PROGRESSIVE EDUCATION SOCIETY'S

MODERN COLLEGE OF ENGINEERING

1186A, SHIVAJINAGAR, OFF J.M, PUNE-411005

(AFFILIATED TO SAVITRIBAI PHULE PUNE UNIVERSIT, PUNE)

DEPARTMENT OF ELECTRICAL ENGINEERING

E-CURRICULUM BOOKLET

ACADEMIC YEAR: 2019-20

FOR THE PROGRAMME

BE – ELECTRICAL ENGINEERING

(SEMISTER-II)

QUALITY POLICY OF THE INSTITUTE

We, PES Modern College of Engineering are committed to develop and foster cultured and promising professionals by imparting quality education in the field of Engineering and Management.

VISION OF THE INSTITUTION

To create a collaborative academic environment to foster professional excellence and ethical values

MISSION OF THE INSTITUTE

1. **To develop outstanding engineers & professionals with high ethical standards capable of creating and managing global enterprises.**
2. **To foster innovation and research by providing a stimulating learning environment.**
3. **To ensure equitable development of students of all ability levels and backgrounds.**
4. **To be responsive to changes in technology, socio-economic levels and environmental conditions.**
5. **To foster and maintain mutually beneficial partnerships with alumni and industry.**

QUALITY POLICY OF THE DEPARTMENT

Electrical Engineering department is committed to develop promising engineers with ethical and social responsibility through excellence in academics, research, skill development and consultancy.

VISION OF THE DEPARTMENT

To build technically competent Electrical Engineers with ethical and social responsibility.

MISSION OF THE DEPARTMENT

- **To develop abilities in students for acquiring knowledge and skills to flourish in dynamic technical environment.**
- **To nurture cultured professionals by providing facilities for their overall development.**
- **To motivate the students for research work and activities beneficial to society.**
- **To enhance strong bonding with various organization and alumni**

Program Educational Objectives (PEOs)

Graduates will be able to:

PEO 1: Solve and analyze problems in Electrical Engineering using fundamental knowledge.

PEO 2: Adopt lifelong learning ability by acquiring various skills.

PEO 3: Practice ethically in their profession.

PEO 4: Achieve global competency through interactions with various industries, research and professional organizations.

PROGRAM OUTCOMES (POs)

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, research literature, and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: The problems that cannot be solved by straight forward application of knowledge, theories and technique applicable to the engineering discipline that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions that require consideration of appropriate constraints/requirements not explicitly given in the problem statement. (Like: cost, power requirement, durability, product life, etc.). Which need to be defined (modeled) within appropriate mathematical framework that often requires use of modern computational concepts and tools.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate: effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES:

PSO 1: Students will have skill set in Energy Audit, Design of Solar System, and Automation in PLC and SCADA Applications, Microcontroller and analysis for power quality in Power System.

PSO 2: Students will be capable of dealing with techno-commercial aspect in Electrical Engineering.

CORE VALUES

- Excellence in the field of Electrical Engineering.
- Social responsibility with integrity.
- Lifelong Learning.
- Unity in Diversity.

SHORT TERM GOALS

- To enhance alumni interaction.
- To develop innovation lab to enhance research and entrepreneurship by providing various facilities.

LONG TERM GOALS

- To promote consultancy activity for revenue generation by developing high-tech standard laboratory.
- To encourage the faculty for research work and up gradation of qualifications.
- To enhance teaching-learning process through ICT.
- To establish competitive entrance exam cell in department.

INDEX

Course Structure

Savitribai Phule Pune University
FACULTY OF ENGINEERING
B.E. Electrical Engineering (2015 Course)
(w.e.f. 2018-2019)

SEMESTER-I

Sr No	Subject Code	Subject Title	Teaching Scheme (Hrs/Week)			Examination Scheme (Marks)					Total Marks	Credit	
						PP							
			Th	Pr	Tu	In Sem	End Sem	TW	PR	OR		TH / TUT	PR+ OR
1	403141	Power System Operation and Control	03	02	--	30	70	25	--	25	150	03	01
2	403142	PLC and SCADA Applications	04	02	--	30	70	25	50	--	175	04	01
3	403143	Elective I	03	02	--	30	70	25	--	--	125	03	01
4	403144	Elective II	03	--	--	30	70	--	--	--	100	03	--
5	403145	Control System II	03	02	--	30	70	25	--	25	150	03	01
6	403146	Project I	--	--	02	--	--	--	--	50	50	--	02
	403152	Audit Course V											
TOTAL			16	08	02	150	350	100	50	100	750	16	06

SEMESTER-II

Sr. No	Subject Code	Subject Title	Teaching Scheme (Hrs/Week)			Examination Scheme (Marks)					Total Marks	Credit	
						PP							
			Th	Pr	Tu	In Sem	End Sem	TW	PR	OR		TH/ TUT	PR +OR
1	403147	Switchgear and Protection	03	02	--	30	70	50	--	25	175	03	01
2	403148	Power Electronic Controlled Drives	04	02	--	30	70	25	50	--	175	04	01
3	403149	Elective III	03	02	--	30	70	25	--	25	150	03	01
4	403150	Elective IV	03	--	--	30	70	--	--	--	100	03	--
5	403151	Project II	--	--	06	--	--	50	--	100	150	06	--
	403153	Audit Course VI											
Total			13	06	06	120	280	150	50	150	750	19	03

Th.	Theory lectures hours/week	TW	Term work
Pr.	Practical hours/week	PR	Theory
Tu.	Tutorial hours/week	OR	Oral
		PP	Paper- In semester and End Semester

Elective I (403143) **A)** Fundamentals of Microcontroller MSP430 and its Applications [Open Elective] **B)** Power Quality **C)** Renewable Energy Systems **D)** Digital Signal Processing	**Elective II (403144)** **A)** Restructuring and Deregulation **B)** Electromagnetic Fields **C)** EHV AC Transmission **D)** Electric and Hybrid Vehicles **E)** Special Purpose Machines
Elective III (403149) **A)** High Voltage Engineering **B)** HVDC and FACTS **C)** Digital Control System **D)** Intelligent Systems and Applications in Electrical Engineering **E)** Analog Electronics and Sensing Technology [Open Elective]	**Elective IV (403150)** **A)** Smart Grid **B)** Robotics and Automation **C)** Illumination Engineering **D)** VLSI Design [Open Elective]

Audit Course

- Audit Course: Optional for 1st and 2nd term of BE Electrical Engineering
- 'Audit Courses' means a Course in which the student shall be awarded Pass or Fail only. It is left to the discretion of the respective affiliated institute to offer such courses to the students. Evaluation of audit course will be done at institute level itself.
- Teaching-learning process for these subjects is decided by concern faculty/industry experts appointed by the affiliated Engineering College based on the syllabus and guidelines given.
- Marks obtained by student for audit course will not be taken into consideration of SGPA or CGPA.

Audit Course V 403152	**(A) Hydro Energy Systems** **(B) Foreign Language – German**
Audit Course VI 403153	**Energy Storage Systems**

SWITCHGEAR AND PROTECTION

Name of the Subject –Switchgear and Protection

Weekly Work Load(in Hrs.)	Lecture	Tutorial	Practical
	03	-	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	25	50	175	4

Syllabus:

Unit 01: Fundamentals of protective relaying (8 hrs)

Need for protective system, nature and causes of fault, types of faults, effects of faults, evolution of protective relaying, classification of relays, zones of protection, primary and backup protection, essential qualities of protective relaying. Trip circuit of circuit breaker, zone of protection. Various basic operating principles of protection- over current, (current graded and time graded),directional over current, differential, distance, induction type relay, torque equation in induction type relay, current and time setting in induction relay, Numericals on TSM , PSM and operating time of relay

Unit 02: Fundamentals of arc interruption: (6 hrs)

Ionization of gases, deionization, Electric arc formation , Current interruption in AC circuit breaker, high and low resistance principles, arc interruption theories, arc voltage, recovery voltage, derivation and definition of restriking voltage and RRRV, current chopping, interruption of capacitive current, resistance switching, Numerical on RRRV, current chopping and resistance switching.

Unit 03: Circuit Breaker (5 hrs)

Different ratings of circuit breaker (like rated voltage, rated current, rated frequency, rated breaking capacity – symmetrical and unsymmetrical breaking, making capacity, rated interrupting duties, rated operating sequence, short time rating). Classification of high voltage circuit breaker. Working and constructional features of ACB, SF6 VCB- advantages, disadvantages and applications. Auto reclosing.

Unit04 **(5hrs)**

A) Static and Digital Relaying

Overview of Static relay, block diagram, operating principal, merits and demerits of static relay. Numerical Relays:-Introduction and block diagram of numerical relay, sampling theorem, Anti –Aliasing Filter, Block diagram of PMU

B) 3 Phase Induction Motor Protection

Abnormal conditions and causes of failures in 3 phase Induction motor, single phasing protection, Overload protection, Short circuit protection.

Unit 05: (6 hrs)

A) Transformer Protection –

Types of faults in transformer, Percentage differential protection in transformers, Restricted E/F protection, incipient faults, Buchholz relay, protection against over fluxing, protection against inrush current

B) Alternator Protection –

Various faults in Alternator, abnormal operating conditions- stator faults, longitudinal percentage differential scheme and transverse percentage differential scheme. Rotor faults- abnormal operating conditions, inter turn fault, unbalance loading, over speeding, loss of excitation, protection against loss of excitation using offset Mho relay, loss of prime mover.

UNIT-06: (6 hrs)

Over current protection for feeder using directional and non directional over current relays, Introduction to distance protection, impedance relay, reactance relay, mho relay and Quadrilateral Relays, Introduction to PLCC, block diagram, advantages, disadvantages, three stepped distance protection, Effect of arc resistance, and power swing on performance of distance relay. Realization of distance relays (impedance, reactance, and mho relay) using numerical relaying algorithm (flowchart, block diagram), Introduction to Wide Area Measurement (WAM) system.

Text Books:

[T1] S. Rao, "Switchgear Protection and Power Systems", Khanna Publications

[T2] Y. G. Paithankar, S. R. Bhide, "Fundamentals of Power System Protection", Prentice Hall of India

[T3] Bhavesh Bhalja,R.P. Maheshwari, N.G. Chothani," Protection and Switchgear", Oxford University Press, 2011 Edition. [T4] J.B.Gupta " Switchgear and Protection", S.K. Kataria and Sons.

Reference Books:

[R1] Badri Ram, D. N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw Hill Publishing Co. Ltd.

[R2] J Lewis Blackburn , "Protective Relaying- Principles and Applications", Dekker Publications.

[R3] Prof. Dr S.A. Soman, IIT Mumbai ,A Web course on "Digital Protection of power System" http://www.cdeep.iitb.ac.in/nptel/Electrical%20Engineering/Power%20System %20Protection/Course_home_L27.html

[R4] A.G. Phadke, J.S. Thorp ,Computer relaying for Power System , Research Studies Press LTD, England.(John Willy and Sons Inc New York)

[R5] Mason C.R., "Art and Science of Protective Relaying", Wiley Eastern Limited.

Unit	Text Books	Reference Books
1	T1,T2,T4	R1,R2
2	T1,T3,T4	R1
3	T1,T4	R1
4	T2,T3,T4	R3,R4
5	T1	R5
6	T1,T4	R2,R5

Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:

1. NPTEL link.

2. www.investopedia.com/terms/w/whitepaper.asp

3. ieeexplore.ieee.org

4.http://www.cdeep.iitb.ac.in/nptel/Electrical%20Engineering/Power%20System%20Protection/Course_home_L27.html

Course Objectives

Course Objectives:

1. Understand construction and working principle of different types of HVCBs

2. Understand the Need of protective Relaying and operating principles of different types of relays.

3. Study different type of faults in transformer, alternator and 3 phase Induction motor and various protective schemes related to them.

4. Learn transmission line protection schemes and characteristics of different types of distance relays

Course Outcomes

After successful completion of the course:

1. Students will be able to explain the need of protective Relaying and operating principles of different types of relays.
2. Students will be able to analyze arc interruption phenomenon and implement protection based on it.
3. Students will be able to summarize construction and working principle of different types of High Voltage Circuit Breakers.
4. Students will be able to explain protection for three phase Induction motor as well as implementation of static and digital relaying.
5. Students will be able to categorize different types of faults in transformer and Alternator and various protective schemes related to them.
6. Students will be able to demonstrate various protection schemes for transmission lines and illustrate PLCC,WAM system.

