Unit-I

Introduction: Energy situation in the world and India, Energy consumption, Conservation, The power flow concept. Codes, standards and Legislation.

Energy Economic Analysis: The time value of money concept, Developing cash flow models, payback analysis, depreciation, taxes and tax credit, Concept of ABT numerical problem. **8Hrs**

Unit-II

Energy Auditing: Introduction, Elements of energy audits, energy use profiles, measurements in energy audits, case studies, presentation of energy audit results. **8Hrs**

Unit-III

Electrical Equipment and power factor correction: Location & sizing of capacitors, energy efficient motors, lighting basics, Numerical on power factor correction **8Hrs**

Unit-IV

Demand Side Management: 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.Tarriff option for DSM, customer acceptance of DSM **8Hrs**

Unit-V

Load management: Load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, promotion of high efficient technologies, DSM implementation issues, Management and Organization of Energy Conservation awareness Programs. **8Hrs**

Text Books:-

1**.** "Fundamentals of Energy Engineering" - Albert Thumann, Prentice Hall Inc, Englewood Cliffs, New Jersey.

2. Electrical distribution – Pabla, TMH Publishers, 2004

Reference Books:-

1. "Demand Side Management"-JyothiPrakash, , TMH Publishers, 2000.
2. Hand book on energy auditing - TERI (Tata Energy Research)
3. Principles of Power system V.K.Mehtha, , S.Chand& Company Ltd. 2002
4. Hand book of Electrical power Distribution, Gorti Ramamurthy, University press, 2nd edition, 2009

Course Title: MODERN POWER SYSTEM PROTECTION			
Course Code: P15EE822	**Semester: VIII**	**L-T-P-H: 3-0-0-3**	**Credits - 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50%; SEE:50%**	

Unit – I

STATIC RELAYS: Introduction, Basic construction, Classification, Basic Circuits, Smoothing Circuits, Voltage regulation, square wave Generator, Time delay Circuits, Level Detectors, Summation device, Sampling Circuits, Zero crossing detector, output devices. **8Hrs**

Unit - II

COMPARATORS: Replica impedance, Mixing Transformers, General equation of phase and Amplitude comparators, Realization of ohm, mho, Impedance and offset impedance characteristics; Duality principle; Static amplitude comparator – Rectifier bridge circulations current type, sampling comparator, Static phase comparator - coincidence circuits type rectifier phase comparator, Block spike comparator, Zener diode phase comparator. **8Hrs**

Unit - III

STATIC OVER CURRENT, TIMER AND VOLTAGE RELAYS: Instantaneous over current Relay, Definite time lag relay, Inverse time over current relay, static timer relay, Basic delay circuits, Monostable delay circuits ,Single phase Instantaneous over voltage and under voltage relays, Instantaneous over voltage relay using Op-amp. **8Hrs**

Unit - VI

DISTANCE RELAY: General principle of operation, Zone discrimination, Fault area on impedance diagram, Basic measuring elements, Different characteristics used in distance relaying- Impedance, Reactance, Admittance, Ohm ; Distance relay settings, Distance measurement Problems. **8Hrs**

Unit - V

DIGITAL / NUMERICAL RELAYS: Block Schematic approach of microprocessor based relays, Over current relay protection, Transformer differential protection, Directional relay scheme, Impedance relay scheme. Definition of Numerical Protection System, Advantages of Numerical relays, Block diagram of Numerical Relays **8Hrs**

Text Books:

1. T.S. MadavaRao, Power System protection, Static Relays with Microprocessor Applications, TMH, Second Edition, 2004.

Reference Books:

1. Patra. S.P. Basu. S.K. Chaudhri.S, Power System Protection, Oxford, and IBH Publications Co-1983.
2. Ravindranath. B and Chanda M., Power System Protection and Switchgear, New Age.
3. B.Ram and D.N Vishwa karma, Power System Protection and Switchgear, TMH., 1997.

