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

DEPARTMENT MISSION

I. To educate students with core knowledge of Electrical and Electronics Engineering to excel in their professional career.

II. To develop problem solving skills, professional skills and ethical values among the students for the betterment of mankind.

III. To prepare technically competent and socially responsible Electrical Engineer to serve the future needs of the society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

Graduates of the program will be able to

PEO1: Achieve successful professional career in Electrical Engineering and allied disciplines.

PEO2: Pursue higher studies and continuously engage in upgrading the professional skills.

PEO3: Demonstrate professional & ethical values, effective communication skills and teamwork to solve issues related to profession, society and environment.

PROGRAM OUTCOMES (POs):

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 (PSOs) :

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

S N	TOPIC	PAGE NO
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8	**Course Plans , Question Bank & Assignment Questions**	
	Theory	
	21EE71-High Voltage & Power System Protection	
	21EE72-Power System Operation & Control	
	21EE731-Power System Planning	
	21EE742-Micro & Nano Scale Sensors & Transducers	
	21EC755 – E-Waste Management	

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, Academic Coordinator		
04	Project Coordinator, KSCST Coordinator, Hobby & Mini Project Coordinator, Dept. Library Coordinator	Prof. S. D. Hirekodi	-
05	Academic Coordinator	Prof. H. R. Zinage	-
06	First Year Coordinator, Dept. NBA Coordinator, Alumni Coordinator	Prof. M. P. Yenagimath	-
07	Dept. Association Coordinator	Prof. O. B. Heddurshetti	-
08	AICTE/VTU/NIRF/LIC Coordinator, AICTE Activity Coordinator, Professional Body (ISTE & IEEE) Coordinator	Prof. A. U. Neshti	-
09	IA & EMS Coordinator	Prof. K. B. Negalur	Shri. S. B. Beelur
10	News letter/Technical Magazine Coordinator, News & Publicity Coordinator, Website Coordinator, Mentorship Coordinator	Prof. S. G. Huddar	--
11	TP Cell Coordinator, IIIC Cell, Internship Coordinator, Technical Seminar Coordinator	Prof. P. I. Savadatti	--
12	Dispensary	Dr. Arun G. Bullannavar, Contact No. 9449141549	
Class Teacher			
13	3rd Semester	Prof. S. D. Hirekodi	Shri. S. B. Beelur
14	5th Semester	Prof. A. U. Neshti	Shri. V. M. Mutalik
15	7th Semester	Prof. H. R. Zinage	Shri. R. S. Bardol

2.0 Departmental Resources

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

2.1 Faculty Position

S.N.	Category	No. in position	Average experience
1	Teaching faculty	10	19 Y
2	Technical supporting staff	3	27 Y
3	Helper	2	21 Y

2.2 Major Laboratories

SL. No.	Name of the laboratory	Area in Sq. Mtrs	Amount Invested (Rs)
01	Electronics Lab	71	4,49,488.00
02	Operational Amplifier & Linear Integrated Lab		1,29,776.00
03	Power Electronics Lab	92	7,85,162.00
04	Control Systems Lab		2,14,127.00
05	Power System Simulation Lab	71	17,95,111.00
06	Computer Aided Electrical Drawing Lab		6,50,988.40
07	Microcontroller Lab / Digital Signal Processing Lab	72	5,94,122.00
09	Electrical Machines Lab	200	14,85,725.0
10	Relay & High Voltage Lab	94	11,72,383.00
11	Basic Electrical Engg. Lab	96	42,321.00
	Total	**696**	73,19,203.40

3.0 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	-	31	9343454993
02	Prof. V. B. Dhere	Asst. Prof.	M. Tech, (Ph. D)	Electronics & Telecommunication	LMISTE, IMPARC	4	27	9886597573
03	Prof. S. D. Hirekodi	Asst. Prof.	M. Tech.	Power Electronics	LMISTE	1	24	9480849338
04	Prof. H. R. Zinage	Asst. Prof.	M. Tech.	Power System	LMISTE	-	24	9480849335
05	Prof. M. P. Yenagimath	Asst. Prof.	M. Tech (Ph. D)	VLSI & ES	LMISTE	1	18.5	9341449466
06	Prof. O. B. Heddurshetti	Asst. Prof.	M. Tech.	Power Electrics	LMISTE	1	17	9448420509
07	Prof. A. U. Neshti	Asst. Prof.	M. Tech.	Digital Electronics	ISTE	-	16	9538223362
08	Prof. K. B. Neglur	Asst. Prof.	M. Tech.	Industrial Electronics	LMISTE	-	11	9886644507
09	Prof. S. G. Huddar	Asst. Prof.	M. Tech.	Power System Engg.	LMISTE	-	11	9742066852
10	Prof. P. I. Savadatti	Asst. Prof.	M. Tech.	Digital Electronics	-	-	09	9964315436

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in Electrical and Electronic Engineering
Scheme of Teaching and Examinations 2021
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021 - 22)

Swappable VII and VIII SEMESTER

VII SEMESTER

Sl. No	Course and Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board	Teaching Hours /Week				Examination				Credits
				Theory Lecture	Tutorial	Practical/ Drawing	Self -Study	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	S					
1	PCC 21EE71	High Voltage and Power System Protection	EE	2	0	2		3	50	50	100	3
2	PCC 21EE72	Power System Operation and Control	EE	1	2	0		3	50	50	100	2
3	PEC **21EE73X**	Professional elective Course-II	EE	3	0	0		3	50	50	100	3
4	PEC **21EE74X**	Professional elective Course-III	EE	3	0	0		3	50	50	100	3
5	OEC **21EE75X**	Open elective Course-II	Concerned Department	3	0	0		3	50	50	100	3
6	Project **21EE76**	Project work	EE	Two contact hours /week for interaction between the faculty and students.				3	100	100	200	10
								Total	**350**	**350**	**700**	**24**

VIII SEMESTER

Sl. No	Course and Course Code		Course Title	Teaching Department	Teaching Hours /Week				Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Self -Study	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1	Seminar 21EE81		Technical Seminar	EE	One contact hour /week for interaction between the faculty and students.				--	100	--	100	01
2	INT 21INT82		Research Internship/ Industry Internship	EE	Two contact hours /week for interaction between the faculty and students.				03 (Batch wise)	100	100	200	15
3	NCMC	21NS83	National Service Scheme (NSS)	NSS	Completed during the intervening period of III semester to VIII semester.				--	50	50	100	0
		21PE83	Physical Education (PE) (Sports and Athletics)	PE									
		21YO83	Yoga	Yoga									
									Total	**250**	**150**	**400**	**16**

Professional Elective - II

21EE731	Power System Planning	**21EE734**	Electric Vehicle Technologies
21EE732	Smart Grid	**21EE735**	PLC and SCADA
21EE733	ANN for Power Systems Applications		

Professional Elective - III

21EE741	Computer Aided Electrical Drawing	**21EE744**	Industrial Drives and Applications
21EE742	Micro- and Nano-Scale Sensors and Transducers	**21EE745**	FACTS and HVDC
21EE743	Big Data Analytics in Power Systems		

Open Electives - II offered by the Department of Electrical and Electronics Engineering to other Department students			
21EE751	Carbon Capture and Storage	**21EE754**	Electrical Power Quality
21EE752	Electric Vehicles	**21EE755**	Energy Conservation and Audit
21EE753	Disasters Management		

Note: PCC: Professional Core Course, **PEC:** Professional Elective Courses, **OEC**–Open Elective Course, **AEC** –Ability Enhancement Courses.
L –Lecture, T – Tutorial, P- Practical / Drawing, S – Self Study Component, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.

Note: VII and VIII semesters of IV year of the programme
(1) Institutions can swap VII and VIII Semester Scheme of Teaching and Examinations to accommodate research internship/ industry internship after the VI semester**.**
(2) Credits earned for the courses of VII and VIII Semester Scheme of Teaching and Examinations shall be counted against the corresponding semesters whether VII or VIII semester is completed during the beginning of IV year or later part of IV year of the programme.

PROJECT WORK (21EEP75): The objective of the Project work is
(i) To encourage independent learning and the innovative attitude of the students.
(ii) To develop interactive attitude, communication skills, organization, time management, and presentation skills.
(iii) To impart flexibility and adaptability.
(iv) To inspire team working.
(v) To expand intellectual capacity, credibility, judgment and intuition.
(vi) To adhere to punctuality, setting and meeting deadlines.
(vii) To instill responsibilities to oneself and others.
(viii) To train students to present the topic of project work in a seminar without any fear, face the audience confidently, enhance communication skills, involve in group discussion to present and exchange ideas.

CIE procedure for Project Work:
(1) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.
The CIE marks awarded for the project work, shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.
(2) Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable. The CIE marks awarded for the project work, shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.
SEE procedure for Project Work: SEE for project work will be conducted by the two examiners appointed by the University. The SEE marks awarded for the project work, shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the ratio 50:25:25.

