



An ISO 9001-2015 Certified Institute

SantGajananMaharaj College of Engineering, Mahagaon

Site- Chinchewadi, Tal- Gadhinglaj, Dist- Kolhapur

Department of Electrical Engineering

COURSE PLAN

Course Code	EE 422	Course Name	HVDC
Prepared by	Prof.Kalas S V	Date	(AY-2018-19)
Verified by	Mr. M.B PATIL	Approved by	Academic Coordinator/ Principal
Objective	Student identified the necessary idea of Power Electronics & Power System		

COURSE OUTCOMES

At the end of this course the students should be able to:

Sr. No.	CO	CO No.
1.	Explain the basic principle HVDC structure and overall HVDC structure.	EE 422.01
2.	Describe the basic concepts of grid control and characteristics.	EE 422.02
3.	Compare the different classifications for protection of HVDC system.	EE 422.03
4.	Analyze the harmonics in HVDC structure and use of different filters in HVDC structure.	EE 422.04
5.	Explain the basic ideas for reactive power compensation in HVDC structure.	EE 422.05
6.	Compare the different categories of multi-terminal DC Structures.	EE 422.06

EXAMINATION SCHEME

Examination Scheme	Theory	Term Work	POE	Total
Maximum Marks	100	0	50	150
Contact Hours	4	0	02	06

MAPPING OF COs-Pos

COs \ POs	POs												
	a	b	c	d	e	f	g	h	i	j	k	l	

EE 422.01	2		3							1		
EE 422.02	1	3										
EE 422.03	2			3								
EE 422.04	2		2			1						
EE 422.05	2					3						
EE 422.06	1			2								

Degree of Compliance of COs and POs 1:Low 2: Medium 3: High

COURSE CONTENTS		
Chapter No.	Contents	No. of Hours
I	General Background: Trends in transmission Voltages, Hierarchical Levels in transmission and distribution, Standard rated voltage of EHV-AC and HVDC, General aspects HVDC Transmission: Constitution of EHVAC and DC links, Kinds of DC links, HVDC projects in India and abroad, limitations and advantages of HVDC transmission over EHVAC, Layout of HVDC station. Deep Hole Ground Electrode, Electrolytic Corrosion, factors for General Design of Electrodes.	8
II	Grid Control and Characteristics: Grid control of thyristor, valve-Analysis with grid control with no overlap, overlap less than 60 degrees and overlap greater than 60 degrees. Basic means of control, Power reversal, manual control and its limitations-constant current versus constant voltage Control, desired features of control, actual control characteristics-constant minimum ignition angle, current and extinction angle controls –power control and current limits. Voltage Dependant Current Limiter (VDCOL), Comparison of Converters - CSC & VSC systems	10
III	Protection: Disoperation of converters-short circuit on a rectifier – commutation failure, causes and remedies – Protection of HVDC system, d.c. reactors, damper circuits, Over current protection and over-voltage protection, clearing fault and reenergizing the line.	6
IV	Harmonics and Filters: Characteristic and uncharacteristic harmonics-causes, consequences and suppression-Troubles caused by harmonics, Harmonic filters-Types, Location, series or shunt, sharpness of tuning, Quality Factor Q for L, C & RLC filter.	6
V	Reactive Power Compensation: Reactive Power Requirement of HVDC Converter- reactive Power balance in HVDC substations-Effect of angle of advance and extinction angle on reactive power requirement of converters.	4
VI	Multi-terminal DC Systems & HvdC Light: Introduction, Configurations and Types of MTDC Systems, Control and Protection of MTDC Systems Configurations and Types of MTDC Systems, Reversal of Power in MTDC	10

	System, Comparison between MTDC and AC Interconnections HVDC Light :- Introduction to VSC transmission & Structure , Introduction to HVDC light technology.	
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EVALUATION SCHEME

Section	Maximum Marks	Question No.	Chapter No.
I	26	Question-1	Chapter-1
	22	Question-2	Chapter-2
	22	Question-3	Chapter-3
II	20	Question-4	Chapter-4
	18	Question-5	Chapter-5
	24	Question-6	Chapter-6

REFERENCES

Books

Sr.No.	Title of the Book	Author	Publisher/Edition
1.	Transmission	E.W. Kimbark	John Wiley, New York Edn. 1971
2.	HVDC Power Transmission System	K.R. Padiya	Wiley Eastern Ltd
3.	Power Transmission by Direct Current	E. Usdimann Springer Verlag	Springer Verlag, Berlin Edn. 1975
4.	EHVAC and HVDC Transmission	S.S. RaoKhanna	Khanna Pub. Delhi.

LIST OF ASSIGNMENTS

Asst. No.	Assignment Title	CO No.
A. Assignment Exercise		
1.	General Background	EE 422.01
2.	Grid Control and Characteristics	EE 422.02
3	Protection:	EE 422.03
4.	Harmonics and Filters	EE 422.04



5.	Reactive Power Compensation	EE 422.05
6	Multi-terminal DC Systems & Hvdc Light	EE 422.06

LIST OF LAB EXPERIMENTS

SL.NO	EXPERIMENT TITLE
1.	Modeling & Simulation of Single Phase Diode Rectifiers.
2.	Modeling & Simulation of Three Phase Diode Rectifier.
3	Modeling & Simulation of Three Phase 12 Pulse Diode Rectifier.
4.	Modeling & Simulation of Single Phase Inverter.
5.	Modeling & Simulation of HVDC System With Single Phase Source and Load.
6.	Modeling & Simulation Three Phase Inverter.
7.	Modeling & Simulation HVDC System With Three Phase Source and Load.
8.	Modeling & Simulation of Three-winding distribution transformer.
B. Beyond Syllabus Activity	
1.	Industrial visit.

