INSTITUTE VISION

To be a preferred institution in Engineering Education by achieving excellence in teaching and research and to remain as a source of pride for its commitment to holistic development of individual and society.

INSTITUTE MISSION

To continuously strive for the overall development of students, educating them in a state-of-the-art-infrastructure, by retaining the best practices, people and inspire them to imbibe real time problem solving skills, leadership qualities, human values and societal commitments, so that they emerge as competent professionals.

DEPARTMENT VISION

To be the centre of excellence in teaching and learning to produce the competent & socially responsible professionals in the domain of Electrical & Electronics Engineering.

DEPARTMENT MISSION

To educate students with core knowledge of Electrical and Electronics Engineering by developing problem solving skills, professional skills and social awareness to excel in their career.

PROGRAM EDUCATIONAL OBJECTIVES (PEO's) :

Graduates of the program will be able to

PEO1: Possess successful career in Electrical Sciences & apply the knowledge of Mathematics & Engineering fundamentals to analyze & formulate the solution to solve real time problems.

PEO2: Excel in Academics, Industry, Entrepreneurship, Administrative Services through lifelong learning.

PEO3: Exhibit professional & ethical values, effective communication skills, teamwork, multidisciplinary approach & realize engineering issues in broader social context.

PROGRAM OUTCOMES (PO's) :

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **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.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **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.
6. **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.

7. **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.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **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.
11. **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.
12. **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's) :

Graduates will be able to

PSO1: Apply knowledge & competencies to analyze & design Electrical & Electronics Circuits, Controls and Power Systems, Machines & Industrial Drives.

PSO2: Use Software/Hardware tools for the design, simulation and analysis of Electrical and Electronics Systems.

Contents of VII-SEM

1.0 Student Help Desk

Sl. No	Coordination Work	Contact Person	
		Faculty	Instructor
01	Attestations	Dr. B. V. Madiggond	--
02	Exam forms signature, Overall department administration, Counseling/interaction with Parents/Students.		
03	Research Centre Coordinator		
04	Academic Coordinator, Seminar Coordinator	Prof. S. D. Hirekodi	--
05	Online submission of exam form/revaluation form to VTU, IA coordinator, Internship, III Cell Coordinator, SC/ST cell Convener, Examination committee member, Hobby Project Coordinator	Prof. K. B. Negalur	Shri. S. B. Beelur
06	Department Association Coordinator (EESSA)	Prof. H. R. Zinage, Prof. O. B. Heddurshetti	--
07	Dept NBA Coordinator, Project/KSCST Coordinator	Prof. M. P. Yanagimath	--
08	AICTE/VTU,NIRF, News Letter Coordinator, News/Publicity committee member	Prof. S. S. Birade	Shri. R. S. Bardol
09	Dept.TP Cell Coordinator, Robovidya, GATE Coaching, Technical magazine	Prof. P. M. Murari	--
10	Dept. Alumni Coordinator, Library Coordinator	Prof. S. B. Patil	Shri. S. B. Beelur
11	Dept, Website, IEEE/ISTE Coordinator	Prof. V. B. Dhere	--
12	Dept meeting Coordinator, Mentorship Coordinator	Prof. A. U. Neshti	--
13	Electrical Maintenance	Prof. S. D. Hirekodi	--
14	Warden HIT Ladies Hostel, I year Coordinator	Prof. H. R. Zinage	--
15	Chief Alumini Coordinator	Prof. O. B. Heddurshetti	--
16	OBC cell Convener	Prof. P. M. Murari	--
17	Entrepreneurship Cell Coordinator	Prof. V. B. Dhere	--
18	Dispensary	Dr. Arun G. Bullannavar, Contact No. 9449141549	
	Class Teacher		
19	3rd Semester	Prof. S. B. Patil	Shri. S. B. Beelur
20	5th Semester	Prof. O. B. Heddurshetti	Shri. V. M. Mutalik
21	7th Semester	Prof. S. D. Hirekodi	Shri. R. S. Bardol

2.0 Departmental Resources

Department of Electrical and Electronics Engineering was established in the year 1996 and is housed in a total area of **1339 Sq. Mtrs.**

2.1 Faculty Position

S.N.	Category	No. in position	Average experience
1	Teaching faculty	12	15.33 Y
2	Technical supporting staff	3	22 Y
3	Helper	2	16 Y

2.2 Major Laboratories

SL. No.	Name of the laboratory	Area in Sq. Mtrs	Amount Invested (Rs)
01	Electronics Lab	71	4,48,518.00
02	Operational Amplifier & Linear Integrated Lab		1,19,042.00
03	Power Electronics Lab	92	7,81,250.00
04	Control Systems Lab		2,12,755.00
05	Power System Simulation Lab	71	11,88,401.00
06	Computer Aided Electrical Drawing Lab		6,50,988.43
07	Microcontroller Lab / Digital Signal Processing Lab	72	5,93,152.00
09	Electrical Machines Lab	200	14,63,682.00
10	Relay & High Voltage Lab	94	11,69,848.00
11	Basic Electrical Engg. Lab	96	38,970.00
	Department , Repair & Maintenance		2,32,933.20
	Total	**696**	**7254938.63**

3.0 Teaching Faculty Details

S.N.	Faculty Name	Designation	Qualification	Area of specialization	Professional membership	Industry Experience (in years)	Teaching Experience (in years)	Contact Nos.
01	Dr. B. V. Madiggond	HOD/Prof.	Ph. D	Power Electronics	LMISTE,YHAI	-	26	9343454993
02	Prof. S. B. Patil	Asst. Prof.	M. Tech	Power & Energy System	LMISTE	-	34	8050234360
03	Prof. V. B. Dhere	Asst. Prof.	M. Tech, (Ph. D)	Electronics & Tele-communication	LMISTE, IMPARC	4	22	9886597573
04	Prof. S. D. Hirekodi	Asst. Prof.	M. Tech.	Power Electronics	LMISTE	1	19	9480849338
05	Prof. H. R. Zinage	Asst. Prof.	M. E.	Power System	LMISTE	-	19	9480849335
06	Prof. M. P. Yanagimath	Asst. Prof.	M. Tech (Ph. D)	VLSI & ES	LMISTE	1	14	9341449466
07	Prof. O. B. Heddurshetti	Asst. Prof.	M. Tech.	Power Electrics	LMISTE	1	12	9448120509
08	Prof. A. U. Neshti	Asst. Prof.	M. Tech.	Digital Electronics	ISTE	-	11	9538223362
09	Prof. P. M. Murari	Asst. Prof.	M. Tech.	PS & PE	LMISTE	-	08	9739733001
10	Prof. S. S. Birade	Asst. Prof.	M. Tech.	VLSI Design & ES	LMISTE	-	07	9945105480
11	Prof. K. B. Neglur	Asst. Prof.	M. Tech.	Industrial Electronics	LMISTE	-	06	9886644507
12	Prof. S. G. Huddar	Asst. Prof.	M. Tech.	Power System	LMISTE	-	06	9742066852

4.0 Institute Academic Calendar

S J P N Trust's
Hirasugar Institute of Technology, Nidasoshi.
Inculcating Values, Promoting Prosperity
Approved by AICTE New Delhi, Recognized by Govt. of Karnataka and Affiliated to VTU Belagavi.
Accredited at 'A' Grade by NAAC and Recognized Under Section 2(f) of UGC Act, 1956.

Institute
File I-11
2019-20 (Odd)
Rev: 0

CALENDAR OF EVENTS FOR THE ACADEMIC YEAR 2019-20 (Odd)

Date	Events
29-07-2019	Commencement of III /V/VII Sem Classes
01-08-2019	Commencement of I Sem Classes
01-08-2019 to 11-08-2019	Induction Program for I Sem students
15-08-2019	Independence Day & Swachh Bharat Abhiyan
05-09-2019	Teachers Day, Mahadasoha
06-09-2019	Indoor Games & & Health Checkup Camp
12-09-2019 to 14-09-2019	First Internal Assessment of I/III/V/VII Sem
15-09-2019	Engineers Day
16-09-2019	Feed Back-1 on Teaching-Learning
18-09-2019	Display of First Internal Assessment Marks & Submission of Feedback-1 report to office
24-09-2019	EDP Activities/ Green Club activites
02-10-2019	Gandhi Jayanti & Swachh Bharat Abhiyan
11-10-2019	Blood donation camp
21-10-2019 to 23-10-2019	Second Internal Assessment of I/III/V/VII Sem
24-10-2019	Feed Back-2 on Teaching-Learning
28-10-2019	Display of Second Internal Assessment Marks & Submission of Feedback-2 Report to Office
01-11-2019	Kannada Rajyotsava
21-11-2019 to 23-11-2019	Third Internal Assessment of I/III/V/VII Sem
25-11-2019 to 27-11-2019	Lab Internal Assessment of I/III/V/VII Sem
28-11-2019	Display of Third & Final Internal Assessment Marks (I/III/V/VII Sem)
29-11-2019	Last Working Day of I Sem
30-11-2019	Last Working Day of III/V/VII Sem
03-12-2019 to 13-12-2019	Practical Exams of I/III/V/VII Sem
16-12-2019 to 07-02-2020	Theory Exams of I/III/V/VII Sem

August-2019

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

12-Bakrid, 15- Independance day, 26- Last Shravana Monday

September-2019

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

02- Ganesh Chaturthi , 05- Mahadasoha, 10- Moharam, 28-Mahalaya Amavasye

October-2019

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

02- Gandhi Jayanti, 07-Ayudha Pooja, 08- Vijayadashami, 13- Valmiki Jayanti, 27- Naraka Chaturdashi, 29- Balipadyami

November-2019

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

01- Kannada Rajyotsava, 10- Id-e-Milad, 15- Kanakadasa Jayanthi

Dr. Shilpa Shrigiri
IQAC Co-ordinator

Hirasugar Institute of Technology, Nidasoshi Pin-591236 Dr. Belagum

Dr. S C Kamate
PRINCIPAL
Hirasugar Institute of Technology
NIDASOSHI-591 236

5.0 Department Academic Calendar

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E&E Engg. Dept | COE | 2019-20 (Odd)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
CALENDAR OF EVENTS FOR THE ACADEMIC YEAR 2019-20 (Odd)

Date	Events
29-07-2019	**Commencement of III /V/VII Sem Classes**
01-08-2019	**Commencement of I Sem Classes**
01-08-2019 to 11-08-2019	Induction Program for I Sem students
15-08-2019	Independence Day & Swachh Bharat Abhiyan
23-08-2019	**Inauguration of EESSA & Guest Lecture by Alumni/Industry person.**
28-08-2019	**Submission of First Assignment**
05-09-2019	Teachers Day, Mahadasoha
06-09-2019	Indoor Games & & Health Checkup Camp
09-09-2019	**Submission of Second Assignment**
12-09-2019 to 14-09-2019	**First Internal Assessment of I/III/V/VII Sem**
15-09-2019	Engineers Day
16-09-2019	Feed Back-1 on Teaching-Learning
18-09-2019	Display of First Internal Assessment Marks & Submission of Feedback-1 report to office
19-09-2019 to 21-09-2019	**Three days workshop on MATLAB for staff & students**
24-09-2019	EDP Activities/ Green Club activities
30-09-2019	**Submission of Third Assignment**
02-10-2019	Gandhi Jayanti & Swachh Bharat Abhiyan
04-10-2019	**Group Discussion for Final Year Students**
11-10-2019	Blood donation camp
18-10-2019	**Submission of Fourth Assignment**
21-10-2019 to 23-10-2019	**Second Internal Assessment of I/III/V/VII Sem**
24-10-2019	Feed Back-2 on Teaching-Learning
25-10-2019	**Industrial Visit for 3rd & 5th Semester Students.**
28-10-2019	Display of Second Internal Assessment Marks & Submission of Feedback-2 Report to Office
01-11-2019	Kannada Rajyotsava
16-11-2019	**Submission of Fifth Assignment**
21-11-2019 to 23-11-2019	**Third Internal Assessment of I/III/V/VII Sem**
25-11-2019 to 27-11-2019	**Lab Internal Assessment of I/III/V/VII Sem**
28-11-2019	Display of Third & Final Internal Assessment Marks (I/III/V/VII Sem)
29-11-2019	**Last Working Day of I Sem**
30-11-2019	**Last Working Day of III/V/VII Sem**
03-12-2019 to 13-12-2019	**Practical Exams of I/III/V/VII Sem**
16-12-2019 to 07-02-2020	**Theory Exams of I/III/V/VII Sem**

August-2019

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

12-Bakrid, 15- Independence day,
26- Last Shravana Monday

September-2019

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

02- Ganesh Chaturthi ,
05- Mahadasoha,
10-Moharam
28-Mahalaya Amavasye

October-2019

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

02- Gandhi Jayanti, 07-Ayudha Pooja,
08- Vijayadashami, 13- Valmiki Jayanti,
27- Naraka Chaturdashi, 29- Balipadyami

November-2019

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

01- Kannada Rajyotsava,
10- Id-e-Milad,
15- Kanakadasa Jayanthi

Coordinator H.O.D. 12/7 Principal 13/12

5.1 Scheme of Teaching & Examination

Sl. No	Course Code	Title	Teaching Department	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Drawing	Duration in hours	SEE Marks	CIE Marks	Total Marks	
1	15EE71	Power System Analysis – 2 (Core)	EEE	04	--	03	20	80	100	04
2	15EE72	Power System Protection (Core)	EEE	04	--	03	20	80	100	04
3	15EE73	High Voltage Engineering (Core)	EEE	04	--	03	20	80	100	04
4	15EE74X	Professional Elective – III	EEE	04	--	03	20	80	100	03
5	15EE75Y	Professional Elective – IV	EEE	04	--	03	20	80	100	03
6	15EEL76	Power system Simulation Laboratory	EEE	01-Hour Instruction 02-Hour Practical		03	20	80	100	02
7	15EEL77	Rely and High Voltage Laboratory	EEE	01-Hour Instruction 02-Hour Practical		03	20	80	100	02
8	15EEP78	Project Phase – I + Seminar	EEE	--		--	100	--	100	02
			Total	Theory:24 hours Practical: 06 hours		**21**	**240**	**560**	**800**	**24**

Professional Elective-1		**Open Elective – 1**	
Courses under Code 15EE74X	**Title**	**Courses under Code 15EE75Y**	**Title**
15EE741	Advanced Control Systems	15EE751	FACTs and HVDC Transmission
15EE742	Utilization of Electrical Power	15EE752	Testing and Commissioning of Power System Apparatus
15EE743	Carbon Capture and Storage	15EE753	Spacecraft Power Technologies
15EE744	Power System Planning	15EE754	Industrial Heating

1. Core subject: This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
2. Professional Elective: Elective relevant to chosen specialization/ branch.
3. Project Phase –I + Seminar: Literature Survey, Problem Identification, objectives and Methodology. **Submission of synopsis and seminar.**

1. Internship / Professional Practice: To be carried between the VI and VII semester vacation or VII and VIII semester vacation period.

Subject Title	**POWER SYSTEM ANALYSIS -2**		
Subject Code	15EE71	**IA Marks**	20
Number of Lecture Hrs / Week	04	**Exam Marks**	80
Total Number of Lecture Hrs	50	**Exam Hours**	03

FACULTY DETAILS:		
Name: Prof. Hemalata R Zinage	**Designation:** Asst. Professor	**Experience:**18
No. of times course taught:-01		**Specialization:** Power System

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical and Electronics Engineering	I/II	Basic Electrical Engineering
02	Electrical and Electronics Engineering	III/IV	Electric Power Generation
03	Electrical and Electronics Engineering	VI	Power system analysis & stability

2.0 Course Objectives

- To explain formulation of network models and bus admittance matrix for solving load flow problems.
- To discuss solution of nonlinear static load flow equations by different numerical techniques and methods to control voltage profile.
- To discuss optimal operation of generators on a bus bar, optimal unit commitment, reliability considerations and optimum generation scheduling.
- To discuss optimal power flow solution, scheduling of hydro-thermal system, power system security and reliability.
- To explain formulation of bus impedance matrix for the use in short circuit studies on power systems.
- To explain numerical solution of swing equation for multi-machine stability.