Course Title: Smart Grid			
Course Code: P15EE823	**Semester: VIII**	**L-T-P-H: 3-0-0-3**	**Credits - 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50%; SEE:50%**	

Course Content

Unit-1

Smart Grid Architectural Designs: Introduction, Today's Grid versus the Smart Grid, Energy Independence and Security Act of 2007: Rationale for the Smart Grid, Computational Intelligence, Power System Enhancement, Communication and Standards, Environment and Economics, General View of the Smart Grid Market Drivers, Stakeholder Roles and Function, Working Definition of the Smart Grid Based on Performance Measures, Representative Architecture, Functions of Smart Grid Components. Smart Grid Communications and Measurement Technology: Communication and Measurement, Monitoring, PMU, Smart Meters, and Measurements Technologies, GIS and Google Mapping Tools, Multiagent Systems (MAS) Technology, Microgrid and Smart Grid Comparison.

Performance Analysis Tools for Smart Grid Design: Introduction to Load Flow Studies, Challenges to Load Flow in Smart Grid and Weaknesses of the Present Load Flow Methods, Load Flow State of the Art: Classical, Extended Formulations, and Algorithms, Congestion Management Effect, Load Flow for Smart Grid Design, DSOPF Application to the Smart Grid, Static Security Assessment (SSA) and Contingencies, Contingencies and Their Classification, Contingency Studies for the Smart Grid.

8Hrs

Unit-2

Stability Analysis Tools for Smart Grid: Introduction to Stability, Strengths and Weaknesses of Existing Voltage Stability Analysis Tools, Voltage Stability Assessment, Voltage Stability Assessment Techniques, Voltage Stability Indexing, Analysis Techniques for Steady-State Voltage Stability Studies, Application and Implementation Plan of Voltage Stability, Optimizing Stability Constraint through Preventive Control of Voltage Stability, Angle Stability Assessment, State Estimation.

8Hrs

Unit-3

Computational Tools for Smart Grid Design: Introduction to Computational Tools, Decision Support Tools, Optimization Techniques, Classical Optimization Method, Heuristic Optimization, Evolutionary Computational Techniques, Adaptive Dynamic Programming Techniques, Pareto Methods, Hybridizing Optimization Techniques and Applications to the Smart Grid, Computational Challenges. Pathway for Designing Smart Grid: Introduction to Smart Grid Pathway Design, Barriers and Solutions to Smart Grid Development, Solution Pathways for Designing Smart Grid Using Advanced Optimization and Control Techniques for Selection Functions, General Level Automation, Bulk Power Systems Automation of the Smart Grid at Transmission Level, Distribution System Automation Requirement of the Power Grid, End User/Appliance Level of the Smart Grid, Applications for Adaptive Control and Optimization.

8Hrs

Unit-4

Renewable Energy and Storage: Renewable Energy Resources, Sustainable Energy Options for the Smart Grid, Penetration and Variability Issues Associated with Sustainable Energy Technology, Demand Response Issues, Electric Vehicles and Plug-in Hybrids, PHEV Technology, Environmental Implications, Storage Technologies, Tax Credits. Interoperability, Standards, and Cyber Security: Introduction, Interoperability, Standards, Smart Grid Cyber Security, Cyber Security and Operation for Improving Methodology for Other Users. **8Hrs**

Unit-5

Research, Education, and Training for the Smart Grid: Introduction, Research Areas for Smart Grid Development, Research Activities in the Smart Grid, Multidisciplinary Research Activities, Smart Grid Education, Training and Professional Development.

Case Studies and Test beds for the Smart Grid: Introduction, Demonstration Projects, Advanced Metering, Microgrid with Renewable Energy, Power System Unit Commitment (UC) Problem, ADP for Optimal Network Reconfiguration in Distribution Automation, Case Study of RER Integration, Test beds and Benchmark Systems, Challenges of Smart Transmission, Benefits of Smart Transmission.