✓ **Academic Activity Planner**

Units	Unit Test1 (30marks)	Unit Test2 (30marks)	Assignment (Each 10marks)	Industrial Visit/ Workshop
I	✓		✓	✓
II	✓		✓	✓
III	✓		✓	✓
IV		✓	✓	✓
V		✓	✓	✓
VI		✓	✓	✓

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DEPARTMENT OF ELECTRICAL ENGINEERING

Teaching Plan

Teaching plan as per University Syllabus

Sr.No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	I	Fundamentals of protective relaying	10
2	II	Fundamentals of arc interruption:	8
3	III	Circuit Breaker	8
4	IV	A. Protection against overvoltage due to lightning: B. Static & Digital Relaying	8
5	V	A. Transformer Protection B. Alternator Protection C. 3 Phase Induction Motor Protection	12
6	VI	A.Bus Bar Protection B.Transmission line	8

Unit wise Lecture Plan

Unit No.-I: Fundamentals of protective relaying

Pre-requisites:-Concepts of Power system-I & II, Electrical Measurements and instrumentation

Objectives:-

- To understand fundamentals of protective relaying.
- To study the schemes of protective relaying.

Outcomes:

- **Explain** the basic concepts of protective relaying.
- **Analysis** of various schemes of protective relaying.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Need for protective system, nature & causes of fault	T2, T1,R1	Chalk & Talk
2	types of faults, effects of faults	T2, T1,R1	Chalk & Talk
3	evolution of protective relaying	T2, T1,R1	PPT
4	classification of relays, zones of protection	T2, T1,R1	PPT
5	primary and backup protection	T2, T1,R1	PPT
6	essential qualities of protective relaying	T2, T1,R1	Chalk & Talk
7	Trip circuit of circuit breaker	T2, T1,R1	Chalk & Talk
8	Various basic operating principles of protection- over current, (current graded & time graded),directional over current, differential, distance	T2, T1,R1	Chalk & Talk
9	Various basic operating principles of protection- over current, (current graded & time graded),directional over current, differential, distance	T2, T3,R2	PPT
10	current and time setting in induction relay, Numerical on TSM, PSM and operating time of relay	T2, T1,R5	Chalk & Talk
11	Video Lecture	YouTube	Demonstration of relay, Circuit Breaker concept

Question Bank – Unit I

Q.1 Explain classification of relays.
Q.2 Explain zones of protection. Hence explain primary and backup protection.
Q.3 With neat diagram, explain trip circuit of circuit breaker.
Q.4 Classify various induction type of relays and explain any one.
Q.5 Define Plug Setting Multiplier and Time Setting Multiplier for relays.
Q.6 Explain the desirable properties of protection system.
Q.7 Current rating of an over current relay is 5 A. Relay has plug setting of 175%
And time setting of 0.4. C.T ratio is 400:5. Determine operating time of relay for fault current of 6000 A.
At Time Setting Multiplier =1, Operating time at various P.S.M are given as follows:

P.S.M	2	4	5	8	10	20
Operating time	10	5	4	3	2.8	2.4

Unit No.-II: Fundamentals of arc interruption

Pre-requisites:-

Ionization & Material Science basics

Objectives:-

To understand formation of arc between the contacts of C.B.
To explain the methods of arc quenching and definitions.

Outcomes:-After successfully completing this unit students will be able:
To describe the process of arc extinction and derive expressions for RRRV.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Ionization of gases, deionization,	R1,R2, T1	Chalk & Talk
2	Electric arc formation	R1,R2, T1	Chalk & Talk
3	Current interruption in AC circuit breaker,	R1,R2, T1	PPT
4	high & low resistance principles,	R1,R2, T1	PPT
5	arc interruption theories,	R1,R2, T1	PPT
6	arc voltage, recovery voltage, derivation and definition of restriking voltage and RRRV	R1,R2, T1	Chalk & Talk
7	current chopping, interruption of capacitive current	R1,R2, T1	Chalk & Talk
8	resistance switching, Numerical on RRRV, current chopping and resistance switching	R1,R2, T1	Chalk & Talk

Question Bank: Theory

Unit 2:

Q1. Explain the methods of arc interruption.

Q.2 Define following terms.

1. Recovery voltage
2. Restriking voltage
3. RRRV

Q.3 Derive the expression for RRRV.

Q.4 A circuit breaker interrupts magnetizing current of 200 MVA transformer at220 kV. Magnetizing current of transformer is 7% of full load current. If current is interrupted at 61% of its peak value. Find the voltage which appears across the gap. The capacitance is 2700 μF and inductance is 30H.

Q.5 In 165 kV system, the reactance is 9Ω and capacitor of 0.03 μF connected along contacts of circuit breaker. Determine natural frequency of oscillation also find critical value of R which is to be connected so as to be have no transient oscillations.

Q.6. Analyze the equivalent circuit obtained after adding resistance referred as resistance switching.

Q.7. Explain the current chopping phenomenon.

Q.8. What happens when interruption of highly capacitive current takes place? Explain using appropriate illustration.

Unit No.-III: Circuit Breaker

Pre-requisites:-

Basic concepts of AC and DC transmission, various dielectric mediums.

Objectives:-

To explain the construction and working of LT & HT circuit breakers.

Outcomes:-After successfully completing this unit students will be able to:

Understand the working of different LT & HT circuit breakers.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Different ratings of circuit breaker (like rated voltage, rated current, rated frequency	T1, T3, R1	Chalk & Talk
2	rated breaking capacity – symmetrical and unsymmetrical breaking	T1, T3, R1	Chalk & Talk
3	making capacity,	T1, T3, R1	Chalk & Talk
4	Classification of high voltage circuit breaker.	T1, T3, R1	Chalk & Talk
5	Working and constructional features of ACB, advantages & disadvantages, applications.	T1, T3, R1	Chalk & Talk
6	Working and constructional features of SF6 VCB- disadvantages and advantages,	T1, T3, R1	Chalk & Talk
7	Auto reclosing	T1, T3,c	Chalk & Talk
8	Numerical on making and breaking capacities.	T1, R1	Chalk & Talk

Question Bank: Theory

Theory Paper

Unit No.-III

Q1. Explain the classification of Circuit breakers
Q2. What are the properties of SF6 gas?
Q3. With neat diagram explain the construction and working of ACB (Air circuit breaker).
Q4. Explain the VCB (Vacuum Circuit breaker) with a neat diagram.
Q5. Compare various types of circuit breakers on the basis of their utilization.
Q6. Define the following terms w.r.t. circuit breakers: rated voltage, rated current, rated frequency, rated breaking capacity – symmetrical and unsymmetrical breaking, making capacity, rated interrupting duties, rated operating sequence, short time rating.
Q7. Describe SF6 circuit breaker with a neat diagram and list the advantages and disadvantages.
Q8. Describe the concept of auto reclosing in detail.

Unit No.-IV:

A. Protection against overvoltage due to lightning

B. Static & Digital Relaying

Pre-requisites:-

- Basic concepts of generation lightning phenomenon
- Concepts of traditional relays.

Objectives:-

- To understand protection against lightning.
- To learn Static and Digital Relaying.

Outcomes:-After successfully completing this unit students will be able to:

Analyze requirements of protection against Lightning.

Students will also be able to describe the construction and working of Static and Digital relays.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Overview of Static relay, block diagram,	T3, T4, R1, R3	Chalk & Talk
2	Operating principal, merits & demerits of static relay.	T3, T4, R1, R3	Chalk & Talk
3	Numerical Relays :-Introduction, Block diagram of numerical relay, Sampling theorem	T3, T4, R1, R3	Chalk & Talk
4	Anti – Aliasing Filter, Block diagram of PMU	T3, T4, R1, R3	Chalk & Talk
5	Abnormal conditions and causes of failures in 3 phase Induction motor	T3, T4, R1, R3	Chalk & Talk
6	Single phasing protection for I.M.	T3, T4, R1, R3	Chalk & Talk
7	Overload protection, Short circuit protection.	T3, T4, R1, R3	Chalk & Talk

Question Bank: Theory

Unit No.-IV

1) Give the comparison of static, numerical and electromechanical relays.
2) Explain PMU with block diagram.
3) With a neat diagram explain static relays along with their advantages and disadvantages.
4) With a neat diagram explain numerical relays along with their advantages and disadvantages.
5) Explain wide area measurement.
6) What is Aliasing? Hence explain Anti-aliasing filter.
7) Explain PMU with a neat diagram.
8) What happens if sampling frequency is not taken as per sampling theorem?

Unit No.-V:

A) Transformer Protection

B) Alternator Protection

C) 3 Phase Induction Motor Protection

Pre-requisites:-Basics of Electrical Machines.

Objectives:-

To understand protection of transformer, alternator and 3phase Induction Motor.

Outcomes:-After successfully completing this unit students will be able to:

Design protective schemes for protection of equipments like Transformer, Alternator & 3phase Induction Motor.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Types of faults in transformer.	T1, T2,R1	Chalk & Talk
2	Percentage differential protection in transformers,	T1,T2,R2	Chalk & Talk
3	Restricted E/F protection	T1, T2,R1	Chalk & Talk
4	Incipient faults, Buchholz relay	T1, T2,R1	Chalk & Talk
5	protection against over fluxing. Protection against inrush current,	T1, T2,R1	Chalk & Talk
6	Various faults in Alternator, abnormal operating conditions-stator faults	T1, T2,R1	Chalk & Talk
7	longitudinal percentage differential scheme and transverse percentage differential scheme.	T1, T2,R1	Chalk & Talk
8	Rotor faults- abnormal operating conditions, inter turn fault, unbalance loading, over speeding, loss of excitation	T1, T2,R1	Chalk & Talk

9	protection against loss of excitation using offset Mho relay, loss of prime mover.	T1, T2,R1	Chalk & Talk
10	Abnormal conditions & causes of failures in 3 phase Induction motor	T1, T2,R1	Chalk & Talk
11	single phasing protection,	T1, T2,R1	Chalk & Talk
12	Overload protection, Short circuit protection.	T1, T2,R1	Chalk & Talk
	Ruberics		

Question Bank: Theory
Unit No.-V

1. What is magnetizing inrush current? Explain protection scheme for the same.
2. A 3phase 11KV/66KV delta star connected transformer is protected by differential protection. The CTs on LV side have ratio 500/1. What should be the current ratio of CTs on HV side & how should they be connected.
3. Explain the transverse protection for alternator.
4. 11KV, 125MVA alternator is grounded through a resistance of 7ohm. The CTs have ratio of 1000/5. The relay is set to operate when there is an out of balance current of 1.5A. What percentage of generator winding will be protected by differential protection scheme?
5. Explain single phasing protection for 3phase Induction motor.
6. Explain merz prize protection for alternator
7. What are incipient faults? Explain the Bucholz relay used for protection against incipient faults.

Unit No.-VI:

A) Bus bar Protection

B) Transmission line

Pre-requisites:-

Basic concepts of power transmission & distribution.

Objectives: -To enable candidate to study regarding protective schemes for bus bars and transmission lines.

Outcomes:-After successfully completing this unit, students will be able to:

Suggest the methods of Bus bar and Transmission line protection.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Differential protection of bus bars.	T1, T3, R1	Chalk & Talk
2	Selection of C.T. ratios for bus bar protection	T1, T3, R1	Chalk & Talk
3	High impedance differential relay	T1, T3, R1	Chalk & Talk
4	over current protection for feeder using directional &non-directional overcurrent relays	T1, T3, R1	Chalk & Talk
5	Introduction to distance protection, impedance relay,	T1, T3, R1	Chalk & Talk
6	reactance relay, mho relay & Quadrilateral Relays	T1, T3, R1	Chalk & Talk
7	Introduction to PLCC, block diagram, advantages, disadvantages, three stepped distance protection	T1, T3, R1	Chalk & Talk
8	Effect of arc resistance, and power swing on performance of distance relay.	T1, T3, R1	Chalk & Talk
9	Realisation of distance relays (impedance , reactance, & mho relay) using numerical relaying algorithm	T1, T3, R1	Chalk & Talk
10	Introduction to Wide Area Measurement (WAM) system	T1, T3, R1	Chalk & Talk

Question Bank: Theory

Theory Paper

1. Explain the effect of arc resistance on the performance of distance relay.
2. Describe wide area measurement with a neat block diagram.
3. Explain any one type of relay used for distance protection.
4. Explain the method of selection of CT ratios for differential protection of busbars
5. Explain the effect of power swing on performance of distance relays.
6. Compare all the distance relays.
7. Which type of protection is used for busbars and why?
8. Explain earth fault relay and restricted earth fault protection.
9. Explain directional relays with neat diagram

List of Text books and Reference books

T1	S. Rao, "Switchgear Protection & Power Systems", Khanna Publications
T2	Y. G. Paithankar, S. R. Bhide, "Fundamentals of Power System Protection", Prentice Hall of India
T3	Bhavesh Bhalja, R.P. Maheshwari, N.G. Chothani," Protection and Switchgear", Oxford University Press, 2011 Edition.
R1	Badri Ram, D. N. Vishwakarma, "Power System Protection & Switchgear", Tata McGraw Hill Publishing Co. Ltd.
R2	J. Lewis Blackburn , Thomas J. Domin, "Protective Relaying: Principles and Applications", Fourth Edition, CRC Press.
R3	Prof. Dr S.A. Soman, IIT Mumbai , A Web course on "Digital Protection of power System" http://www.cdeep.iitb.ac.in/nptel/Electrical%20Engineering/Power%20System%20Protection/Course_home_L27.html
R4	A.G. Phadke and J.S. Thorp , Computer relaying for Power System, Research Studies Press LTD, England.(John Willy & Sons Inc New York)
R5	Crussel Mason, "The Art and Science of Protective Relaying", Wiley Eastern Limited

Practical Assessment

List of Experiments

Sr. No.	Name of the Practical
1.	Study of switchgear testing kit
2.	Study of Fuse, MCB & their testing.
3.	Study and testing of contactors
4.	Study and testing of MCCB
5.	Study and testing of ACB
6.	Study and testing of thermal overload relay for Induction Motor protection
7.	Study and plotting Characteristics of IDMT type Induction over current relay
8.	Study and plotting Characteristics of digital over current relay
9.	Percentage differential protection of transformer
10.	Protection of alternator
11.	Protection of Transmission line using Impedance relay
12.	Study of various LT switchgears like RCCB, timers

POWER ELECTRONIC CONTROLLED DRIVES

Name of the Subject – Power Electronic Controlled Drives

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	4	-	2

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	50	-	25	175	-

.