3.0 Course Outcomes

Having successfully completed this course, the student will be able to

	Course Outcome	Cognitive Level	POs
CO 401.1	Formulate network matrices and models for solving load flow problems.	U	5,9,11
CO 401.2	Perform steady state power flow analysis of power systems using numerical iterative techniques .	U	1,2,3
CO 401.3	Suggest a method to control voltage profile.	U	2,3,4
CO 401.4	Show knowledge of optimal operation of generators on a bus bar, optimal unit commitment	U U	1,2,3,4
CO 401.5	Discuss optimal scheduling for hydro-thermal system, power system security and reliability.	U	1,2,4
CO 401.6	Analyze short circuit faults in power system networks using bus impedance matrix.	U	1,2,3,4
CO 401.7	Perform numerical solution of swing equation for multi-machine stability	U	2,4

4.0 Course Content

Module-1	**Teaching Hours**
Load Flow Studies: Introduction, Network Model Formulation, Formation of Y_{bus} by Singular Transformation, Load Flow Problem, Gauss-Seidel Method. ■	**10**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying L_4 – Analysing	.
Module-2	
Load Flow Studies (continued): Newton-Raphson Method, Decoupled Load Flow Methods, Comparison of Load Flow Methods, Control of Voltage Profile.■	**10**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying L_4 – Analysing	.
Module-3	
Optimal System Operation: Introduction, Optimal Operation of Generators on a Bus Bar, Optimal Unit Commitment, Reliability Considerations, Optimum Generation Scheduling.■	**10**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying L_4 – Analysing	.
Module-4	
Optimal System Operation (continued): Optimal Load Flow Solution, Optimal Scheduling of Hydrothermal System, Power System Security, Maintenance Scheduling, Power System Reliability.■	**10**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying L_4 – Analysing.	
Module-5	
Symmetrical Fault Analysis: Algorithm for Short Circuit Studies, Z_{bus} Formulation. **Power System Stability:** Numerical Solution of Swing Equation, Multimachine Stability.■	**10**
Revised Bloom's Taxonomy Level L_1 – Remembering, L_2 – Understanding, L_3 – Applying L_4 – Analysing	.

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
1	VIII	PSOC	ALL

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Power system operation
02	Carryout load flow analysis
03	Power system stability studies

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Visit to power plant	Power system operation study

8.0 Books Used and Recommended to Students

Text Books
1 Modern Power System Analysis D. P. Kothari McGraw Hill 4th Edition, 2011
Reference Books
1. Stag, G. W., and EI-Abiad, A. H., "Computer Methods in Power System Analysis", McGraw Hill International Student Edition. 1968
2. .Pai, M. A., "Computer techniques in Power System Analysis", TMH, 2nd edition, 2006.

4.Hadi Saadat,"power system analysis" McGraw Hill 2nd Edition, 2002
Additional Study material & e-Books
1. http://pdfstuff4u.com/ebook.php?id=1071881 2. http://sjbit.edu.in

9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
1) ieeexplore.ieee.org/document/152452/ 2) https://engineering.purdue.edu/jump/8cb309 *3)nptel.iitg.ernet.in*

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Society of energy engineers and managers	www.energyprofesionals.in
2	IEEE Explore	***ieeexplore.ieee.org/xpl/RecentIssue***
3	Journal *of Modern* Power Systems *and Clean Energy*	***www.springer.com***

11.0 Examination Note

Internal Assessment: 20Marks

Three internal assessment tests will be conducted. Out of the three tests, average marks of the best two tests marks will be considered. The students will write the internal assessment tests in separate IA test books.

Internal Assessment:15 Marks

Assignment:05 Marks

Scheme of Examination:

- The question paper will have ten questions
- There will be three full questions from each module.
- Students have to answer 5 full questions, selecting one full question from each module.

12.0 Course Delivery Plan

UNIT No.	Lecture No.	Content of Lecture	% of Portion
I	1.	**Load Flow Studies:** Introduction	20
	2.	Network Model Formulation	
	3.	Formation of Y_{bus} by Singular Transformation,	
	4.	Numerical problems	
	5.	Numerical problems	
	6.	Load Flow Problem	
	7.	Gauss-Seidel Method	
	8.	Numerical problems	
	9.	Numerical problems	
	10.	Numerical problems	
II	11.	**Load Flow Studies (continued):** Newton-Raphson Method,	20
	12.	Newton-Raphson Method	
	13.	Flow chart of Newton-Raphson Method	

	14.	Numerical problems	
	15.	Decoupled Load Flow Methods	
	16.	Flow chart Decoupled Load Flow Methods,	
	17.	Comparison of Load Flow Methods	
	18.	Control of Voltage Profile	
	19.	Types of Control of Voltage Profile	
	20.	Types of Control of Voltage Profile	
III	21.	**Optimal System Operation :** Introduction, Performance curves	**20**
	22.	Optimal Operation of Generators on a Bus Bar	
	23.	Optimal Unit Commitment	
	24.	Optimal Unit Commitment	
	25.	Reliability Considerations	
	26.	Reliability Considerations	
	27.	Optimum Generation Scheduling	
	28.	Optimum Generation Scheduling	
	29.	Numerical problems	
	30.	Numerical problems	
IV	31.	**Optimal System Operation (continued):** Optimal Load Flow Solution,	**20**
	32.	Optimal Load Flow Solution,	
	33.	Optimal Scheduling of Hydrothermal System,	
	34.	Optimal Scheduling of Hydrothermal System,	
	35.	Power System Security	
	36.	Power System Security	
	37.	Maintenance Scheduling	
	38.	Power System Reliability	
	39.	Power System Reliability	
	40.	Power System Reliability	
V	41.	**Symmetrical Fault Analysis:** Algorithm for Short Circuit Studies	
	42.	Algorithm for Short Circuit Studies	
	43.	Z_{bus} Formulation	
	44.	Z_{bus} Formulation	
	45.	Numerical on Z_{bus} Formulation	
	46.	**Power System Stability:** Numerical Solution of Swing Equation	
	47.	Numerical Solution of Swing Equation	
	48.	Multimachine Stability	
	49.	Multimachine Stability	
	50.	Multimachine Stability	

13.0 Assignments

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment1: University Questions on network topology	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1 of the syllabus	3	Individual Activity.	Book 1 of the Text book list. Website of the Reference list
2	Assignment 2: University Questions on energy economic	Students study the Topics and write the Answers. Get practice	Module 2 of the syllabus	5	Individual Activity.	Book 1 of the Text book list. Website of the

	analysis	to solve university questions.				Reference list
3	Assignment 3: University Questions on energy auditing	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 3 of the syllabus	7	Individual Activity.	Book 1 of the reference list. Website of the Reference list
4	Assignment 4: University Questions on electrical system optimization	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 4 of the syllabus	8	Individual Activity.	Book 1 of the reference list. Website of the Reference list
5	Assignment 5: University Questions on power factor correction & location of capacitors, energy efficient motors	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 5 of the syllabus	9	Individual Activity.	Book 5 of the reference list. Website of the Reference list

14.0 QUESTION BANK

Module -1

Explain the formation of Y_{Bus} by method of inspection.

Explain the formation of Y_{Bus} by method of singular transformation.

1. What are different types of buses considered during power system load flow analysis.
2. Explain G-S load flow solution procedure for a system having both PV & PQ buses. Derive the associated algorithmic expressions used for determining the unknown variables.
3. With the help of flow chart, explain the procedure of fast decoupled load flow analysis.
4. With the help of flow chart explain G-S method Of load flow analysis
5. What are the advantages of Y_{Bus} based power flow analysis

.

6. The following is the system data for a load flow solution:

Bus code	Admittance
1-2	2.0 -j8.0
1-3	1.0 – j3.0
2-3	0.6 – j2.0
2-4	1.0 –j4.0
3-4	2.0 –j8.0

The schedule of active and reactive power is

Bus code	P	Q	V	Remarks
1	-	-	1.05+j0.0	Slack
2	0.5	0.2	1.0+j0.0	PQ
3	0.4	0.3	1.0+j0.0	PQ
4	0.3	0.1	1.0+j0.0	PQ

Determine the voltage at the end of first iteration Using 1)Gauss – Seidal 2)N-R method.

Take acceleration factor = 1.4

7. What is the need for acceleration factor?
8. What is Q-limit of generator?

Module -2

1. **1.** Explain the significance of Jacobian matrix of N-R LF analysis.
2. With the help of flow chart explain N-R method Of load flow analysis
3. Compare different method of load flow solution procedure in respect of the following.
   I) Time per iteration
   ii) Total solution time
   iii) Acceleration of convergence of iterative solution
   iv) Adaptability for power system calculations
4. What are all the approximations made in fast decoupled load flow solution?
5. What is voltage stability problem in power system? Explain with suitable figure and illustrations, how does

it depend upon temperature and power factor?

6. Clearly distinguish between the angle stability and voltage stability of a power system
7. Describe the various factors affecting the voltage stability and voltage collapse.
8. What is voltage instability? Explain the phenomenon of voltage collapse with relevant PV and QV diagrams.
9. What is voltage collapse? Explain with PV and QV characteristics of loads

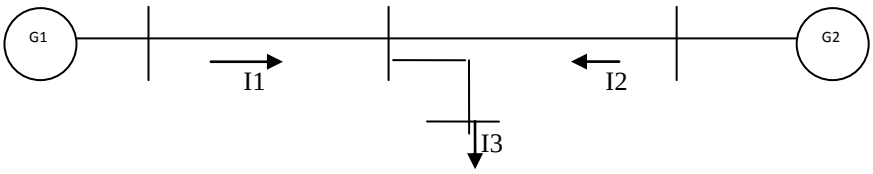
Module -3

1 Explain with reference to economic operation of electric power system, the equal incremental cost criterion. Comment on the same, if the filtration way to include the effect of transmission line losses also.

2 What are transmission line loss coefficients? Obtain the general expression B_{mn} with usual notations.

3. Explain in brief penalty factors & loss co-efficient. Derive the relevant expression.

4. For the system shown in figure, obtain the loss co-efficient. Assume I_1 & I_2 are in phase.



Module -4

1. Explain problem formulation, solution procedure & algorithm for hydrothermal coordination.
2. Explain the modes of failures of a system.
3. Explain the generating system and its performance,
4. Derive the expression of reliability index.
5. Discuss reliability measure for N- unit system
6. What are cumulative probability outages- Recursive Relation
7. What is loss of load probability?
8. Define system security and explain major functions involved in the system security.
9. Explain the importance of security assessment in the power system. What are the constraints and how these constraints differ from the normal operating constraints?
10. Distinguish between the normal operating constraints and security constraints of a power system.
11. What are the factors which affect the power system security?
12. Explain the contingency analysis with the help of flow chart.
13. Explain the role of sensitivity factors in the contingency analysis.
14. Explain the contingency analysis using sensitivity factors with the help of flow chart

Module-5

1. Derive the swing equation in the form
   $d^2 / dt^2 = \Pi f / H (Pm-Pe)$
2. Explain the simplified representation of synchronous machine for transient stability studies. Why its detailed representation of synchronous machine is also necessary for stability studies?
3. Explain clearly the representation of load for transient stability studies.
4. Explain how the network performs equation used for load flow analysis can be applied to describe the performance of the network during a transient period.
5. Starting from the pair of equations representing a swing equation, explain the modified Eulers method of obtaining swing curie.
6. With the help of flow diagram, explain the method of finding the transient stability of a given power system based on Runga-Kutta method.
7. Explain step by step method for the numerical analysis of swing equation.
8. Explain Milne's predictor-corrector method for transient stability studies.
9. Explain the Z BUS building algorithm.

Course Plan 2019-20Odd – Semester - Electrical and Electronics Engineering

15.0 University Result

Examination	FCD	FC	SC	% Passing
Jan2019	17	12	18	100

Prepared by	Checked by		
		9.7.19	
Prof. Hemalata R Zinage	Prof. Hemalata R Zinage	HOD	Principal

Subject Title	**POWER SYSTEM PROTECTION**		
Subject Code	15EE72	**IA Marks**	20
Number of Lecture Hrs / Week	04	**Exam Marks**	80
Total Number of Lecture Hrs	50	**Exam Hours**	03
			CREDITS – 04

FACULTY DETAILS:		
Name: Prof.Mahesh P. Yanagimath	**Designation:** Asst.Professor	**Experience:**13
No. of times course taught:01	**Specialization:** VLSI and Embedded System	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical & Electronics Engineering	I/II	BEE
02	Electrical & Electronics Engineering	III	T&G

2.0 Course Objectives

The subject aims to provide the student with:

1. To discuss performance of protective relays, components of protection scheme and relay terminology.
2. To explain relay construction and operating principles.
3. To explain Overcurrent protection using electromagnetic and static relays and Overcurrent protective schemes.
4. To discuss types of electromagnetic and static distance relays, effect of arc resistance, power swings, line length and source impedance on performance of distance relays.
5. To discuss pilot protection; wire pilot relaying and carrier pilot relaying.
6. To discuss construction, operating principles and performance of various differential relays for differential protection.
7. To discuss protection of generators, motors, Transformer and Bus Zone Protection.
8. To explain the principle of circuit interruption and different types of circuit breakers.
9. To describe the construction and operating principle of different types of fuses and to give the definitions of different terminologies related to a fuse.
10. To discuss protection Against Overvoltages and Gas Insulated Substation (GIS)

3.0 Course Outcomes

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

	Course Outcome	Cognitve Level	POs
C402.1	Discuss performance of protective relays, components of protection scheme and relay terminology overcurrent protection.	R,U,A,A	PO1,PO2, PO3,PO8, PO10,PO12
C402.2	Explain the working of distance relays and the effects of arc resistance, power swings, line length and source impedance on performance of distance relays.	R,U,A,A	PO1,PO2, PO3,PO8, PO10,PO12

C402.3	Discuss pilot protection; wire pilot relaying and carrier pilot relaying, and construction, operating principles, performance of differential relays for differential protection and protection of generators, motors, Transformer and Bus Zone Protection.	R,U,A,A	PO1,PO2, PO3,PO8, PO10,PO12
C402.4	Explain the principle of circuit interruption in different types of circuit breakers.	R,U,A,A	PO1,PO2, PO3,PO8, PO10,PO12
CO402.5	Describe the construction and operating principle of different types of fuses and to give the definitions of different terminologies related to a fuse and discuss protection against Overvoltages and Gas Insulated Substation (GIS).	R,U,A,A	PO1,PO2, PO3,PO8, PO10,PO12
	Total Hours of instruction	**50**	

4.0 Course Content

MODULE-1

Introduction to Power System Protection: Need for protective schemes, Nature and Cause of Faults, Types of Fault, Effects of Faults, Fault Statistics, Zones of Protection, Primary and Backup Protection, Essential Qualities of Protection, Performance of Protective Relaying, Classification of Protective Relays, Automatic Reclosing, Current Transformers for protection, Voltage Transformers for Protection.

Relay Construction and Operating Principles: Introduction, Electromechanical Relays, Static Relays – Merits and Demerits of Static Relays, Numerical Relays, Comparison between Electromechanical Relays and Numerical Relays.