TECHNICAL SEMINAR (21EES81): The objective of the seminar is to inculcate self-learning, present the seminar topic confidently, enhance communication skill, involve in group discussion for exchange of ideas. Each student, under the guidance of a Faculty, shall choose, preferably, a recent topic of his/her interest relevant to the programme of Specialization.
(i) Carry out literature survey, systematically organize the content.
(ii) Prepare the report with own sentences, avoiding a cut and paste act.
(iii) Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
(iv) Present the seminar topic orally and/or through PowerPoint slides.
(v) Answer the queries and involve in debate/discussion.
(**vi)** Submit a typed report with a list of references.
The participants shall take part in the discussion to foster a friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.
Evaluation Procedure:
The CIE marks for the seminar shall be awarded (based on the relevance of the topic, presentation skill, participation in the question and answer session, and quality of report) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three teachers from the department with the senior-most acting as the Chairman.
Marks distribution for CIE of the course:
Seminar Report:50 marks
Presentation skill:25 marks
Question and Answer: 25 marks.■ No SEE component for Technical Seminar

Non – credit mandatory courses (NCMC):
National Service Scheme/Physical Education (Sport and Athletics)/ Yoga:
(1) Securing 40 % or more in CIE,35 % or more marks in SEE and 40 % or more in the sum total of CIE + SEE leads to successful completion of the registered course.
(2) In case, students fail to secure 35 % marks in SEE, they has to appear for SEE during the subsequent examinations conducted by the University.
(3) In case, any student fails to register for NSS, PE or Yoga/fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have not completed the requirements of the course. In such a case, the student has to fulfill the course requirements during subsequently to earn the qualifying CIE marks subject to the maximum programme period.
(4) Successful completion of the course shall be indicated as satisfactory in the grade card. Non-completion of the course shall be indicated as Unsatisfactory.
(5) These course shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the courses shall be mandatory for the award of degree.

Subject Title	**HIGH VOLTAGE AND POWERSYSTEMPROTECTION**		
Subject Code	**21EE71**	**CIE Marks**	50
Number of Lecture Hrs/Week	3:0:0	**SEE Marks**	50
Credits	03	**Exam Hours**	03

FACULTYDETAILS:		
Name: Prof. Amit U. Neshti	**Designation:** Asst.Professor	**Experience:**16Years
No. of times course taught: 01		**Specialization:** Digital Electronics

1.0 PrerequisiteSubjects:

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

2.0 Course Objectives

The subject aims to provide the student with:

1. To discuss conduction and breakdown in gaseous, liquid and solid dielectrics.
2. To discuss generation and measurement of high voltages and currents.
3. To discuss non-destructive testing of insulating materials and electrical apparatus.
4. To discuss the construction, operating principles and performance characteristics of protective devices.
5. To discuss the different protection schemes used in power system apparatus.
6. To discuss protection against overvoltages, insulation coordination in electric power systems and Gas Insulated Substation (GIS).

3.0 Course Outcomes

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

	Course Outcome	RBT Level	POs
C401.1	Apply the knowledge of dielectric property for insulation, it's performances as per Standards and High voltage application in power system Equipment's.	L3	1,2,3,6,8,12
C401.2	Analyze the circuits of high voltages, high currents in Generation and Measurements.	L3	1,2,3,6,8,12
C401.3	Apply relays to the power system protection and discuss overcurrent protection.	L3	1,2,3,6,8,12
C401.4	Discuss protection of generators, motors, Transformer and Bus Zone Protection, distance and differential protection , pilot relaying schemes.	L3	1,2,3,6,8,12
C401.5	Discuss the construction, operating principles and performances of circuit breaker and describe the causes of over voltages and their remedial measures.	L3	1,2,3,6,8,12

4.0 Course Content

MODULE-1

Introduction to high voltage engineering: Advantages, Limitations and applications.
Conduction and Breakdown in Gases: Introduction, Ionization Processes, Townsend's Current Growth Equation and it's Criterion 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: Introduction, Conduction and Breakdown in Liquid Dielectrics
Breakdown in Solid Dielectrics: Introduction, Different types of break studies in Solid Dielectrics.

MODULE-2

Generation of High Voltages and Currents: Generation of High Direct Current Voltages, High Alternating Voltages, Impulse Voltages and Impulse Currents.
Measurement of High Voltages and Currents: Measurement of High Direct Current Voltages, High AC and Impulse Voltages, High Currents of Direct, Alternating and Impulse.
Non-Destructive Testing of Materials and Electrical Apparatus: Introduction, Measurement of Dielectric Constant and Loss Factor, Partial Discharge Measurements.

MODULE-3

Introduction to Power System Protection: Need for protective schemes, Types of Fault and it's Effects, Essential Qualities of Protection, Primary and Backup 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, Directional Relay, Protection of Parallel Feeders and Ring Mains, Earth Fault, Phase Fault Protection and Combined Earth and Phase Fault Protective Scheme, Static Overcurrent Relays, Numerical Overcurrent Relays.

MODULE-4

Distance Protection: Introduction, Impedance Relay, Reactance Relay, Mho Relay, Effect of Power Surges, Line Length and Source Impedance on Performance of Distance Relays.
Pilot Relaying Schemes: Introduction, Wire Pilot Protection, Carrier Current Protection.
Differential Protection: Introduction, Differential Relays, Percentage Differential Relay, Balanced Voltage Differential Protection.
Protection of Generators, Transformer and Bus zone Protection: Introduction, Protection of Generators. Transformer Protection, Buszone Protection.

MODULE-5

Circuit Breakers: Introduction, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Current Chopping. Air Circuit Breakers, SF6 Circuit Breakers, Vacuum Circuit Breakers, Rating of Circuit Breakers, Testing of Circuit Breakers.
Protection against Overvoltages: Causes of Overvoltages, Lightning phenomena, Klydonograph and Magnetic Link, Protection of power stations and Sub–Stations, Insulation Coordination.

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Use of protection schemes against faults in final year projects.
02	VII	Power System Operation and Control	Use of relays and circuit breakers in power system.

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 realize use of protective devices.
02	NPTEL	Working of restricted earth fault relay & pole discrepancy relay.
03	Mipower tool	Simulation of relay coordination

8.0 Books Used and Recommended to Students

Text Books

1. High Voltage Engineering, M.S.Naidu and Kamaraju- 5th Edition, THM, 2013
2. Power System Protection and Switchgear Badri Ram, D.N. Vishwakarma McGraw Hill 2nd Edition

Reference Books

1. High Voltage Engineering Fundamentals, E.Kuffel and W.S. Zaengl, 2nd Edition, Elsevier Press, 2000.
2. High Voltage Engineering, C.L.Wadhwa, New Age International Private limited, 3rd Edition, 2012.
3. Protection and Switchgear, Bhavesh et al, Oxford, 1st Edition, 2011.
4. Power System Switchgear and Protection, N. Veerappan, S.R. Krishnamurthy, S. Chand, 1st Edition, 2009

Additional Study material & e-Books

1. "Switchgear & Protection", by U. A. Bakshi & M. V. bakshi.
2. Electrical power system by Subir ray PHI publication

9.0 Relevant Websites(ReputedUniversitiesandOthers)forNotes/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

Assessment Details (both CIE and SEE)
The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:
Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**
(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:
Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

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12.0 Course Delivery Plan

Module No	Lecture No.	Content of Lecture	% of Portion
1	1	**Introduction to high voltage engineering:** Advantages, Limitations and applications.	20%
	2	**Conduction and Breakdown in Gases:** Introduction, Ionization Processes and collision process	
	3	Townsend's Current Growth Equation and it's Criterion for Breakdown	
	4	Breakdown in electronegative gases and time lag and problems	
	5	Streamer Theory of Breakdown in Gases, Paschen's Law Breakdown in Non-Uniform Fields and Corona Discharges.	
	6	**Conduction and Breakdown in Liquid Dielectrics:** Introduction, Conduction and Breakdown in pure Liquid Dielectrics	
	7	Conduction and Breakdown in commercial Liquid Dielectrics	
	8	**Breakdown in Solid Dielectrics:** Introduction, Different types of break studies in Solid Dielectrics	