Syllabus:

403148: Power Electronic Controlled Drives

Teaching Scheme		**Examination Scheme**	
Lectures	**04 hrs/week**	**In-Sem Assessment**	**30**
Practical	**02 hrs/week**	**End-Sem Assessment**	**70**
Practical		**50**	
TW		**25**	

Prerequisites:

1. Construction, working and characteristic of different electrical motors
2. Power Electronic Applications such as converter, inverter, chopper etc.
3. Basic concept of control system

Course Objectives: The course aims to

- To understand motor load dynamics.·
- To study and analyze the operation of the converter fed and chopper fed dc drives.
- ·To study and understand braking methods of D.C. and Induction motor drive.·
- To study vector control of induction motor.·
- To study synchronous and BLDC motor drive.·
- To study classes and duty of motor.·
- To understands the modes of operation of drive in various applications

Unit 01: Electrical Drives (8 hrs)

A. Definition, Advantages of electrical drives, Components of Electric drive system, Selection Factors, Types of Electrical Drives (DC & AC).

B. Motor-Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters. Load Torque Components, Nature and classification of Load Torques, Constant Power operation of a Drive. Steady state stability, Numerical based on motor load dynamics

Unit 02: DC Motor Drives (8 hrs)

A. Braking methods: Rheostatic, Plugging, and Regenerative. Closed loop control of drives: current limit control, torque control and speed control.

B. Single phase and three phases fully controlled converter drives and performance of converter fed separately excited DC Motor for starting and speed control operations. Chopper controlled drives for separately excited and series DC Motor operations. Numerical based on above. Closed loop speed control of DC motor below and above base speed.

Unit 03: Induction Motor Drives-I (8 hrs)

Braking methods: DC Dynamic Braking, AC Rheostatic braking, Plugging, Regenerative Braking, V/f control and comparison with stator voltage control, voltage source inverter (VSI) control, Steady State Analysis. Current source inverter (CSI) control-open and closed loop, Regenerative braking and multiquadrant operation of Induction motor drives, relative merits and demerits of VSI and CSI for induction motor drives,Numerical on VSI and CSI fed I.M. drives

Unit 04: Induction Motor Drives-II (8 hrs)

A. Principle of vector control, Block diagram of Vector control of induction motor. Servo mechanism in drives and block diagram for position control(Descriptive treatment only).

B. Thermal model of motor for heating and cooling ,classes of motor duty, types of enclosures for motor

Unit 05: Synchronous motor Drives **(8 hrs)**

Types of motor, cylindrical rotor wound field motor, equivalent circuit, speed torque characteristics and effect of power factor, salient pole wound field motor, phasor diagram, simple numerical based on above, closed loop speed control of self-controlled synchronous motor drives fed from VSI and CSI. BLDC drives, block diagram and speed torque characteristics.

Unit 06: Industrial application **(8 hrs)**

A. Specific requirement and choice of drives for following applications.1. Machine tools2. Textile mills3. Steel rolling mills3. Sugar mills4. Traction drives5. Crane and hoist drives6. Solar and battery powered drives

Text Books:

1. G. K. Dubey, “Fundamentals of Electric Drives”, 2nd Edition, Narosa Publishing House
2. N. K. De, P. K. Sen, “Electric Drives”, Prentice Hall of India Eastern Economy Edition
3. S. K. Pillai, “Analysis of Thyristor Power Conditioned Motors”, University Press
4. R. Krishnan, “Electric Motor Drives – Modeling Analysis and Control”, PHI India
5. G.K. Dubey, “Power Semiconductor controlled drives”, PHI publication

References:

1. B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education
2. Malcolm Barnes, “Practical Variable Speed Drives and Power Electronics”, Elsevier Newnes Publications
3. V. Subrahmanyam, “Electric Drives: Concepts & Application”, Tata Mc-Graw Hill (An imprint of Elsevier)
4. M.D. Singh and Khanchandani “Power Electronics”, Tata Mc-Graw Hill
5. Austin Huges, “Electrical motor and drives: Fundamental, types and applications”, Heinemann Newnes, London

Reference web links/ research paper/ referred book other than mention in syllabus:

1. P. R. Joshi and G. K. Dubey, "Optimum DC Dynamic Braking Control of an Induction Motor Using Thyristor Chopper Controlled Resistance," in *IEEE Transactions on Industrial Electronics and Control Instrumentation*, vol. IECI-21, no. 2, pp. 60-65, May 1974.

2. R. M. Rezeck, A. J. J. Rezek, A. T. L. de Almeida, R. Di Lorenzo Corrêa, V. F. da Silva and P. F. Ribeiro, "A controlled dynamic braking of a separate excitation DC machine," *2015 IEEE 13th Brazilian Power Electronics Conference and 1st Southern Power Electronics Conference (COBEP/SPEC)*, Fortaleza, 2015, pp. 1-6.

Course Objectives

The course aims to·

- To understand motor load dynamics.
- To study and analyze the operation of the converter fed and chopper fed dc drives.
- To study and understand braking methods of D.C. and Induction motor drive.
- To study vector control of induction motor.
- To study synchronous and BLDC motor drive.
- To study classes and duty of motor.
- To understands the modes of operation of drive in various applications

Course Outcomes

Upon successful completion of this course,

CO1. Students will be able to understand motor load dynamics and multi quadrant operation of drives.
CO2. Students will be able to analyze operation of converter fed and chopper fed DC drives
CO3. Students will be able to understand braking of DC motors and three phase induction motor drives
CO4. Students will be able to analyze inverter fed induction motor drives and understand vector control of induction motor drives
CO5. Students will be able to understand synchronous motor and BLDC(Brushless DC) motor drives
CO6. Students will be able to understand classes and duty cycle of motor and applications of drives in industries.

PROGRESSIVE EDUCATION SOCIETY'S

MODERN COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING

Academic Activity Planner

Units	Unit Test1 (10 Marks) CO1	Unit Test2 (10 Marks) CO2	Assignment(Simulation Problem Statement (10 Marks) CO3	Assignment (10 Marks) CO4	Assignment (Simulation Problem Statement (10marks) CO5	Assignment (10 Marks) CO6
1	✓					
2		✓				
3			✓			
4				✓		
5					✓	
6						✓

Teaching plan as per University Syllabus

Sr. No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	**I**	Electrical Drives	8 hrs
2	**II**	DC Motor Drives	8 hrs
3	**III**	Induction Motor Drives-I	8 hrs
4	**IV**	Induction Motor Drives-II	8 hrs
5	**V**	Synchronous motor Drives	8 hrs
6	**VI**	Industrial Applications	8 hrs

Unit wise Lecture Plan

Unit No.-I: Electrical Drives

Pre-requisites:
Basics of electrical drives, basic operation and types of electrical drives.

Objectives: To understand the basic operation of electrical drives and types of electrical drives along with the advantages.

Outcomes: Students will be able to apply the knowledge of power electronics and fundamental of electrical drives.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Definition, Advantages of electrical drives, Components of Electric drive system	T1	Chalk & Board
2	Selection Factors, Types of Electrical Drives (DC & AC).	T1	Chalk & Board
3	Motor-Load Dynamics, Speed Torque conventions and multi quadrant operation	T2,T3	Chalk & Board
4	Equivalent values of drive parameters. Load Torque Components	T2,T3	Chalk & Board
5	Nature and classification of Load Torques	T1,T2,T3	Chalk & Board
6	Constant Power operation of a Drive.	T2,T3	Chalk & Board
7	Steady state stability, Numericals	T1,T2,T3	Chalk & Board
8	Numericals	T1,T2,T3	Chalk & Board

Question Bank – Unit I

1. Explain speed torque conventions and multi quadrant operation of drives.
2. What is an electric drives? Discuss, essential parts of Electric Drive with the help of a Block diagram.
3. Write a brief note no, speed torque characteristics of Drive operated in all four quadrants. Use the example of hoist load.
4. Define electric Drives & Write all basic elements of electric drives
5. Write the functions of power modulators.
6. What are the types of electric Drives? Define individual drive, group drive, multi motor drive.
7. Mention the different types of classes of duty.
8. What are the main factors influencing to select the electric drives for particular applications?
9. What are the applications of electrical drives?
10. What is meant by overload current capacity of motor?
11. Define continuous rating of a motor. Continuous rating of a motor is denotes operation at constant load of sufficient duration
12. Compare AC and DC drives.DC drives

Unit No.-II: DC Motor Drives

Pre-requisites:

- Starting and braking methods, 1 phase &3 phases fully controlled converter drives.

Objectives:

- To understand the stable steady-state operation and transient dynamics of a motor-load system.
- To study and analyze the operation of the converter, chopper fed dc drive.

Outcomes: Students will be able to analyze operation of converter fed and chopper fed dc drives.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Starting and braking methods	T1, R1	Chalk & Board
2	Characteristics of DC Motors: Rheostatic, Plugging,.	T2,R3	Chalk & Board
3	Characteristics of DC Motors: Regenerative.	T1,T2,T3,R3,R1	Chalk & Board
4	Single phase and three phases fully controlled converter drives and performance of converter fed separately excited DC Motor for starting and speed control operations.	T1,T2,T3,R3,R1	Chalk & Board
5	Single phase and three phases fully controlled converter drives and performance of converter fed separately excited DC Motor for starting and speed control operations.	T1,T2,T3,R3,R1	Chalk & Board
6	Chopper controlled drives for separately excited and series DC Motor operations	T1,T2,T3,R3,R1	Chalk & Board
7	Closed loop speed control of DC motor below and above base speed.	T1,T2,T3,R3,R1	Chalk & Board
8	Numericals	T1,T2,T3	Chalk & Board

Question Bank – Unit II

1. What are the different Starting and braking methods.
2. Explain the Characteristics of DC Motors: Rheostatic, Plugging, and Regenerative.
3. Explain Single phase and three phases fully controlled converter drives.
4. Explain the performance of converter fed separately excited DC Motor for starting and speed control operations.
5. Explain the Chopper controlled drives for separately excited and series DC Motor operations
6. Explain Closed loop speed control of DC motor below and above base speed.

Unit No.-III: Induction Motor Drives-I

Pre-requisites: operation of induction motor drives

Objectives:

- To study and understand the operation of both classical induction motor drives.

Outcomes:

- Students will be able to analyze operation of classical and modern induction motor drives.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	DC Dynamic Braking	T1,T2,T3,T4,R1,R3	Chalk & Board
2	Plugging, Regenerative Braking	T1,T2,T3,T4,R1,R3	Chalk & Board
3	AC Rheostatic braking, motor braking methods using static devices	T1,T2,T3,T4,R1,R3	Chalk & Board
4	V/f control and comparison with stator voltage control,	T1,T2,T3,T4,R1,R3	Chalk & Board
5	Voltage source inverter (VSI) control, Steady State Analysis.	T1,T2,T3,T4,R1,R3	Chalk & Board
6	Current source inverter (CSI) control-open and closed loop,	T1,T2,T3,T4,R1,R3	Chalk & Board
7	Regenerative braking and multiquadrant operation of Induction motor drives, relative merits and demerits of VSI and CSI for induction motor drives	T1,T2,T3,T4,R1,R3	Chalk & Board
8	Numerical on VSI and CSI fed I.M. drive	T1,T2,T3,T4,R1,R3	Chalk & Board

Question Bank – Unit III

1. What is DC Dynamic Braking
2. Explain the phenomenon of Plugging, Regenerative Braking
3. Explain AC Rheostatic braking using static devices
4. Explain motor braking methods using static devices
5. Explain Closed loop control of drives: current limit control, torque control and speed control
6. What is Thyristorised stator voltage control (using ac regulators, for fixed frequency variable voltage control), Explain in brief.
7. Explain V/f control of AC drives.
8. Explain voltage source inverter (VSI) control,
9. Explain Steady State Analysis.
10. What is Current source inverter (CSI) control-open and closed loop, Explain in brief.
11. Explain regenerative braking of Induction motor drives
12. Expalin the multi quadrant operation of Induction motor drives
13. What are the relative merits and demerits of VSI and CSI for induction motor drives. Compare them.