Overcurrent Protection: Introduction, Time – current Characteristics, Current Setting, Time Setting. **10 Hours**

MODULE-2

Overcurrent Protection (continued): Overcurrent Protective Schemes, Reverse Power or Directional Relay, Protection of Parallel Feeders, Protection of Ring Mains, Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme, Phase Fault Protective Scheme, Directional Earth Fault Relay, Static Overcurrent Relays, Numerical Overcurrent Relays.

Distance Protection: Introduction, Impedance Relay, Reactance Relay, Mho Relay, Angle Impedance Relay, Effect of Arc Resistance on the Performance of Distance Relays, Reach of Distance Relays. Effect of Power Surges (Power Swings) on Performance of Distance Relays, Effect of Line Length and Source Impedance on Performance of Distance Relays. **10 Hours**

MODULE-3

Pilot Relaying Schemes: Introduction, Wire Pilot Protection, Carrier Current Protection **Differential Protection**: Introduction, Differential Relays, Simple Differential Protection, Percentage or Biased Differential Relay, Differential Protection of 3 Phase Circuits, Balanced (Opposed) Voltage Differential Protection.

Rotating Machines Protection: Introduction, Protection of Generators. **Transformer and Buszone Protection:** Introduction, Transformer Protection, Buszone Protection, Frame Leakage Protection. **10 Hours**

MODULE-4

Circuit Breakers: Introduction, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers, Air –

Break Circuit Breakers, Oil Circuit Breakers, Air – Blast Circuit Breakers, SF6 Circuit Breakers, Vacuum Circuit Breakers, High Voltage Direct Current Circuit Breakers, Rating of Circuit Breakers, Testing of Circuit Breakers.

10 Hours

MODULE-5

Fuses: Introductions, Definitions, Fuse Characteristics, Types of Fuses, Applications of HRC Fuses, Selection of Fuses, Discrimination.

Protection against Overvoltages: Causes of Overvoltages, Lightning phenomena, Wave Shape of Voltage due to Lightning, Over Voltage due to Lightning, Klydonograph and Magnetic Link, Protection of Transmission Lines against Direct Lightning Strokes, Protection of Stations and Sub – Stations from Direct Strokes, Protection against Travelling Waves, Insulation Coordination, Basic Impulse Insulation Level (BIL).

Modern Trends in Power System Protection: Introduction, gas insulated substation/switchgear (GIS). **10 Hours**

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Student come to know Protection of faults in final year projects
02	VII	Testing & commissioning of electrical equipments	Study of Relays & Different types of faults.

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Student understands the usage of fuses & circuit breakers in home & industrial applications.
02	Use of different types of relays & circuit breakers in substations & receiving stations & power generating stations.

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Practical approach	Visiting the substations & generating stations to see use of protective devices.
02	NPTEL	Working of restricted earth fault relay & pole discrepancy relay.
03	Mi power tool	Simulation of relay coordination

8.0 Books Used and Recommended to Students

Text Books
1. Power System Protection and Switchgear Badri Ram, D.N. Vishwakarma McGraw Hill 2nd Edition.
2. Power System Protection and Switchgear BhuvaneshOza et al McGraw Hill 1st Edition, 2010.
Reference Books
1. Protection and Switchgear Bhavesh et al Oxford 1st Edition, 2011.
2. Power System Switchgear and Protection N. Veerappan S.R. Krishnamurthy S.Chand 1st Edition, 2009.
3. Fundamentals of Power System Protection Y.G.Paithankar S.R. Bhide PHI 1st Edition, 2009.
Additional Study material & e-Books
1. "Switchgear & Protection", by U.A. Bakshi & M.V.bakshi. 2. www.NPTEL.com

9.0 Relevant Websites (Reputed Universities and Others) for Notes / Animation/Videos Recommended

Website and Internet Contents References
1) Electrical4u.com
2) http://books.google.co.in/books
3) http://www.vlab.co.in/
4) https://www.accessengineeringlibrary.com
5) WWW.NPTEL.com

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Electrical construction & maintenance magazine	ecmweb.com
2	IEEE industry applications Magazine	ieeexplore.ieee.org

11.0 Examination Note

Internal Assessment: 20 Marks

There are four main questions of 10 Marks

Students have to answer any two full questions of each 10Marks selecting from Q.No 1 & Q.No 2.

Scheme of Evaluation for Internal Assessment (20 Marks)

(a) Internal Assessment test will be done in the same pattern as that of the main examination (Better of the two Tests):

SCHEME OF EXAMINATION:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

12.0 Course Delivery Plan

Module No	Lecture No.	Content of Lecture	% of Portion
1	1	**Introduction to Power System Protection:** Need for protective schemes, Nature and Cause of Faults,	20%
	2	Types of Fault, Effects of Faults, Fault Statistics,	
	3	Zones of Protection, Primary and Backup Protection,	
	4	Essential Qualities of Protection, Performance of Protective Relaying,	
	5	Classification of Protective Relays, Automatic Reclosing.	
	6	Current Transformers for protection, Voltage Transformers for Protection.	
	7	**Relay Construction and Operating Principles:** Introduction, Electromechanical Relays,	
	8	Static Relays – Merits and Demerits of Static Relays	
	9	Numerical Relays, Comparison between Electromechanical Relays and Numerical Relays.	
	10	**Over current Protection:** Introduction, Time – current Characteristics, Current Setting, Time Setting.	

2	11	Over current Protective Schemes, Reverse Power or Directional Relay.	20%
	12	Protection of Parallel Feeders, Protection of Ring Mains.	
	13	Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme.	
	14	Phase Fault Protective Scheme, Directional Earth Fault Relay.	
	15	Static Over current Relays, Numerical Over current Relays.	
	16	**Distance Protection:** Introduction, Impedance Relay.	
	17	Reactance Relay, Mho Relay.	
	18	Angle Impedance Relay, Effect of Arc Resistance on the Performance of Distance Relays.	
	19	Reach of Distance Relays. Effect of Power Surges on Performance of Distance Relays.	
	20	Effect of Line Length and Source Impedance on Performance of Distance Relays.	
3	21	**Pilot Relaying Schemes:** Introduction, Wire Pilot Protection, Carrier Current Protection.	20%
	22	**Differential Protection**: Introduction, Differential Relays.	
	23	Simple Differential Protection, Percentage or Biased Differential Relay,	
	24	Differential Protection of 3 Phase Circuits	
	25	Balanced (Opposed) Voltage Differential Protection.	
	26	**Rotating Machines Protection:** Introduction.	
	27	Protection of Generators	
	28	**Transformer and Buszone Protection:** Introduction, Transformer Protection	
	29	Buszone Protection	
	30	Frame Leakage Protection	
4	31	**Circuit Breakers:** Introduction, Fault Clearing Time of a Circuit Breaker	20%
	32	Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage,	
	33	Current Chopping, Interruption of Capacitive Current,	
	34	Classification of Circuit Breakers,	
	35	Air – Break Circuit Breakers, Oil Circuit Breakers	
	36	Air – Blast Circuit Breakers, SF6 Circuit Breakers,	
	37	Vacuum Circuit Breakers,	
	38	High Voltage Direct Current Circuit Breakers	
	39	Rating of Circuit Breakers,	
	40	Testing of Circuit Breakers	
5	41	**Fuses:** Introductions, Definitions, Fuse Characteristics, Types of Fuses,	20%
	42	Applications of HRC Fuses, Selection of Fuses, Discrimination.	

43	**Protection against Over voltages:** Causes of Over voltages, Lightning phenomena.
44	Wave Shape of Voltage due to Lightning, Over Voltage due to Lightning.
45	Klydonograph and Magnetic Link, Protection of Transmission Lines against Direct Lightning Strokes.
46	Protection of Stations and Sub – Stations from Direct Strokes.
47	Protection against Travelling Waves, Insulation Coordination.
48	Basic Impulse Insulation Level (BIL).
49	**Modern Trends in Power System Protection:** Introduction.
50	Gas insulated substation/switchgear (GIS).

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: Introduction to power system protection	Students study the Topics and write the Answers. Get practice to solve university questions.	Unit 1 of the syllabus	2	Individual Activity. Written solution is expected.	Book 1 of the reference list. Website of the Reference list
2	Assignment 2: Over current & Distance protection	Students study the Topics and write the Answers. Get practice to solve university questions.	Unit 2 of the syllabus	4	Individual Activity. Written solution is expected.	Book 1 of the reference list. Website of the Reference list
3	Assignment 3: Pilot relaying schemes & rotating machine, Transformer & Buszone protection.	Students study the Topics and write the Answers. Get practice to solve university questions.	Unit 3,4 of the syllabus	6	Individual Activity. Written solution is expected.	Book 1 of the reference list. Website of the Reference list
4	Assignment 4: Circuit breakers	Students study the Topics and write the Answers. Get practice to solve university questions.	Unit 3,4 of the syllabus	8	Individual Activity. Written solution is expected.	Book 1 of the reference list. Website of the Reference list
5	Assignment 5: Fuses, Protection against overvoltage's Modern trends in power system protection.	Students study the Topics and write the Answers. Get practice to solve university questions.	Unit 5 of the syllabus	10	Individual Activity. Written solution is expected.	Book 1 of the reference list. Website of the Reference list

14.0 QUESTION BANK

Module No. 1:

1. Explain need of protection schemes?
2. Mention different types of faults?
3. With neat sketch explain primary and backup protection?
4. Explain the classification of protective relays?
5. Mention merits and demerits of static relays?
6. Compare electromechanical and Numerical relays?

Module No. 2:

1. Explain over current protective schemes?
2. With neat sketch explain the operation of Directional relay?
3. Explain the protection of parallel feeders & Ring mains?
4. Explain earth fault and phase fault protection?
5. Explain the operation of static over current relay?
6. With neat sketch explain the operation of impedance relay?
7. With neat sketch explain the operation of reactance relay & Mho relay?
8. Explain the effect of arc resistance on the performance of Distance relays?
9. Explain the effect of power surges on performance of Distance relays?
10. Mention effect of source impedance & line length on performance of distance relays?

Module No. 3

1. Explain carrier current protection?
2. With neat sketch explain the operation of differential relay?
3. With neat diagram explain the operation of percentage or biased differential relay?
4. Explain differential protection of 3 phase circuits?
5. Explain the operation of balanced voltage differential protection?
6. Explain the protection of Generators?
7. Explain transformer protection?
8. Explain buszone protection?

Module No. 4

1. Explain the basic principle of operation of Circuit breaker?
2. Explain arc interruption in circuit breaker?
3. Define restriking & recovery voltage?
4. With neat sketch explain interruption of capacitive current?
5. With neat sketch the operation of fallowing circuit breakers?
    - Air-break circuit breaker
    - Oil circuit breaker
    - Air-blast circuit breaker
    - SF6 circuit breaker
    - Vacuum circuit breaker
    - High voltage direct current circuit breaker

6. Explain the ratings of circuit breaker?
7. Explain various methods of testing of circuit breakers?

Module No. 5

1. Mention different types of fuses?
2. With neat sketch explain the operation of HRC fuse?
3. With neat sketch explain the construction & working of Liquid fuse?
4. Explain the procedure for selection of fuses and define discrimination?
5. Mention the causes of over voltages?
6. Explain the lightning phenomena?
7. Explain the protection of transmission lines against direct lightning strokes?
8. Explain the protection of substations from direct strokes?
9. Explain the basic Impulse insulation level?
10. Explain about Gas insulated substation?

Prepared by	Checked by		
Prof. Mahesh P.Yanagimath	Prof.S.B.Patil	HOD	Principal

Subject Title	HIGH VOLTAGE ENGINEERING		
Subject Code	**15EE73**	**IA Marks**	20
Number of Lecture Hrs / Week	04	**Exam Marks**	80
Total Number of Lecture Hrs	50	**Exam Hours**	03
		CREDITS – 04	

FACULTY DETAILS:		
Name: Prof. S.D. Hirekodi	**Designation:** Asst.Professor	**Experience:**18.6 years
No. of times course taught:02	**Specialization:** Power Electronics	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical and Electronics Engineering	I/II	Basic Electrical Engineering
02	Electrical and Electronics Engineering	III	Electrical Measurements
03	Electrical and Electronics Engineering	IV	Transformers
04	Electrical and Electronics Engineering	V	Transmission and Distribution
05	Electrical and Electronics Engineering	VI	Switchgear and Protection
06	Electrical and Electronics Engineering	VI	Engineering Material science

2.0 Course Objectives

- To discuss conduction and breakdown in gases, liquid dielectrics.
- To discuss breakdown in solid dielectrics.
- To discuss generation of high voltages and currents and their measurement.
- To discuss overvoltage phenomenon and insulation coordination in electric power systems.
- To discuss non-destructive testing of materials and electric apparatus.
- To discuss high-voltage testing of electric apparatus

3.0 Course Outcomes

Having successfully completed this course, the student will be able to

	Course Outcome	Cognitive Level	POs
CO403.1	Explain conduction and breakdown phenomenon in gases, liquid dielectrics.	R,U	1,2,3,6,8,9,10,12
CO403.2	Explain breakdown phenomenon in solid dielectrics.	R,U	1,2,3,6,8,9,10,12
CO403.3	Explain generation of high voltages and currents	R,U,A	1,2,3,6,8,9,10,12
CO403.4	Discuss measurement techniques for high voltages and currents.	R,U	1,2,3,6,8,9,10,12
CO403.5	Discuss overvoltage phenomenon and insulation coordination in electric power	R,U	1,2,3,6,8,9,10,12
CO403.6	Discuss non-destructive testing of materials and electric apparatus and high-voltage testing of electric apparatus	R,U	1,2,3,6,8,9,10,12
Total Hours of instruction		**50**	

4.0 Course Content

Module-1

Conduction and Breakdown in Gases: Gases as Insulating Media, Collision Process, Ionization Processes, Townsend's Current Growth Equation, Current Growth in the Presence of Secondary Processes, Townsend's Criterion for Breakdown,

Experimental Determination of Coefficients α and γ, Breakdown in Electronegative Gases, Time Lags for Breakdown, Streamer Theory of Breakdown in Gases, Paschen's Law, Breakdown in Non-Uniform Fields and Corona Discharges.
Conduction and Breakdown in Liquid Dielectrics: Liquids as Insulators, Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure Liquids, Conduction and Breakdown in Commercial Liquids. **Breakdown in Solid Dielectrics:** Introduction, Intrinsic Breakdown, Electromechanical Breakdown, Thermal Breakdown. 10Hours
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding

Module-2
Generation of High Voltages and Currents: Generation of High Direct Current Voltages, Generation of High Alternating Voltages, Generation of Impulse Voltages, Generation of Impulse Currents, Tripping and Control of Impulse Generators. 10Hours
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding L_3 – Applying

Module-3
Measurement of High Voltages and Currents: Measurement of High Direct Current Voltages, Measurement of High AC and Impulse Voltages, Measurement of High Currents – Direct, Alternating and Impulse, Cathode Ray Oscillographs for Impulse Voltage and Current Measurements. 10Hours
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding L_3 – Applying

Module-4
Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems: 10Hours
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding

Module-5
Non-Destructive Testing of Materials and Electrical Apparatus: Introduction, Measurement of Dielectric Constant and Loss Factor, Partial Discharge Measurements.
High Voltage Testing of Electrical Apparatus: Testing of Insulators and Bushings, Testing of Isolators and Circuit Breakers, Testing of Cables, Testing of Transformers, Testing of Surge Arrestors, Radio Interference Measurements, Testing of HVDC Valves and Equipment. 10Hours
Revised Bloom's Taxonomy Level: L_1 – Remembering, L_2 – Understanding

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
1	VII	Testing and Commissioning of Power System Apparatus	Switchgear and Protective Devices

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Electric breakdown in gases, liquid and solid dielectrics.
02	High voltage AC, DC and impulse generation in power research laboratory for testing.
03	High voltage and current measurements in research laboratory for testing.
04	Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems.
05	Non-destructive test techniques in high voltage engineering. High voltage tests on power system apparatus and switchgear such as circuit breakers, insulators, transformers and cables in site and research laboratory.