ASSIGNMENT QUESTIONS/QUESTION BANK

Unit- I (Assignment 1) General Background			
Que. No.	Question	CO No.	Remark
1.	Give comparison between HVDC and EHVAC transmission systems.	EE 422.01	Common for All
2.	Explain the types (Kinds) of DC links used in DC transmission system	EE 422.01	
3.	Discuss application of DC transmission system. Also state limitations of it.	EE 422.01	Additional questions for Fast Learner
Unit-II: (Assignment 2) Grid Control and Characteristics			
1.	Draw & explain equivalent circuit of DC transmission for average current & voltages in steady state. Hence explain basic means of control.	EE 422.02	Common for

	and explain the individual and combined converter characteristics.	EE 422.02	
	Assignment 3) Protection		
No.	Question	CO No.	Remark
1.	Explain power control and current limits for DC transmission. Draw relevant sketch showing these limits.	EE 422.03	Common for All
2.	Explain the converter analysis with overlap less than 60° . Hence find the expression for V_d & I_d .	EE 422.03	
Unit- IV:(Assignment 4) Harmonics and Filters			
1.	State and discuss basic types of converter faults in HVDC systems.	EE 422.04	Common for All
2.	State/Explain the functions performed by DC reactor in HVDC system.	EE 422.04	
3.	Explain causes of over voltages and their means of reducing in HVDC system	EE 422.04	
Unit- V: (Assignment 5) Reactive Power Compensation			
1.	1. Discuss sources of reactive power requirements of the converter in HVDC systems. 2. Explain the configurations & types of MTDC systems. State their applications	EE 422.05	Common for All
		EE 422.05	
		EE 422.05	
Unit- V: (Assignment 6) Multi-terminal DC Systems & HvdC Light			
1.	1. Control and Protection of HVDC system 2. Compare MTDC interconnection & AC interconnection	EE 422.06	Common for All

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Department of Electrical Engineering

COURSE PLAN

Course Code	EE421/68526	Course Name	Law For Engineers
Prepared by	Mr. Y. S. Bhajantri	Date	10/12/2018 (AY-2018-19)

MAPPING OF COs-Pos

Verified by	Mr. M. B. Patil (HOD EE)	Approved by	Academic Coordinator/ Principal	
Objective	The objective of the course is to familiarize students (Prospective engineers) with elementary knowledge of laws that would be of utility in their profession. The syllabus covers constitution of India and new areas of law like IPR, ADR, Human Rights, and Right to information, corporate law.			
COURSE OUTCOMES				
<i>At the end of this course the students should be able to:</i>				
Sr. No.	CO		CO No.	
1.	Outline ² of Constitutional Law and Law of contract covering the preamble, List of Fundamental Rights, Judicial Structure, Types of Petition, Structure of Legislation		EE421.01	
2.	Outline ² of General principles of contract under Indian contract Act, Classify ² Kinds of government contracts and dispute settlements, Standard form of contracts		EE421.02	
3.	Outline ² of Intellectual Property, copyright, Trademarks, Patents and Designs, Secrets, Explain ⁵ Law relating to copyright India, Law relating to trademarks under Trademark Act, Law relating to Patents under Patent Act.		EE421.03	
4.	Outline ² of RTI-2005, ITS Act, Legislation and Procedures, Cyber-Crimes.		EE421.04	
5.	Outline ² of Industrial employment Act-1946; corporate Law, Law relating to companies, Public and Private (companies Act-1956).		EE421.05	
6.	Outline ² of Human Rights, List ⁴ of Amnesty of international, NHRC and SHRC (Structures and functions).		EE421.06	
EXAMINATION SCHEME				
Examination Scheme	Theory	Term Work	#POE	Total
Maximum Marks	50	0	0	50
Contact Hours	2	0	0	2

COs \ POs	POs											
	a	b	c	d	e	f	g	h	i	j	k	l
EE325.01			3			1	1	1				
EE325.02			3			1	1	1				
EE325.03			3			1	1	1				
EE325.04			3			1	1	1				
EE325.05			3			1	1	1				
EE325.06			3			1	1	1				

Degree of Compliance of COs and POs 1: Low 2: Medium 3: High

COURSE CONTENTS

Chapter No.	Contents	No. of Hours
I	Module 1: Constitutional Law and Law of contract covering the preamble, Fundamental Rights, Judicial Structure, Types of Petition, Structure of Legislation.	3Hrs.
II	Module 2: General principles of contract under Indian contract Act, 1872 covering general principles of Indian contract act, Government as contracting party, Kinds of government contracts and dispute settlements, Standard form of contracts.	3 Hrs.
III	Module 3: Law relating to Intellectual Property covering introduction- Meaning of Intellectual Property, main forms of IP, copyright, Trademarks, Patents and Designs, Secrets, Law relating to copyright India, Law relating to trademarks under Trademark Act, Law relating to Patents under Patent Act.	5 Hrs.
IV	Module 4: Right to information Act, 2005 covering evolution and concept, Information Technology Act, Legislation and Procedures, Cyber-Crimes.	3 Hrs.
V	Module 5: Industrial employment Act, 1946; corporate Law, covering meaning of corporation, Law relating to companies, Public and Private (companies Act, 1956), general Provisions.	4 Hrs.
VI	Module 6: Human Rights covering International agency, Amnesty international, National human rights commission and state human rights commission (Structures and functions).	2 Hrs.