Unit No.-IV: Induction Motor Drives-II

Pre-requisites:

Operation of both classical and modern induction motor drives

Objectives:

- To study and understand the operation of both classical and modern induction motor drives.

Outcomes:

- Students will be able to design current and speed controller for solid state controlled PMSM and BLDC drives.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Principle of vector control	T1,T2,T3,T4,R1,R3	Chalk & Board
2	Block diagram of Vector control of induction motor.	T1,T2,T3,T4,R1,R3	Chalk & Board
3	Servo mechanism in drives and block diagram for position control(Descriptive treatment only)	T1,T2,T3,T4,R1,R3	Chalk & Board
4	Servo mechanism in drives and block diagram for position control(Descriptive treatment only)	T1,T2,T3,T4,R1,R3	Chalk & Board
5	Thermal model of motor for heating and cooling ,	T1,T2,T3,T4,R1,R3	Chalk & Board
6	classes of motor duty,	T1,T2,T3,T4,R1,R3	Chalk & Board
7	Types of enclosures for motor.	T1,T2,T3,T4,R1,R3	Chalk & Board
8	Numericals	T1,T2,T3,T4,R1,R3	Chalk & Board

Question Bank – Unit IV

1. What is Principle of vector control, Explain Vector control of induction motor.
2. Explain the functions of Commentator less DC Motor (How Induction Motor is converted to Characteristics of DC Motor)
3. Explain AC Servo Drives.
4. Write a detail note on Thermal model of motor for heating and cooling .
5. Explain classes of motor duty.
6. List out types of enclosures for motor.

Unit No.-V: Synchronous motor Drives

Pre-requisites: PMSM and BLDC drives operation

Objectives:

- To study and analyze the operation of PMSM and BLDC drives.

Outcomes:

- Students will be able to select the drive for any particular application.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Types of motor, cylindrical rotor wound field motor,	T1,T4,R1	Chalk & Board
2	Equivalent circuit, speed torque characteristics	T1,T4,R1	Chalk & Board
3	effect of power factor, salient pole wound field motor	T1,T4,R1	Chalk & Board
4	phasor diagram, simple numerical based on above,	T1,T4,R1	Chalk & Board
5	closed loop speed control of self-controlled synchronous motor drives fed from VSI and CSI	T1,T4,R1	Chalk & Board
6	BLDC drives, block diagram	T1,T4,R1	Chalk & Board
7	speed torque characteristics	T1,T4,R1	Chalk & Board
8	Design of current and speed controller	T1,T4,R1	Chalk & Board

Question Bank – Unit V

1. Explain the Permanent Magnet Synchronous Motor Drive, with diagram.
2. Explain the Control Strategies, constant torque angle control Permanent Magnet Synchronous Motor Drive
3. What is unity power factor control, Explain the Speed controller design of PMSM.
4. What is Permanent Magnet Brushless DC Motor Drive, Explain in brief.
5. Explain Half Wave drives
6. Explain Sensor less control
7. Explain the Design of current and speed controller.
8. Explain block diagram of BLDC motor drive, draw its speed torque characteristics and list out its applications.

Unit No.-VI: Industrial Applications

Pre-requisites: Analysis and design of the current and speed controllers for different drives.

Objectives:

- To analyze and design the current and speed controllers for different drives

Outcomes:

- Students will be able to acquire and practice the knowledge of braking used in dc drives and Induction motor drives

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Drive Selection: Selection criteria of motors, motor duties	T1,T2,T3,R3	Chalk & Board
2	Specific requirement and choice of drives for following applications. Machine tools	T1,T2,T3,R3	Chalk & Board
3	Textile mills	T1,T2,T3,R3	Chalk & Board
4	Steel rolling mills	T1,T2,T3,R3	Chalk & Board
5	Sugar Mills	T1,T2,T3,R3	Chalk & Board
6	Traction drives	T1,T2,T3,R3	Chalk & Board
7	Crane and hoist drives	T1,T2,T3,R3	Chalk & Board
8	Solar and battery powered drives	T1,T2,T3,R3	Chalk & Board

Question Bank – Unit VI

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1) What are the Industrial Applications, Process/operation—Requirements of load—Suitable Drive—Advantages
2) Explain the industrial applications of electrical drives in
    a. Rolling mills
    b. Machine tools
    c. Textile mills
    d. Sugar Mills
    e. Centrifuged Pump
    f. Traction drives
    g. Aeronautic applications
    h. Electric and Hybrid Vehicle
    i. Solar Pumps

Practical Assessment

List of Experiments

Sr. No.	Name of Experiments
1	Study of Electrical braking of D.C. Shunt motor (Rheostatic, Plugging).
2	Study of Chopper fed D.C. series/separately motor speed control characteristics.
3	Study of electrical braking of 3 phase Induction Motor (DC dynamic, Plugging)
4	Study of VSI fed 3 phase Induction Motor (using V/f control PWM inverter) speed control characteristics.
5	Study of Solid state stator voltage control of 3 phase Induction Motor (Using AC voltage Regulator).
6	Simulation of starting characteristics of D.C. motor.
7	Simulation of starting characteristics of 3-phase Induction Motor
8	Simulation of chopper controlled DC series motor.
9	Simulation of BLDC Motor (Beyond Syllabus)

HIGH VOLTAGE ENGINEERING

Name of the Subject –Elective –III : High Voltage Engineering Code: 403149

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	03	-	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	25	25	150	

Syllabus:

Unit 01: Breakdown in Gases:

Ionization process in gas, Townsend's Theory, current growth equation in presence of primary and secondary ionization processes, Townsend's breakdown criterion, primary and secondary ionization coefficients, limitations of Townsend's theory, Streamer mechanism of breakdown, Paschen's Law and its limitations, Corona discharges for point plane electrode combination with positive and negative pulse application, time lag for and factors on which time lag depends. (Numerical on Townsend's theory and Paschen's law).

Unit 02

1. Breakdown in Liquid Dielectrics: Pure and commercial liquids, Different breakdown theories: Breakdown in Pure liquid and breakdown in commercial liquids: Suspended Particle theory, Cavitations and bubble theory, Thermal mechanism of breakdown and Stressed Oil volume theory.

2. **Breakdown in Solid Dielectrics:** Intrinsic breakdown: electronic breakdown, avalanche or streamer breakdown, electromechanical breakdown, thermal breakdown, treeing and tracking phenomenon, Chemical and electrochemical breakdown, Partial discharge(Internal discharge),Composite dielectric material, Properties of composite dielectrics, breakdown in composite dielectrics.

(Numerical on theories of liquid and solid dielectric materials)

Unit 03

Generation of High Voltages and Current:

a) Generation of high ac voltages-Cascading of transformers, series and parallel resonance system, Tesla coil

b) Generation of impulse voltages and current-Impulse voltage definition, wave front and wave tail time, Multistage impulse generator, Modified Marx circuit, Tripping and control of impulse generators, Generation of high impulse current

Unit 04

Measurement of High Voltage and High Currents:

Sphere gap voltmeter, electrostatic volt meter, generating voltmeter, peak reading voltmeter, resistive, capacitive and mixed potential divider , capacitance voltage transformer, cathode ray oscilloscope for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements. Measurement of high power frequency a.c using current transformer with electro-optical signal converter, Radio interference measurements.

Unit 05

Lightning and Switching Over Voltages:

Causes of over voltages, lightning phenomenon, Different types of lightening strokes and mechanisms of lightening strokes, Charge separation theories, Wilson theory, Simpson theory, Reynolds and Mason theory, Over voltage due to switching surges and methods to minimize switching surges. Statistical approach of insulation coordination.

Unit 06

High Voltage Testing of Electrical Apparatus and H V Laboratories:

A) Testing of insulators and bushings, Power capacitors and cables testing, testing of surge arresters.

B) Design, planning and layout of High Voltage laboratory:-Classification and layouts, earthing and shielding of H.V. laboratories.

Text Books:

1. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers Ltd.
2. M. S. Naidu, V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill Publication Co. Ltd. New Delhi

Reference Books:

1. E. Kuffel, W. S. Zaengl, J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication
2. Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia, "High Voltage Engineering", Khanna Publishers, New Delhi
3. Ravindra Arora, Wolf Gang Mosch, "High Voltage Insulation Engineering", New Age International Publishers Ltd. Wiley Estern Ltd.
4. High Voltage Engineering Theory and Practice by M. Khalifa Marcel Dekker Inc. New York and Basel.
5. Subir Ray, "An Introduction to High voltage Engineering" PHI Pvt. Ltd. New Delhi

IS/IEEE Standards:

Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:

Prerequisite:
Students should have knowledge of various classes of materials like solid, liquid, gaseous, conducting, insulating and resistive along with their basic characteristics.

Course Objective:

1) To make students able to explain the various breakdown processes in solid, liquid and gaseous materials and describe Lightning phenomenon, natural cause of overvoltage in detail with formation of charge in clouds.
2) To provide sound knowledge of Testing, Generation & measurement methods of DC, AC and impulse voltages and current.
3) To develop ability to carry out various testing procedures as per IS in laboratory with knowledge of earthing, safety and shielding of HV laboratory.

Course Outcomes:

Upon successful completion of this course, the students will be able to:-

CO1. Students will be able to utilize various concept of breakdown phenomenon of gaseous dielectric materials.
CO2. Students will be able to identify various concept of breakdown phenomenon in liquid & solid dielectric materials.
CO3. Student will be able to list and categorize various methods of generation of High AC, DC and Impulse voltage.
CO4. Students will be able to distinguish various methods of measurement of High AC, DC and Impulse voltage.
CO5. Students will be able to apply concepts of various causes of overvoltage & select protective devices for the same.
CO6. Students will be able to build high voltage laboratory and demonstrate various test on high voltage equipment's.

✓ **Academic Activity Planner**

Units	Unit Test1 (20marks)	Unit Test2 (10marks)	OBT (20marks)	Unit Test3(70marks)
	U1	U2,U3	U5,U6	U123456
1	✓			✓
2	✓			✓
3		✓		✓
4			✓	✓
5			✓	✓
6			✓	✓

Teaching Plan:
Teaching plan as per University Syllabus

Sr.No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	I	Breakdown in Gases:	8 Hrs
2	II	Breakdown in Liquid Dielectrics Breakdown in Solid Dielectrics:	8 Hrs
3	III	Generation of High Voltages and Current:	8 Hrs
4	IV	Measurement of High Voltage and High Currents	8 Hrs
5	V	Lightning and Switching Over Voltages:	8 Hrs
6	VI	High Voltage Testing of Electrical Apparatus and H V Laboratories:	8 Hrs

Unit wise Lecture Plan

Unit No.-I: Breakdown in Gases:

Pre-requisites:- Students should have knowledge of various basic classifications of gases.
Objectives:-

- ✓ To understand ionization process in Gases

Outcomes:-
Upon successful completion of this course, the students will be able to :-

- ✓ To explain ionization process in Gases

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Ionization process in gas, ,	T1, T2, R5	Chalk & Talk
2	Townsend's Theory, current growth equation in presence of primary ionization coefficients,		Chalk & Talk
3	current growth equation in presence of secondary ionization coefficients, limitations of Townsend's theory,		Chalk & Talk
4	Streamer mechanism of breakdown,		Chalk & Talk
5	Paschen's Law and its limitations		Chalk & Talk
6	Corona discharges for point plane electrode combination with positive and negative pulse application		Chalk & Talk
7	time lag for and factors on which time lag depends.		Chalk & Talk
8	Numerical on Townsend's theory and Paschen's law.		Chalk & Talk

Question Bank: Theory

Unit :I

1. State and explain Townsend's first ionization coefficient.
2. Write short note on Townsend's breakdown criterion.
3. What do you mean by time lag?
   What are the factors which affects time lag?
4. Explain corona discharge.
5. Compare Between
   1) Uniform and Non-uniform field.
   2) Positive and Negative corona.