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Practical Assignment	Practical assignments will be given to the students to study electric breakdown in gases, liquids and solid dielectrics and generation and measurement of different forms of high voltages in laboratory and testing of high voltage power system apparatus and switchgears.
02	Power point presentation	Topic related to High voltage engineering subject.

8.0 Books Used and Recommended to Students

Text Books
1. **High Voltage Engineering** by M.S.Naidu and Kamaraju- 5th Edition, McGraw Hill. 2013.
Reference Books
1**. High Voltage Engineering Fundamentals** by E.Kuffel and W.S. Zaengl, 2nd Edition, Newnes 2000. 2. **High Voltage Engineering** by C.L.Wadhwa, New Age International Private limited, 3rd Edition 2012. 3. **High-Voltage Test and Measuring Techniques** by Wolfgang Hauschild & Eberhard Lemke, Springer 1st Edn.2014. 4. **High Voltage Engineering by** Farouk A.M. Rizk , CRC Press ,1st Edition2014 .
Additional Study material & e-Books
1. High Volatge test and measuring techniques: Springer 2. High voltage and electrical insulation engineering by Ravindra Arora

9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
1) www.nptelviodes.in 2)www.freevideolectures.com

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	IET Digital library	***www.digital-library.theiet.org/content/journals/hve***
2	High Voltage Engineering	**www.oriprobe.com/journals/gdyjs.html**
3	IEEE Electrical Insulation engineering	***http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=57***

11.0 Examination Note

Scheme of Evaluation for Internal Assessment (20 Marks)

Internal Assessment test will be done in the same pattern as that of the main examination

Internal Assessment: 15 Marks

Assignment: 05 Marks

SCHEME OF EXAMINATION:

The question paper will have ten questions.

- Each full question is for 16 marks.
- There will be 2 full questions (with a maximum of three sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

12.0 Course Delivery Plan

Module No.	Lecture No.	Content of Lecture	% of Portion
2	1	HV transformer, Need for cascade connection and working of transformers units connected in cascade.	20%
	2	Resonant Transformers. Tesla coil.	
	3	HV DC- voltage doubler circuits	
	4	Voltage Multiplier circuits: Cock croft- Walton type high voltage DC set	
	5	Calculation of high voltage regulation and ripple	
	6	Optimum number of stages for minimum voltage drop.	
	7	Introduction to standard lightning and switching impulse voltages, Analysis of single stage impulse generator-expression for Output impulse voltage	
	8	Multistage impulse generator- working of Marx impulse generator, Rating of impulse generator, Components of multistage impulse generator	
	9	Generation of switching impulse voltage, Generation of high impulse current	
	10	Tripping and Control of Impulse Generators.	
3	11	Series resistance micro ammeter for HV DC measurements	20%
	12	Generating voltmeter- Principle, construction	
	13	Standard sphere gap measurements of HV AC, HV DC and impulse voltages	
	14	Factors affecting the measurements	
	15	Electrostatic voltmeter-principle, construction	
	16	Chubb and Fortescue method for HV AC measurement	
	17	Resistance potential dividers	
	18	Capacitance dividers, Mixed RC potential dividers	
	19	Measurement of High Currents – Direct, Alternating and Impulse	
	20	Cathode Ray Oscillographs for Impulse Voltage and Current Measurements.	
1	21	Gases as Insulating Media, Collision Process	20%
	22	Ionization processes	
	23	Townsend's Current Growth Equation, Current Growth in the Presence of Secondary Processes, Townsend's Criterion for Breakdown.	
	24	Experimental Determination of Coefficients of α and γ, Breakdown in Electronegative Gases, Time Lags for Breakdown.	
	25	Streamer Theory of Breakdown in Gases.	
	26	Paschen's Law, Breakdown in Non-Uniform Fields and Corona Discharges.	
	27	Liquids as Insulators, Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure Liquids.	
	28	Conduction and Breakdown in Commercial Liquids	
	29	Breakdown in Solid Dielectrics: Introduction, Intrinsic Breakdown,	
	30	Electromechanical Breakdown, Thermal Breakdown.	
4	31	Lightning Phenomenon, Mechanism of lighting strokes	20%
	32	Mathematical Model for Lighting	
	33	Overvoltage due to Switching Surges: Origin and Characteristics of Switching surges	
	34	Switching over voltages in EHV and UHV systems.	
	35	Power frequency over voltages in power systems.	
	36	Protection of Transmission lines against overvoltages.	
	37	Principles of Insulation Coordination: Surge Arresters	
	38	Protection of lines with Surge Arresters.	
	39	Insulation Coordination in EHV and UHV Systems	
5	40	Measurement of Dielectric Constant and Loss Factor: Introduction	20%
	41	HV Schering Bridge	
	42	Transformer ratio arm bridges	
	43	Detectors in Dielectric Measurements	

	44	Partial Discharge Measurements:Introduction	
	45	Discharge detection using Straight Detectors and Balanced Detection method	
	46	Testing of Insulators and Bushings	
	47	Tests on isolators, circuit breakers	
	48	Tests on cables, Tests on transformers	
	49	Testing of Surge Arrestors, Radio Interference Measurements	
	50	Testing of HVDC Valves and Equipment	

13.0 Assignments

Sl. No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: Questions on Generation of High voltages and Currents.	Students will be able to explain different techniques of high voltage AC, DC and Impulse generation and solve examples.	Module 2 of the syllabus	5	Individual Activity.	Books 1, 2 & 3 of the book list
2	Assignment 2: Questions on Measurement of high voltages and currents	Students will be able to explain different techniques of high voltage and current measurements and solve examples.	Module 3 of the syllabus	7	Individual Activity.	Books 1, 2 & 3 of the book list.
3	Assignment 3: Questions on conduction and breakdown in gases, liquid and solid dielectrics.	Students will be able to explain breakdown theories in different dielectrics, Paschen's law, Time lags of breakdown	Module 1 of the syllabus	10	Individual Activity.	Books 1, 2 & 3 of the book list.
4	Assignment 4: Questions on Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems	Students will be able to explain Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems	Module 4 of the syllabus	12	Individual Activity.	Books 1, 2 & 3 of the book list
5	Assignment 5: Questions on non-destructive Testing of materials and HV testing of electrical apparatus	Students will be able to explain Non-destructive test techniques and testing of Transformer, Insulator, CB Cables and Surge Arrestors	Module 5 of the syllabus	16	Individual Activity.	Books 1, 2 & 3 of the book list

14.0 Assignment Questions

Assignment No	Questions	Marks
I	1. Describe with the help of neat diagram, the cascade connection of transformer units for the generation of power frequency high voltages. 2. Explain Cock Croft Walton voltage Multiplier circuit with neat circuit diagram. Show input and output wave form with certain load.	5marks 5marks 5marks

	3. Describe the working of a multistage Marx impulse generator with a neat sketch. 4.A 100KVA, 400V/200KV feed transformer has resistance and reactance of 1% and 5% respectively. This transformer is used to test a cable at 400KV, 50HZ. The cable takes a charging current of 0.5A at 400KV.Determine the series inductance required, assuming 1% resistance for the inductor. Also, determine the input voltage to the transformer. 5. A Cock Croft-Walton type voltage multiplier has 8 Stages with capacitances, all equal to 0.05 µF. The supply transformer secondary voltage is 125KV at a frequency of 150Hz. If the load current to be supplied is 5mA, find i) The percentage ripple ii) The regulation iii) The Optimum number of stages for minimum regulation or voltage drops.	5marks 5marks
II	1.Explain the working principle of series capacitor peak voltmeter based on Chubb-Fortesque method 2. Explain how a sphere gap can be used to measure the peak value of high voltages. What are the factors that influence the measurement of such voltages? 3 A generating voltmeter is required to measure voltage 15 to 250 KV D.C. If the indicating meter reads a minimum current of 2µA and maximum current of 35 µA, determine the capacitance of the generating voltmeter. Assume that, the speed of driving synchronous motor is 1500 rpm. 4. An electrostatic voltmeter has movable circular plate 8 cms in diameter. If the distance between the plates during a measurement is 8mm, determine the potential difference when the force of attraction is 0.5 gm.wt. 5.A resistance divider of 1400 KV (impulse) has a high voltage arm of 16KΩ and a low voltage arm consisting of 16 members of 250Ω, 2 W resistors in parallel. The divider is connected to a CRO through a cable of surge impedance 75Ω and is terminated at the other end through a 75Ω resistor. Calculate the exact divider ratio.	5marks 5marks 5marks 5marks 5marks
III	1.Explain the process of ionization by collision and hence derive the Townsend's Current growth equation. 2. What is meant by time lag of breakdown? Explain briefly formative time lag and Statistical time lag. 3. In an experiment in a certain gas it was found that the steady state current is $5.5X10^{-8}$A at 8KV at a distance of 0.4cm between the plane electrodes. Keeping the field constant and reducing the distance to 0.1 cm results in a current of $5.5X10^{-9}$A. Calculate Townsend's primary ionization coefficient α. 4. Explain thermal breakdown in solid dielectrics. 5. Explain suspended particle, Cavitation and bubble theories that describe breakdown in commercial liquid dielectrics.	5marks 5marks 5marks 5marks 5marks
IV	1.Give the mathematical models for lighting discharges and explain them 2. What are the different methods employed for lightning protection of overhead lines? 3. What is a surge arrester? Explain its function as a shunt protective device. 4. What is meant by insulation co-ordination? How are are the protective devices chosen for optimal insulation level in a power system? 5.Explain the different aspects of insulation design and insulation co-ordination adopted for EHV systems.	5Marks 5 Marks 5marks 5marks 5marks
V	1. Explain the method of measurement of capacitance and tan ∂ using H.V. Schering bride. 2. Write a short note on Transformer ratio Arm Bridge. 3. What are the different power frequency tests done on insulators? Mention the procedure for testing. 4. Why is synthetic testing advantageous over the other testing methods for short circuit tests? Give the layout for synthetic testing.	5Marks 5marks 5marks 5marks 5marks

	5. What is the significance of impulse tests? Briefly explain the impulse testing of insulators.	

15.0 QUESTION BANK

Module 1:

1. What is ionization?Explain the different types of primary and secondary ionization processes of a gaseous insulation subjected to high voltage.
2. Explain Townsend's theory of gaseous breakdown. Derive the equations for the current growth and the Townsend's criterion for breakdown.
3. Explain in detail the streamer mechanism of breakdown in gases.
4. Explain briefly formative time lag and statistical time lag.
5. What are electronegative gaes? Why the breakdown strength of these gases higher is compared to that of other gases?
6. What is Paschen's law? How do you account for the minimum voltage for breakdown under a given 'pxd' condition?
7. Briefly explain "Cavitation and Bubble theory" in the context of liquid dielectric breakdown.
8. Discuss the electrical properties that determine the dielectric performance of liquid dielectrics?
9. What is "Stressed oil volume theory" and how does it explain breakdown in large volume of commercial dielectrics?
10. Explain the different mechanisms by which breakdown occurs in solid dielectrics in practice.
11. Explain the terms dielectric strength,electric field intensity and electron negativity related to breakdown process of gases.
12. Explain thermal breakdown in solid dielectrics and how it is more significant than other breakdown mechanisms.
13. Define Townsend's first and second ionization coefficients.Explain the Townsend's criterion for breakdown.
14. Explain the various factors which deteriorate the strength of dielectric materials used in various electrical equipments
15. Explain any two theories that explain breakdown in commercial liquid dielectrics.

Module 2:

1. Explain with diagrams, different types of rectifier circuits for producing high voltages.
2. Explain with circuit diagram, the working of simple voltage doubler circuit for generation of D.C high voltage.
3. Explain the different schemes for cascade connection of transformers for producing very high a.c. voltages.
4. load Why is a Cockcroft-Walton circuit preferred for voltage multiplier circuits? Explain its working with a schematic diagram.
5. Explain Cock Croft Walton voltage Multiplier circuit with neat circuit diagram. Show input and output wave form with certain.
6. Explain the no-load operation of a CockCroft- Walton voltage Multiplier circuit.
7. Derive expressions for ripple and voltage drop in cascaded voltage multiplier circuit.
8. State the chief advantages of resonant transformers.

9. What is tesla coil?How are damped high frequency oscillations obtained from a Tesla coil.
10. What is the principle of operation of a resonant transformers?How is it advantageous over the cascade connected transformers?
11. Define the front and tail times of an impulse wave. What are the tolerances allowed as per specification?
12. Give the different circuits that produce impulse waves, explain clearly their merits and demerits.
13. How will you specify impulse generator? Describe the working of a multistage Marx impulse generator with a neat sketch. How is the basic arrangement modified to accommodate the wave time control?
14. Explain the different methods of producing switching impulses in the test laboratories.
15. Outline the method of tripping a multistage impulse generator using three electrode gap arrangements.
16. What is trigatron gap?Explain its function and operation.
17. Define an impulse wave and show that the output voltage of impulse generation circuit is double exponential in nature.
18. Give the general equation of a standard impulse wave and explain the wave shape giving the percentage tolerances allowed for front, tail and the peak.
19. Discuss the components of a multistage impulse generator of less than 1MV.

Module 3:

1. Explain the working principle of series capacitor peak voltmeter based on Chubb-Fortesque method.
2. Briefly explain factors influencing spark over voltage of sphere gap.
3. Write a short note on MIX- RC potential dividers.
4. Explain the principle of measurement of high AC voltage using sphere gap & discuss the effect of atmosphere condition for its calibration.
5. Describe the construction & working of Electrostatic voltmeter. State its advantages & limitations.
6. Write a short note on the resistance dividers.
7. Draw a neat schematic diagram of generating voltmeter & explain its operation & discuss its applications.
8. Which are the four main sources of errors in the measurements of impulse voltages with potential dividers?
9. Explain the Chubb- Fortesque method for peak voltage measurement. Bring out the sources that contribute to the errors in the measurement.
10. Explain the importance of Sphere gap in Measurement of high voltages and high currents.
11. How Capacitance Potential Dividers are used for the impulse voltage measurements.

Module 4:

1. Explain the different theories of charge formation in clouds.
2. What are the mechanisms by which lighting strokes develop and induce overvoltages on overhead power lines
3. Give the mathematical models for lighting discharges and explain them
4. What are the causes for switching and power frequency overvoltages? How are they controlled in power systems
5. What are the different methods employed for lightning protection of overhead lines?
6. What is a surge arrester? Explain its function as a shunt protective device.

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7. What is meant by insulation co-ordination? How are are the protective devices Chosen for optimal insulation level in a power system?
8. Explain the different aspects of insulation design and insulation co-ordination

Module 5:

1. What are partial discharges & how are they detected under power frequency operating conditions?
2. Discuss the method of balanced detection for locating partial discharges in electrical equipment.
3. Explain the method of measurement of capacitance and tan ∂ using H.V. Schering bride.
4. Why partial discharge tests are performed on H.V. cables? Describe partial discharge testing of cables.
5. Write a short note on Transformer ratio Arm Bridge.
6. Explain the method of measuring dielectric loss at power frequency using high voltage Schering Bridge.
7. Explain the partial discharge diction using straight detectors.
8. Define the following i) Disruptive discharge voltage ii) withstand voltage iii) 50% flash over voltage. iv)Creeping distance.
9. Explain the method of impulse testing of high voltage transformers. What is the procedure adopted for locating the failure.
10. Name and explain in brief different tests that are carried out on high voltage insulators.
11. What are the different power frequency tests done on insulators? Mention the procedure for testing.
12. Mention the different electrical tests done on isolators and circuit breakers.
13. Why is synthetic testing advantageous over the other testing methods for short circuit tests? Give the layout for synthetic testing.
14. What is the significance of impulse tests? Briefly explain the impulse testing of insulators.