EVALUATION SCHEME

Section	Maximum Marks	Question No.	Chapter No.
No Sections	16-18 Marks	Question-1	Chapter-1 To 6 (Module-1 To 6)
	14-16 Marks	Question-2	
	14-16 Marks	Question-3	

REFERENCES

Text Books and Reference Books	
1.	B. K. Goel Business Law for Managers Biztantra, Indian Test edition
2.	D.D. Basu (1996) Shorter Constitution of India, Prentice Hall of India
3.	M.P. Jain (2005) Indian Constitutional Law, Wadhwa & Co.
4.	Agarwal H.O.(2008) International Law and Human Rights, Central Law Publications
5.	Meena Rao (2006) Fundamental concepts in Law of Contract, 3rd Edn. Professional Offset
6.	Cornish W. R. (2008) Intellectual Property Rights, Patents, Trademarks, Copyrights & Allied Rights, Sweet & Maxwell
7.	Wadhwa (2004) Intellectual Property Rights, Universal Law Publishing Co.
8.	Bare text (2005) Right to Information Act.
9.	O.P. Malhotra Law of Industrial Disputes, N.M. Tripathi Publishers
10.	K.M. Desai (1946) The Industrial Employment (Standing Orders) Act
11.	Rustamji R.F. Introduction to the Law of Industrial Disputes, Asia Publishing House
12.	Avtarsingh (2007) Company Law, Eastern Book Co.
13.	R.R. Pennington Company Law, Butterworth Publications
Data Manuals	
1.	*
E-books/E-Links	
1.	https://nios.ac.in/media/documents/SecSocSciCour/English/Lesson-16.pdf
2.	https://en.wikipedia.org/wiki/Fundamental_rights_in_India
3.	https://vakilsearch.com/advice/writ-petition-india-filing-drafting/
4.	https://www.vidhikarya.com/blog/category/intellectual-property-copyright-patent-trademark/
5.	http://www.ipindia.nic.in/public-training-schedule-rg.htm
6.	http://www.ipindia.nic.in/right-to-information.htm
7.	http://www.un.org/en/sections/issues-depth/human-rights/
8.	https://en.wikipedia.org/wiki/Cybercrime
NPTEL /Other Video Links	
1.	https://www.youtube.com/watch?v=Z149N2iSyyg
2.	https://www.youtube.com/watch?v=nmfYLcIAJ6k
3.	https://www.youtube.com/watch?v=NlZj4zEsmBU
4.	https://www.youtube.com/watch?v=pdZ3JDIYqjU
5.	https://www.youtube.com/watch?v=gmNh_E-TLE0
6.	https://www.youtube.com/watch?v=BGSgZ1J8-yQ
7.	https://www.youtube.com/watch?v=lyDfovqz1_g
8.	https://www.youtube.com/watch?v=Qy064xFEW64
9.	https://www.youtube.com/watch?v=jHGcn5TIVUk

ASSIGNMENT QUESTIONS/QUESTION BANK
(Assignment 1)

Unit- I		Module-1	16 to 18Marks
Que. No.	Question	CO No.	Remark
4.	Explain the fundamental rights of Indian citizens	EE421.01	Common for All
5.	Explain the essential features of Indian constitution	EE421.01	
6.	Explain Judicial structure of Indian	EE421.01	
7.	What is Petition? Explain its types	EE421.01	
8.	Explain the structure of Legislation	EE421.01	

ASSIGNMENT QUESTIONS/QUESTION BANK
(Assignment 2)

Unit- 2		Module-2	16 to 18Marks
Que. No.	Question	CO No.	Remark
1.	What is contract and What are the essential elements of contract	EE421.02	Common for All
2.	What are the different kinds of government contract	EE421.02	
3.	What are the standard forms of contract	EE421.02	
4.	Explain the different methods of dispute settlement	EE421.02	

ASSIGNMENT QUESTIONS/QUESTION BANK
(Assignment 3)

Unit- 3		Module-3	16 to 18Marks
Que. No.	Question	CO No.	Remark
1.	What is the related to copyright in India	EE421.03	Common for All
2.	What do you mean by Intellectual property? Distinguish between copyright, trademarks and Patents	EE421.03	
3.	What is the law related to patents and designs in India	EE421.03	
4.	What is the law related to trademark in India	EE421.03	

ASSIGNMENT QUESTIONS/QUESTION BANK
(Assignment 4)

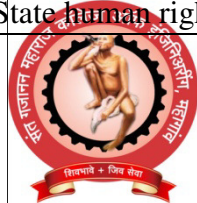
Unit- 4		<i>Module-4</i>	16 to 18 Marks
Que. No.	Question	CO No.	Remark
1.	Explain the objective and importance of RTI Act	EE421.04	Common for All
2.	Enlist and Explain Cyber-crimes	EE421.04	
3.	Explain the process of filing application under RTI act	EE421.04	
4.	Explain the significance and features of IT Act	EE421.04	

ASSIGNMENT QUESTIONS/QUESTION BANK
(Assignment 5)

Unit- 5		<i>Module-5</i>	16 to 18 Marks
Que. No.	Question	CO No.	Remark
1.	Explain corporate Law in details	EE421.05	Common for All
2.	Explain Law relating to companies and differentiate public and private companies	EE421.05	
3.	Explain the provision in Industrial Employment Act, 1946 about service conditions of employees	EE421.05	