Unit No.-II: Breakdown in Liquid Dielectrics & Breakdown in Solid Dielectrics

Pre-requisites:- Students should have knowledge of different types of liquid & solid dielectric materials .

Objectives:- To understand breakdown process of different liquid & solid dielectric materials .

Outcomes:-After successfully completing this unit students will be able:

To explain breakdown process of different liquid & solid dielectric materials.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**1. Breakdown in Liquid Dielectrics:** Pure and commercial liquids, Different breakdown theories: Breakdown in Pure liquid 2.	**T1, T2**	Power Point Presentation
2	breakdown in commercial liquids: Suspended Particle theory, Cavitations and bubble theory,		
3	Thermal mechanism of breakdown and Stressed Oil volume theory.		
4	**Breakdown in Solid Dielectrics:** Intrinsic breakdown: electronic breakdown		Power Point Presentation
5	avalanche or streamer breakdown, electromechanical breakdown, thermal breakdown,		
6	treeing and tracking phenomenon, Chemical and electrochemical breakdown,		
7	Partial discharge (Internal discharge),		
8	Composite dielectric material, Properties of composite dielectrics,		
9	breakdown in composite dielectrics. (Numerical on theories of liquid and solid dielectric materials)		Chalk & Talk

Question Bank: Theory

Unit 2: Breakdown in Liquid Dielectrics & Breakdown in Solid Dielectrics

1. Explain:
   i. Cavitation and bubble theory.
   ii. Stressed oil volume theory.
   iii. Suspended particle theory
2. Explain properties of good transformer oil and its applications.
3. Explain treeing and tracking phenomenon.
4. Explain thermal breakdown process in case of solid insulating materials.
5. Explain properties of composite dielectric and state breakdown mechanism in composite dielectric.

Unit No.-III: Generation of High Voltages and Current:

Pre-requisites:- Students should have knowledge of basic circuits of HV & high current generation.
Objectives:- To learn new methods of HV & high current generation.

Outcomes:-After successfully completing this unit students will be able to:
To select method for HV & high current generation

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**Generation of High Voltages and Current:** a) Generation of high ac voltages-Cascading of transformers,	T1, T2	Chalk & Talk
2	series and parallel resonance system,		Chalk & Talk
3	Tesla coil		Chalk & Talk
4	b) Generation of impulse voltages and current-Impulse voltage definition, wave front and wave tail time,		Chalk & Talk
5	Generation of impulse current		Chalk & Talk
6	Multistage impulse generator,		Chalk & Talk
7	Modified Marx circuit,		Chalk & Talk
8	Tripping and control of impulse generators,		Chalk & Talk
9	Generation of high impulse current		Chalk & Talk

Question Bank: Theory

Unit 03: Generation of High Voltages and Current:

1. Explain principle of operation of multistageimpulse generator & describe any one tripping method.
2. With neat sketch explain Van- de- Graff generator.
3. Describe cascading transformer. What is its use?State its merits & demerits.

Unit No.-IV: Measurement of High Voltage and High Currents:

Pre-requisites:-. Students should have knowledge of methods of current & voltage measurement.
Objectives:- To learn different methods of HV & high current measurement.

Outcomes:-After successfully completing this unit students will be able to:

To select different methods of HV & high current measurement.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**Measurement of High Voltage and High Currents:** Sphere gap voltmeter	T1, T2	Chalk & Talk
2	electrostatic volt meter, generating voltmeter, peak reading voltmeter		Chalk & Talk
3	resistive, capacitive and mixed potential divider, capacitance voltage transformer		Chalk & Talk
4	cathode ray oscilloscope for impulse voltage and current measurement,		Chalk & Talk
5	measurement of dielectric constant and loss factor,		Chalk & Talk
6	partial discharge measurements		Chalk & Talk
7	Measurement of high power frequency a.c using current transformer with electro-optical signal converter,		Chalk & Talk
8	Radio interference measurements.		Chalk & Talk

Question Bank:

Unit 04 : Measurement of High Voltage and High Currents:

1. Describe any one method of impulse current measurement.
2. Explain in detail electrostatic volymeter with neat diagram.
3. Explain method of using sphere gap for measurement of High Voltage.
4. Write short note on :
   i. RI measurement.
   ii. Parcial Discharge measurement

Unit No.-V: Lightning and Switching Over Voltages:

Pre-requisites :- Students should have lightening basics & ligntening arrestors
Objectives :- To find causes of over voltages, lightning phenomenon, overvoltages.

Outcomes:-After successfully completing this unit students will be able to:

To select lightening arrester for diffrerent location.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**Lightning and Switching Over Voltages:** Causes of over voltages, lightning phenomenon,	**T1, T2**	Power Point Presentation
2	Charge separation theories	**T1, T2**	Chalk & Talk
3	Different types of lightening strokes and mechanisms of lightening, strokes	**T1, T2**	Power Point Presentation
4	Wilson theory, Simpson theory,	**T1, T2**	
5	Reynolds and Mason theory,	**T1, T2**	
6	Over voltage due to switching surges	**T1, T2**	
7	methods to minimize switching surges.	**T1, T2**	
8	Statistical approach of insulation coordination	**T1, T2**	Chalk & Talk

Question Bank: Theory

Unit 5: Lightning and Switching Over Voltages

1. Explain in detail Reynold's and Mason's theory of charge formation in clouds.
2. Compare:
   1) Simpson and Wilson theory of charge formation in clouds.
   2) Horn gap LA with ZnO metal oxide LA
   3) Gap and gapless arrestor.
3. Explain various reasons for over voltage.
4. Explain remedial actions for switching surges.

Unit No.-VI: High Voltage Testing of Electrical Apparatus and H V Laboratories

Pre-requisites:- Students should have knowledge various basic tests on equipment.

Objectives: - To develop ability to test different equipment as per IS.

Outcomes:-After successfully completing this unit, students will be able to:

To develop ability to test different equipment as per IS in HV lab.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	**High Voltage Testing of Electrical Apparatus and H V Laboratories:** A) Testing of insulators and bushings, testing,	T1, T2,R5	Power Point Presentation
2	Testing of Power capacitors and cables		
3	Testing of surge arresters		
4	B) Design, of High Voltage laboratory:- earthing and		
5	planning and layout of High Voltage laboratory,		
6	shielding of H.V. laboratories.		

Question Bank: Theory

Unit 6: High Voltage Testing of Electrical Apparatus and H V Laboratories:

1. Describe any three tests conducted on bushings.
2. State & explain classification of H.V. Laboratories.
3. Describe any one method of Partial Discharge measurement.
4. Write down specific characterictics of C.R.O. used for impulse voltage measurement.
5. With neat sketch describe electrostatic voltmeter with its advantages & disadvantages.
6. Describe any three tests conducted on insulator
7. Write short note on:

i. Grounding
ii. Earthing
iii. Fencing
iv. Shielding Of High Voltage laboratory.

Practical Assessment
List of Experiments

Sr.No.	Name of the Practical
1	To perform breakdown test on transformer oil and obtain constants of breakdown voltage equation and breakdown strength
2	Measurement of unknown high A.C. voltage using sphere gap
3	To obtain breakdown strength of composite insulation system
4	Study of uniform and non uniform field in breakdown strength of air insulation system
5	To study surface flashover on corrugated porcelain/polymeric insulation system.
6	To perform experiment on horn gap arrestor and understand arc quenching phenomenon
7	To observe development of tracks and trees on polymeric insulation system
8	To Study effect of barrier on breakdown voltage of transformer oil.

HVDC AND FACTS

Name of the Subject – (403149-B) HVDC and FACTS

Weekly Work Load (in Hrs)	Lecture	Tutorial	Practical
	03	-	02

Online/ In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	25	25	150	03, 01

Syllabus:

Unit 01: General back ground (6 hrs)

EHVAC versus HVDC transmission, power flow through HVDC link, Graetz circuit, equation for HVDC power flow bridge connection, control of DC voltage and power flow, effects of angle of delay and angle of advance commutation, CIA, CC and CEA control.

Unit02: Multi terminal HVDC system (6 hrs)

Twelve pulse converter operation, Harmonics in HVDC systems. HVDC system layout and placement of components, HVDC protection, grounding, multi terminal HVDC systems, configurations and types.

Unit 03: HVDC Light (6 hrs)

Introduction to VSC transmission, power transfer characteristics, structure of VSC link, VSC DC system control, HVDC light technology. HVDC plus, introduction, construction, operation and applications to renewable energy sources

Unit 04: Power Electronic Controllers (6 hrs)

Basics, Challenges and needs, Review of rectifiers and inverters, back to back converter, dc link converter, static Power converter structures, AC controller based structures, DC link converter topologies, converter output and harmonic control, power converter control.

Unit05: Shunt and series compensation (6 hrs)

Operation and control of SVC, STATCOM configuration and control, applications of SVC and STATCOM. TCSC operation, layout and operation, static Synchronous series compensator (SSSC).

Unit 06: Unified Power Flow Controller (6 hrs)

UPFC configuration, steady state operation control and characteristics, operational constraints of UPFC, Power flow studies in UPFC embedded systems.

Text Books:

T-1. E. Acha, V.A. Agelidis, O.Anaya-lara and TJE Miller, "Power Electronic control in Electrical Systems" Newnes, Oxford.

T-2. J. Arrillaga, "High Voltage Direct Current Transmission" Peter Peregrinus Ltd., London,UK.

T-3. N.G. Hingorani and L.Gyugi, "Understanding FACTS" IEEE Press[Indian Edition], New York.

T-4. J. Arrillaga, Y.H.Liu and N.R.Watson, "Flexible Power Transmission The HVDC Options",John Wiley and sons Ltd., New York.

T-5. Erich Uhlmann, "Power Transmission by Direct Current" Springer International.

Reference books:

R-1. Yong Hua Song and Allan T Johns, "Flexible ac transmission systems(FACTS), Published by The Institution of Electrical Engineers, London.

R-2. K.R.Padiyar, "FACTS controllers in transmission and Distribution" New Age Publications,New Delhi.

R-3. K.R.Padiyar , "HVDC Power Transmission Systems", New Age Publications, New Delhi, (2nd Edition)

R-4. M.H.Rashid , "Power Electronics Handbook", Academic Press.

R-5. Prabha Kundur, "Power System Stability and Control", McGraw Hill

R-6. S Kamakshaiah, V Kamaraju, "HVDC Transmission", McGraw Hill

UNIT	TEXT BOOKS	REFERENCE BOOKS
1	T2, T4, T5	R3, R6
2	T1, T3	R3, R4, R7
3	T1, T2	R1, R6
4	T2	R5, R6
5	T6	R2
6	T2, T3	R6

Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:

1. NPTEL Website: http://nptel.ac.in/courses/108104013/
2. https://www.youtube.com/watch?v=yP7OACmLP48&list=PL4B78E9972172086A

Course Objectives

The course aims to:

- To provide students' knowledge about modern trends in Power Transmission Technology
- To make students understand applications of power electronics in the control of power transmission.
- To educate students for utilization of software such as ETAP, MATLAB for power transmission and control.

Course Outcomes

After successfully completing the course students will able to:

1. Extend the general back ground of HVDC System.
2. Reproduce the layout of HVDC system with various components including protective devices.
3. Differentiate VSC HVDC and conventional HVDC system.
4. Differentiate various types of Power Electronic Controllers.
5. Analyse Series and Shunt Compensation in terms of FACTS devices.
6. Identify in-depth understanding of Unified Power Flow Controller.

Academic Activity Planner

Units	Unit Test 1 (30 marks)	MCQ (30 marks)	Assignment (60 marks)
I	√	√	√
II	√		√
III			√
IV			√
V			√
VI			√

Teaching Plan

Teaching plan as per University Syllabus

Sr. No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	I	General back ground	06
2	II	Multi terminal HVDC system	06
3	III	HVDC Light	06
4	IV	Power Electronic Controllers	06
5	V	Shunt and series compensation	06
6	VI	Unified Power Flow Controller	06

Unit wise Lecture Plan

Unit No.-I: General back ground

Pre-requisites:-Basic knowledge of Transmission System

Objectives:-

- To gain knowledge of general back ground of HVDC System.
- To understand the Control modes of HVDC Transmission System.

Outcomes:-

- Identify various Converter Circuits used for HVDC Transmission System
- Analyse the control modes of HVDC Transmission System.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	EHVAC versus HVDC transmission	T2, T4, T5, R3, R6	Chalk and talk
2	power flow through HVDC link, Graetz circuit,		Chalk and talk
3	equation for HVDC power flow bridge connection,		Chalk and talk
4	control of DC voltage and power flow,		Chalk and talk and PPT
5	effects of angle of delay and angle of advance commutation,		Chalk and talk and PPT
6	CIA, CC and CEA control,		Chalk and talk and PPT

Question Bank: Theory

Q.1 Explain Graetz circuit. Draw relevant waveforms.