8Hrs

Textbook: 1. Smart Grid, Fundamentals of Design and Analysis James Momoh Wiley 1st Edition, 2012

Course Title: Artificial Neural Networks			
Course Code: P15EE824	**Semester: VIII**	**L-T-P-H: 3-0-0-3**	**Credits – 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50%; SEE:50%**	

Course Content

Unit –I

Introduction :

Human Brain, Biological Neuron networks –Artificial Neural networks (ANN). Comparison between ANN and Biological Neuron networks.Basic building blocks of ANN. Neural Networks viewed as directed graphs, ANN terminologies: Weights, Activation functions, sigmoidal functions, Calculation of net input using matrix multiplication method, Bias, Threshold. Network Architectures- Feedforward and Feedback architecture.Multilayer Networks. **8Hrs**

Unit-II

Fundamental models of ANN & Learning Processes:

McCullock-Pitts neuron model – Architecture. Learning rules: Hebbian learning rule, Perception Learning rules, delta Learning rules, Competitive learning, Boltzmann learning, Memory-based learning. Hebb net – architecture, algorithm. **8Hrs**

Unit-III

(1) Perceptron Networks

Single Layer Perceptron:**A**rchitecture, algorithm, Application procedure. Perceptron algorithm for several output classes. Brief introduction to Multi-Layer Perceptron networks.

(2)Adaline and Madline networks

Adaline networks-Architecture, algorithm, Application procedure and Madline networks Architecture, algorithm, Application procedure. **8Hrs**

Unit-IV

Feedback networks: Discrete Hopfield Net –architecture, training algorithm, application algorithm, analysis. Continuous Hopfield Net.Bi-directional Associative Memory (BAM).Relation between BAM & Hopfield Net.

Feedforward networks: Introduction, Back Propagation Network (BPN), - Generalized Delta learning rule (or) Back Propagation rule. Architecture, training algorithm, selection parameters, Learning in Back Propagation, Application algorithm. Merits and Demerits of Back Propagation Network (BPN), Applications.Radial-Basic Function Networks (RBFN): - Architecture, Training algorithm for a RBFN.

8Hrs

Unit-V

Self-organizing feature Map (SOM): Kohonen Self-organizing feature Map (SOM)- Architecture, training algorithm. Learning vector quantization (LVQ) - Architecture, training algorithm.

Adaptive Resonance Theory (ART) : ART fundamentals, Basic architecture, Basic operation, Learning in ART. Basic training steps. ART1 &ART2 - Architecture, training algorithms. **8Hrs**

Text books:

1. "Introduction to Artificial Neural networks" .By: S N Sivanandum, S Sumathi& S N Deepa. Tata McGraw Hill publications.Year-2014

2." Principals of Soft-computing" – By: S N Shivanadum, & S N Deepa. Wiley Eastern (India) Ltd. - publication.Year- 2013.

Reference books:

1. "Neural Networks and Fuzzy Systems", by: Bart Kosko. PHI - publications.Year-2014.

Course Title: HVDC Power Transmission			
Course Code: P15EE831	**Semester: VIII**	**L-T-P-H: 2-2-0-4**	**Credits – 3**
Contact period : Lecture: 40 Hrs, Exam 3 Hrs		**Weightage : CIE:50%; SEE:50%**	

Course content

Unit- I

General Aspects of DC Transmission and Comparison of it with AC Transmission: Historical sketch, Types of DC links, Comparison of AC and DC transmission, Applications of DC transmission, Description of DC transmission systems. **8hrs**

Unit –II

Converter circuits:Valve characteristics, Properties of converter circuits, assumptions, single phase and three phase converters. **8hrs**

Unit -III

Analysis of bridge converter: Analysis with grid control without overlap, Analysis with grid control and overlap less than 60Ú. Complete characteristics of rectifier, Inversion **8hrs**

Unit –IV

Control strategies: Basic means of control, Power reversal, Limitations of manual control, Constant voltage versus constant current control, desired features of control, Actual control characteristics, Constant minimum ignition angle control, Constant current control, Stability of control, Tap changer control, Power control and current limits, MTDC systems. **8hrs**

Unit –V

Protection: General, DC reactors, Prevention of consequent commutation failures, Converter faults, DC Circuit breakers, Clearing line faults and re-energizing the line. **4hrs**

Harmonics and Filter: Characteristic and Uncharacteristic harmonics, Telephone interference, Troubles caused by harmonics, Means of reducing harmonics, Harmonic filters. **4 hrs**

Text Book:1. Power System Stability and Control, PrabhaKundur , Tata McGraw Hill, 9th Reprint, 2007.