2	9	**Generation of High Voltages and Currents:** Generation of High Direct Current Voltages	20%
	10	Generation of High Direct Current Voltages	
	11	Generation of High Alternating Voltages	
	12	Generation of Impulse Voltages.	
	13	Generation of Impulse Currents and problems.	
	14	**Measurement of High Voltages and Currents:** Measurement of High Direct Current Voltages, High AC and Impulse Voltages(2)	
	15	Measurement of High Currents of Direct, Alternating and Impulse(1)	
	16	**Non-Destructive Testing of Materials and Electrical Apparatus**: Introduction, Measurement of Dielectric Constant and Loss Factor, Partial Discharge Measurements.(2)	
3	17	**Introduction to Power System Protection:** Need for protective schemes, Types of Fault and it's Effects, Essential Qualities of Protection,Primary and Backup Protection	20%
	18	**Relay Construction and Operating Principles**: Introduction, Electromechanical Relays	
	19	Electromechanical Relays	
	20	Static Relays – Merits and Demerits of Static Relays, Numerical Relays, Comparison between Electromechanical Relays and Numerical Relays.	
	21	Overcurrent Protection: Introduction, Time–current Characteristics, Current Setting	
	22	Time Setting, schemes and problem	
	23	Directional Relay, Protection of Parallel Feeders and Ring Mains, Earth Fault	
	24	Phase Fault Protection and Combined Earth and Phase Fault Protective Scheme, Static Overcurrent Relays, Numerical Overcurrent Relays	
4	25	**Distance Protection:** Introduction, Impedance Relay, Reactance Relay	20%
	26	Mho Relay, Effect of Power Surges, Line Length and Source Impedance on Performance of Distance Relays.	
	27	**Pilot Relaying Schemes:** Introduction, Wire Pilot Protection	
	28	Carrier Current Protection	
	29	**Differential Protection:** Introduction, Differential Relays	
	30	Percentage Differential Relay, Balanced Voltage Differential Protection.	
	31	**Protection of Generators, Transformer and Bus zone Protection:** Introduction, Protection of Generators.	
	32	**Transformer Protection, Buszone Protection**	
5	33	**Circuit Breakers:** Introduction, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage	20%
	34	Current Chopping.,	
	35	Air Circuit Breakers	
	36	SF6 Circuit Breakers	
	37	Vacuum Circuit Breakers, Rating of Circuit Breakers,	
	38	Testing of Circuit Breakers.	
	39	Protection against Overvoltages: Causes of Overvoltages, Lightning phenomena, Klydonograph and Magnetic Link,	
	40	Protection of power stations and Sub–Stations, Insulation Coordination	

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	Assignment1	Students study the Topics and write the Answers. Get Practice to solve university questions.	Module 1 to 2 of syllabus	4	Individual Activity. Written solution is expected.	Book1 of the text list.
2	Assignment 2	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 3 to 4 of syllabus	9	Individual Activity. Written solution is expected.	Book2 of the text list.
3	Quiz:	Students study the Topics and write the Answers. Get practice to solve university questions.	All Module of the syllabus	13	Individual Activity. Written solution is expected.	Book1 and 2 of the text list.

14.0 QUESTIONBANK

ModuleNo.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.

ModuleNo.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. loadWhy 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.

ModuleNo.3

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?
7. With a neat diagram, explain zones of protection in a power system.
8. Explain the various methods of backup protection.
9. Briefly explain essential qualities of protective relay.
10. Draw the schematic diagram of Numerical relay and briefly describe its various components.
11. Explain over current protective schemes?
12. With neat sketch explain the operation of Directional relay?
13. Explain the protection of parallel feeders & Ring mains?
14. Explain earth fault and phase fault protection?
15. Explain the operation of static over current relay.

ModuleNo.4

1. With neat sketch explain the operation of impedance relay?
2. With neat sketch explain the operation of reactance relay & Mhorelay?
3. Explain the effect of arc resistance on the performance of Distance relays?
4. Explain the effect of power surges on performance of Distance relays?
5. Mention effect of source impedance & line length on performance of distance relays?
6. With neat sketch, explain Directional over current relay.
7. With a neat circuit diagram, explain Directional overcurrent relay.
8. Explain carrier current protection?
9. With neat sketch explain the operation of differential relay?
10. With neat diagram explain the operation of percentage or biased differential relay?

11. Explain differential protection of 3 phase circuits?
12. Explain the operation of balanced voltage differential protection?
13. Explain the protection of Generators?
14. Explain transformer protection?
15. Explain bus zone protection?
16. Explain the term Pilot with reference to powerline protection.
17. Describe the balanced (opposed)voltage differential protection scheme.
18. With a neat diagram. Explain the working of Buchholz relay.

ModuleNo.5

1. Explain arc interruption in circuit breaker?
2. Define re striking & recovery voltage?
3. With neat sketch explain interruption of capacitive current?
4. Explain the ratings of circuit breaker?
5. Explain various methods of testing of circuit breakers?
6. Explain how interruption of capacitive current takes place in AC circuit breaker.
7. With a neat sketch, explain the construction and working of Non-Puffer type of SF6 Circuit breaker.
8. With the help of Schematic diagram, explain the working of short circuit test plant.
9. Explain the procedure for selection of fuses and define discrimination?
10. Mention the causes of over voltages?
11. Explain the lightning phenomena?
12. Explain the protection of transmission lines against direct lightning strokes?
13. Explain the protection of substations from direct strokes?
14. Explain the basic Impulse insulation level?
15. Explain about Gas insulated substation?
16. Define the fusing factor and Fuse.
17. With a neat sketch, explain the working of Klydonograph.
18. What are the various components of a GIS? Briefly describe the ir functions.

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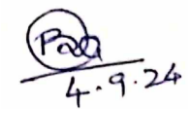
			
Prof. A U Neshti	**Prof. H. R. Zinage**	**HOD**	**Principal**

Subject Title	**POWER SYSTEM OPERATION &CONTROL**		
Subject Code	21EE72	**CIE Marks**	50
Number of Lecture Hrs / Week	03	**SSE Marks**	50
Total Number of Lecture Hrs	40	**Exam Hours**	03
			CREDITS-2

FACULTY DETAILS:		
Name: Prof. Hemalata R Zinage	**Designation:** Asst. Professor	**Experience:**24
No. of times course taught:12	**Specialization:** Power system	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical &Electronics Engineering	V	Power system analysis -I
02	Electrical &Electronics Engineering	VI	Power system analysis -II

2.0 Course Objectives

1 To describe various levels of controls in power systems and the vulnerability of the system.
2 To explain components, architecture and configuration of SCADA.
3 To explain basic generator control loops, functions of Automatic generation control, speed governors and mathematical models of Automatic Load Frequency Control
4 To explain automatic generation control, voltage and reactive power control in an interconnected power system.
5 To explain reliability and contingency analysis, state estimation and related issues

3.0 Course Outcomes

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

	Course Outcome	**Cognitive Level**	**POs**
402.1	Describe various levels of controls in power systems, architecture and configuration of SCADA	L3	1,2,3,4,5,8,9,10, 12
402.2	Develop and analyze mathematical models of Automatic Load Frequency Control.	L3,l4	1,2,3,4,5,8,9,10. 12
402.3	Develop mathematical model of Automatic Generation Control in Interconnected Power system	L3,L4	1,2,3,4,5,8,9,10, 12
402.4	Discuss the Control of Voltage , Reactive Power and Voltage collapse	L3,L4	1,2,3,4,5,8,9,10, 12
402.5	Explain security, contingency analysis, state estimation of power systems	L3,L4	1,2,3,4,5,8,9,10, 12
Total Hours of instruction		**40**	

4.0 Course Content

Module-1

Introduction: Operating States of Power System, Objectives of Control, Key Concepts of Reliable Operation, Preventive and Emergency Controls, Energy Management Centers.

Supervisory Control and Data acquisition (SCADA): Introduction, components, application in Power System, basic functions and advantages. Building blocks of SCADA system, components of RTU, communication subsystem, IED functional block diagram. R2

Classification of SCADA system: Single master–single remote; Single master–multiple RTU; Multiple master–multiple RTUs; and Single master, multiple submaster, multiple remote. R2

Module-2
Automatic Generation Control (AGC): Introduction, Schematic diagram of load frequency and excitation voltage regulators of turbo generators, Load frequency control (Single area case), Turbine speed governing system, Model of speed governing system, Turbine model, Generator load model, Complete block diagram of representation of load frequency control of an isolated power system, Steady state analysis, Control area concept, Proportional plus Integral Controller. T1
Module-3
Automatic Generation Control in Interconnected Power system: Two area load frequency control, Optimal (Two area) load frequency control by state variable, Automatic voltage control, Load frequency control with generation rate constraints (GRCs), Speed governor dead band and its effect on AGC, Digital LF Controllers, Decentralized control. T1
Module-4
Control of Voltage and Reactive Power: Introduction, Generation and absorption of reactive power, Relation between voltage, power and reactive power at a node, Methods of voltage control: i) Injection of reactive power, Shunt capacitors and reactors, Series capacitors, Synchronous compensators, Series injection. ii) Tap changing transformers. Combined use of tap changing transformers and reactive power injection, Booster transformers, Phase shift transformers, Voltage collapse. T3
Module-5
Power System Security: Introduction, Factors affecting power system security, Contingency Analysis, Linear Sensitivity Factors, AC power flow methods, Contingency Selection and Ranking. T2
State estimation of Power Systems: Introduction, Linear Least Square Estimation T2

5.0 Relevance to future subjects

SL No	Semester	Subject	Topics
01	VIII	Project work	SCADA, Automatic Generation Control, Voltage and Reactive Power Control, Power System Reliability and Security

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Model creation for analysis
02	Development of a software applications

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Visit to power plant	Operation of energy control center, SCADA system

8.0 Books Used and Recommended to Students

Text Books
1. Power System Operation and Control,K.Uma Rao,Wiley ,1st edition,2012
2. Modern Power System Analysis, D. P. Kothari, McGraw Hill, 4 th Edition, 2011
3. Power Generation Operation and Control, Allen J Wood etal, Wiley, 2nd Edition, 2003
4. Electric Power Systems, B M Weedy, B J Cory, Wiley, 4 th Edition, 2012
Reference Books
1. Computer-Aided Power System Analysis, G. L. Kusic, CRC Press, 2nd Edition, 2010 2. Power System SCADA and Smart Grid, Mini S Thom and John D. McDonald, CRC Press, 2015 3. Power System Stability and Control, Kundur, McGraw Hill, 8 th Reprint, 2009
Additional Study material & e-Books
1. Research Papers on Power System Operation and Control published in Journals

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

Website and Internet Contents References
1) *nptel.ac.in/courses/108104052*
2) *freevideolectures.com › Electrical Engineering › IIT Kanpur*
3) *nptel.iitg.ernet.in*

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	IEEE Explore	***ieeexplore.ieee.org/xpl/RecentIssue***
2	Journalof Modern *Power Systems* and Clean Energy	***www.springer.com***

11.0 Examination Note

SCHEME OF EVALUATION FOR CIE (50 MARKS)

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of 10 Marks

1. First assignment at the end of 4th week of the semester
2. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

3. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methodsof the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per theoutcome defined for the course.