Q.2 Explain rectifier operation in HVDC systems with ignition delay angle and commutation overlap angle. Derive equations for ΔV_d and V_d.

Q.3 Explain inverter operation in HVDC systems with extinction angle and overlap angle. Derive necessary equations.

Q.4 Develop equivalent circuit of HVDC link.

Q.5 Compare CIA control and CEA control used in HVDC Systems converter station.

Q.6 Explain effect of delay angle and angle of advance commutation on operation HVDC system.

Q.7 Explain rectifier operation in HVDC systems with ignition delay angle and commutation overlap angle.

Q.8 Compare HVDC with EHV AC system.

Q.9 Explain with suitable diagram 12 pulse converter operation.

Q.10 Explain Harmonic generation in HVDC system.

Unit No.-II: Multi terminal HVDC system

Pre-requisites:-Basic knowledge of HVDC System.

Objectives:-

- To understand the Layout and Placement of HVDC Components
- To understand the knowledge about modern trends in HVDC Transmission Technology.

Outcomes:-After successfully completing this unit students will be able:

- Find knowledge of HVDC Components
- Understand the configuration and types of Multiterminal HVDC System

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction	T1, T3, R3, R4, R7	Chalk and talk, PPT
2	Twelve pulse converter operation,		Chalk and talk, PPT
3	Harmonics in HVDC systems.		Chalk and talk, PPT
4	HVDC system layout and placement of components,		Chalk and talk, PPT
5	HVDC protection, grounding,		Chalk and talk, PPT
6	Multi terminal HVDC systems, configurations and types.		Chalk and talk, PPT

Question Bank: Theory

Q.1 Explain protection against over voltages in HVDC system. Explain advantages of Single wire ground return (SWGR) system and also state why negative pole is preferred in SWGR systems.
Q.2 Give typical layout of HVDC system
Q.3 Draw schematic of Multiterminal HVDC systems and state applicability of each.
Q.4 State advantages of Multiterminal HVDC with classical HVDC system.
Q.5 What is single wire ground return system? Which configuration is commonly employed in such system?
Q.6 Explain protection schemes employed for HVDC system.
Q.7 Explain any one type of Multiterminal HVDC system in detail.
Q.8 Give classification of Multiterminal HVDC.
Q.9 List various components used in HVDC system and state role of each.

Unit No.-III: HVDC Light

Pre-requisites:-Basic knowledge of HVDC System

Objectives:-

- To gain knowledge of fundamental concept of VSC Transmission System
- To provide in-depth understanding of HVDC Light Technology.

Outcomes:-After successfully completing this unit students will be able to:

- Analyze VSC Transmission
- Obtain detail knowledge of HVDC Light technology

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction to VSC transmission,	T1, T2, R1, R6	Chalk and talk, PPT
2	power transfer characteristics, structure of VSC link,		Chalk and talk, PPT
3	VSC DC system control, HVDC light technology.		Chalk and talk, PPT
4	HVDC plus, introduction,		Chalk and talk, PPT
5	construction, operation and applications to renewable energy sources		Chalk and talk, PPT
6	operation and applications to renewable energy sources		Chalk and talk, PPT

Question Bank: Theory

Q.1 What is HVDC Light System? What are the characteristics features of HVDC light system? Explain Control and Power transfer characteristics of VSC based HVDC system.
Q.2 Explain structure of VSC based HVDC system.
Q.3 Discuss the operation of VSC based HVDC system.
Q.4 Compare classical HVDC system with VSC based HVDC system.
Q.5 Explain Power transfer characteristics of VSC HVDC system.
Q.6 What is HVDC Light? Explain.
Q.7 Explain principle of control of HVDC light.
Q.8 Explain DC system control in VSC system.
Q.9 In VSC based HVDC system is superior to classical HVDC system? Justify your answer.

Unit No.-IV: Power Electronic Controllers

Pre-requisites:-Basic Knowledge of Power Electronics Devices

Objectives:-

- To understand different converter structures
- To understand applications of power electronics in the control of power transmission

Outcomes:-After successfully completing this unit students will be able to:

- To analyze the converters
- Analyze the applications of power electronics

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Basics, Challenges and needs,	T2, R5, R6	Chalk and talk, PPT
2	Review of rectifiers and inverters, back to back converter		Chalk and talk, PPT
3	dc link converter, static Power converter structures		Chalk and talk, PPT
4	AC controller based structures,		Chalk and talk, PPT
5	DC link converter topologies,		Chalk and talk, PPT
6	Converter output and harmonic control, power converter control.		Chalk and talk, PPT

Question Bank: Theory

Q.1 With suitable diagram explain DC link converter topologies.
Q.2 Explain different mechanisms used for controlling harmonic generation in converter used in HVDC systems.
Q.3 Explain AC controller based structures.
Q.4 Explain operation of back to back converters.
Q.5 Compare current source converter and voltage source converters.

Unit No.-V: Shunt and series compensation

Pre-requisites:-Basic knowledge of Compensation in Power System

Objectives:-

- To understand concept of Series and Shunt Compensation in Power System.
- To understand Series and Shunt Compensation in terms of FACTS Devices.

Outcomes:-After successfully completing this unit students will be able to:

- Analyze the Series and Shunt Compensation in Power System.
- Analyze the Series and Shunt Compensation in terms of FACTS Devices.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction	T6, R2	Chalk and talk, PPT
2	Operation and control of SVC,		Chalk and talk, PPT
3	STATCOM configuration and control,		Chalk and talk, PPT
4	Applications of SVC and STATCOM.		Chalk and talk, PPT
5	TCSC operation, layout and operation,		Chalk and talk, PPT
6	Static Synchronous series compensator (SSSC).		Chalk and talk, PPT

Question Bank: Theory

Q.6 Explain the principle, working and characteristics of static VAR compensator with a neat circuit diagram.
Q.7 Explain the working and characteristics of Thyristor switched series capacitor with a neat diagram.
Q.8 Discuss briefly about the variation of the TCSC reactance with firing angle 'alpha'.
Q.9 Explain the V-I capability characteristics of single module TCSC.
Q.10 Explain with neat circuit diagram about fixed capacitor-Thyristor controlled reactor.
Q.11 Explain the design of SVC voltage regulator. Also discuss the influence of SVC on system voltage.
Q.12 Discuss in detail the effect of SVC for the enhancement of transient stability.
Q.13 Using a general schematic diagram, explain the three basic modes of SVC control in detail.
Q.14 Explain the application of SVC for prevention of voltage instability.
Q.15 How do you enhance the damping in power system using SVC?
Q.16 Explain the design of SVC voltage regulator and discuss the voltage control capability of SVC. What are the advantages of slope in dynamic characteristics of SVC?
Q.17 Discuss in detail about the role of SVC in improving the stability limit and enhancing the power system damping
Q.18 Explain the principle of operation of TCSC. Also discuss the different modes of TCSC.
Q.19 Explain the effect of TCSC for the enhancement of system damping.
Q.20 Describe the variable reactance model of TCSC.
Q.21 Explain the different modes of operation of TCSC.
Q.22 Describe the modeling of TCSC for load flow study.
Q.23 Explain the working, characteristics and operating modes of variable reactance model of thyristors controlled series capacitor.
Q.24 Explain in detail the applications of thyristors controlled series capacitor.
Q.25 How TCSC is used for the improvement of the stability of a system.
Q.26 Explain the working of STATCOM with a neat sketch. In what way it differs from SVC?
Q.27 Explain the operation of STATCOM with its V-I characteristics.
Q.28 Explain the performance of VSC based STATCOM.
Q.29 Draw a practical structure of TCSC and explain principle of operation and different operating modes of TCSC.
Q.30 In TCSC, reactance of TCR branch is twice the capacitive reactance. Compute XTCSC/XC and ITCR/IL. Also specify whether TCSC operation is Capacitive or inductive with justification.
Q.31 Compare STATCOM with SVC.

Unit No.-VI: Unified Power Flow Controller

Pre-requisites:-Basic knowledge of Series and Shunt Compensation

Objectives: -

- To understand
- To provide in-depth understanding of Unified Power Flow Controller.

Outcomes:-After successfully completing this unit, students will be able to:

- To get the knowledge of UPFC Configuration
- To analyze the operational constraints of UPFC

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction	T2, T3, R6	Chalk and talk, PPT
2	UPFC configuration,		Chalk and talk, PPT
3	steady state operation control and characteristics,		Chalk and talk, PPT
4	operational constraints of UPFC,		Chalk and talk, PPT
5	Power flow studies in UPFC embedded systems.		Chalk and talk, PPT
6	Power flow studies in UPFC embedded systems.		Chalk and talk, PPT

Question Bank: Theory

Q.1 Explain the operation of UPFC with diagram.
Q.2 With a neat sketch, explain the implementation of UPFC.
Q.3 Describe the modeling of UPFC for power flow and transient stability studies.
Q.4 Explain the basic principle and control capability of unified power flow controller.
Q.5 Explain the power transfer capability of UPFC and compare its capabilities with other FACTS controllers.
Q.6 Describe the construction of UPFC with a block diagram and its characteristic with phasor diagrams.
Q.7 Explain the power flow control and oscillation damping in the two area system using UPFC.
Q.8 Explain the overall control structure of UPFC.
Q.9 Explain Power flow studies in UPFC embedded systems and operational constraints.

List of Practical's

1	Study and simulation of 6 pulse HVDC system
2	Study of 12 pulse HVDC System
3	Study of various FACTS Controllers models. (Extra Practical)
4	Study and simulation of Three phase TCR with and without shunt capacitor
5	Study and simulation of resonance in electrical Power systems
6	Application study of SVC in Power System
7	Application study of TCSC in Power System.
8	Application study of DSTATCOM in Power System
9	Study and simulation of Power Flow control in a five bus system using UPFC

SMART GRID

Name of the Subject – Smart Grid

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	03	-	-

In-sem	End-Sem	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	-	-	100	

Syllabus:

Unit 01: Introduction to Smart Grid: (6 hrs)

Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Drivers of SG in India, Challenges for SG, Difference between conventional & smart grid, Smart Grid Vision & Roadmap for India, Concept of Resilient and Self Healing Grid, Present development & International policies in Smart Grid, Smart Cities, Pilot projects in India.

Unit 02: Smart Grid Technologies: (6 hrs)

Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Phase Measurement Unit (PMU). Smart Substations, Substation and Feeder Automation, application for monitoring, protection and control, Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid(V2G), Grid to vehicles(G2V), Smart storage technologies – Battery(flow and advanced), SMES, Super Capacitors, Pumped Hydro, Compressed Air Energy Storage(CAES) and its comparison, Optimal Location of PMUs for Complete Observability.

Unit 03: Smart Meters and Advance Metering Infrastructure: (6 hrs)

Introduction to Smart Meters, Advanced Metering Infrastructure (AMI), Real Time Prizing, Automatic Meter Reading (AMR), Outage Management System (OMS) Smart Sensors, Smart Appliances, Home & Building Automation, Geographic Information System (GIS).

Unit 04: Microgrids: (6 hrs)

Concept of Microgrid, need & applications of Microgrid, Microgrid Architecture, DC Microgrid, Formation of Microgrid, Issues of interconnection, protection & control of Microgrid, Integration of renewable energy sources, Smart Microgrid, Microgrid and Smart Grid Comparison, Smart Microgrid Renewable Green Energy System, Cyber Controlled Smart Grid

Unit 05: Power Quality Management in Smart Grid: (6 hrs)

Power Quality and EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit

Unit 06: Communication Technology for Smart Grid: (6 hrs)

Communication Architecture of SG, Wide Area Measurement System (WAMS), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid, Broadband over Power line (BPL), IP based protocols.

Text Books:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response",CRC Press
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley Publications.
4. Stuart Borlase, "Smart Grids-Infrastructure, Technology and Solutions", CRC Press, Taylor and Francis group
5. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu and Akihiko Yokoyama, "Smart Grid-Technology and applications", Wiley Publications.
6. James Momoh, "Smart Grid-Fundamentals of design and analysis", Wiley Publications.