Reference Books:

1. Direct Current Transmission, E. W. Kimbark, - Volume I, Wiley futerscience, 1971.
2. HVDC Power transmission systems - Technology and System Interactions, K. R. Padiyar, Wiley Eastern Limited, 1992.

Course Title: COMPUTER CONTROL OF ELECTRIC DRIVES			
Course Code: P15EE832	**Semester: VIII**	**L-T-P-H: 3-0-0-3**	**Credits – 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50%; SEE:50%**	

Course Content

UNIT-I

Review of Microcontrollers in industrial drives system. Typical Microcontrollers, 8 bit/16 bit/32 bit (only block diagram), Digital Data Acquisition System, voltage sensors, current sensors, frequency sensors and speed sensors, Block diagram for power integrated circuit for DC motor drives. **8Hrs**

UNIT-II

Induction Motor Drives: General classification and National Electrical manufacturer Association (NEMA) classification, Speed control of induction motors with Variable voltage, constant frequency, constant voltage variable frequency,(V/f) Constant operation, drive operating regions. Variable stator current operation**.** **8Hrs**

Unit-III

Synchronous Machine drives: wound field machine, comparison of induction and wound field synchronous machines and torque angle characteristics of salient Pole synchronous machine.

Phase controlled converters :converter controls, linear firing angle control, Cosine wave crossing control, Phase- locked oscillator principle, cyclo-converters, voltage fed converters, PWM Rectifiers and current fed converters **8Hrs**

Unit-IV

Principle of slip power Recovery schemes Static Kramer Drive system, block schematic diagram and phasor diagram and Limitations, static Scherbius scheme system using DC link converters with Cyclo converter modes of operation; Modified Scherbius drives for variable Source Constant Frequency (VSCF) generation. **8Hrs**

Unit-V

Principle of Vector control of AC drives :Phasor diagram, digital implementation block diagram, flux vector-estimation, Indirect vector control block diagram with open loop flux control, synchronous Motor control with compensation. **8 Hrs**

Text Books:-

1. Modern Power Electronics & Drives, BimalK.Bose, Pearson Education,4th edition, 2003.
Reference Books:
2. Power Electronics and motor drives, BimalK.Bose, Elsevier, 2006.
3Fundamentals of Microprocessors and applications, BadriRam ,Pearson, 2001.

Course Title: Power System Operation And Control			
Course Code: P15EE833	**Semester: VIII**	**L.T.P.H: 3-0-0-3**	**Credits:03**
Contact Period: Lecture:40Hrs., Exam 3 Hrs	**Weightage: CIE:50%; SEE:50%**		

Course Content

Unit – I

Control center operation of power systems: Introduction to Computer Control center, digital computer configuration, Automatic generation control, Area control error, Operation without central computers, Expression for tie-line flow and frequency deviation, Parallel operation of generators. **8Hrs**

Unit – II

Automatic Generation Control: Automatic control loops of generators: AGC and AVR. Automatic Load Frequency Control (ALFC/LFC), ALFC of single area systems, Concept of control area, multi-area systems, Pool operation-two area systems. **8Hrs**

Unit – III

Control of voltage and Reactive Power: Introduction, generation and absorption of reactive power, relation between voltage, power and reactive power at a node, Single machine infinite bus systems, methods of voltage control, Voltage stability,and Voltage collapse **8Hrs**

Unit –IV

Unit Commitment: Statement of the problem, need and importance of unit commitment, Methods of Unit commitment -priority lists method, constraints, spinning reserve, and examples. **8Hrs**

Unit –V

Power System Security: Introduction, factors affecting power system security, Power system contingency analysis, Detection of network problems, network sensitivity methods, calculation of network sensitivity factor, contingency ranking. **8Hrs**

Text Books:

1. "Power generation, operation and control", by: Allen J.Wood& B F Woollenberg.John Wiley and Sons, Publications II-Edition 2010.
2 "Computer Aided Power System Analysis", by: G.L.Kusic, PHI,2010
3. "Electric Power Systems", by: B. M. Weedy, B.J. Cory, Wiley, 5th Edition, 2010.