16.0 University Result

Prepared by	Checked by		
Prof. S.D.Hirekodi	Prof.O.B.Heddurshetti	HOD	Principal

Subject Title	UTILISATION OF ELECTRICAL POWER		
Subject Code	15EE742	IA Marks	20
Number of Lecture Hrs / Week	03	Exam Marks	80
Total Number of Lecture Hrs	40	Exam Hours	03

FACULTY DETAILS:		
Name: Prof. Onkar B Heddurshetti	Designation: Asst.Professor	Experience: 13
No. of times course taught(including present): 2	Specialization: Power Electronics	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical and Electronics Engg	I/II	Basic Electrical Engineering
02	Electrical and Electronics Engg	IV	Transformers & Induction Machines
03	Electrical and Electronics Engg	V	DC Machines & Synchronous

2.0 Course Objectives

- To discuss electric heating, air-conditioning and electric welding.
- To explain laws of electrolysis, extraction and refining of metals and electro deposition.
- To explain the terminology of illumination, laws of illumination, construction and working of electric lamps.
- To explain design of interior and exterior lighting systems- illumination levels for various purposes light fittings- factor of lighting- flood lighting-street lighting.
- To explain systems of electric traction, speed time curves and mechanics of train movement.
- To discuss motors used for electric traction and their control.
- To discuss braking of electric motors, traction systems and power supply and other traction systems.
- To give awareness of technology of electric and hybrid electric vehicles.

3.0 Course Outcomes

Having successfully completed this course, the student will be able to,

	Course Outcome	Cognitive Level	POs
CO 405.1:	Discuss different methods of electric heating & welding, laws of electrolysis, extraction, refining of metals and electro deposition process.	U	1,2,3
CO 405.2:	Explain the laws of illumination, different types of lamps, lighting schemes and design lighting systems.	U	1,2,3,6,7, 8,9
CO 405.3:	Explain systems of electric traction, speed time curves and mechanics of train movement.	U	1,2,3
CO 405.4:	Explain the motors used for electric traction, their control & braking and power supply system used for electric traction.	A	1,2,3
CO 405.5:	Explain the working of electric and hybrid electric vehicles.	U	1,6,7
	Total Hours of instruction	**40**	

4.0 Course Content

MODULE - 1

Heating and welding: Electric Heating, Resistance ovens, Radiant Heating, Induction Heating, High frequency Eddy Current Heating, Dielectric Heating, The Arc Furnace, Heating of Buildings, Air – Conditioning, Electric Welding, Modern Welding Techniques.

Electrolytic Electro – Metallurgical Process: Ionization, Faraday's Laws of Electrolysis, Definitions, Extraction of Metals, Refining of Metals, Electro Deposition **08 Hours**

MODULE - 2

Illumination: Introduction, Radiant Energy, Definitions, Laws of Illumination, Polar Curves, Photometry, Measurement of Mean Spherical Candle Power by Integrating Sphere, Illumination Photometer, Energy Radiation and luminous Efficiency, electric Lamps, Cold Cathode Lamp, Lighting Fittings, Illumination for Different Purposes, Requirements of Good Lighting. **08 Hours**

MODULE - 3

Electric Traction Speed - Time Curves and Mechanics of Train Movement: Introduction, Systems of Traction, Systems of electric Traction, Speed - Time Curves for Train Movement, Mechanics of Train Movement, Train Resistance, Adhesive Weight, Coefficient of Adhesion.

Motors for Electric traction: Introduction, Series and Shunt Motors for Traction Services, Two Similar Motors (Series Type) are used to drive a Motor Car, Tractive Effort and Horse Power, AC Series Motor, Three Phase Induction Motor.

Control of motors: Control of DC Motors, Tapped Field Control or Control by Field Weakening, Multiple Unit Control, Control of Single Phase Motors, Control of Three Phase Motors. **08 Hours**

MODULE - 4

Braking: Introduction, Regenerative Braking with Three Phase Induction Motors, Braking with Single Phase Series Motors, Mechanical braking, Magnetic Track Brake, Electro – Mechanical Drum Brakes.

Electric Traction Systems and Power Supply: System of Electric Traction, AC Electrification, Transmission Lines to Sub - Stations Sub - Stations, Feeding and Distribution System of AC Traction, Feeding and Distribution System for Dc Tramways, Electrolysis by Currents through Earth, Negative Booster, System of Current Collection, Trolley Wires.

Trams, Trolley Buses and Diesel – Electric Traction: Tramways, The Trolley – Bus, Diesel Electric Traction.

08 Hours

MODULE – 5

Electric Vehicles: Configurations of Electric Vehicles, Performance of Electric Vehicles, Tractive Effort in Normal Driving, Energy Consumption.

Hybrid Electric Vehicles: Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains.

08 Hours

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Industrial Drives and Applications	Application of Drives
02	VIII	Project work	Students can apply the knowledge of electric vehicles to implement their projects.

6. Relevance to Real World

Sl. No	Real World Mapping
01	Students can utilize the knowledge of electric wiring installations and electric traction systems while working in industries and various public/private sector organizations.

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Practical	Students can perform electric wiring of residential and commercial installations based on illumination level required.

8.0 Books Used and Recommended to Students

Text Books				
1	A Text Book on Power System Engineering	A. Chakrabarti et al	Dhanpat Rai and Co	2nd Edition, 2010
2	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design (Chapters 04 and 05 for modules 3 & 4)	Mehrdad Ehsani et al	CRC Press	1st Edition, 2005
Reference Books				
1	Generation, Utilization and Conservation of Electrical Energy	Sunil S Rao	Khanna Publishers	1st Edition, 2011
2	Utilization of Electric Power and Electric Traction	G.C. Garg	Khanna Publishers	9th Edition, 2014
Additional Study Material & e-Books				
•	Utilization of electric power & electric traction by J.B.Gupta			
•	https://www.vtubooks.com/downloads/download/eee-vii-electrical-power-utilization-notes-pdf/			

9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Websites	Contents References
1)	http://nptel.ac.in/courses/108105061/5#
2)	http://nptel.ac.in/downloads/108105061/
3)	http://nptel.ac.in/courses/108105060/
4)	http://nptel.ac.in/courses/108103009/
5)	http://nptel.ac.in/downloads/108103009/

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	International journal of electrical power and energy systems	https://www.journals.elsevier.com/international-journal-of-electrical-power-and-energy-systems
2	Electric power quality and utilization journal	http://www.epqu.agh.edu.pl/index.php?option=com_content&view=category&layout=blog&id=38&Itemid=166

11.0 Examination Note

Internal Assessment: 20 Marks (15 Marks for IA Test+05 Marks for Assignment)

Two Internal Assessment tests are conducted for 25 marks each. Best of the two tests average marks are taken. The average IA marks is scaled down to a value out of 15 which is the final IA marks.

Question paper will contain questions of 13 or 12 Marks.

Students have to answer any two full questions by selecting one question from Q. No.1 or Q. No. 2 and one question from Q. No. 3 or Q. No. 4.

Assignments: Five assignments are given on five modules. Each assignment carries 25 marks. Average marks of assignments is calculated and scaled down to a value out of 05.

SCHEME OF EXAMINATION:

Question paper will have ten questions.

- Each full question is for 16 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

12. Course Delivery Plan

Module No.	Lecture No.	Content of Lecture	% of Portion
I	1.	Electric Heating, Resistance ovens, Radiant Heating	20
	2.	Induction Heating, High frequency Eddy Current Heating	
	3.	Dielectric Heating	
	4.	The Arc Furnace, Heating of Buildings, Air – Conditioning	
	5.	Electric Welding, Modern Welding Techniques.	
	6.	Ionization, Faraday's Laws of Electrolysis	
	7.	Definitions, Extraction of Metals	
	8.	Refining of Metals, Electro Deposition	
II	9.	Introduction, Radiant Energy, Definitions	20
	10.	Laws of Illumination	
	11.	Polar Curves, Photometry	
	12.	Measurement of Mean Spherical Candle Power by Integrating Sphere	
	13.	Illumination Photometer, Energy Radiation and luminous Efficiency	
	14.	electric Lamps, Cold Cathode Lamp	
	15.	Lighting Fittings	
	16.	Illumination for Different Purposes, Requirements of Good Lighting	
III	17.	Introduction, Systems of Traction	20
	18.	Systems of electric Traction, Speed - Time Curves for Train Movement	
	19.	Mechanics of Train Movement, Train Resistance,	
	20.	Adhesive Weight, Coefficient of Adhesion	
	21.	Introduction, Series and Shunt Motors for Traction Services, Two Similar Motors (Series Type) are used to drive a Motor Car	
	22.	Tractive Effort and Horse Power, AC Series Motor, Three Phase Induction Motor	
	23.	Control of DC Motors, Tapped Field Control or Control by Field Weakening	
	24.	Multiple Unit Control, Control of Single Phase Motors, Control of Three Phase Motors	
IV	25.	Introduction, Regenerative Braking with Three Phase Induction Motors, Braking with Single Phase Series Motors	20
	26.	Mechanical braking, Magnetic Track Brake, Electro – Mechanical Drum Brakes	
	27.	System of Electric Traction, AC Electrification, Transmission Lines to Sub - Stations, Sub – Stations	
	28.	Feeding and Distribution System of AC Traction, Feeding and Distribution System for Dc Tramways	
	29.	Electrolysis by Currents through Earth, Negative Booster	
	30.	System of Current Collection, Trolley Wires	
	31.	Tramways, The Trolley – Bus	
	32.	Diesel Electric Traction	
V	33.	Configurations of Electric Vehicles	20
	34.	Performance of Electric Vehicles	
	35.	Tractive Effort in Normal Driving	

	36.	Energy Consumption	
	37.	Energy Consumption	
	38.	Concept of Hybrid Electric Drive Trains	
	39.	Architectures of Hybrid Electric Drive Trains	
	40.	Architectures of Hybrid Electric Drive Trains	

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: Questions on heating, welding and electrolytic	Students understand heating, welding and electrolytic process methods and solve university questions.	Module 1 of the syllabus	2	Individual Activity. Written solution expected.	Book 1 of the text book list. & additional reference 2
2	Assignment 2: University questions on illumination	Students learn properties of illumination and get practice to solve university questions.	Module 2 of the syllabus	4	Individual Activity. Written solution expected.	Book 1 of the text book list. & additional reference 2
3	Assignment 3: Questions on systems of electric traction, speed time curves and mechanics of train movement	Students study the systems of electric traction, speed time curves and mechanics of train movement and get practice to solve university questions.	Module 3 of the syllabus	6	Individual Activity. Written solution expected.	Book 1,2 of the text book list. & additional reference 2
4	Assignment 4: Questions on motors used for electric traction, their control & braking and power supply system used for electric traction	Students study the motors used for electric traction, their control & braking and power supply system used for electric traction & get practice to solve university questions.	Module 4 of the syllabus	8	Individual Activity. Written solution expected.	Book 1,2 of the text book list. & additional reference 1,2
5	Assignment 5: Questions on electric and hybrid vehicles	Students learn electric and hybrid vehicles & get practice to solve university questions.	Module 5 of the syllabus	10	Individual Activity. Printed solution expected.	Book 2 of the text book list. & additional reference 1,2

14.0 QUESTION BANK

MODULE 1

1. Discuss in advantages of electric heating over other system of heating (namely,coal, oil or gas heating).
2. Discuss vantages and disadvantages of resistance electric welding.
3. A 15 , single phase resistance oven employ nickel-chrome wire for its heating elements. If the wire not to exeed 1000 deg. Celcius and the temperature of the charge is to be 600 deg cel. Calculate the meter of the wire. Assume radiating efficiency to be 0.6 and emissivity as 0.9 Resistivity for nicket-6*10^{-6}.
4. advantages of electric heating? Give classification of various electric heating methods.
5. construction and operation of an electric arc furnace.
6. sketches, describe the working of a coreless-type induction furnace.

7. Describe the Ajax Wyatt type induction furnace and explain its working.
8. Discuss the following applications of dielectric heating:
   a) Heating of raw plastics b) Gluing of wood c) Food processing.
9. Determine the length and diameter of the nichrome wire in the resistance element of a single phase electric furnace rated at 20kW and 220V. The wire temperature is not to exceed 1,170°C and the temperature of the charge is to be 500°C. Take k=0.57, e=0.95 and ρ=10μΩ-cm.
10. A low frequency induction furnace has a secondary voltage of 15V and takes 400kW ot 0.6pf when the herath is full. If the secondary voltage is maintained at 15V, determine the power absorbed and the power factor when the hearth is half-full. Assume the resistance of the secondary circuit to be there by doubled and reactance to remain the same.
11. Describe with neat sketch the various methods of electric resistance welding. Give its merits and demerits.
12. Explain the principle of electric spot welding and seam welding.
13. What is the difference between arc welding and resistance welding.
14. Discuss in detail the principle of operation of i) Ultrasonic welding ii) Laser welding
15. What is electric welding? Describe briefly any three types of electric arc welding.
16. Define and explain briefly the following terms referred to electrolytic processes. I)Electro-chemical equivalent ii) current efficiency iii)Energy efficiency.
17. Explain the following processes. i) extraction of metals ii)anodizing.
18. State and explain Faradays laws of electrolysis.
19. Explain the factors affecting the appearance of deposition in electro-deposition.
20. Explain in brief the factors affecting the deposition of metals in electroplating.
21. Write a note on electro-extraction of metals
22. Explain the terms used in electrolyte process i) Throwing of power ii) Current efficiency iii) Energy efficiency iv) Electro chemical equivalent.
23. Nickel coating of 1mm thickness is to be built on a cyclindrical surface 15cms diameter and 20cm long in 1 and half hour. Calculate the electrical energy needed if ECE of nickel is 0.3043 mgm/coulomb. Specific gravity 8.9 and voltage used in electroplating is 10Volts.

MODULE II

1. With neat sketch explain the construction and working principle of a low pressure mercury vapour lampt.
2. Explain the principle of street lighting, types of street lighting and lamps used in street lighting.
3. A 100 watt, 250 volt metal filament lamp has a measured candle power of 71.5 CP at 260 volts and 50CP at 240 Volts find the constant for the lamp in the expression $C=aV^b$ where C=candle power and V=voltage. Ii) Calculate the change of candle power per volt at 250V. Determine the percentage variation of candle power due to a voltage variation of plus or minus 4% from the normal value.
4. State and explain laws of illumination.
5. Describe the construction and working of a mercury vapour lamp.
6. Explain with neat diagram the principle of operation of a sodium vapour lamp. Mention its use.
7. Explain with circuit diagram the working of a fluorescent lamp. Enumerate its advantages and disadvantages.
8. What do you understand by direct, indirect, and semi-indirect lighting?
9. State and explain the inverse square law of illumination.
10. A 250 W lamp having MSCP of 800 is suspended 3m above the working plane. Determine i)illumination directly below the lamp at working plane ii)lamp efficiency iii)illumination at a point 2.4m away on the horizontal plane from the point below the lamp.
11. Two lamps L1 and L2 are hung at a height of 9m from the floor level. The distance between the lamp is 1m. If the lamp L1 is 500CP. If the illumination on the floor vertically below this lamp is 20lux find the candle power of lamp L2.
12. Explain the light flux method of calculation of light, considering relevant factors. Mention its application and limitations.
13. Explain the principles which are adapted in street lighting.
14. With neat sketch explain the construction and working of a sodium vapour lamp.
15. Two lamp posts are 16m apart and are fitted with 500CP lamp each at a height of 6m above the ground. Calculate i) the illumination mid way between the posts ii)illumination under each lamp.