Reference Books:

1. Nikos Ziargyriour, "Micro grid, Architecture and Control", IEEE Press, Wiley Publications.
2. Yang Xiao, "Communication and Networking in Smart Grids", CRC Press, Taylor and Francis group 3.Lars T. Berger and Krzysztof Iniewski, "Smart Grid-Applications, Communications and Security", Wiley Publications.
4. Mladen Kezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert "Substation Automation (Power Electronics and Power Systems)", Springer Publications.
5. Stephen F.Bush, "Smart Grid-Communication Enabled Intelligence for the Electric Power Grid", IEEE Press, Wiley Publications
6. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Publication.
7. Jean Claude Sabonnadière, Nouredine Hadjsaïd, "Smart Grids", Wiley Blackwell

Link:
https://www.indiasmartgrig.org

https://www.youtube.com/watch?v=JwRTpWZReJk

https://www.youtube.com/watch?v=5cIy-5c1DdE

Course Objectives

- To understand the concept of Smart Grid, compare with conventional grid, and identify its opportunities and barriers.
- To understand the concept of Smart Meter, Smart Appliances, Automatic Meter Reading, Outage Management System, Plug in Hybrid Electric Vehicles, Vehicle to Grid, Smart Sensors, Home & Building Automation, and Phase Shifting Transformers.
- To understand the concept of Substation Automation, Feeder Automation. Intelligent Electronic Devices, Smart storage like Battery, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System, and Phase Measurement Unit.
- To understand the concept of micro grid
- To understand the concept of Power Quality and its issues of Grid connected Renewable Energy Sources, Web based Power Quality monitoring, Power Quality Audit.

Course Outcomes

CO1. Students will be able to **explain** and **compare** Conventional and Smart Grid.
CO2. Students will be able to **identify** the need of Smart Grid, Micro Grid, smart metering and storage.
CO3. Students will be able to **outline** new technologies of Automation and communication in Smart grid.
CO4. Students will be able to **choose** the recent trends for various electric grids
CO5. Students will be able to **assess** current professional issues in electric Grid and evaluate the emerging technologies
CO6. Students will be able to **define** and **formulate** the necessity of global smart communication system.

PROGRESSIVE EDUCATION SOCIETY'S

MODERN COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING

Academic Activity Planner

Unit	Test-01 (30 Marks)	Assignment-01 (30 Marks)	Assignment-02 (30 Marks)	End Term Test (30 Marks)
I	✓	✓		
II	✓	✓		
III	✓	✓		
IV			✓	✓
V			✓	✓
VI			✓	✓

Teaching Plan

Teaching plan as per University Syllabus

Sr.No.	Unit	Broad Topics to be Covered	Total Lecture Planned
1	I	Introduction to smart grids, Present developments,smart cities	06
2	II	Smart Substations,Electric vehicles,storage,Wide Area Monitoring and Control	06
3	III	Smart metering,Smart Appliances,Outgae Management	06
4	IV	Introduction to Microgrids,architecture,Interconnectio,protection,control,Security	06
5	V	Power Quality issues,Conditioners,Monitoring and Audit	06
6	VI	Communication Architecture,Cloud Computing,IP based Protocols	06

Unit wise Lecture Plan

Unit I: Introduction to Smart Grid

Pre-requisite:- Power system,Energy Audit and Management.

Objective :-

- To understand the concept of Smart Grid, compare with conventional grid, and identify its opportunities and barriers

Outcome :

- Students list the difference between Conventional and Smart Grid.
- Students identify the need of Smart Grid, Micro Grid,advantages of smart metering and storage

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Evolution of Electric Grid, Concept of Smart Grid, Definitions	T1 T2 T3 R6 R7	Chalk and talk(C&T)
2	Need of Smart Grid, Functions of Smart Grid, Opportunities		C&T
3	Barriers of Smart Grid, Drivers of SG in India		C&T
4	Difference between conventional & smart grid, Resiliency		C&T
5	Smart Cities		Soft Copy Presentation
6	International policies in Smart Grid, Roadmap for India,Projects in India(Beyond syllabus)		Softcopy

Question Bank:
Theory- Unit :I

Unit1

1. Define and explain the Smart Grid concept and also give its need.
2. Give CDM opportunities in Smart Grid
3. Give functions of Smart Grid also state its opportunities and Barriers
4. Write the list of difference between conventional grid and Smart Grid.
5. High light on evolution of electric grid and the concept of Smart Grid
6. Give CDM opportunities in Smart Grid. Also explain Carbon Credits.
7. Explain the Resilient and Self Healing grid.
8. Give present development and international policies in Smart Grid.
9. Explain National and International policies of Smart Grid.
10. Write a note on present development in smart grid considering any one case study.

Unit II: Smart Grid Technologies:

Pre-requisite:- Power Generation Technique

Objective:-

- ✓ To understand the concept of Smart Meter, Smart Appliances, Automatic Meter Reading, Outage Management System, Plug in Hybrid Electric Vehicles, Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers

Outcomes:- After successfully completing this unit:

- ✓ Students identify the need of Smart Grid, Micro Grid,advantages of smart metering and storage.
- ✓ Students assess current professional issues in electric Grid and evaluate the emerging technologies.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED),	T1 T4 T6 R7	C&T
2	Substation and Feeder Automation, application for monitoring, protection and control,		C&T
3	Phase Measurement Unit (PMU).		C&T
4	Smart Storage		C&T
5	Smart Storage (Beyond syllabus)		PPT
6	Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid(V2G), Grid to vehicles(G2V)		PPT

Question Bank: Theory

Unit 2: Smart Grid Technologies

1. How Smart Grid can be benefited by implementing PHEV technology and also give different modes of operation of PHEV.
2. Explain the role of smart substations in Smart Grid, and also give its function.
3. Explain PMU and its importance in Smart Grid.
4. Write a note on ‘‘IED, Feeder Automation.
5. Write a note on PHEV
6. Explain any two smart storage equipment’s.
7. Write a note on smart Substations.
8. Write a note on SMES.
9. Explain the phase shifting transformer.
10. Explain the concept Vehicle to Grid

Unit III: Smart Meters and Advance Metering Infrastructure

Pre-requisite: Power Electronics, PLC and SCADA.

Objective:

To understand the concept of Substation Automation, Feeder Automation. Intelligent Electronic Devices, Smart storage like Battery, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System, Phase Measurement Unit.

Outcomes: - After successfully completing this unit:

- Students recognize new technologies like Home Automation and smart communication and recent trends in automation like Hybrid vehicle.
- Students analyze the upcoming concepts in electrical from Utility to Consumers filter

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Introduction to Smart Meters, Advanced Metering Infrastructure (AMI)	T1 T3 T5 R3 R7	C&T
2	Real Time Prizing, Automatic Meter Reading (AMR)		C&T
3	Real Time Prizing		PPT
4	Outage Management		PPT
5	Smart Sensors, Smart Appliances, Home & Building Automation,		C&T, Softcopy
6	Geographic Information System (GIS).		C&T

Question Bank: Theory
Unit III

1. Give functions and benefits of smart meter.
2. How outages can be managed by implementing OMS.
3. Why Real Time prizing should be implemented and give its development stages.
4. Write a note on OMS.
5. Explain home and building automation.
6. Explain Smart Meters and give its functions when deployed in domestic sector.
7. What is meant by outage management?What is present status of OMS?How it will be improved in smart grid?
8. Highlight on geographic information system in Smart Grid and also give its function.
9. Explain smart sensors and how it will reduce the stress on system and make it smart.
10. Explain how Smart meters can play an important role to make a system smart.

Unit IV: Microgrids

Pre-requisite:-

- PowerGeneration Technique,PLC and Scada

Objectives:-

- To understand the concept of microgrid

.

Outcomes:- After successfully completing this unit:

- Students analyze the upcoming concepts in electrical from Utility to Consumers

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Microgrid-Introduction	T1 T2 T3 R1 R7	C&T
2	Microgrid Architecture,Drivers,Issues		C&T
3	Formation of Microgrid, Issues of interconnection,protection		C&T
4	Protection & control of Microgrid, Integration of renewable energy sources, Cyber Controlled Smart Grid		C&T
5	MRG systems ,formation of Microgrid		Softcopy

Question Bank: Theory

Unit No.-IV

1. Explain concept of Microgrid, and state its issues related to interconnection.
2. Explain about formation of Microgrid and also its need.
3. Write a note on the Captive power plant.
4. Write a note on the Thin film solar cells.
5. Explain the protection and control strategy implemented in smart grid.
6. Write a note on formation of Smart grid.
7. Write a note on “plastic and organic Solar cells”.
8. Write a note on Fuel cells its need and applications.
9. Write a note on Micro turbine.
10. Write a note on variable speed wind generators.

Unit V: Power Quality Management in Smart Grid

Pre-requisite:- Control system

Objective:-

- To understand the concept of Power Quality and its issues of Grid connected Renewable Energy Sources, Web based Power Quality monitoring, Power Quality Audit..

Outcome:- After successfully completing this unit:

- Students assess current professional issues in electric Grid and evaluate the emerging technologies.

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Power Quality and EMC in Smart Grid	T3 T6 R4 R7 R6	C&T
2	Power Quality issues of Grid connected Renewable Energy Sources,		C&T
3	Power Quality Conditioners for Smart Grid,		C&T
4	Web based Monitoring		C&T
5	Power Quality Audit		C&T

Question Bank: Theory

Unit V

1. Explain power Quality importance in Smart Grid and how can it be improved.
2. Explain role of Power Quality Audit in Smart Grid.
3. Explain Power Quality issues of Grid connected Renewable Energy Sources.
4. Explain web based Power Quality monitoring.
5. Write a note on, power quality management in smart grid.
6. Explain power quality conditioners for smart gird.
7. Highlight on the power quality issues of grid connected renewable energy sources.
8. Describe EMC and how its role in smart grid.
9. Explain how power Quality can be improved in Smart grid by monitoring with the help of web based technology.
10. Describe the concept ,power quality conditioners related to smart grid.

Unit VI: Communication Technology for Smart Grid

Pre-requisite:-

Energy Audit and Management,Industrial and technology Management

Objective: -To understand various communication networks ,their architecture and security settings in smartgrid communication process.

Outcomes:- After successfully completing this unit:

- Students can express and formulate the necessity of global smart communication system

Lecture No.	Details of the Topic to be covered	References	Mode of Delivery
1	Communication Architecture of SG, Wide Area Measurement System (WAMS)	T1 T5 R2 R5	C&T, softcopy
2	Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN),Broadband over Power line (BPL),		C&T
3	Wi-Fi, Wi-Max based communication, Wireless Mesh Network,		C&T
4	Bluetooth, ZigBee, GPS		C&T
5	Basics of CLOUD Computing		PPT
6	IP based protocols.		Soft copy

Question Bank: Theory

Unit VI

1. Explain WAMS and gives its advantages
2. Explain role of HAN in Smart Grid.
3. Why cyber security is of prime importance in Smart Grid and how it can be achieved.
4. Explain the role of GPS in smart grid.
5. Write the importance of Bluetooth in smart grid.
6. Explain Cloud computing and its need.
7. Explain the role of Wireless Mesh Network in smart grid.
8. Write a note on broad band over powerline.
9. Write a note on "IP based protocols".
10. Write a note on Wi-Max based communication in smart grid.

ILLUMINATION ENGINEERING

Name of the Subject: 403150 (C): Illumination Engineering

Weekly Work Load(in Hrs)	Lecture	Tutorial	Practical
	03	-	-

In-sem	Theory	Practical	Oral	Term-work	Total Marks	Credit
30	70	-	-	-	100	

Syllabus:

Unit 01 : Importance of Lighting in Human Life (05 Hrs)

Optical systems of human eye ,Dependence of human activities on light, performance characteristics of human visual system, External factors of vision-visual acuity, contrast, sensitivity, time illuminance, colour, visual perception, optical radiation hazards, Good and bad effects of lighting and perfect level of illumination, Artificial lighting as substitute to natural light, Ability to control natural light, Production of light, physics of generation of light, Properties of light, Quantification and Measurement of light.

Unit 02 : Light Sources and Electrical Control of Light Sources (08 Hrs) (A) Light Sources-

Lamp materials: Filament, glass, ceramics, gases, phosphors and other metals and non-metals. Discharge Lamps: Theory of gas Discharge phenomena, lamp design considerations, characteristics of low and high pressure mercury and Sodium vapour lamps, Low Vapour Pressure discharge lamps - Mercury Vapour lamp, Fluorescent Lamp, Compact Fluorescent Lamp (CFL) High Vapour Pressure discharge lamps - Mercury Vapour lamp, Sodium Vapour lamp, Metal halide Lamps, Solid Sodium Argon Neon lamps, SOX lamps, Electro luminescent lamps, Induction lamps. Ballast, ignitors and dimmers for different types of lamps,

(B) Control of Light Sources Photometric Control of Light Sources and their Quantification:

Types of Luminaries, factors to be considered for designing luminaries Types of lighting fixtures. Optical control schemes, design procedure of reflecting and refracting type of luminaries. Lighting Fixture types, use of reflectors and refractors, physical protection of lighting fixtures, types of lighting fixtures according to installation type, types of lighting fixtures according to photometric usages, luminaries standard (IEC-598-Part I).