SCHEME OF EXAMINATION: 100 Marks, scaled down to 50 in VTU result sheet.

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers forthe subject (**duration 03 hours)**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of3 sub-questions), **should have a mix of topics** under that module.

The students 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
	1.	**Introduction:** Operating States of Power System, Objectives of Control,	**20**
	2.	Key Concepts of Reliable Operation Preventive and Emergency Controls, Energy Management Centers	

I	3.	**Supervisory Control and Data acquisition (SCADA):** Introduction, components, application in Power System,	
	4.	Basic functions and advantages. Building blocks of SCADA system, components of RTU,	
	5.	Communication subsystem, IED functional block diagram. R2 Single master–multiple RTU;	
	6.	**Classification of SCADA system:** Single master–single remote;	
	7.	Multiple master–multiple RTUs	
	8.	Single master, multiple sub master, multiple remote. R2	
II	9.	**Automatic Generation Control (AGC):** Introduction, Schematic diagram of load frequency	**20**
	10.	Excitation voltage regulators of turbo generators,	
	11.	Load frequency control (Single area case),	
	12.	Turbine speed governing system,	
	13.	Model of speed governing system, Turbine model, Generator load model,	
	14.	Complete block diagram of representation of load frequency control of an isolated power system,	
	15.	Steady state analysis, Control area concept,	
	16.	Proportional plus Integral Controller. T1	
III	17.	**Automatic Generation Control in Interconnected Power system**:	**20**
	18.	Two area load frequency control,	
	19.	Optimal (Two area) load frequency control by state variable,	
	20.	Automatic voltage control,	
	21.	Load frequency control with generation rate constraints (GRCs),	
	22.	Speed governor dead band and its effect on AGC,	
	23.	Digital LF Controllers,	
	24.	Decentralized control. T1	
IV	25.	**Control of Voltage and Reactive Power:** Introduction, Generation Absorption of reactive power, Relation between voltage, power and reactive power at a node,	**20**
	26.	Methods of voltage control: i) Injection of reactive power,	
	27.	Shunt capacitors and reactors, Series capacitors	
	28.	Synchronous compensators, Series injection.	
	29.	ii) Tap changing transformers.	
	30.	Combined use of tap changing transformers and	
	31.	Reactive power injection,	
	32.	Booster transformers, Phase shift transformers, Voltage collapse. T3	
V	33.	**Power System Security:** Introduction,	**20**
	34.	Factors affecting power system security,	
	35.	Contingency Analysis,	
	36.	Linear Sensitivity Factors,	
	37.	AC power flow methods	
	38.	Contingency Selection and Ranking. T2	
	39.	**State estimation of Power Systems:** Introduction,	
	40.	Linear Least Square Estimation T2	

3.0 Assignments

Sl. No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: University Questions on Supervisory Control and Data acquisition &Unit Commitment	Students study the Topics and write the Answers. Get practice to solve university questions.	module 1&2 of the syllabus	4	Individual Activity.	Book 1, 2 of the reference list. Website of the Reference list
2	Assignment 2: University Questions on Hydro-thermal Scheduling	Students study the Topics and write the Answers. Get practice to solve university questions.	Module3,4 &5 of the syllabus	10	Individual Activity.	Book 1 ,2of the Text book list. Website of the Reference list

14.0 QUESTION BANK

MODULE -1 Introduction to Power System Operation and Control

[1] Explain the Operating states of power system.
[2] Discuss the preventive and emergency controls of power system.
[3] Explain the operation of energy management system.
[4] Explain the SCADA system and its components.
[5] What are the common communication channels for SCADA?
[6] Discuss the challenges for implementation of SCADA.

MODULE-2 Automatic Generation control

[1] Why automatic generation & voltage control is required? Explain.
[2] Explain the objectives and functions of Automatic Generation Control (AGC) in a Power System
[3] Explain the complete block diagram representation of load frequency control of an isolated power system.
[4] Explain how mathematical model of speed governing system is developed for automatic generation control

MODULE-3 Automatic Generation Control in interconnected Power System

[1] Explain the steady state analysis of load frequency control of an isolated system & hence draw the characteristic.
[2] Explain the dynamic state analysis of load frequency control of an isolated power system & hence draw the characteristic.
[3] Show that active power generation is proportional to power command $\Delta P_{c.}$
[4] What is area control error? Explain the advantages of pool operation.
[5] Explain how we can bring frequency deviation will be zero under steady state condition.
[6] With the help of neat block diagram explain the execution of economic dispatch using area control error (ACE) and base load deviation (BLD)
[7] Explain the parallel operation of alternators.
[8] A 100 MVA synchronous generator operates on full load at frequency of 50 Hz. The load is suddenly reduced to 50MW. Due to time lag in governor system, the steam valve begins to close after 04 seconds. Determine the change in frequency that occurs in this time. Given H= 5Kw-sec/KVA of generator capacity.
[9] Explain with the help of block diagram, the automatic load frequency and voltage regulator loops of a synchronous generator.
[10] Describe the function of AVR with a neat block diagram.
[11] With a neat diagram, explain the brushless AVR loop.
[12] Obtain the brushless excitation modeling & explain the static performance of the brush-less AVR Loop.

[13] Two generators are supplying power to a system, their rating is 50 MW & 500 MW respectively, frequency is 50 Hz and each generator is half loaded. The system load increases by 110 MW and as a result the frequency drops to 49.5 Hz. What must be the individual regulation if the two generators should increase their power in proportion to their rating? (Assuming governor free action and constant B is negligible)

[14] Two generating units rated 200MW and 400MW are operating in parallel. The droop characteristics of their governors are 4% and 5% respectively from no load to full load. Assuming that the generators are operating at 50Hz at no load, how would a load of 600MW is shared between them? What will be the system frequency at this load? Assume free governor operation. Repeat the problem if both governors have a droop of 4%.

[15] Two synchronous generators operate in parallel and supply a total load of 200MW. The capacities of the machines are 100MW and 200MW and both have governor droop characteristics of 4% from no load to full load. Calculate the load taken by each machine assuming free governor action.

[16] Two synchronous generators operate in parallel and supply a total load of 400MW. The capacities of the machines are 200MW and 500MW and both have governor droop characteristics of 4% from no load to full load. Calculate the load taken by each machine, assuming free governor action. Also find system frequency at this load.

[17] Two identical 60MW synchronous generators operate in parallel. The governor settings on the machines are such that they have 4% and 3% droops (no load to full load % speed drop).Determine
(a) The load taken by each generator (machine) for a total load of 100MW.
(b) The % adjustment in the no load speed to be made by the speeder motor if the machines are to share the load equally. Assume frequency as 60Hz.

[18] For an isolated single area, consider the following data,
Area capacity, Pr =1000MW
Nominal operating load = P^0_D =500MW
Inertia constant, H= 5Kw-sec/KVA
Regulation = R = 5%
Nominal frequency=f^0 = 50 Hz
Load decreased by 1% for a decrease in frequency by 1%
Find the gain and time constant of power system tube represented with a first order transfer function.
Corresponding to a change of load by 50MW, what would be the change in frequency for the system if it is uncontrolled one?

[19] For the single area control system shown in Fig.1, we have following data:
T_p = 10 seconds, T_g= T_t=0, Kp= 100Hz/pu.Mw, D = 3Hz/pu.Mw, ΔP_D = 0.1puMw, K_i = 0.1
Compute the time error caused by a step disturbance of magnitude given above. Prove that the error is reduced by increasing the given K_i. Express the error in seconds and cycle if the system frequency is 50 Hz

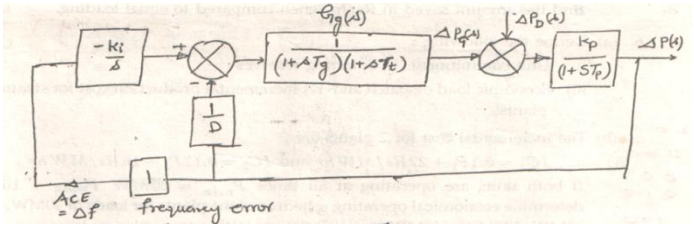


Fig.1

MODULE-4

[5] Describe the various factors affecting the voltage stability and voltage collapse.