MODULE III & IV

1. State the main requirements of an ideal traction system.
2. Explain the various systems of track electrification.
3. Define i)test speed ii)average speed iii)schedule speed. Discuss the factors which affect the schedule speed of a train.
4. Define specific energy output and specific energy consumption. Derive the expression of specific energy o/p and specific energy consumption using simplified speed time curve.
5. Discuss the mechanical features and electrical characteristics of electric motors used for traction work.
6. Discuss briefly different systems of traction.
7. Explain electric traction system and discuss its merits over other traction systems.
8. Draw a typical speed-time curve for train movement, and explain i) acceleration ii) free running iii) coasting iv) braking.
9. Define test speed and schedule speed and discuss the factors which affect the schedule speed of a train.
10. Draw speed-time curve for a main line service and derive the expression $\frac{1}{2}[1/\alpha+1/\beta]=(3600D/Vm^2)[(V_1^2-V_2^2)]$ where the symbols have their usual meanings.
11. Derive the expression for:i)The tractive effort exerted by road wheel in terms of wheel diameter, motor torque, gear ratio and efficiency of transmission of power through gears.(ii) The tractive effort for the propulsion of train on a level track and on the gradient.
12. What is specific energy consumption of a train? Discuss various factors affecting it.
13. Derive an expression for the maximum power output of traction motor.
14. Derive an expression for specific energy consumption of a suburban train.
15. An electric train has quadrilateral speed-time curve as follows:i)Uniform acceleration from rest at 2kmphps for 30 sec. ii)Coasting for 50 sec. iii)Braking for 20 sec.
    Assuming a uniform down gradient of 1%, tractive resistance 40N/tonne, rotational inertia effect 10% of dead weight, acceleration of stop 15sec and overall efficiency of transmission gear and motor as 75%. Calculate its schedule speed and specific energy consumption of run.
16. An electric train has an average speed of 42kmph on a level track between stops 1,400m apart. It is accelerated at 1.6kmphps and is braked at 3.3kmphps. Draw the speed-time curve for the run.

MODULE V

1. Explain concept and its subsystem of modern electric drives in detail. Draw relevant figure/diagram
2. Explain configuration and performance on hybrid vehicle.
3. What is hybrid electric vehicle?
4. What are the advantages of HEVs as compared to conventional vehicles?
5. What are the components of a hybrid electric vehicle?
6. Explain types of energy storage systems in HEVs.
7. Explain types of propulsion in HEVs.
8. Compare electrical vehicles EVs over conventional internal combustion engine vehicles ICEVs.
9. What is hybrid vehicle? Explain configuration and performance of hybrid vehicle.
10. Explain the advantages of electric vehicle over the conventional internal combustion engine vehicle.
11. Explain tractive effort and transmission requirement for electric vehicle.
12. Explain hybrid electric vehicle working principle with relevant block diagram.

	Checked by		
		27/7/19	
Prof.O.B.Heddurshetti	Prof.O.B.Heddurshetti	HOD	Principal

Subject Title	FACTS AND HVDC TRANSMISSION (Professional Elective)		
Subject Code	15EE751	CIE Marks	20
Number of Lecture Hrs / Week	3	SEE Marks	80
Total Number of Lecture Hrs	40	Exam Hours	03
CREDITS – 03			

FACULTY DETAILS:		
Name: Prof. Sagar S B	Designation: Asst. Professor	Experience: 07 Years
No. of times course taught: 01	Specialization: VLSI Design & Embedded Systems	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical &Electronics Engineering	IV	Transmission and Distribution
02	Electrical &Electronics Engineering	V	Estimation & Costing

2.0 Course Objectives

1. To discuss transmission interconnections, flow of Power in an AC System, limits of the loading capability and dynamic stability considerations of transmission interconnection and controllable parameters.
2. To explain the basic concepts, definitions of flexible ac transmission systems and benefits from FACTS technology.
3. To describe shunt controllers, Static VAR Compensator and Static Compensator for injecting reactive power in the transmission system in enhancing the controllability and power transfer capability.
4. To describe series Controllers Thyristor-Controlled Series Capacitor (TCSC) and the Static Synchronous Series Compensator (SSSC) for control of the transmission line current.
5. To explain advantages of HVDC power transmission, overview and organization of HVDC system.
6. To describe the basic components of a converter, the methods for compensating the reactive power demanded by the converter.
7. Explain converter control for HVDC systems, commutation failure and control functions.

3.0 Course Outcomes

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

CO	Course Outcome	POs
CO 1	Discuss transmission interconnections, flow of Power in an AC System, limits of the loading capability, dynamic stability considerations of a transmission interconnection and controllable parameters. Also explain the basic concepts, definitions of flexible ac transmission systems and benefits from FACTS technology.	PO's 1,2,3, 4,5,8,9,12
CO 2	Describe shunt controllers, Static Var Compensator and Static Compensator for injecting reactive power in the transmission system in enhancing the controllability and power transfer capability.	PO's 1,2,3, 4,5,8,9,12
CO 3	Describe series Controllers Thyristor-Controlled Series Capacitor (TCSC) and the Static Synchronous Series Compensator (SSSC) for control of the transmission line current.	PO's 1,2,3, 4,5,8,9,12
CO 4	Explain advantages of HVDC power transmission, overview and organization of HVDC system.	PO's 1,2,3, 4,5,8,9,12
CO 5	Describe the basic components of a converter, the methods for compensating the reactive power demanded by the converter. And explain converter control for HVDC systems, commutation failure, control functions	PO's 1,2,3, 4,5,8,9,12
	Total Hours of instruction	**40**

4.0 Course Content

Module-1

FACTS Concept and General System Considerations: Transmission Interconnections, Flow of Power in an AC System, What Limits the Loading Capability? Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of Controllable Parameters, Basic Types of FACTS Controllers, Brief Description and Definitions of FACTS Controllers, Checklist of Possible Benefits from FACTS Technology, In Perspective: HVDC or FACTS.

8 Hours

Module-2

Static Shunt Compensators: Objectives of Shunt Compensation - Midpoint Voltage Regulation for Line Segmentation, End of Line Voltage Support to Prevent Voltage Instability, Improvement of Transient Stability. Methods of Controllable Var Generation –Thyristor controlled Reactor (TCR) and Thyristor Switched Reactor (TSR), Thyristor Switched Capacitor (TSC).Operation of Single Phase TSC – TSR. Switching Converter Type Var Generators, Basic Operating Principles, Basic Control Approaches. Static VAR Compensators: SVC and STATCOM, the Regulation Slope. Comparison between STATCOM and SVC, V –I and V –Q Characteristics, Transient stability, Response Time

8 Hours

Module-3

Static Series Compensators: Objectives of Series Compensation, Concept of Series Capacitive Compensation, Voltage Stability, Improvement of Transient Stability. GTO Thyristor- Controlled Series Capacitor, Thyristor-Switched Series Capacitor, Thyristor-Controlled Series Capacitor, The Static synchronous Series Compensator, Transmitted Power Versus Transmission Angle Characteristic.

8 Hours

Module-4

Development of HVDC Technology: Introduction, Advantages of HVDC Systems, HVDC System Costs, Overview and Organization of HVDC Systems, HVDC Characteristics and Economic Aspects.
Power Conversion: 3-Phase Converter, 3-Phase Full Bridge Converter, 12-Pulse Converter.

8 Hours

Module-5

Control of HVDC Converter and System: Converter Control for an HVDC System, Commutation Failure, HVDC Control and Design, HVDC Control Functions, Reactive Power and Voltage Stability.

8 Hours

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	PSOC	Stability and control of power systems
02	VIII	Smart Grid	Control of Grid

6.0 Relevance to Real World

Sl No	Real World Mapping
01	Interconnection of two separate power systems
02	Installation of HV-DC links

7.0 Gap Analysis and Mitigation

Sl No	Delivery Type	Details
01	NPTEL	FACTS technology, HVDC links etc

8.0 Books Used and Recommended to Students

Text Books
1. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems by Narain G Hingorani, Laszlo Gyugyi, Wiley Publications 1st Edition, 2000 2. HVDC Transmission: Power Conversion Applicationsin Power Systems by Chan-Ki Kim et al, Wiley Publications 1st Edition, 2009
Reference Books
1. Thyristor Based FACTS Controllers for Electrical Transmission Systems by R. Mohan Mathur, Rajiv K. Varma, Wiley Publications 1st Edition, 2009

9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
https://en.wikipedia.org/wiki/facts_hvdc https://en.wikipedia.org/wiki/static_series_compensators

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	Website
1	IEEE	www.ieeexplore.com

11.0 Examination Note

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

12.0 Course Delivery Plan

Module	Lecture No.	Content of Lecturer	% of Portion
MODULE 1	1	**FACTS Concept and General System Considerations:** Transmission Interconnections,	20
	2	Flow of Power in an AC System, What Limits the Loading Capability?	
	3	Power Flow and Dynamic Stability Considerations of a Transmission Interconnection	
	4	Relative Importance of Controllable Parameters	
	5	Basic Types of FACTS Controllers	
	6	Brief Description and Definitions of FACTS Controllers	
	7	Checklist of Possible Benefits from FACTS Technology	
	8	In Perspective: HVDC or FACTS	
MODULE 2	9	**Static Shunt Compensators:** Objectives of Shunt Compensation - Midpoint Voltage Regulation for Line Segmentation	20
	10	End of Line Voltage Support to Prevent Voltage Instability, Improvement of Transient Stability	
	11, 12	Methods of Controllable Var Generation –Thyristor controlled Reactor (TCR) and Thyristor Switched Reactor (TSR), Thyristor Switched Capacitor (TSC).	
	13	Operation of Single Phase TSC – TSR. Switching Converter Type Var Generators, Basic Operating Principles, Basic Control Approaches	
	14	Static VAR Compensators: SVC and STATCOM, the Regulation Slope.	
	15	Comparison between STATCOM and SVC, V –I and V –Q Characteristics	
	16	Transient stability, Response Time	
	17	**Static Series Compensators:** Objectives of Series Compensation	20

MODULE 3	18	Concept of Series Capacitive Compensation	
	19	Voltage Stability, Improvement of Transient Stability	
	20	GTO Thyristor- Controlled Series Capacitor	
	21	Thyristor-Switched Series Capacitor	
	22	Thyristor-Controlled Series Capacitor	
	23	The Static synchronous Series Compensator	
	24	Transmitted Power Versus Transmission Angle Characteristic.	
MODULE 4	25	**Development of HVDC Technology:** Introduction	20
	26	Advantages of HVDC Systems, HVDC System Costs	
	27	Overview and Organization of HVDC Systems	
	28	HVDC Characteristics and Economic Aspects.	
	29	**Power Conversion:** 3-Phase Converter	
	30	3-Phase Full Bridge Converter	
	31	12-Pulse Converter	
	32		
MODULE 5	33, 34	**Control of HVDC Converter and System:** Converter Control for an HVDC System	20
	35	Commutation Failure	
	36, 37	HVDC Control and Design	
	38	HVDC Control Functions	
	39, 40	Reactive Power and Voltage Stability	

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl. No	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: Questions on module 1	Students study basics of FACTS and General Considerations.	Module 1 of the syllabus	3	Individual Activity.	Text 1
2	Assignment 2: Questions on module 2	Students study the Static Shunt Compensators	Module 2 of the syllabus	5	Individual Activity.	Text 1
3	Assignment 3: Questions on module 3	Students study the Static Series Compensators	Module 3 of the syllabus	8	Individual Activity.	Text 1
4	Assignment 4: Questions on module 4	Students study the Development of HVDC Technology	Module 4 of the syllabus	10	Individual Activity.	Text 2
5	Assignment 5: Questions on module 5	Students Study Control of HVDC Converter	Module 5 of the syllabus	12	Individual Activity.	Text 2

Prepared by	Checked by		
Prof. Sagar S Birade	Prof. S D Hirekodi	HOD	Principal

Subject Title	**TESTING AND COMMISSIONING OF POWER SYSTEM APPARATUS**		
Subject Code	15EE752	**IA Marks**	20
Number of Lecture Hrs / Week	03L	**Exam Marks**	80
Total Number of Lecture Hrs	40	**Exam Hours**	03
CREDITS – 04			

FACULTY DETAILS:		
Name: Prof. S.B. PATIL	**Designation:** Asst .Professor	**Experience:**33 years
No. of times course taught:01	**Specialization:** Power & Energy system	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical & Electronics Engineering	I/II	Basic Electrical Engineering
02	Electrical & Electronics Engineering	III	Transformer & Generator
03	Electrical & Electronics Engineering	IV	Electric motor
04	Electrical & Electronics Engineering	V	Direct current and synchronous machine
05	Electrical & Electronics Engineering	VI	Electrical machine design

2.0 Course Objectives

1. Describe the process to plan, control and implement commissioning of electrical equipment's.
2. Differentiate the performance specifications of transformer and induction motor.
3. Demonstrate the routine tests for synchronous machine, induction motor, transformer & switchgears.
4. Identification of tools and equipment's used for installation and maintenance of electrical equipment.
5. Explain the operation of an electrical equipment's such as isolators, circuit breakers, insulators and switchgears.■

3.0 Course Outcomes

Having successfully completed this course, the student will be able to

	Course Outcome	Cognitive Level	POs
CO1	Describe the process to plan, control and implement commissioning of electrical equipment's.	L1,L2	1,3,6,7
CO2	Differentiate the performance specifications of transformer and induction motor.	L1,L2 & L3	1,2,3,4,6, 7,8
CO3	Demonstrate the routine tests for synchronous machine, induction motor, transformer & switchgears.	L1,L2,L3, L4& L5	1,2,3,6,7, 9,
CO4	Describe corrective and preventive maintenance of electrical equipment's.	L1,L2,L3, L4& L5	1,2,3,6,9
CO5	Explain the operation of an electrical equipment's such as isolators, circuit breakers, induction motor and synchronous machines .	L1,L2,L3, L4& L5	1,2,3,4,6
Total Hours of instruction		**40**	

4.0 Course Content

Module-1 **08 Hours**

Electrical Tools, accessories: Tools, Accessories and Instruments required for Installation, Maintenance and Repair Work, India Electricity Rules, Safely Codes Causes and Prevention of Accidents, Artificial Respiration, Workmen's Safety Devices.

Transformers:

Installation, Location Site Selection, Foundation Details, Code of Practice for Terminal Plates, Polarity and Phase Sequence, Oil Tanks, Drying of Winding sand General Inspection. Commissioning Tests As Per National and International Standards - Volts Ratio Earth Resistance, Oil Strength, Insulation Tests, Impulse Tests Polarizing Index, Load Temperature Rise Tests. Specific Tests for Determination of Performance Curves like Efficiencies, Regulation Etc., Determination Mechanical Stress Under Normal and Abnormal Conditions.

Module-2 **08 Hours**

Synchronous Machines: Specifications as per BIS Standards. Installation - Physical Inspection, Foundation Details, Alignments, Excitation Systems, Cooling and Control Gear, Drying Out.

Commissioning Tests - Insulation, Resistance Measurement of Armature and Field Windings, Wave Form and Telephone Interference Tests, Line Charging Capacitance. Performance Tests -Various Tests to Estimate the Performance of Generator Operations, Slip Test, Maximum Lagging Current, Maximum Reluctance Power Tests, Sudden Short Circuit Tests, Transient Sub Transient Parameters, Measurement of Sequence Impedances, Capacitive Reactance, and Separation Of Losses, Temperature Rise Test, and Retardation Tests. Factory Tests -Gap Length, Magnetic Eccentricity, Balancing Vibrations, Bearing Performance.