ASSIGNMENT QUESTIONS/QUESTION BANK
(Assignment 6)

Unit- 6		<i>Module-6</i>	16 to 18Marks
Que. No.	Question	CO No.	Remark
1.	What is human right? How it is protected in Indian constitution	EE421.06	Common for All
2.	Describe the structures and functions of National human rights commission	EE421.06	
3.	Describe the structures and functions of State human rights commission	EE421.06	



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Department of Electrical Engineering

COURSE PLAN

Course Code	EE826	Course Name	Electrical Maintenance and Energy Audit
Prepared by	Mr. P.S.Chindhi	Date	10/12/2018(AY-2018-19)
Verified by	Mr. M.B.Patil(HOD EE)	Approved by	Academic Coordinator/ Principal
Objective	Provide an introduction and basic understanding of electrical maintenances, energy audit process and energy efficiency in electrical utilities.		

COURSE OUTCOMES

At the end of this course the students should be able to:

Sr. No.	CO	CO No.
7.	Recall ¹ and Summarize ² maintenances of transmission and distribution system	EE826.01
8.	Recall ¹ maintenances of distribution transformer	EE826.02
9.	Explain ² and Examine ⁴ maintenances of grid substation	EE826.03
10.	Recall ¹ Illustrate ² and Apply ³ energy management and audit	EE826.04
11.	Categorize ⁴ materials for direct energy conversion devices	EE826.05
12.	Explain ² energy efficiency in electrical utilities	EE826.06

EXAMINATION SCHEME

Examination Scheme	Theory	Term Work	#POE	Total
Maximum Marks	100	50	**	150
Contact Hours	04		02	06

MAPPING OF COs-POs

COs \ POs	POs											
	A	B	C	D	E	F	G	H	I	J	K	L
EE212.01	3											
EE212.02	3											

EE212.03	3											
EE212.04	1		3	1								
EE212.05	1		3	1								
EE212.06	1	3										

Degree of Compliance of COs and POs 1:Low 2: Medium 3: High

COURSE CONTENTS

Unit No.	Contents
Unit 1	Maintenance: Types of maintenance, maintenance schedules, procedures, Maintenance of Motors: motors, preventive maintenance, trouble shopping of electric motors. Maintenance of Transmission System, danger notice, caution notice permit to work, arranging of shutdowns personally and to cancellation of permit and restoration of supply, Patrolling and visual inspection of lines – points to patrolling from ground: special inspections and night inspections, Location of faults using Meggar, loose neutral connections provision of proper fuses on service lines and their effect on system, cause flickering lights
Unit 2	Maintenance of Distribution Transformers: Transformer maintenance and points to be attended to respect of various items of equipment, Checking of insulation resistance transformer oil level and measurement of earth resistance.
Unit 3	Maintenance of Grid Substations: Checking and maintenance of bus bars, isolating switches, breakers, LT switches, Power Transformers.
Unit 4	General Aspects of Energy Management and Energy Audit: Definition, Need and types of energy management (audit) approach-understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximum efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments
Unit 5	Energy Audit Methodology & Recent Trends: Current Practices, Integration of two or more systems Energy Sources, Reportwriting,preparations and presentations of energy audit reports, Post energyconservation projects, MIS ,Case-studies / Report studies of Energy Audits. Guidelines for writing report, data presentation in report, findings recommendations, impact of renewable energy on recommendations. Case studies of implemented energy cost optimization projects in electrical utility thermal utilities.

Unit 6	<p>Energy Efficiency in Electrical Utilities:</p> <p>Electrical system:Electricity billing, electrical load management and maximum demand control location of capacitors, performance assessment of PF capacitors, distribution and transformer losses.</p> <p>Electric motors:Types, losses in induction motors, motor efficiency, factors affecting motor performance and motor replacement issues, energy saving opportunities with energy efficient motors.</p> <p>Fans and blowers:Types, performance evaluation, efficient system operation, flow control strategies, energy conservation opportunities.</p> <p>Lighting System:Light source, choice of lighting, luminance requirements, and energy conservation</p>
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EVALUATION SCHEME

Section	Maximum Marks	Question No.	Chapter No.
I	16-24 Marks	Question-1	Unit 1
	16-24Marks	Question-2	Unit 2
	16-24 Marks	Question-3	Unit 3
II	16-24 Marks	Question-4	Unit 4
	16-24Marks	Question-5	Unit 5
	16-24 Marks	Question-6	Unit 6

REFERENCES

Books

14.	Testing, Commissioning Operation and Maintenance of Electrical Equipment: S Rao, Khanna Technical Publications
15.	Preventive Maintenance of Electrical Apparatus : SK Sharotri, Katson Publishing House Ludhiana
16.	Electric Energy Generation, Utilisation and Conservation Sivaganaraju, S Pearson, New Delhi, 2012
17.	Energy Management: W.R.Murphy, G.Mckay (Butterworths).
18.	Industrial Energy Conservation: D.A. Reay (Pergammon Press)
19.	Energy Management Handbook – W.C. Turner (John Wiley and Sons, A Wiley Interscience Publication).