[6] What is voltage instability? Explain the phenomenon of voltage collapse with relevant PV and QV diagrams.

[7] What is voltage collapse? Explain with PV and QV characteristics of loads

[8] Explain how the voltage control is achieved by injection of reactive power at nodes
[9] Explain the following methods of the voltage control in a power system:
(i) Injection of capacitive or inductive reactive power.(ii) By tap changing of transformers
[10]. Explain different methods of voltage control.
[11] Describe the control characteristics of an SVC.
[12 Show that the power flow between two nodes is determined by the transmission angle and the flow of reactive power is determined by the scalar voltage difference between the two nodes
[13] A single line diagram for a typical 3 supply points A, B, & C is shown in Fig.1. Determine the reactive power compensation required to inject at point 'M' to reestablish original value when the voltage at 'M' falls by 6 kV (Assume 500 MVA Base and Neglect resistances)

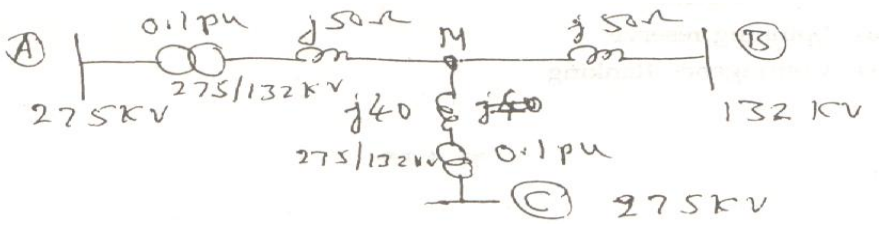


Fig.3

[14] Mention and explain in detail about generators of reactive power and absorbers of reactive power.
[15] In view of reactive power generation and absorption, briefly explain the characteristics of synchronous generator, overhead lines and cables.

MODULE-5
[1] Define system security and explain major functions involved in the system security.
[2] Explain the importance of security assessment in the power system. What are the constraints and how these constraints differ from the normal operating constraints?
[3] Distinguish between the normal operating constraints and security constraints of a power system.
[4] What are the factors which affect the power system security?
[5] What is contingency Analysis? Explain any one method of contingency evaluation
[6] What are credible contingencies? Explain the methods of analyzing such contingencies.
[7] What is Contingency Ranking?
[8] Explain the contingency analysis with the help of flow chart.
[9] Explain the role of sensitivity factors in the contingency analysis.
[10] Explain the contingency analysis using sensitivity factors with the help of flow chart
[11] What are the actions that must be taken for correcting the generation dispatch by sensitivity method?
[12] Explain the detection of network problems.

Prepared& Checked by		
2/9/24	4.9.24	
Prof. Hemalata R Zinage	**HOD**	**Principal**

Subject Title	**POWER SYSTEM PLANNING**		
Subject Code	21EE731	**CIE Marks**	50
Number of Lecture Hrs / Week	03	**SEE Marks**	50
Total Number of Lecture Hrs	40	**Exam Hours**	03
			CREDITS – 03

FACULTY DETAILS:		
Name: Prof: Sujata.G.Huddar	**Designation:** Asst. Professor	**Experience: 10** Years
No. of times course taught: 01	**Specialization:** Power system Engineering	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical and Electronics Engg	III	EPG
02	Electrical and Electronics Engg	V	TD

2.0 Course Objectives:

After the completion of course, the students will be able to

- To discuss primary components of power system planning namely load furcating, evaluation of energy resources, provisions of electricity Act and Energy Conservation Act.
- To explain planning methodology for optimum power system expansion, various types of generation, transmission and distribution.
- To explain forecasting of anticipated future load requirements of both demand and energy by deterministic and statistical techniques using forecasting tools.
- To discuss methods to mobilize resources to meet the investment requirement for the power sector.
- To perform economic appraisal to allocate the resources efficiently and take proper investment decisions
- To discuss expansion of power generation and planning for system energy in the country
- To discuss evaluation of operating states of transmission system, their associated contingencies and determination of the stability of the system for worst case conditions
- To discuss principles of distribution planning, supply rules, network development and the system studies.
- To discuss reliability criteria for generation, transmission, distribution and reliability evaluation and analysis.
- To discuss grid reliability, voltage disturbances and their remedies.
- To discuss planning and implementation of electric –utility activities designed to influence consumer uses of electricity.
- To discuss market principles and the norms framed by CERC for online trading and exchange in the interstate power market.

3.0 Course Outcomes

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

	Course Outcome	**RBT Level**	**Pos**
C403.1	Discuss primary components of power system planning, planning methodology for optimum power system expansion and load forecasting.	L3	1, 6-12
C403.2	Understand economic appraisal to allocate the resources efficiently and appreciate the investment decisions.	L3	1, 6-12
C403.3	Discuss expansion of power generation and planning for system energy in the country, evaluation of operating states of transmission system, their associated contingencies and the stability of the system.	L3	1, 6-12
C403.4	Discuss principles of distribution planning, supply rules, network development and the system studies.	L3	1, 6-12
C403.5	Discuss planning and implementation of electric –utility activities, market principles and the norms framed.	L3	1, 6-12
	Total Hours of Pedagogy	**40 hours**	

4.0 Course Content

Module-1

Power System: Planning Principles, Planning Process, Project Planning, Power Development, National and Regional Planning, Enterprise Resources Planning, Planning Tools, Power Planning Organisation, Scenario Planning.

Electricity Forecasting: Load Requirement, System Load, Electricity Forecasting, Forecasting Techniques, Forecasting Modelling, Spatial – Load Forecasting, Peak Load - Forecast, Reactive – Load Forecast, Unloading of a System.

Module-2

Power-System Economics: Financial Planning, Techno – Economic Viability, Private Participation, Financial Analysis, Economic Analysis, Transmission, Rural Electrification Investment, Total System Analysis, Credit - Risk Assessment.

Generation Expansion: Generation Capacity and Energy, Generation Mix, Clean Coal Technologies Renovation and Modernisation of Power Plants.

Module-3

Transmission Planning: Transmission Planning Criteria, Right – of – Way, Network Studies, High – Voltage Transmission, HVDC Transmission, Conductors, Sub – Stations, Power Grid, Reactive Power Planning, Energy Storage.

Module-4

Distribution: Distribution Deregulation, Planning Principles, Electricity – Supply Rules, Criteria and Standards, Sub – Transmission, Basic Network, Low Voltage Direct Current Electricity, Up gradation of Existing Lines and Sub – Stations, Network Development, System Studies, Urban Distribution, Rural Electrification.

Reliability and Quality: Reliability Models, System Reliability, Reliability and Quality Planning, Functional Zones, Generation Reliability Planning Criteria, Transmission Reliability Criteria, Distribution Reliability, Reliability Evaluation, Grid Reliability, Quality of Supply.

Module-5

Demand-Side Planning: Demand Response, Demand – Response Programmes, Demand– Response Technologies, Energy Efficiency, Energy - Economical Products, Efficient – Energy Users, Supply – Side Efficiency, Energy Audit.

Electricity Market: Market Principles, Power Pool, Independent System Operator, Distribution System Operator, Power Markets, Market Rules, Bidding, Trading, Settlement System, Merchant Power, Differential Electricity, Congestion Management, Ancillary Services, Hedging, Smart Power Market.

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Project planning

6.0 Relevance to Real World

Sl No	Real World Mapping
01	Planning in power system.
03	Development of a project cases

7.0 Gap Analysis and Mitigation

Sl No	Delivery Type	Details
01	Activity	Group discussion on a trending topic to build communication skills.

8.0 Books Used and Recommended to Students

Text Books				
1.	Electric Power System Planning	A. S. Pabla,	McGraw Hill,	2nd Edition, 2016.