Reference Books:

1."Modern Power System Analysis", by D.P.KothariandI.J.Nagrath, ThirdEdition,Tata-McGrawHillPublishingCompanyLimited,NewDelhi,2010.

Course Title: Insulation Engineering			
Course Code: P15EE834	**Semester: VIII**	**L-T-P-H: 3-0-0-3**	**Credits – 3**
Contact period : Lecture: 40Hrs, Exam 3 Hrs		**Weightage : CIE:50%; SEE:50%**	

Course Content

Unit-1

INSULATION SYSTEM IN POWER SYSTEM APPARATUS

Insulation system in capacitors, bushings, and transformers modes of failure of insulation systems, Insulations used in rotating machines. **8Hrs**

Unit-2

DIELECTRIC PHENOMENA

Dielectric phenomena in solid insulation. Macroscopic approach for describing the Dielectric phenomena microscopic treatment for Dielectric phenomena. **8Hrs**

Unit-3

PROPERTIES OF INSULATION MATERIALS

Introduction to properties of solid insulating materials (both of natural origin and synthetic types) Properties of liquid insulating materials. **8Hrs**

Unit-4

GASEOUS INSULATION

Requirement of gaseous insulation. Breakdown process: types of collision, Elastic and inelastic, collision cross-section, Mobility of ions, Diffusion of charges, Emission of radiation and excitation, various secondary process and recombination, Mobility controlled and diffusion controlled breakdown. Gas insulated substations. **8Hrs**

Unit-5

AGEING PHENOMENA

Failure of electric insulation due to ageing.Ageing mechanisms- Thermal ageing, Electrical ageing, combined thermal and electrical ageing.Analysis of insulation failure data, Power law model, Graphical estimation of power law constants, ageing date. **8Hrs**

Text Book:

1. Reliability and Life Estimation of Power Equipment, T. S. Ramu and Chakradhar Reddy, , New Age International, 1st Edition ,2009.

Reference Books:

1. Electrical insulation ,Bradwell A., , Peter peregrinus Ltd., London, 1983.

2. Fundamentals of gaseous ionization and plasma electronics ,Nasser E, John Wiley interscience, New York, 1971.

Course Title: Renewable Energy Sources			
Course Code: P15EE841	**Semester: VIII**	**L.T.P.H: 3-0-0-3**	**Credits:03**
Contact Period: Lecture: 50Hrs., Exam 3 Hrs		**Weightage: CIE:50%; SEE:50%**	

Course Content

UNIT-1

Energy Sources: Introduction, Importance of energy consumption as measure of prosperity, per capita energy consumption ,Classification of energy resources; Conventional energy resources-availability and their limitations, non-conventional energy resources-Classifications, advantage ,limitations;comparison of conventional and non-conventional energy resources; world energy scenario; Indian energy Scenario.

04Hrs

Solar Energy Basics: Introduction, Solar constant, Basic sun-Earth angle-definition & their representation, solar radiation geometry(Numerical Problems) Estimation of solar radiation of horizontal and tidal surface(Numerical Problems) Measurement of Solar Radiation data-pyranometer & pyrheliometer. **04 Hrs**

UNIT-2

Solar Thermal System: Principle of conversion of solar radiation into heat, solar water heater(Flat plat collectors)solar cookers-boxtype,concentrating dish type,solar driers,still furnaces, green houses.