IE Rules

1	http://www.derc.gov.in/actspolicies/actspolicesfiles/ier1956.pdf
2	http://bescom.org/wp-content/uploads/2014/12/IE-rules.pdf
3	http://www.electrical-installation.org/enwiki/Electrical_regulations_and_standards#Standards
4	http://mailweb.iacs.res.in/tender/240_TECHNICAL_SPECIFICATION_IACS_WS_SB_2015-16_46-09.01.2015.pdf

E-books/E-Links

9.	https://www.courses.netc.navy.mil/courses/14009A/14009A_ch2.pdf
10.	https://www.nfpa.org/Assets/files/AboutTheCodes/70B/1973_TCR-70B.pdf
11.	https://www.cablejoints.co.uk/upload/Electrical-Distribution-Maintenance-Services-Guide.pdf
12.	https://www.usbr.gov/power/data/fist/fist4_1B/41B%20Maintenance%20Scheduling%20for%20Electrical%20
13.	https://beeindia.gov.in/sites/default/files/1Ch3.pdf
14.	https://www.beeindia.gov.in/

NPTEL /Other Video Links

10.	https://www.youtube.com/watch?v=XCvGOBjxJSw
11.	https://www.youtube.com/watch?v=8eKpfjnT0ro
12.	https://www.youtube.com/watch?v=FTpMWXMBSyM
13.	https://www.youtube.com/watch?v=7hDyLuFJ0c8
14.	https://www.youtube.com/watch?v=6R1cn-45q5Y
15.	https://www.youtube.com/watch?v=vWSXu4y14to
16.	https://www.youtube.com/watch?v=M1zijCmeXJg
17.	https://nptel.ac.in/courses/108105058/8

ASSIGNMENT QUESTIONS/QUESTION BANK

Unit- I (Assignment 1) Maintenance:: 16 to 24 Marks			
Que. No.	Question	CO No.	Remark
9.	List and Explain types of maintenance in electrical system.	EE826.01	Common for All
10.	Explain maintenance of electrical motors.	EE826.01	
11.	Explain maintenance of transmission and distribution system.	EE826.01	
12.	Explain patrolling of transmission line.	EE826.01	
13.	List and explain various IE codes.	EE826.01	
14.	List the causes and dim and flickering lights.	EE826.01	
Unit-II: (Assignment 2) Maintenance of Distribution Transformers:16 to 24 Marks			
3.	Explain maintenance procedure for the distribution transformer	EE826.02	Common for All
4.	Explain BDV test for the distribution transformer	EE826.02	

Unit- III:(Assignment 3) Maintenance of Grid Substations : 16 to 24Marks			
Que. No.	Question	CO No.	Remark
3.	List and explain maintenance steps for substation component	EE826.03	Commonfor All
4.	Explain maintenance procedure for power transformer	EE826.03	
Unit- IV:(Assignment 4) General Aspects of Energy Management and Energy Audit: 12 to24Marks			
4.	Define energy audit and benchmark	EE826.04	Common for All
5.	List and explain energy audit procedure	EE826.04	
6.	List and explain energy audit instruments	EE826.04	
7.	Write short notes on fuel & energy substitution	EE826.04	
Unit- V: (Assignment 5)Energy Audit Methodology & Recent Trends 16 to 24Marks			
2.	Explain report writing steps in energy audit	EE826.05	Common for All
3.	Explain current practices in energy audit.	EE826.05	
Unit- VI:(Assignment 6)Energy Efficiency in Electrical Utilities :16 to 24Marks			
1.	Write short notes of load management, maximum demand control and bill.	EE826.06	Common for All
2.	Write short note on distribution and transformer losses	EE826.06	
3.	Explain energy efficiency in case of electric motor	EE826.06	
4.	Explain energy efficiency in case fan and blowers	EE826.06	
5.	Explain energy efficiency in case lightning system	EE826.06	



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Department of Electrical Engineering

COURSE PLAN

Course Code	EE423	Course Name	EHVAC
Prepared by	Ms. N H M Netravati	Date	10/12/2018 (AY-2018-19)

Verified by	Mr. M.B.Patil (HOD E&E)	Approved by	Academic Coordinator/ Principal
Objective	This course covers all topics that are considered essential for understanding the operation and design of EHV ac overhead lines and underground cables. Theoretical analyses of all problems combined with practical application are dealt in this course.		

COURSE OUTCOMES

At the end of this course the students should be able to:

Sr. No.	CO	CO No.
13.	To Provide In-depth understanding ² of different aspects of Extra High Voltage AC transmission system design and Analysis.	EE423.1
14.	To understand ² the concept of Voltage gradients of conductors and develop the empirical formula to determine the Corona loss occurring in EHV AC transmission Line.	EE423.2
15.	To develop ³ the expression and possible solution for travelling wave and its source of excitation.	EE423.3
16.	To illustrate ² the mechanism of lighting strokes and the propagation of lighting surges.	EE423.4
17.	To explain ⁵ the generation of switching transients and their control using circuit-theoretical concept, integrated power system.	EE423.5
18.	To develop ⁶ Power circle diagram and understand various Line Compensating systems.	EE423.6

EXAMINATION SCHEME

Examination Scheme	Theory	Term Work	#POE	Total
Maximum Marks	100	0	0	100
Contact Hours	4	0	0	4

MAPPING OF COs-POs

COs \ POs	POs											
	a	b	c	d	e	f	g	h	i	j	k	l
EE423.1	1	-	-	-	2	-	2	-	2	1	-	2
EE423.2	2	-	-	2	-	-	-	-	2	2	-	-
EE423.3	3	-	2	2	-	-	-	-	-	-	-	-