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

Website and Internet Contents References
1) https://www.youtube.com/watch?v=ucjBhIOtEYA
2) https://www.youtube.com/watch?v=6lRGovZYeIk
3) youtube.com/watch=gqgKNVXLf7g
4) https://www.youtube.com/watch?v=eUi7NCsp6p4
5) https://www.teriin.org/video/demand-side-management
6) https://www.youtube.com/watch?v=RBSB4L-MqO8

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Journal of Electrical Systems	https://journal.esrgroups.org/jes/index
2	MDPI Journals	https://www.mdpi.com/journal/energies/special_issues/power_system_planning
3	International Journal on Power System Optimization	https://serialsjournals.com/index.php?route=product/product&path=52&product_id=554
4	Academia	https://www.academia.edu/18735238/Electric_Power_System_Planning_Issues_Algorithms_and_Solutions_Power_Systems

11.0 Examination Note

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be scaled down to 50 marks

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

12.0 Course Delivery Plan

Module	Lecture No.	Content of Lecturer	% of Portion
1	1.	**Power System:** Planning Principles & Planning Process	20
	2.	Project Planning, Power Development	
	3.	National and Regional Planning, Enterprise Resources Planning	
	4.	Planning Tools, Power Planning Organisation, Scenario Planning.	
	5.	**Electricity Forecasting:** Load Requirement, System Load	
	6.	Electricity Forecasting, Forecasting Techniques & Modeling,	
	7.	Spatial – Load Forecasting, Peak Load - Forecast	
	8.	Reactive – Load Forecast, Unloading of a System.	
2	9.	**Power-System Economics:** Financial Planning	20
	10.	Techno – Economic Viability, Private Participation	
	11.	Financial and Economic Analysis,	
	12.	Transmission, Rural Electrification Investment	
	13.	Total System Analysis, Credit - Risk Assessment	
	14.	**Generation Expansion:** Generation Capacity and Energy	
	15.	Generation Mix, Clean Coal Technologies,	
	16.	Renovation and Modernisation of Power Plants.	
3	17.	**Transmission Planning:** Transmission Planning Criteria	20
	18.	Right – of – Way, Network Studies	
	19.	High – Voltage Transmission	
	20.	HVDC Transmission	
	21.	Conductors, Sub – Stations	
	22.	Power Grid	
	23.	Reactive Power Planning	
	24.	Energy Storage	
4	25.	**Distribution:** Distribution Deregulation, Planning Principles	20
	26.	Electricity – Supply Rules, Criteria and Standards	
	27.	Basic Network, Low Voltage Direct Current Electricity, Up gradation of Existing Lines and Sub – Stations,	
	28.	Network Development , System Studies, Urban Distribution, Rural Electrification	
	29.	**Reliability and Quality:** Reliability Models, System Reliability	
	30.	Reliability and Quality Planning, Functional Zones	
	31.	Generation Reliability Planning Criteria, Transmission Reliability Criteria	
	32.	Distribution Reliability, Reliability Evaluation, Grid Reliability, Quality of Supply.	
5	33.	**Demand-Side Planning:** Demand Response, Demand – Response Programmes,	20
	34.	Demand– Response Technologies, Energy Efficiency	
	35.	Energy - Economical Products, Efficient – Energy Users	
	36.	Supply – Side Efficiency, Energy Audit.	
	37.	Electricity Market: Market Principles, Power Pool,	
	38.	Independent System Operator, Distribution System Operator, Power Markets,	
	39.	Market Rules, Bidding, Trading, Settlement System, Merchant Power, Differential Electricity	
	40.	Congestion Management, Ancillary Services, Hedging, Smart Power Market.	

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 management & Planning.	Students study the Topic and write the Answers. Get practice to solve university questions.	module 2 of the syllabus	2	Individual Activity. Written answers are expected.	Text book 1
2	Assignment 2: University Questions on organizing, staffing, directing & controlling.	Students study the Topic and write the Answers. Get practice to solve university questions.	module 4 of the syllabus	4	Individual Activity. Written answers are expected.	Text book 1

14.0 QUESTION BANK

MODULE 1

1. What do you mean by planning process? Mention the step-by-step procedure for planning action with block diagram.
2. With structural model explain different organizations in power system.
3. With the aid of schematic diagram, explain various strategies of load management.
4. Explain different demand forecasting techniques used in power system planning.
5. With the help of a flow chart, explain the least cost utility planning.
6. What is national and regional planning? Discuss the advantages and disadvantages.
7. Explain the need and importance of load forecasting in power system. Mention the different techniques of load forecasting.
8. Explain enterprise resource planning with the module diagram.
9. Write a short note on i) Reactive load forecast ii) Peak load forecast

MODULE 2

1. With the block diagram explain private participation with respect to ownership options and modes of participation in power system planning.
2. Mention national tariff policies and explain two types of basic tariffs.
3. What is generation mix? Explain the importance of pumped storage system.
4. Explain clean coal technologies used in coal based plants.
5. Write a note on private participation in power sector.
6. Explain the generation mix, with the help of relevant graphs.
7. Explain the pricing structure with respect to rational tariffs.
8. Explain the conventional generation resources in brief.
9. Explain renovation and modernization of power plants.
10. Write a short note on i) Rural electrification Investment ii) Credit Risk Assessment
11. Explain the broad options available with respect to power sector finance.
12. Explain the concepts of clean coal technologies.

MODULE 3

1. Describe the criteria for transmission planning in power system.
2. What is distributed generation and explain with figure biomass gasification
3. What are the reasons and advantages favoring HVDC transmission lines?
4. Mention and explain different conductors used in transmission system.
5. Explain the distributed power generation with the special reference to its advantages over integrated (centralized) power generation.
6. Explain the sub-station development with respect to transmission.
7. Enumerate the technical and economic aspects considered for substation development. Brief about various substation bus bar schemes.

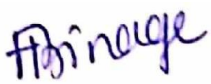
8. Illustrate the advantages and disadvantages of HVDC transmission system. Also mention few applications of HVDC transmission system.
9. Explain the planning criteria for reactive power compensation.

MODULE 4

1. What are the different basic distribution systems used by utilities and explain radial and loop systems with figure.
2. What are the national rural electrification policies and main components of rural electrification?
3. Explain criteria for generation reliability.
4. With flow diagram explain total system reliability cost analysis.
5. Explain the distribution planning principles.
6. Define system reliability and explain reliability planning criteria.
7. Write a short note on self generation.
8. Briefly explain the different electricity supply rules.
9. Explain the benefits of deregulation.
10. Mention the adequacy indices in Distribution system reliability evaluation.
11. Explain the need for power system studies.
12. Illustrate the concept of reliability by citing a suitable reliability model.

MODULE 5

1. With block diagram, explain energy- efficient programmes.
2. What is demand response? Explain demand response planning with block diagram.
3. What are the principles for the electricity market?
4. Name different types of power markets.
5. Explain the demand response technologies with reference to demand side management.
6. Write a short note on energy audit.
7. What is differential electricity? Explain.
8. Explain the smart power market.
9. Enumerate the demand response programmes.
10. Enumerate the principles of electricity market.
11. Write a short note on i) Smart power market ii) Power pool.

Prepared by	Checked by		
			
Prof.S.G.Huddar	Prof. H.R.Zinage	**HOD**	**Principal**

Subject Title	**MICRO- AND NANO-SCALE SENSORS AND TRANSDUCERS**		
Subject Code	21EE742	**CIE Marks**	50
Number of Lecture Hrs / Week	03	**SEE Marks**	50
Total Number of Lecture Hrs	40	**Exam Hours**	03
CREDITS – 03			

FACULTY DETAILS:		
Name: Prof. P .I .Savadatti	**Designation:** Asst. Professor	**Experience:**09
No. of times course taught:01		**Specialization:** Digital Electronics

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical & Electronics Engg.	III	Electrical and Electronics Measurement
02	Electrical & Electronics Engg.	I/II	Basic Electrical Engineering

2.0 Course Objectives

- To explain measurement of pressure using sensors based nanotechnology, their structure, theory of operation.
- To explain structure, theory of operation of sensors based on nanotechnology for Motion, acceleration, measurement, gas and smoke detection.
- To explain sensors based on nanotechnology for the measurement of atmospheric moisture and moisture inside the electronic components.
- To explain Optoelectronic and Photonic Sensors used in optical microphones, fingerprint readers, and highly sensitive seismic sensors.
- To explain the structure, operation of Biological Sensors, Chemical Sensors, and the so-called "Lab-on-a-Chip" sensors used in multipurpose biological and chemical analysis devices and Electric, Magnetic, and RF/Microwave, Integrated Sensor/Actuator Units and Special Purpose Sensors driven by nanotechnology.

3.0 Course Outcomes

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

	Course Outcome	RBT Level	POs
C409.1	Explain the structure, theory of pressure sensors based on nanotechnology.	L2	PO1,PO2,PO3,PO6 PO7,PO8,PO12
C409.2	Describe structure, theory and operation of sensors based on nanotechnology for Motion, acceleration measurement, gas and smoke detection.	L3	PO1,PO2,PO3,PO6, PO7,PO8,PO12
C409.3	Discuss structure, working of moisture sensors & Optoelectronic and Photonic Sensors based on nanotechnology.	L3,L4	PO1,PO2,PO3,PO6, PO7,PO8,PO12
C409.4	Analyze the structure, operation of Biological Sensors, Chemical Sensors, and the so-called "Lab-on-a-Chip" sensors.	L3,L4	PO1,PO2,PO3,PO6, PO7,PO8,PO12
C409.5	Analyze the performance & design of Integrated Sensor/Actuator Units and Special Purpose Sensors.	L3,L4	PO1,PO2,PO3,PO6, PO7,PO8,PO12
Total Hours of instruction		**40**	

4.0 Course Content

Module-1
Pressure Sensors: Capacitive Pressure Sensors, Inductive Pressure Sensors, Ultrahigh Sensitivity Pressure Sensors.

Module-2
Motion and Acceleration Sensors: Ultrahigh Sensitivity, Wide Dynamic Range Sensors, Other Motion and Acceleration Microsensors.
Gas and Smoke Sensors: A CO Gas Sensor Based on Nanotechnology, Smoke Detectors.

Module-3
Moisture Sensors: Structure, Theory, Main Experimental Results, Auxiliary Experimental Results.
Optoelectronic and Photonic Sensors: Optoelectronic Microphone, Other Optoelectronic and Photonic Micro Sensors.