Solar Electric System: Solar thermal electric power generation-solar pond & concentrating solar collector(Parabolic trough, parabolic dish central collector)advantages and disadvantages; Solar Photovoltaic-solar cell fundamentals,characteristic,classification,construction of module,panel & array.Solar PV systems-stand-alone/grid connected;applications-street lightning,domestic lightning & solar water pumping systems. **8 Hrs**

UNIT-3

Wind Energy: Introduction, wind & its property, history of wind energy,scenario-world&India.Basic principle of Wind energy conversion system(WECS),classifications of WECS,part of aWECS. Derivation of power in the wind,electrical power output & capacity factor of WECS ,wind site selection consideration, advantages & disadvantages of WECS **8Hrs**

UNIT-4

Biomass Energy: Introduction photosynthesis process , biomass fuel, biomass conversion technologies urban waste to energy conversion, Biomass gasification, biomass to ethanol production, Biogas production from the waste biomass, factors affecting Biogas generation, types of Biogas plants – KVIC &Janata Model; Biomass programme in India. **8Hrs**

UNIT-5

Energy From Ocean: Tidal energy-principle of tidal power, components of tidal power plant(TPP) classification of tidal power plant estimation of energy-single Basin & Double Basin type TTP(no derivation, simple numerical problems),Advantages & Limitation ofTTP.Ocean thermal Energy Conversion(OTEC) principle of OTEC System, method of OTEC power generation-open cycle(Claude Cycle),Closed cycle(Anderson cycle) &Hybrid cycle(Block diagram description of OTEC).

8 Hrs

TextBook

Rai,GD,Non-conventional sources of energy,4th Edition ,Khannapublishers,New Delhi,2007.

Reference Books:

1.KhanBH,Non-conventional energy resources,TMH,New Delhi,2006.

2.Mukherjee,D&ChakrabortiS,Fundamentals of Renewable Energy Systems,New Age International Publishers,2005.

Course Title: : Utilization of Electrical Power			
Course Code : P15EE842	**Semester : VIII**	**Credits:03**	**L-T-P-H: 3-0-0-3**
Contact Period: Lecture: 40 Hr. Exam 3 Hr		**Weightage: CIE:50%: SEE:50%**	

Course Content

Unit – I

Heating and Welding: Introduction, mode of heat transfer, advantages and methods of electric heating, resistance ovens, resistance heating, induction heating, the arc furnaces, vertical core type furnace, Indirect core type furnace, Induction furnace, coreless Induction furnace, heating of building, electric welding and their types , control device and electric equipment **8Hrs**

Unit – II

Illumination : Laws of illumination, light schemes, Design of lighting scheme, factory lighting, flood lighting, different types of lamps: Incandescent, mercury, arc, electric discharge lamps, mercury vapour lamps, fluorescent, vapour and CFL and their working **8Hrs**

Unit – III

Electric Traction : Introduction, scheme of traction, types of electric traction, electric trains, systems of electrification for traction purposes: direct current, 1 phase AC system, composite system. Applications of systems for railway electrification. **8Hrs**

Unit – IV

Speed-Time Characteristics: Analysis of speed-time curve for electric train, tractive effort, specific energy output on the level track, various factors affecting energy consumption. **8Hrs**

Unit – V

Traction Motors: Introduction, selection of traction motors, methods of speed control, energy saving by series-parallel method, AC traction equipment, AC series motor, characteristics, electric braking, regenerative braking on AC& DC series motor, linear induction motor and their use. **8Hrs**

Text Books:

1.Electrical Power systems by Dr. S.L. Uppal , Prof. S Rao , Khanna Publishers

2. Power System Engineering by A Chakrabarti M.L. Soni , P.V. Gupta Bhatnagar, DhanpatRai& Co (pvt) Ltd., 2013

3.Utilization of Electrical power by R K Rajput, Laxmi publication

REFERENCE BOOKS:

1. Utilization of Electric Energy-Open shaw Taylor, Unniversity Press,3rd Edition,2009.
2. Utilization of Electrical power by Dr. Ramesh L Chakrasali.