Unit 03 : Design Considerations for illumination schemes (04Hrs)

Zonal cavity method for general lighting design, determination for zonal cavities and different shaped ceilings using COU (coefficient of utilization), beam angles and polar diagrams. Factors to be considered for design of indoor illumination scheme

Unit 04 : Design of lighting schemes-I (06 Hrs)

Indoor illumination design for following installations- Residential (Numerical) Educational institute Commercial installation Hospitals Industrial lighting Special purpose lighting schemes Decorative lighting Theatre lighting Aquarium, swimming pool lighting

Unit 05 : Design of lighting schemes-II (08 Hrs)

Factors to be considered for design of outdoor illumination scheme Outdoor Lighting Design: Road classifications according to BIS, pole arrangement, terminology, lamp and luminaries' selection, different design procedures, beam lumen method, point by point method, isolux diagram, problems on point by point method. Outdoor illumination design for following installations: Road lighting (Numerical) Flood lighting (Numerical) Stadium and sports complex Lighting for advertisement/hoardings

Unit 06 : Modern trends in illumination (05 Hrs)

LED luminary designs Intelligent LED fixtures Natural light conduiting Organic lighting system LASERS, characteristics, features and applications, non-lighting lamps Optical fiber, its construction as a light guide, features and applications

Text Books:

1. H. S. Mamak, "Book on Lighting", Publisher International lighting Academy
2. Joseph B. Murdoch, "Illumination Engineering from Edison's Lamp to Lasers" Publisher -York, PA : Visions Communications
3. M. A. Cayless, A. M. Marsden, "Lamps and Lighting", Publisher-Butterworth-Heinemann(ISBN 978-0-415-50308-2)
4. Designing with light: Lighting Handbook., Anil Valia; Lighting System 2002

Reference Books:

1. "BIS, IEC Standards for Lamps, Lighting Fixtures and Lighting", Manak Bhavan, New Delhi
2. D. C. Pritchard, "Lighting", 4th Edition, Longman Scientific and Technical, ISBN 0-582-23422-0.
3. "IES Lighting Handbook", (Reference Volume 1984), Illuminating Engineering Society of North America.
4. "IES Lighting Handbook", (Application Volume 1987), Illuminating Engineering Society of North America
5. IESNA lighting Handbook., Illuminating Engineering Society of North America 9th edition 2000
6. Applied Illumination Engineering, Jack L. Lindsey FIES (Author), Scott C. Dunning PHD PE CEM (Author) ,ISBN-13: 978-0824748098 ISBN-10: 0824748093, 3rd Edition.
7. IS 3646: Part I: 1992, *Code of practice for interior illumination.*
8. Organic Light Emitting Diodes (OLEDs): Materials, Devices and Applications, Alastair Buckley, University of Sheffieid, UK, ISBN: 978-0-85709-425-4.

Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:

http://www.elcomaindia.com/

http://isleind.org/

Course Objectives:

The course aims :- ·

- To get the detailed information about conventional and modern lamps and their accessories.
- To get detailed insight of indoor and outdoor illumination system components, its controls and design aspects.
- To know the requirements of energy efficient lighting.
- To introduce the modern trends in the lighting

Course Outcomes:

After successfully completing the course students will be able to:

CO1. Students will be able to describe relation between human optical system and illumination fundamental concepts.
CO2. Students will be able to define and reproduce various terms in illumination.
CO3. Students will be able to identify various parameters for illumination system.
CO4. Students will implement design techniques in indoor lighting systems.
CO5. Students will implement design techniques in outdoor lighting systems.
CO6. Students will be able to enlist state of the art illumination systems.

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Academic Activity Planner

Units	Test	MCQ test	Assignment	Open book test	Seminar, ppt
1	10				
2			10		
3		10			
4				10	
5			10		
6					10

Teaching Plan

Teaching plan as per University Syllabus

Sr. No.	Unit	Broad Topic to be covered	Total Lectures Planned
1	I	Importance of Lighting in Human Life:	5
2	II	Light Sources and Electrical Control of Light Sources	8
3	III	Design Considerations for illumination schemes	4
4	IV	Design of lighting schemes-I	6
5	V	Design of lighting schemes-II	8
6	VI	Modern trends in illumination	5

Unit wise Lecture Plan

Unit No.-I: Importance of Lighting in Human Life:

Pre-requisites:-

Student should have a knowledge about physics of light.

Objective:-

To know the requirements of energy efficient lighting.

Outcome:

Student can describe relation between human optical system and illumination fundamental concepts.

Lecture No.	Details of the Topic to be covered
1	Optical systems of human eye ,Dependence of human activities on light,
2	performance characteristics of human visual system,
3	External factors of vision-visual acuity, contrast, sensitivity, time illuminance, colour, visual perception, optical radiation hazards,
4	Good and bad effects of lighting and perfect level of illumination, Artificial lighting as substitute to natural light, Ability to control natural light,.
5	Production of light, physics of generation of light, Properties of light,
6	Quantification and Measurement of light

Question Bank: Theory

1. Enlist various effects of bad lighting. Explain methods of controlling natural light.
2. Explain the properties of light.
3. What is visual acuity?
4. Explain difference between artificial light and natural light.

Unit 02: Light Sources and Electrical Control of Light Sources:

Pre-requisites:-

- Student should know about types of light.
- Student should know about material used for different lamps.

Objectives:-

To get the detailed information about modern lamps and their accessories.

To get detailed insight of indoor and outdoor illumination system components, its controls

Outcomes:-After successfully completing this unit students will be able:

Students can identify various parameters for illumination system design.

Lecture No.	Details of the Topic to be covered
1	Lamp materials: Filament, glass, ceramics, gases, phosphors and other metals and non-metals. Discharge Lamps: Theory of gas Discharge phenomena,
2	lamp design considerations, characteristics of low and high pressure mercury and Sodium vapour lamps, Low Vapour Pressure discharge lamps - Mercury Vapour lamp,
3	Fluorescent Lamp, Compact Fluorescent Lamp (CFL) High Vapour Pressure discharge lamps - Mercury Vapour lamp, Sodium Vapour lamp, Metal halide Lamps, Solid Sodium Argon Neon lamps, SOX lamps,
4	Electro luminescent lamps, Induction lamps.
5	Ballast, ignitors and dimmers for different types of lamps, (Types of Luminaries,
6	factors to be considered for designing luminaries Types of lighting fixtures. Optical control schemes, design procedure of reflecting and refracting type of luminaries.
7	Lighting Fixture types, use of reflectors and refractors, physical protection of lighting fixtures
8	types of lighting fixtures according to installation type, types of lighting fixtures according to photometric usages, luminaries standard (IEC-598-Part I).

Question Bank: Theory

Theory Paper

Unit 2

1. Explain with sketch.
   a) Sodium vapour lamp b) Fluorescent tube
2. Explain with sketch.
   a) Metal halide lamp. b) Sox lamp.
3. What is stroboscopic effect? How it can be avoided?
4. Describe the construction and working of mercury vapour lamp with sketch.
5. Enlist advantages of gas discharge lamp over incandescent lamp.
6. Explain design consideration of electromagnetic ballast for HID lamps
7. Explain types of lightning fixtures according to installation type
8. Explain design consideration of Electronic ballast for TL lamps
9. What are different types of lighting fixtures according to photometric usages? Explain each type in brief.

Unit 03: Design Considerations for illumination schemes

Pre-requisites :-

Student should know about various design consideration in illumination schemes.

Objectives:-

Student should know about various design consideration in illumination schemes.

Outcomes:-After successfully completing this unit students will be able to:

- Student can define and reproduce various terms in illumination.
- Students can identify various parameters for illumination system design.

Lecture No.	Details of the Topic to be covered
1	Zonal cavity method for general lighting design,
2	determination for zonal cavities and different shaped ceilings using COU (coefficient of utilization
3	beam angles and polar diagrams
4	Factors to be considered for design of indoor illumination scheme

Question Bank: Theory
Unit No.-III

Theory Paper

1. Explain zonal cavity method.
2. Which factors are considered while indoor illumination design.
3. Write a short note on 1. Beam angle 2. Polar diagrams
4. Explain COU.

Unit No.-IV: Design of lighting schemes-I

Pre-requisites:-
Students should know indoor design considerations.

Objectives:-

- To get detailed insight of indoor illumination system components, its controls and design aspects.
- To know the requirements of energy efficient lighting.

Outcomes:-After successfully completing this unit students will be able to:
Implement design techniques in indoor lighting systems.

Lecture No.	Details of the Topic to be covered
1	Residential (Numerical)
2	Residential (Numerical)
3	Educational institute Commercial installation
4	Hospitals
5	Industrial lighting Special purpose lighting schemes
6	Decorative lighting Theatre lighting
7	Aquarium, swimming pool lighting

Question Bank: Theory

Theory Paper

Unit No.-IV

1. Elaborate the steps involved in design of illumination scheme for indoor installation- Educational institute
2. Elaborate the steps involved in design of illumination scheme for indoor installation- Theatre
3. Elaborate the steps involved in design of illumination scheme for hospital.
4. Elaborate the steps involved in design of illumination scheme for swimming pool.

Unit No.-V: Design of lighting schemes-II

Pre-requisites:-

Students should know design considerations.

Objectives:-

To get detailed insight of outdoor illumination system components, its controls and design aspects.

Outcomes:-After successfully completing this unit students will be able to:
Students will be able to implement design techniques in outdoor lighting systems.

Lecture No.	Details of the Topic to be covered
1	Factors to be considered for design of outdoor Road classifications according to BIS
2	pole arrangement, terminology, lamp and luminaries' selection,
3	different design procedures, beam lumen method,
4	point by point method, isolux diagram, problems on point by point method.
5	problems on point by point method.
6	Outdoor illumination design for following installations: Road lighting (Numerical)
7	Road lighting (Numerical)
8	Flood lighting (Numerical)
9	Stadium and sports complex Lighting for advertisement/hoardings

Question Bank: Theory

Theory Paper

Unit No.-V

1. With suitable diagrams explain beam lumen method for designing of out door illumination scheme.
2. State and explain the road classification as per BIS
3. With a suitable example explain point by point method for outdoor illumination scheme design.

Unit No.-VI: Modern trends in illumination

Pre-requisites:-

Students should know various lights and specifications.

Objectives: -

- To know the requirements of energy efficient lighting.
- To introduce the modern trends in the lighting

Outcomes:-After successfully completing this unit, students will be able to:

Students can enlist state of the art illumination systems.

Lecture No.	Details of the Topic to be covered
1	LED luminary designs Intelligent LED fixtures
2	Natural light conduiting Organic lighting system
3	LASERS, characteristics, features and applications,
4	non-lighting lamps Optical fiber, its construction as a light guide,
5	features and applications

Question Bank: Theory

Theory Paper

1. Write a short note on LED
2. Explain LASER characteristics
3. Explain optical fiber applications.

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Unit No.__

Theory Paper

[Total No. of Questions = 3]

[Total No. of Pages = 1]

B.E. (Electrical) 2015-Course

Subject Code:_____ Subject Name: _____

Semester: II (2019-20) Exam: _____

[Time: 1 Hours] [Max Marks = 10]

Instructions to Candidates:

1. **Answer any __2___ Questions out of _____3__ questions**
2. **Use single answer book for all questions.**
3. **Figures to the right of each question indicate full marks.**
4. **Use of Scientific calculator is allowed.**

Q. 1	**a)**		**[ ]**
	b)		**[ ]**
Q. 2	**a)**		**[ ]**
	b)		**[ ]**
Q. 3	**a)**		**[ ]**
	b)		**[ ]**

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Tutorial

[Total No. of Questions = 5]

[Total No. of Pages = 1]

B.E. (Electrical) 2015-Course

Subject Code:_____ Subject Name: _____

Semester: II (2019-20) Exam: _____

[Time: 1 Hours] [Max Marks = 20]

Instructions to Candidates:

1. **Answer any ___4__ Questions out of __5_____ questions**
2. **Use single answer book for all questions.**
3. **Figures to the right of each question indicate full marks.**
4. **Use of Scientific calculator is allowed.**

Q. 1		**[ ]**
Q. 2		**[ ]**
Q. 3		**[ ]**
Q. 4		**[ ]**
Q. 5		**[ ]**

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Assignment

[Total No. of Questions = 5]
[Total No. of Pages = 1]
B.E. (Electrical) 2015-Course (Credit pattern)
Subject Code:_____ Subject Name: _____
Semester: II (2019-20) Exam: _____
[Time: 1 Hours] [Max Marks = 20] [-Credits]

Instructions to Candidates:

1. **All Questions are compulsory.**
2. **Use of Scientific calculator is allowed.**

Q. 1		**[ ]**
		[ ]
Q.2		
Q.3		
Q.4		
Q.5		

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