Module-4
Biological, Chemical, and "Lab on a Chip" Sensors: Lab on a Chip Sensors, Other Biochemical Micro- and Nano-Sensors.

Electric, Magnetic, and RF/Microwave Sensors: Magnetic Field Sensors, Other Important Electromagnetic/RF Micro- and Nano-Sensors.

Module-5
Integrated Sensor/Actuator Units and Special Purpose Sensors: Aircraft Icing Detectors, Other Special Purpose Small-Scale Devices.

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Students can apply the knowledge of different type's Sensors & transducers working principle to implement their projects.
02	VIII	Seminar work	Students can utilize the basic knowledge of different types of sensors & transducers during seminar preparation.

6.0 Relevance to Real World

Sl.No	Real World Mapping
01	Students can utilize the knowledge of the subject while working in industries as various industries use different types of sensors and transducers in the operation.

7.0 Gap Analysis and Mitigation

Sl.No	Delivery Type	Details
01	Power Point Presentation and Videos	PPTs and videos of working of different sensors and transducers in industrial operations are shown to the students.

8.0 Books Used and Recommended to Students

Text Books
➢ Micro- and Nano-Scale Sensors and Transducers by Ezzat G. Bakhoum CRC Press, 2015
Reference Books
➢ A Course in Electronics and Electrical Measurements and Instruments by J.B. Gupta 13th Edition, 2008 Katson Books. ➢ A Course in Electrical and Electronic Measurements and Instrumentation by A. K. Sawheny 2015 DhanpatRai.
Additional Study material & e-Books
➢ Electrical & Electronic measurements by P.M.Chandrashekar.

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

Website and Internet Contents References
1) https://books.google.co.in/books?isbn=125902959X
2) http://NPTEL.com/
3) www.electrical4u.com

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	IEEE Instrumentation & measurement magazine	ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=5289
2	Electrical & Electronic industry trade publications journals magazines	www.industrymart.com › Industrial Publications
3	IEEE journals & magazines	https://www.ieee.org › Publications

11.0 Examination Note

Scheme of Evaluation for CIE (50 Marks)

- **Internal Assessment: 20 Marks**

Total of Three Internal Assessment tests will be conducted for 20 Marks each.
2 Assignments**: 10 Marks each, 1** quiz**: 20marks.**
The sum of three tests, two assignments and quiz will be out of 100 marks and will be scaled down to 50 marks

SCHEME OF EXAMINATION: 100 Marks, scaled down to 50 in VTU result sheet.
The question paper will have ten questions.

- Each full question is for 20 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	Lecture No.	Content of Lecture	% of Portion
1	1.	**Pressure Sensors:** Capacitive Pressure Sensors	20%
	2.	**Pressure Sensors:** Capacitive Pressure Sensors	
	3.	Capacitive Pressure Sensors	
	4.	Inductive Pressure Sensors,	
	5.	Inductive Pressure Sensors,	
	6.	Inductive Pressure Sensors,	
	7.	Ultrahigh Sensitivity Pressure Sensors.	
	8.	Ultrahigh Sensitivity Pressure Sensors.	
2	9.	**Motion and Acceleration Sensors:** Ultrahigh Sensitivity,	20%
	10.	Ultrahigh Sensitivity,	
	11.	Wide Dynamic Range Sensors,	
	12.	Other Motion and Acceleration Microsensors.	
	13.	**Gas and Smoke Sensors:** A CO Gas Sensor Based on Nanotechnology,	
	14.	A CO Gas Sensor Based on Nanotechnology,	
	15.	A CO Gas Sensor Based on Nanotechnology,	
	16.	Smoke Detectors	
3	17.	**Moisture Sensors:** Structure, Theory,	

	18.	Main Experimental Results	20%
	19.	Auxiliary Experimental Results	
	20.	Auxiliary Experimental Results	
	21.	**Optoelectronic and Photonic Sensors:** Optoelectronic Microphone	
	22.	Optoelectronic Microphone	
	23.	Other Optoelectronic and Photonic Micro Sensors	
	24.	Other Optoelectronic and Photonic Micro Sensors	
4	25.	**Biological, Chemical, and "Lab on a Chip" Sensors:** Lab on a Chip Sensors	20%
	26.	Other Biochemical Micro- and Nano-Sensors.	
	27.	Other Biochemical Micro- and Nano-Sensors	
	28.	**Electric, Magnetic, and RF/Microwave Sensors:** Magnetic Field Sensors,	
	29.	Magnetic Field Sensors	
	30.	Magnetic Field Sensors	
	31.	Other Important Electromagnetic/RF Micro- and Nano-Sensors	
	32.	Other Important Electromagnetic/RF Micro- and Nano-Sensors	
5	33.	**Integrated Sensor/Actuator Units and Special Purpose Sensors:** Aircraft Icing Detectors.	20%
	34.	Aircraft Icing Detectors	
	35.	Aircraft Icing Detectors	
	36.	Aircraft Icing Detectors	
	37.	Other Special Purpose Small-Scale Devices	
	38.	Other Special Purpose Small-Scale Devices	
	39.	Other Special Purpose Small-Scale Devices	
	40.	Other Special Purpose Small-Scale Devices	

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 Sensors and transducers	Students are capable to explain working of different sensors & transducers.	Module 1and 2	4	Individual Activity. Written solution expected.	Book 1 of the text book list. Website of the Reference list
2	Assignment 2: University Questions on sensors & transducers (continued)	Students are capable to explain working of different sensors & transducers.	Module 3,4 and 5	8	Individual Activity. Written solution expected.	Book 1 of the text book list. Website of the Reference list
3	Quiz	Students are capable to explain working of different sensors & transducers	All 5 Modules	12	Individual Activity. Written solution expected.	Book 1 of the text book list. Website of the Reference list

14.0 Question Bank

MODULE-1

1. Explain the mechanical structure of capacitive pressure sensors.
2. Explain the mechanical structure of inductive pressure sensors.
3. Discuss the sensor interface circuit used to measure the inductance.
4. Discuss the structural details of ultrahigh sensitive pressure sensor.
5. With block diagram explain the interface circuit used to measure the capacitance using ultrahigh sensitive sensor.
6. Discuss the experimental results for
   1) Sensitivity 2) Temperature hysteresis 3) Pressure hysteresis of an inductive pressure sensor.
7. Derive the equation for inductance as a function of position of iron core for an inductive pressure sensor.
8. Discuss the experimental results for
   1) Sensitivity 2) Temperature hysteresis 3) Pressure hysteresis for an ultrahigh sensitive pressure sensor.
9. Derive the equation for pressure as a function of capacitance for an ultrahigh sensitive pressure sensor.
10. Derive the equation for pressure as a function of capacitance for a capacitive pressure sensor.

MODULE-2

1. Explain with neat figure the principle of the operation of the new acceleration sensor.
2. Explain the mechanical structure of new acceleration sensors.
3. With the help of experimental results explain
   i. Acceleration as a function of capacitance
   ii. Acceleration as a function of capacitance without correction for the value of k For an acceleration sensor.
4. Explain the fundamental principle of operation of CO gas sensor based on nanotechnology.
5. Derive the expression for conversion percentage of the reaction as a function of time for CO gas sensor based on nanotechnology.
6. Explain the results of following experiments on the CO gas sensor based on nanotechnology.
   i. Measurement of the resistance of the CNT array as a function of CO concentration
   ii. Measurement of the conversion percentage as a function of time and temperature
7. With the help of neat figure explain the principle of operation of the traditional α-particle smoke detector.
8. With graph explain the results of following experiments on the α-particle smoke detector
   i. Sensor output as a function of obscuration
   ii. Sensor output as a function of the distance between the a-particle source and the MOSFET gate:

MODULE-3

1. Explain the structural details of moisture sensors.
2. Derive the mathematical relation between capacitance of the ultra capacitor and the conductivity of the electrolyte for the new moisture sensor.
3. Explain the results of following experiments the new moisture sensor.
   i. Conductivity of porous silicon slab as a function of relative humidity at different temperatures
   ii. Change in conductivity and capacitance in response to a unit step rise in relative humidity from 5% to 10%
3. Discuss I)relative humidity hysteresis testing and II) effect of contamination on the performance of new moisture sensor.
5. With neat figure explain the mechanical diagram of the integrated microphone assembly.
6. Discuss the principle of operation of the advanced optical microphone.
7. Describe the image acquisition /pattern recognition hardware and software.
8. Explain the optoelectronic and photonic micro sensors.

MODULE-4

1. Discuss the general structure of "Lab on a chip" sensors.
2. Explain the CMOS on chip sensor for measuring the dielectric constant of organic chemicals.
3. With neat figure explain the porous silicon based sensor for chemical gas vapor detection.
4. Explain the fundamental principle of operation of the magnetic field sensor.
5. With the help of experimental set up, explain the response of magnetic sensor to the DC magnetic field.
6. With the help of experimental set up, explain the response of magnetic sensor to the AC magnetic field.
7. Explain the thermocouple based self heating RF power sensor with GaAs MMIC compatible micromachining technology.
8. Derive the relation for Bending radius of the generated free electrons in a magnetic sensor.
9. Deviation of the electron's path in the horizontal direction for a magnetic sensor.