Module-3 **08 Hours**

Induction Motor: Specifications. Installation- Location of Motors and its Control Apparatus, Shaft Alignment for Various Coupling, Fitting of Pulleys and Coupling, Drying of Windings. Commissioning Tests -Mechanical Tests For Alignment, Air Gap Symmetry, Tests for Bearings, Vibrations and Balancing. Specific Tests -Performance and Temperature Raise Tests, Stray Load Losses, Shaft Alignment, Re-Writing and Special Duty Capability, Site Test

Module- 4 **08 Hours**

Laying of Underground Cables: Inspection, Storage, Transportation and Handling of Cables, Cable Handing Equipment, Cable Laying Depths and Clearances from other Services such as Water Sewerage, Gas, Heating and other Mains, Series of Power and Telecommunication Cables and Coordination with these Services, Excavation of Trenches, Cable Jointing and Terminations Testing and Commissioning. Location of Faults using Megger, Effect of Open or Loose Neutral Connections, Provision of Proper Fuses on Service Lines and their Effect on System, Causes and Dim& Flickering Lights **.**

Module-5 **08 Hours**

Switchgear and Protective Devices: Standards, Types, Specification, Installation, Commissioning Tests, Maintenance Schedule, Type and Routine Tests.

Domestic Installation: Introduction, Testing of Electrical Installation of a Building, Testing of Insulation Resistance to Earth, Testing of Insulation and Resistance between Conductors Continuity or Open Circuit Test, Short Circuit Test, Testing of Earthing Continuity, Location of Faults, IE Rules for Domestic Installation

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VII & VIII	Project work	Testing of machines
02	VII & VIII	Seminar	

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Knowledge of specifications as per BIS for Purchase of electrical machines.
02	Testing and commissioning of Electrical machines at site
03	Testing and commissioning of switchgear and protective devices

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Industry also Field Visit	Testing and commissioning of Electrical machines .
02	Field Visit	Substation.

8.0 Books Used and Recommended to Students

Text & Reference Books

1. Testing, Commissioning, Operation and Maintenance of Electrical Equipment . S. Rao, Khanna Publishers 6th Edition, 19th Reprint, 2015
2. Testing and Commissioning of Electrical Equipment . R.L.Chakrasali , Prism Books Pvt Ltd. 1st Edition,2014
3. Preventive Maintenance of Electrical Apparatus . S.K.Sharotri. Katson Publishing House , 1st Edition, 1980
4. Handbook of Switchgears, BHEL , McGraw Hill , 1st Edition, 2005
5. Transformers, BHEL, McGraw Hill, 1st Edition, 2003
6. The J&P Transformer Book , Martin J. Heathcote , Newnes , 12th Edition, 1998

9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References

1) http://www.electrical4u.com
2) www.nptel.com
3) https://en.wikipedia.org/wiki/**Testing and commissioning of electrical equipment**
4) www.electrical4u.com/**testing and commissioning -of-transformer**/
5) www.ijset.net/journal/68.pdf
6) www.electrical4u.com/**testing and commissioning of induction machine**
7) www.electrical4u.com/**testing and commissioning of synchronous machine**
8) www.electricaleasy.com/.../**tesing and commissioning of circuit breakers**

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Omics journal	**www.omicsonline.org/Engineering/CitationReports**
2	Ge grid journal	**https://www.gegridsolutions.com/multilin/journals/issues/PCJ-October2008.pdf**
3	Neta world journal	**www.wtol.com/.../top-stories-on-electrical-testing-from-neta-world-journals-winter-2016**
4	IAEI magazine	**iaeimagazine.org/magazine/.../third-party-electrical-testing**
5	ES magazine	**www.esmagazine.com/ext/resources/ES/Home/Files/PDF/0906Schneider Electric.pdf**

11.0 Examination Note

Internal Assessment: 20 Marks [15 Marks average of 2 IA + 05 Marks for Assignment]
Three internal assessment tests will be conducted. Out of the three tests, average marks of the best two tests marks will be considered. The students will write the internal assessment tests in separate IA test books.
Assignment will be given on each Module.

Main examination Scheme (80 Marks)

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

12.0 Course Delivery Plan

Unit No.	Lecture No.	Content of Lecture	% of Portion

MODULE-I	1	**Electrical Tools, accessories**: Tools, Accessories and Instruments required for Installation, Maintenance and Repair Work, India Electricity Rules, Safely Codes Causes and Prevention of Accidents, Artificial Respiration, Workmen's Safety Devices	20.00%
	2	**Installation:** Location, site,oil tanks, drying of windings and general inspection.	
	3	selection, foundation details (like bolts size, their number, etc)	
	4	Code of practice for terminal plates,	
	5	polarity & phase sequence, Oil tanks, Drying of windings	
	6	**Commissioning tests:** As per national & International Standards,. Volt ratio test, Earth resistance, oil strength,	
	7	Insulation test, impulse test, Polarizing index, load & temperature rise test	
	8	**Specific Tests:** Determination of performance curves like efficiency, regulation etc, &abnormal conditions. Determination of mechanical stress under normal & abnormal conditions	
MODULE-II	9	**Synchronous machines: Specifications-** As per BIS standards	20%
	10	**Installation:** Physical inspection, foundation details, alignments, excitation systems, cooling and control gear, drying out	
	11	**Commissioning Tests:** Insulation, Resistance measurement of armature & field windings, waveform	
	12	Telephone interference tests, line charging capacitance	
	13	**Performance tests:** Various tests to estimate the performance of generator operations, slip test, maximum lagging current, maximum reluctance power tests	
	14	Sudden short circuit tests, transient & sub transient parameters, Measurements of sequence impedances	
	15	Capacitive reactance, and separation of losses. Temperature rise test, and retardation tests	
	16	**Factory tests:** Gap length, magnetic eccentricity, balancing vibrations, bearing performance	
MODULE-III	17	**INDUCTION MOTORS:** a. **Specifications** for different types of motors, **Installation** Location of Motors	20%
	18	Its control apparatus, shaft & alignment for various coupling	
	19	Fitting of pulleys & coupling, drying of windings	
	20	**Commissioning Test:** Mechanical tests for alignment, air gap symmetry,	
	21	Tests for bearings, vibrations & balancing	
	22	**Specific Tests:** Performance & temperature raise tests,	
	23	Stray load losses, shaft alignment,	
	24	Re-rating & special duty capability, Site test	
MODULE-IV	25	**Laying of Underground Cables:** Inspection, Storage, Transportation and Handling of Cables, Cable Handing Equipment.	20%
	26	Cable Laying Depths and Clearances from other Services such as Water Sewerage, Gas,	
	27	Heating and other Mains, Series of Power and Telecommunication Cables and Coordination with these Services	
	28	Excavation of Trenches, Cable Jointing and Terminations Testing and Commissioning.	
	29	Location of Faults using Megger,	
	30	Effect of Open or Loose Neutral Connections	
	31	Provision of Proper Fuses on Service Lines	
	32	Their Effect on System, Causes and Dim, and Flickering Lights	
MODULE-V	33	**Switch gear & protective devices:** Standards, types, specification.	20%
	34	Installation, commissioning tests, maintenance schedule.	
	35	Type & routine tests.	
	36	**Domestic Instalation:** Introduction, Testing of Electrical Installation of a Building	
	37	Testing of Insulation Resistance to Earth, Testing of Insulation and Resistance between Conductors Continuity	
	38	Open Circuit Test, Short Circuit Test	
	39	Testing of Earthing Continuity, Location of Faults	

	40	IE Rules for Domestic Installation	

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl. No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: University Questions on transformer	Students study the Topics and write the Answers.	Module-I	3	Individual Activity. group activity like site visit.	Book 1, 2 of the reference list. Website of the Reference list
2	Assignment 2: University Questions on synchronous machine	Get practice to solve university questions.	Module-II	5	Individual Activity. group activity like site visit.	Book 1, 2 of the reference list. Website of the Reference list
3	Assignment 3: University Questions on induction motor	Students study the Topics and write the Answers. Get practice to solve university questions.	Module-III	7	Individual Activity. group activity like site visit.	Book 1, 2 of the reference list. Website of the Reference list
4	Assignment 4: University Questions on Cables	Students study the Topics and write the Answers for VTU question papers.	Module-IV	9	Individual Activity./group activity like site visit.	Book 1, 2 of the reference list. Website of the Reference list
5	Assignment 5: University Questions on switchgear and protective device	Students study the Topics and write the Answers. Get practice to solve university questions.	Module-V	10	Individual Activity./ Industrial visit	Book 1, 2 of the reference list. Website of the Reference list

14.0 QUESTION BANK

Module -I

1. Explain the principles, objectives and significance of protection and monitoring of transformers.
2. Explain the principle of circulating current differential protection, supplied to power transformer.
3. Explain the significance of temperature rise test and method to conduct temperature rise test on power transformer.
4. Explain the procedure of drying out of power transformer.
5. State the various commissioning tests on power transformer.
6. Explain the various procedure of procuring power transformer before it is commissioned.
7. What are properties of good insulating oil used in transformer.
8. Explain breakdown voltage test conducted on transformer.
9. What is drying of transformer? Explain different methods of drying out.
10. Explain various accessories of power transformer.
11. Explain different methods of cooling of power transformers.
12. What are different standards and what is the need for standardization of specifications.
13. Mention the specifications of power transformer.
14. What is the significance of testing. Explain various tests performed on power transformers.
15. Mention the safety precautions to be taken while commissioning and maintaining the transformer.

Module -II

1. State and explain essential steps in unit commissioning of synchronous machines.
2. State and explain the procedure of various tests on synchronous machine & their significance.
3. State the causes for vibrations in motors and generators. How are the vibrations measured? State how to overcome the vibration problems at site.
4. Explain the procedures of foundation of electric machines.
5. Mention the various specifications of alternator.
6. Explain suitability of hydrogen as coolant used in turbo alternator.

7. Explain the sudden three phase short circuit test conducted on alternators.
8. Define SCR of synchronous machine. What is its significance? Explain the procedure to determine it.
9. Explain the procedure of measuring DC resistance of armature winding of a synchronous machine.
10. Explain the protection scheme of rotating electrical machine.
11. Describe the negative phase sequence test on synchronous machine.
12. Explain different methods of starting synchronous machines.
13. Explain the typical specification of an alternator.
14. Explain types of methods of cooling and types of enclosures of an alternator.
15. What are steps involved in installation of an alternator?

Module -III

1. Write a short note on Temperature rise in IM
2. Explain the foundation details for installing IM.
3. Explain the various methods of measuring the slip of IM.
4. What are the different methods of measuring temperature rise IM.
5. Explain de-rating of IM.
6. Explain the drying out methods for induction motor.
7. Explain the methods of measuring slip of an IM.
8. Explain different duties of IM.
9. Explain specifications of three phase IM.
10. Write a short note on performance requirements and other special requirements of IM.

Module -IV

1. What are the points to be considered for inspection and storage of UG cables ?
2. How the cables handled and laying of cables.
3. Excavation of Trenches, Cable Jointing and Terminations Testing and Commissioning
4. Explain the Location of Faults using Megger.
5. Effect of Open or Loose Neutral Connections & Provision of Proper Fuses on Service Lines

Module -V

1. What are different types of type tests conducted on CB? Explain.
2. What are the factors to be considered while selecting a CB? Explain.
3. State and explain the various tests performed on high voltage a.c circuit breakers.
4. Explain the various steps in maintenance of CB.
5. Write a short note on various steps in installation and commissioning of outdoor CB.
6. Describe the general guidelines to maintain high voltage CB.
7. Explain briefly testing of Insulation resistance to Earth.
8. Explain the open circuit test & short circuit test and continuity test .
9. What are the I E Rules for Domestic Installation.

16.0 University Result

Examination	FCD	FC	SC	% Passing
Jan 2019	47			100%
Jan 2018	16	9	7	100%
Jan 2017	1	6	24	96.9%

Prepared by	Checked by		
Prof. S.B.Patil	Prof.S.D.Hirekodi	HOD	Principal

Subject Title	**POWER SYSTEM SIMULATION LABORATORY**		
Subject Code	15EEL76	**IA Marks**	20
No of Practical Hrs / Week	03	**Exam Marks**	80
Total No of Practical Hrs	42	**Exam Hours**	03
Credits-02			

FACULTY DETAILS:		
Name: Prof. Hemalata R. Zinage	**Designation:** Asst. Professor	**Experience:** 19Years
No. of times course taught: 01 Time		**Specialization:** Power System

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical and Electronics Engineering	IV	Transmission and Distribution
01	Electrical and Electronics Engineering	VI	Power System Analysis-I
01	Electrical and Electronics Engineering	VII	Power System Analysis-II

2.0 Course Objectives

1.To explain the use of MATLAB package to assess the performance of medium and long transmission lines.
2. To explain the use of MATLAB package to obtain the power angle characteristics of salient and non- salient pole alternator.
3. To explain the use of MATLAB package to study transient stability of radial power systems under three phase fault conditions.
4. To explain the use of MATLAB package to develop admittance and impedance matrices of interconnected power systems.
5.To explain the use of Mi-Power package to solve power flow problem for simple power systems.
6. To explain the use of Mi-Power package to perform fault studies for simple radial power systems.
7. To explain the use of Mi-Power package to study optimal generation scheduling problems for thermal power plants.

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

CO	Course Outcome	Cognitive Level	POs
C406.1	Develop a program in MATLAB to assess the performance of medium and long transmission lines.	L_3-L_6	1,2,9,10
C406.2	Develop a program in MATLAB to obtain the power angle characteristics of salient and non-salient pole alternator	L_3-L_6	1,2,9,10
C406.3	Develop a program in MATLAB to assess the transient stability under three phase fault at different locations in a of radial power systems.	L_3-L_6	1,2,9,10
C406.4	Develop programs in MATLAB to formulate bus admittance and bus impedance matrices of interconnected power systems.	L_3-L_6	1,2,9,10
C406.5	Use Mi-Power package to solve power flow problem for simple power systems.	L_3-L_6	1,2,9,10
C406.6	Use Mi-Power package to study unsymmetrical faults at different locations in radial power systems.	L_3-L_6	1,2,9,10
C406.7	Use of Mi-Power package to study optimal generation scheduling problems for thermal power plants.	L_3-L_6	1,2,9,10
Total Hours of instruction		**42**	

4.0 Course Content

Sl. No		Experiments
1	Use of MATLAB package	Formation for symmetric π /T configuration for Verification of $AD-BC=1$, Determination of Efficiency and Regulation.
2		Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines.
3		To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault On One of the two Lines.
4		Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method.
5		Formation of Z Bus (without mutual coupling) using Z-Bus Building Algorithm.
6		Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile.
7	Use of Mi-Power package	Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates.
8		Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQ and PV Buses.
9		To Determine Fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation.
10		Optimal Generation Scheduling for Thermal power plants by simulation.
Revised Bloom's Taxonomy Level		L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing, L_5 – Evaluating,

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
01	VIII	Project work	Analysis of power system using MATLAB &Mi-power

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Calculating A, B, C, D parameters of transmission line.
02	Stability study of power system.
03	Load flow analysis of power system.
04	Fault analysis of power system.
05	Economic dispatch of power system.