EE423.4	3	1	2	-	-	-	-	-	-	-	-	-
EE423.5	3	2	3	2	3	-	-	-	-	-	-	2
EE423.6	2	1	1	2	-	-	-	-	-	-	-	-

Degree of Compliance of COs and POs 1: Low 2: Medium 3: High

COURSE CONTENTS		
Chapter No.	Contents	No. of Hours
I	Introduction to EHVAC & Calculation of line and ground parameters: Engineering aspect and growth of EHVAC Transmission line trends and preliminaries, power transferability, transient stability, transient stability limit, and surge impedance loading. Resistance power loss, temperature rise properties of bundled conductors, Inductance and Capacitance, calculation of sequence inductions and capacitance line parameters for modes of propagations, resistance and inductance of the ground return.	10 Hrs.
II	Voltage gradients of conductor: Charge potential relations for multi-conductor lines, surface voltage gradients on the conductor line, surface voltage gradients on conductors, distribution of voltage gradients on sub conductors of bundle. I^2R and corona loss corona loss formula charge voltage diagram with corona, attenuation of traveling waves due to corona loss Audible noise, corona pulses, Their generation and properties, limit for radio interface fields.	8 Hrs.
III	Theory of the Traveling waves and standing: The waves at the power frequency, differential equations and solutions for general case, Standing waves and natural frequencies open ended line double exponential response, response to sinusoidal Excitation, line energization with trapped charge voltage, Reflection and refraction of traveling waves.	6 Hrs.
IV	Lighting and lightning protection & Insulation Co-ordinations: Lighting strokes to lines, their mechanism, General principal of the lightning protections problems, low footing resistance, lightning arrester and protection characteristics different arrestors and their characteristics. Insulation level, Voltage withstands levels of protected equipments and insulation condition based on the lighting.	10 Hrs.
V	Over voltage in EHV system covered by switching operation: Over voltage in EHV system covered by switching operations over –voltage their types, recovery voltage and circuits breaks, Ferro resonance over voltage and calculations of switching surges single phase equivalents.	8 Hrs.
VI	Power frequency voltage control and over voltages: Generalized constants, charging current, power circle diagram, and its use, Voltage control shunt and series components, Sub synchronous resonance in series capacitor compensated lines and static reactive compensating systems.	6 Hrs.
EVALUATION SCHEME		

Section	Maximum Marks	Question No.	Chapter No.
I	18	Question-1	Chapter-1
	16	Question-2	Chapter-2
	16	Question-3	Chapter-3
II	18	Question-4	Chapter-4
	16	Question-5	Chapter-5
	16	Question-6	Chapter-6

REFERENCES

Books

20.	Rakosh Das Begamudre ,”Extra high voltage AC transmission engineering”, New Age Publication
21.	EHV –AC and HVDC Transmission Engineering &Practice : S.V. Rao
22.	EHV -AC and HVDC transmission system engineering analysis and design: John Wiley & sons.
23.	EHV AC/DC transmission by Shobhit Gupta/ Deepak Gupta.
24.	EHVAC Transmission Engineering by R.D.Begamudre, New Academic Science

E-books/E-Links

15.	www.academia.edu/6697158/HVDC_and_EHV_AC
16.	ieeexplore.ieee.org
17.	www.ijret.org

ASSIGNMENT QUESTIONS/QUESTION BANK

Unit- I (Assignment 1) Introduction to EHVAC & Calculation of line and ground parameters:

16 Marks

Que. No.	Question	CO No.	Remark
15.	What is transient stability? Explain in detail surge impedance loading and its impact on EHVAC transmission.	EE423.1	Common for All
16.	Derive equation for capacitance in EHVAC transmission system.	EE423.1	
17.	Explain temperature rise properties of bundled conductors and resistance power loss in EHVAC transmission system.	EE423.1	
18.	Compare various EHVAC transmission lines on the basis of power handling capacity and losses for different voltages.	EE423.1	

19.	Derive the expression for self inductance of transmission line with bundled conductor.	EE423.1	
20.	Explain the bundled conductors. State their advantages. Derive the expression for equivalent radius of bundled conductors.	EE423.1	
21.	State and explain the heat balance equation of transmission line conductor.	EE423.1	Additional questions for Fast Learner
22.	Derive the equation for voltage gradient distribution on sub-conductors of a Bundle.	EE423.1	
Unit-II: (Assignment 2) Voltage gradients of conductor			18
Marks			
5.	What is corona? Properties of generation and properties.	EE423.2	Common for All
6.	Derive equation of surface voltage gradients on conductors in EHVAC.	EE423.2	
7.	Explain attenuation of traveling waves due to corona loss Audible noise.	EE423.2	
8.	Derive the sequence inductance of 3 phase AC line. Explain the effect of use of bundled conductor on the inductance.	EE423.2	
9.	Explain Corona Pulses and their properties.	EE423.2	
Unit- III:(Assignment 3) Theory of the Traveling waves and standing			16
Marks			
Que. No.	Question	CO No.	Remark
5.	Derive differential equations and solutions for general case in travelling waves.	EE423.3	Common for All
6.	What are standing waves? Derive equation for natural frequencies open ended line double exponential response.	EE423.3	
7.	Explain the diagonalisation procedure to obtain Eigen vectors and interpret them as three modes of propagation.	EE423.3	
8.	Derive the expression for corona loss using Q_V diagram.	EE423.3	
9.	Explain the principles of travelling wave protection for EHVAC lines.	EE423.3	
6	Explain the concept of line energization with tapped charge voltage.	EE423.3	Additional question for Fast Learner
Unit- IV:(Assignment 4) Lighting and lightning protection & Insulation Co-ordinations			16
Marks			
8.	Explain the concept of lightning stroke mechanism in detail.	EE423.4	Common for All
9.	Explain the concept of insulation co-ordination.	EE423.4	
10.	Explain the general principles of lightning protection problem in detail.	EE423.4	
11.	Define Lighting arrestors and its characteristics.	EE423.4	

12.	What is tower footing resistance? With neat sketches, explain measures taken to reduce it.		
13.	Explain construction of Sic and Zno arresters. Compare them	EE423.4	Additional question for Fast Learner
Unit- V: (Assignment 5) Over voltage in EHV system covered by switching operation			
18 Marks			
4.	What is mean by ferro resonance overvoltage? Explain in detail.	EE423.5	Common for All
5.	Explain the over voltages caused by interruption of low inductive current and interruption of capacitive current.	EE423.5	
6.	Explain causes of Over voltage in EHV system	EE423.5	
7.	Explain Ferro resonance over voltage and calculations of switching surges.	EE423.5	
8.	Explain recovery voltage and circuits breaks and its impact on over voltages.	EE423.5	Additional question for Fast Learner
Unit- VI: (Assignment 6) Power frequency voltage control and over voltages			
16 Marks			
6.	Explain the advantages of static VAR compensation and different schemes used.	EE423.6	Common for All
7.	Derive the expression for open-end voltage step response of a Transmission line with losses and attenuation included. Sketch the response.	EE423.6	
8.	Explain causes of Over voltage in EHV system.	EE423.6	
9.	Explain recovery voltage and circuits breaks and its impact on over voltages.	EE423.6	



An ISO 9001-2015 Certified Institute

SantGajananMaharaj College of Engineering, Mahagaon

Site- Chinchewadi, Tal- Gadhinglaj, Dist- Kolhapur

Department of Electrical Engineering

COURSE PLAN

Course Code	EE 414	Course Name	ELECTRICAL GENERATION & UTILIZATION
Prepared by	Prof.Bhalekar R.P.	Date	(AY-2018-19)
Verified by	Mr. M.B PATIL	Approved by	Academic Coordinator/ Principal

Objective	This course requires the student to know about the basic concepts of conventional and non-conventional Power Generations, traction phenomemon in details
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COURSE OUTCOMES

At the end of this course the students should be able to:

Sr. No.	CO	CO No.
19.	Describe various generation plants which include conventional energy source.	EE414.01
20.	Explain solar power generation system with application	EE414.02
21.	Explain wind power generation system with application	EE414.03
22.	Introduce industrial application like electrical welding and heating	EE414.04
23.	Describe different method of electrification system in traction	EE414.05
24.	Derive energy consumption in train movement and various braking arrangements in electrical traction system.	EE414.06

EXAMINATION SCHEME

Examination Scheme	Theory	Term Work	POE	Total
Maximum Marks	100	50	00	150
Contact Hours	4	**	**	4

MAPPING OF COs-Pos

COs \ POs	POs											
	a	b	c	d	e	f	g	h	i	j	k	l
EE 221.01	2	1	2	2	1	1	2	1				
EE 221.02	2	2	2	2	1		1	2	1			
EE 221.03	2	2	2	2	1		1	2	1			
EE 221.04	1			2			1					
EE 221.05	2	1			2							

Degree of Compliance of COs and POs 1:Low 2: Medium 3: High

COURSE CONTENTS

Chapter No.	Contents	No. of Hours
I	<p>Electrical Energy Generation using Conventional Energy Sources: Electrical Energy Generation using Conventional Energy Sources Electric energy demand, Electric energy growth in India, Power crisis in India. Types of Generation: Diesel & Gas Power Plant: Advantages, Disadvantages, applications of Diesel plant. Gas Turbine plant: Principle of operation, Open cycle, closed cycle plant & Applications of gas plant. Thermal power plant: Main & auxiliary equipments in Thermal plant. Hydro electric Plant: Advantages, disadvantages, & Classifications of hydro plant. Nuclear Power Plant: Main parts of nuclear plant, advantages & disadvantages of nuclear plant Co Generation: Technologies, Industries suitable for Cogeneration.</p>	08 Hrs.
II	<p>Solar Energy: A) Introduction, Beam & Diffuse solar radiation, Measurement of solar radiation, Derived solar angles, sunrise sunset & day length, sunrise hour angle, solar collectors, storage of solar energy, solar water heaters, distillation, solar still, solar cooker, estimation of average solar radiation. B) Solar Photovoltaic: Introduction, Solar cell characteristics & losses. Emerging solar technologies, Solar PV modules, Design of PV module, Sizing of Battery, inverter & charge controller. C) PV module power output, IV curve for PV module, batteries for PV cell, Battery charge controllers, Types of PV systems: Grid tie PV system, Stand-alone PV system, direct PV system.</p>	08Hrs.
III	<p>Wind Energy: Introduction, Principle of wind energy conversion, power duration & velocity duration characteristics of wind, advantages & disadvantages of WECS, Classification of windmills, basic components of wind mill, aerodynamic forces acting on wind mill blades, Design considerations of horizontal axis & vertical axis wind mill, Wind Data & site selection considerations, Social economic & environmental considerations.</p>	08 Hrs.
IV	<p>Electric Heating and Welding: Classification of electric heating, heating methods, Resistance heating, design of heating element, Arc furnaces, induction heating, Induction furnaces, Dielectric heating, Electric arc welding, welding transformer, Power supply and control of electric welding, Laser beam welding.</p>	08 Hrs.
V	<p>Electric traction: DC, AC and composite traction systems, main line and suburban systems, Comparison with Diesel-Electric traction, traction equipment's, Trolley wire, catenaries, Feeding and distribution systems, negative booster, overhead lines, current collectors, traction substations .</p>	08 Hrs.
VI	<p>A) Train movement and Energy consumption: Trapezoidal and quadrilateral speed-time curves, Maximum, average and scheduled speeds, Mechanics of train movement, tractive effort calculation, Power and energy output from driving axles, Specific Energy Output. B) Braking & control of traction motors: Vacuum brake and Air brake systems, regenerative braking, calculation of energy returned during regenerative braking. D.C. series, A.C. series and 3 Phase Induction motors for traction, Brief introduction to rheostatic speed control methods, drum controller, Multiple Unit Control, Static control of traction motors. Use of</p>	08 Hrs