7.0 Books Used and Recommended to Students

Text Books

Text Books:1 Modern Power System Analysis D. P. Kothari McGraw Hill 4th Edition, 2011

Reference Books

1. Stag, G. W., and EI-Abiad, A. H., "Computer Methods in Power System Analysis", McGraw Hill International Student Edition. 1968
2. .Pai, M. A., "Computer techniques in Power System Analysis", TMH, 2nd edition, 2006.
4. Hadi Saadat,"power system analysis" McGraw Hill 2nd Edition, 2002

Additional Study material & e-Books

1. http://pdfstuff4u.com/ebook.php?id=1071881
2. http://sjbit.edu.in

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
1)ieeexplore.ieee.org/document/152452/
2) https://engineering.purdue.edu/jump/8cb309
3)nptel.iitg.ernet.in

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Society of energy engineers and managers	www.energyprofesionals.in
2	IEEE Explore	ieeexplore.ieee.org/xpl/RecentIssue
3	Journal of Modern Power Systems and Clean Energy	www.springer.com

Internal Assessment:
Scheme of Evaluation for Internal Assessment (20 Marks)
(a) Internal Assessment test in the same pattern as that of the main examination: 10marks.
Writeup-03 marks, Conduction-05 marks, Viva-Voce-02 marks
(b) Continuous assessment for laboratory experiments: 10marks.

SCHEME OF EXAMINATION:
One question is to be set for 80marks.
a) Write-up: 15% of Maximum marks b)Conduction: 70% of Maximum marks
c) Viva-voce: 15% of Maximum marks

11.0 Course Delivery Plan

Sl. No		Experiments	% of Portion
1	Use of MATLAB package	Formation for symmetric π /T configuration for Verification of $AD-BC=1$, Determination of Efficiency and Regulation.	10
2		Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines.	10
3		To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault On One of the two Lines.	10
4		Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method.	10
5		Formation of Z Bus (without mutual coupling) using Z-Bus Building Algorithm.	10
6		Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile.	10
7	Use of Mi-Power package	Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates.	10
8		Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQ and PV Buses.	10
9		To Determine Fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation.	10
10		Optimal Generation Scheduling for Thermal power plants by simulation.	10
Revised Bloom's Taxonomy Level		L_1 – Remembering, L_2 – Understanding, L_3 – Applying, L_4 – Analysing, L_5 – Evaluating,	

Course Plan 2019-20 Odd / Semester 7th
Electrical and Electronics Engineering

12.0 QUESTION BANK

1. What is importance of Y_{bus}?
2. What is reactance diagram?
3. Define Per Unit.
4. What are symmetrical components?
5. How symmetrical components are useful in solution of Power System?
6. What are unsymmetrical faults?
7. Define Stability.
8. What is singular transformation?
9. What is load flow study?
10. What are the different methods of LFS?
11. Compare different methods of LFS?
12. What is the importance of Jaccobian matrix?
13. What is bus building algorithm?
14. Give formulas for different modifications in building algorithm?
15. What are A, B, C, D parameters?
16. How transmission lines are classified &represented?
17. What is voltage regulation?
18. What is maximum& minimum voltage regulation?
19. What is power angle diagram?
20. What are salient & non salient pole machines?
21. What is reluctance power?
22. What is the effect of saliency &saturation
23. What is the effect of saliency &saturation?
24. What is swing equation?
25. What is the importance of swing curve?
26. What is critical clearing angle &time?
27. How to determine critical clearing time graphically?
28. Classify faults in the power system?
29. What are sequence impedances &sequence networks?
30. Explain different types of buses in the power system
31. What is single line diagram?
32. What are the conditions to draw single line diagram?
33. How sequence networks are connected in case of different faults?
34. What is economic operation of power system ?
35. What are the conditions for economic dispatch with &without loss?
36. What are the guidelines to select initial value of lambda?
37. What is spinning reserve?
38. Give guidelines to select spinning reserve?
39. What are the constraints in unit commitment &economic dispatch?
40. What is the difference between steady state & transient stability?
41. Stability limits have single or multiple values?
42. What are the methods to improve steady state & transient stability?
43. Explain equal area criterion?
44. How stability is improved using equal area criterion?
45. What is the advantage of MATLAB& simulation?

Prepared by	HOD	Principal
Prof. H.R.Zinage	27/7/19	

Subject Title	**RELAY AND HIGH VOLTAGE LAB**		
Subject Code	15EEL77	**IA Marks**	20
No of Practical Hrs / Week	03	**Exam Marks**	80
Total No of Practical Hrs	42	**Exam Hours**	03
Credits-02			

FACULTY DETAILS:		
Name: Prof. S. D. Hirekodi	**Designation:** Asst. Professor	**Experience:** 18.6Years
No. of times course taught: 02	**Specialization:** Power Electronics	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical and Electronics Engineering	VII	High Voltage Engineering

2.0 Course Objectives

1.To conduct experiments to verify the characteristics of over current, over voltage, under Voltage relays both electromagnetic and static type.
2. To verify the operation of negative sequence relay.
3. To conduct experiments to verify the characteristics of microprocessor based over current, Over Voltage, under voltage relays and distance relay.
4. To conduct experiments on generator, motor and feeder protection.
5.To conduct experiments to study the spark over characteristics for both uniform and non-Uniform Configurations using High AC and DC voltages.
6.To measure high AC and DC voltages
7. To experimentally measure the breakdown strength of transformer oil.
8. To experimentally measure the capacitance of different electrode configuration models using Electrolytic Tank. To generate standard lightning impulse voltage and determine efficiency, Energy of Impulse generator and 50% probability flashover voltage for air insulation.

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

CO	Course Outcome	Cognitive Level	POs
CO407.1	Experimentally verify the characteristics of over current, over voltage, under voltage and negative sequence relays both electromagnetic and static type.	L_3-L_6	1,2,8,9,10
CO407.2	Experimentally verify the characteristics of microprocessor based over current, over voltage, under voltage relays and distance relay.	L_3-L_6	1,2,8,9,10
CO407.3	Show knowledge of protecting generator, motor and feeders.	L_3-L_6	1,2,8,9,10
CO407.4	Analyze the spark over characteristics for both uniform and non-uniform configurations using High AC and DC voltages.	L_3-L_6	1,2,8,9,10
CO407.5	Measure high AC and DC voltages and breakdown strength of transformer oil.	L_3-L_6	1,2,8,9,10
CO407.6	Draw electric field and measure the capacitance of different electrode configuration models.	L_3-L_6	1,2,8,9,10

CO407.7	Show knowledge of generating standard lightning impulse voltage to determine efficiency, energy of impulse generator and 50% probability flashover voltage for air insulation.	L_3-L_6	1,2,8,9,10
Total Hours of instruction		**42**	

4.0 Course Content

PART A

1. over current relay
   (a) IDMT non-directional characteristics
   (b) Directional features
   (c) IDMT directional
2. IDMT characteristics of over voltage or under voltage relay (Solid state or electromechanical type)
3. Operation of negative sequence relay.

PART B

4. Operating characteristics of microprocessor based (numeric) over current relay.
5. Operating characteristics of microprocessor based (numeric) distance relay.
6. Operating characteristics of microprocessor based (numeric) over/under voltage relay.

PART C

7. Generator protection –Merz-Price- protection scheme.
8. Feeder protection against faults.
9. Motor protection against faults.

PART D

10. Spark Over Characteristics of Air subjected to High Voltage AC with Spark Voltage Corrected to Standard Temperature and Pressure for Uniform [as per IS1876: 2005] and Non-uniform [As per IS2071 (Part 1): 1993] Configurations: Sphere – Sphere, Point –Plane, Point – Point and Plane – Plane.
11. Spark over characteristics of air subjected to high voltage DC.
12. Measurement of HVAC and HVDC using standard spheres as per IS 1876:2005
13. Measurement of Breakdown Strength of Transformer Oil as per IS 1876:2005
14. Field Mapping using Electrolytic Tank for any one of the following Models: Cable/ Capacitor/ Transmission Line/ Sphere Gap.
15. (a) Generation of standard lightning impulse voltage and to determine efficiency and energy of impulse Generator. (b) To determine 50 % probability flashover voltage for air insulation subjected to Impulse voltage.

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
01	VIII	Project work	Design and Testing of hardware models related to HVE

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Electric breakdown phenomena in gases and liquid dielectrics
02	High voltage AC, DC generation in power research laboratory for insulation testing of electrical equipments and switchgear.
03	High voltage measurements in research laboratory during testing of electrical equipments and switchgear.
04	Working of electromechanical type over current, over voltage and microprocessor based over current and over /under voltage relay.

05	Equi-potential lines of different electrode models
06	Fault analysis of 3-phase Induction motor

7.0 Books Used and Recommended to Students

Text Books
1. **High Voltage Engineering** by M.S.Naidu and Kamaraju- 4th Edition, THM, 2008. 2. **High Voltage Engineering Fundamentals** by E.Kuffel and W.S. Zaengl, 2nd Edition, Elsevier Press, 2005. 3. **High Voltage Engineering** by C.L.Wadhwa, New Age International Private limited, 1995.
Reference Books
1.**High Voltage Engineering Theory and Practice** by Mazen Abdel-Salam, Hussein Anis, Ahdab El-Morshedy, Roshdy Radwan, 2nd Edn(Revised & Expanded) Marcel-Dekker Publishers (Special Indian Edn.). 2. **High voltage Engineering** by Subir Ray, Newage International
Additional Study material & e-Books
1. High Volatge test and measuring techniques: Springer 2. High voltage and electrical insulation engineering by Ravindra Arora

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
1) http://www.cpri.in/about-us/departmentsunits/high-voltage-division-hvd.html 2) http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6432571

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	IEEE Technology Navigator	http://technav.ieee.org/tag/8470/relays#concepts

10.0 Examination Note

Internal Assessment:

Scheme of Evaluation for Internal Assessment (20 Marks)

(a) Internal Assessment test in the same pattern as that of the main examination: 10marks.
Writeup-03 marks, Conduction-05 marks, Viva-Voce-02 marks

(b) Continuous assessment for laboratory experiments: 10marks.

SCHEME OF EXAMINATION:

One question is to be set for 80marks.

a) Write-up: 15% of Maximum marks b)Conduction: 70% of Maximum marks
c) Viva-voce: 15% of Maximum marks

11.0 Course Delivery Plan

Part	Expt. No.	Name of the experiment	% of Portion
D	1	Spark over characteristics of air subjected to high voltage DC.	-
	2	Measurement of HVAC and HVDC using standard spheres as per IS 1876:2005	
	3	Spark Over Characteristics of Air subjected to High Voltage AC with Spark Voltage Corrected to Standard Temperature and Pressure for Uniform [As per IS1876: 2005] and Non-uniform [As per IS2071 (Part 1): 1993] Configurations: Sphere – Sphere, Point –Plane, Point – Point and Plane – Plane.	
	4	Measurement of Breakdown Strength of Transformer Oil as per IS 1876:2005	

	5	Field Mapping using Electrolytic Tank for any one of the following Models: Cable/ Capacitor/Transmission Line/ Sphere Gap.	
C	6	Motor protection against faults	
	7	Generator protection –Merz-Price- protection scheme.	
B	8	Operating characteristics of microprocessor based (numeric) over current relay	
	9	Operating characteristics of microprocessor based (numeric) over/under voltage relay.	
A	10	Over current relay (a) IDMT non-directional characteristics (b) Directional features (c) IDMT directional	
	11	IDMT characteristics of over voltage or under voltage relay (Electromechanical type)	

12.0 QUESTION BANK

1. What is protective relay? Explain its function in an electrical system.
2. What are the fundamental requirements of protective relaying?
3. Define the following terms as applied to protective relaying.
    a. Pick up current
    b. Current setting
    c. Plug setting multiplier (PSM)
    d. Time setting multiplier (TSM)
4. What is the difference between a fuse and a relay?
5. What is the difference between an over current relay and current differential relay?
6. Why are differential relays more sensitive than over current relays?
7. Sketch a typical time Vs PSM curve.
8. What do you understand by differential relay?
9. What are the different types of differential relay?
10. How do you classify relays based on their time of operation?
11. How do you classify relays based on their operating principle?
12. How do you classify relays based on their application?
13. List out some important types of electromagnetic attraction relays.
14. What are the various steps to be followed for calculating the actual relay operating time?
15. How do you classify relays based on their application?
16. What is a fuse? What are its advantages and disadvantages?
17. Why do we prefer silver as a fuse element?
18. Define the following terms as applied to fuse.
    Fusing current, Cut-off current, Operating Time, Breaking capacity, Fusing factor, Current rating of fuse element, Prospective current, Pre-arcing time, Arcing time
19. What is the difference between a fuse and a circuit breaker?
20. Why are circuit breakers preferred to fuses?
21. Why fuses cannot provide adequate discrimination on heavy short circuit?
22. Why fuses can interrupt heavy short circuit currents successfully?
23. On what factors fusing current of fuse element depends?
24. What are commonly used materials for manufacturing fuse elements?
25. What are desirable characteristics of fuse elements?
26. What is fuse law?
27. What do you understand by fuse constant? What are typical values of fuse constant for different fuse elements?
28. How do you classify fuses?
29. What are the protection schemes available for induction motor?
30. What are causes of over currents in an Induction motor?
31. How to protect Induction motor against over currents?
32. What do you understand by "single phasing'' of an Induction motor?

Course Plan 2019-20 Odd / Semester 7th
Electrical and Electronics Engineering

36. What are the advantageous of micro-processor based relays over electro-mechanical relays?
37. What is the definition of high voltage?
38. What are the different types of voltages occurring in high voltage practice?
39. What is the usual classification of voltages used in A.C. transmission?
40. What are the materials used for high voltage equipment and transmission lines?
41. For what purposes are materials used in H.V. work?
42. What are the usual materials for conductors used in high voltage equipment and transmission lines/
43. What are the salient characteristics of metals to consider for use in high voltage work?
44. How are insulating materials used in H.V. work classified?
45. What are the most important types of solid insulation?
46. What are the physical and electrical properties of important solid insulations suitable for high voltage work?
47. Define the following terms as applied to solid insulation
    1) Dielectric strength 2) Loss angle 3) Dielectric constant.
48. What are most usual insulating materials used in high voltage equipment?
49. What are the salient properties of liquid insulating materials?
50. What are the most usual gaseous insulating media used in high voltage equipment?
51. What are the physical and electrical properties of important gaseous insulating media?
52. What are the important properties of vacuum as insulation?
53. What is meant by Electrical Breakdown?
54. What are the units for measurement of the breakdown strength of insulating materials?
55. What is meant by the withstand strength of an insulations?
56. What are the breakdown voltage values of some important insulating materials?
57. What are the shapes of electrodes in common use in high voltage equipment?
58. What are the major factors causing electrical breakdown of solid insulation?
59. What is the mechanism of electrical breakdown of a solid insulating material such as paper?
60. What are the mechanisms for breakdown of liquid dielectrics?
61. What is the principal mechanism for breakdown of a gaseous insulation?
62. What is the formula for spark over voltage for an air gap in uniform field?
63. What is meant by Corona in non-uniform field gaps?
64. What are the different types of cables used for high voltage work?
65. What is meant by Corona? How and where does it occur in high voltage equipment?
66. What are the effects of corona in high voltage equipments?
67. What is the minimum clearance prescribed by the national electrical Code or Codes for high voltage transmission lines from safety considerations?
68. What is a cascade –connected transformer and where is this used?
69. What are the standard high voltages used for A.C. transmission lines and high voltage equipment?
70. What are the types of protection required in high voltage systems?
71. What are the types of sources required to perform tests on equipment in a high voltage laboratory?
72. What is the wave shapes of voltage and current used in high voltage testing?
73. What are the major types of measurement to be carried out in a high voltage laboratory for testing equipment?
74. How does a sphere gap measure a voltage? What is the technique to be followed in using this?
75. How is a resistive voltage divider used for measuring high voltage?

Prepared by	Checked by		
		26/7	
Prof. S. D. Hirekodi	Prof. M. P. Yanagimath	HOD	Principal