microprocessors for control of traction motors.

EVALUATION SCHEME

Section	Maximum Marks	Question No.	Chapter No.
I	18	Question-1	Chapter-1
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	16	Question-3	Chapter-3
II	16	Question-4	Chapter-4
	16	Question-5	Chapter-5
	18	Question-6	Chapter-6

REFERENCES

Books

Sr.No.	Title of the Book	Author	Publisher/Edition
1.	Generation of Electrical energy.	Dr. B.R. Gupta	S. Chand Publications
2.	Non Conventional& Renewable energy sources	S.S. Thipse	Narosa publishing house
3.	Utilization of Electric Power and Electric Traction	J.B. Gupta, 8th Edition	S.K.Kataria& Sons
4.	Art and science of Utilization of Electric Energy	H. Partab	GaganKapur
5.	Utilization of Electric Energy	Openshaw Taylor	DhanpatRai and co. publications

E-books/E-Links

18. http://www.academia.edu/34040906/P_s_bimbhra_electrical_machines_pdf

NPTEL /Other Video Links

18. <https://www.youtube.com/watch?v=20Vb6hLQSg>

19. <https://www.youtube.com/watch?v=xKxrkt7CpY>

20. <https://www.youtube.com/watch?v=GExTwRNkQBg>

21. https://www.youtube.com/watch?v=Bk_mzWoPXDo&list=PLEprwsbQ0B8LwyVcXqzXkkwG68gKIrJoQ

LIST OF ASSIGNMENTS

Asst. No.	Assignment Title	
B. Assignment Exercise		CO No.
1.	Electrical Energy Generation using Conventional Energy Sources	EE414.01
2.	Solar Energy	EE414.02
3.	Wind Energy	EE414.03
4.	Electric Heating and Welding:	EE414.04
5.	Electric traction	EE414.05
6.	A) Train movement and Energy consumption B) Braking & control of traction motors	EE414.06

ASSIGNMENT QUESTIONS/QUESTION BANK

Unit- I (Assignment 1) Electrical Energy Generation using Conventional Energy Sources			
Que. No.	Question	CO No.	Remark
23.	Explain Electrical Energy scenario in India	EE414.01	Common for All
24.	What are the Conventional Energy sources and Explain Thermal power plant	EE414.01	
25.	Explain what are factors to consider for solar Energy and its application	EE414.01	Fast learner
26.	Mention Different types of PV System and Explain any one in Detail	EE414.01	
Unit-II: (Assignment 2) Solar Energy			
10.	What are the Design consideration for horizontal & vertical axis wind mills	EE414.02	Common for All
11.	Explain Principle of wind energy conversion	EE414.02	
12.	Explain what are factors to consider for solar Energy and its application	EE414.02	
13.	A resistance oven employing nichrome wire is to be operated from 220 V single-phase supply and is to be rated at 16 kW. If the temperature of the element is to be limited to 1,170°C and average temperature of the charge is 500°C, find the diameter and length of the element wire. Radiating	EE414.02	Fast learner

Unit- III:(Assignment 3) Wind Energy			
Que. No.	Question	CO No.	Remark
10.	Compare A.C and D.C welding	EE414.03	Common for All
11.	Explain the principles of Induction heating	EE414.03	
12.	Explain the properties of good heating element	EE414.03	
Unit- IV:(Assignment 4) Electric Heating and Welding			
14.	Explain how series motors are ideally suited for traction service.Explain any one method for regenerative braking of D.C. motor for traction	EE414.04	Common for All
15.	Explain the various modes of operation in traction services with neat speed-time curve	EE414.04	
Unit- V: (Assignment 5)Electric traction			
9.	1. What are the advantages and disadvantages of electric traction? 2. Draw the speed-time curve of a suburban service train and explain. 3. Derive an expression for specific energy output on level track using a simplified speed-time 4. For a trapezoidal speed-time curve of a electric train, derive expression for maximum speed and distance between stops. 5. Derive expression for the tractive effort for a train on a level track.	EE414.05	Common for All
Unit- VI: (Assignment 6A)Train movement and Energy consumption			
B) Braking & control of traction motors			
1	Explain the advantages of series parallel control of starting as compared to the Rheostatic starting for a pair of dc traction motors.	EE414.06	Common for All
2	Discuss the relative merits of electric traction and the factors on which the choice of traction system depends.	EE414.06	