MODULE-5

1. Explain the principle of operation of the α-particle icing detector.
2. Discuss the other special purpose small-scale devices.
3. Derive the equation for minimum steady-state current that is expected to reach the gate of the MOSFET to turn it ON, for an aircraft icing detector.
4. Discuss the results of testing with dry air, moist air, and super-saturated water vapor for an aircraft icing detector.
5. Discuss the on-chip cell factory with a high-speed micro robot driven by permanent magnets.

Prepared by	Checked by		
Prof. P I Savadatti	**Prof. O. B. Heddurshetti.**	**HOD**	**Principal**

Subject Title	**E-waste Management**		
Subject Code	21EC755	**CIE Marks**	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	**SEE Marks**	50
Total Number of Lecture Hrs	40 (08 Hrs/Module)	**Exam Hours**	03
Credits: 03			

FACULTY DETAILS:		
Name: Prof. S. J. Patil	**Designation:** Assistant Professor	**Experience:**12 Years
No. of times course taught: 01	**Specialization:** Industrial Electronics	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
1	-----		

2.0 Course Objectives

This course will enable students to:

Current Status: According to a report on e-waste presented by the United Nations (UN) in World Economic Forum on January 24, 2019, the waste stream reached 48.5 MT in 2018. With such a large quantity of e-waste being generated each year, the future of e-waste recycling in India looks pretty bright. The E-waste (Management) Rules, 2016, enacted on October 1, 2017, added over 21 products (Schedule-I) under the purview of the rule.

Purview: This course covers an extensive review of e-waste management in India. With a focus on the evolution of legal frameworks in India and the world, it presents impacts and outcomes; challenges and opportunities; and management strategies and practices to deal with e-waste. It also includes a survey of pan-India initiatives and trajectories of law-driven initiatives for effective e- waste management along with responses from industries and producers.

Scope: There is a considerable scope for e-waste recycling in India. It is not only a solution to help mitigate e-waste management issues, but it also helps to generate employment. With the rise in e- waste recycling plants, the demand for employees with all levels of qualification and skills also increases.

3.0 Course Outcomes

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

	Course Outcome	RBT Level	POs
C417.1	Understand the existing discourse on e-waste and its management, statistics across the world, opportunities, and challenges w.r.t. regulatory framework, SDGs, CE, and LCIA (Life Cycle Impact Assessment) and MFA (Material Flow Analysis), Indian scenario.	**L1,L2**	PO1,PO2,PO3,PO4,PO6,PO8, PO9,PO10,PO11,Po12
C417.2	Describe EPR, a regulatory framework for achieving specified goals across different countries and impacts on environment and human health	**L1,L2, L3**	PO1,PO2,PO3,PO4,PO6,PO8, PO9,PO10,PO11,Po12

C417.3	Explain themes in the context of resource use and sustainable development. Urban mining, informal sector operations and need for resource use policy, financial support for recycling infrastructure building, etc. in Indian context and also explain to what extent – different aspects of e-waste management have been incorporated in the existing regulatory framework in comparison with international legislatures.	**L1,L2, L3**	PO1,PO2,PO3,PO4,PO6,PO8, PO9,PO10,PO11,Po12
C417.4	Identify and infer pan-Indian initiatives dealing with e-waste management, ranging from building knowledge base through research and social action by different stakeholders to technological and legal advancements, and industrial initiatives. Analyze roadmap for the Agenda 2030	**L1,L2, L3**	PO1,PO2,PO3,PO4,PO6,PO8, PO9,PO10,PO11,Po12
C417.5	Use opportunities and challenges around four domains: legal and judicial domain; economic concerns; recycling culture/society; and environment concerns.	**L1,L2, L3**	PO1,PO2,PO3,PO4,PO6,PO8, PO9,PO10,PO11,Po12
Total Hours of instruction		**40**	

4.0 Course Content

Module 1

Sustainable development and e-waste management: Importance of electrical and electronic equipment in a nation's development, and e-waste as toxic companion of digital era, I: Let's understand e-waste, II: E-waste statistics: quantities, collection and recycling, E-waste categories and harmonizing statistics, III: An overview on status of e-waste related legislation across the globe; IV: UN initiatives for e-waste management: creating partnerships and achieving Agenda 2030; V: Indian scenario: e-waste generation, collection and recycling

Module 2

Extended producer responsibility: a mainstay for e-waste management: Evolution of concept of 'extended producer responsibility', EPR applied for waste management and extended for e-waste management, EPR: goals, implementation, and challenges for e-waste management, EPR implemented for e-waste management under the existing regulatory frameworks in different countries, Role of a PRO prescribed in regulatory framework, Considerations for successful implementation of EPR, Challenges in implementation of EPR for e-waste management, Impact of EPR, EPR and e-waste management in India. Toxicity and impacts on environment and human health: Toxicity, recycling, and regulations, I: Environmental concerns, II: Human health concerns.

Module 3

Treating e-waste, resource efficiency, and circular economy: Safe environment, resource use, and circular economy, Circular economy: recycling, resource recovery, and resource efficiency, Potentials of urban mining in circular economy, Recycling and resource efficiency related challenges to the circular economy, Urban mining, recycling, resource use, resource efficiency, and circular economy in India.

E-waste management through legislations in India: I: Historical backdrop of regulatory regime for e-waste in India, II: E-waste (management) Rules, 2016 and E-waste (management) Amendment Rules, 2018, III: Analyzing performance of EPR and CPCB as regulatory mechanisms, IV: Legal cases and judicial directives

Module 4

Strategies and initiatives for dealing with e-waste in India: I: Overview of pan-India initiatives for dealing with e-waste during 2000 and 2012, II: Law-driven e-waste management – initiatives by the government, non-government agencies, and judiciary.

Module 5

Moving towards horizons: I: Legal and judicial domain, II: Economic concerns, III: Environment concerns, IV: Recycling culture/recycling society

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Project identification, Project documentation, Project Report

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Help to development of nation economically
02	Increase the recycling
03	Start e-waste management

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Tutorial	e- waste managements, recycling, collection etc..
02	NPTEL	http://nptel.ac.in/courses

8.0 Books Used and Recommended to Students

Text Books
1. Varsha Bhagat Gangulay, 'E-Waste Management', Taylor and Francis, 2022.

Additional Study material & e-Books
1. NPTEL notes and Videos 2. VTU notes from website.

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

Website and Internet Contents References
•https://link.springer.com/book/10.1007/978-3-030-14184-4 •https://rajyasabha.nic.in/rsnew/publication_electronic/E-Waste_in_india.pdf •https://greene.gov.in/wp-content/uploads/2018/01/E-waste-Vol-II-E-waste-Management-Manual.pdf •https://nptel.ac.in/courses/105105169

10.0 Magazines/Journals Used and Recommended to Students

Sl. No	Magazines/Journals	website
1	International Journal of e-Education, e-Business	https://www.ijeeee.org/
2	International Journal of e- waste Management.	https://www.tandfonline.com/genv20

11.0 Examination Note

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of50) in the semester-end examination (SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE(Semester End Examination)taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the10th week of the semester
3. Third test at the end of the 15th week of the semester Two

assignmentseachof**10 Marks**

4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20Marks** (**duration01 hours**)

At the end of the 13th week of the semester The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50marks** (to have less stressed CIE, the portion of the syllabus should not be common/repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will b e conducted by University as per the scheduled time table, with common question papers for the subject (**duration 03 hours)**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module(with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module. Marks scoredoutof100shallbe reducedproportionallyto50marks

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours).

1. The question paper will have ten questions. Each question is set for 20 marks.

2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of three sub-questions), should have a mix of topics under that module.

The students have to answer 5 full questions, selecting one full question from each module. Marks scored shall be proportionally reduced to 50 **marks**

12.0 Course Delivery Plan

Course Delivery Plan:

MODULE	LECTURE NO.	CONTENT OF LECTURE	% OF PORTION
1	1	Importance of electrical and electronic equipment in a nation's development, and e-waste as toxic companion of digital era	20
	2	Importance of electrical and electronic equipment in a nation's development, and e-waste as toxic companion of digital era	
	3	I: Let's understand e-waste	
	4	II: E-waste statistics: quantities, collection and recycling, E-waste categories and harmonizing statistics,	
	5	II: E-waste statistics: quantities, collection and recycling, E-waste categories and harmonizing statistics,	
	6	III: An overview on status of e-waste related legislation across the globe	
	7	IV: UN initiatives fore-waste management: creating partnerships and achieving Agenda 2030.	
	8	V: Indian scenario: e-waste generation, collection and recycling.	
2	9	**Extendedproducerresponsibility:amainstayfore-wastemanagement**:Evolutionofconceptof 'extended producer responsibility'	40
	10	EPR applied for waste management and extended for e-waste management	
	11	EPR: goals, implementation, and challenges for e-waste management.	
	12	EPR implementedfore-wastemanagementundertheexistingregulatoryframeworksindifferentcountries	
	13	Role of a PRO prescribed in regulatory framework	
	14	Considerations for successful implementation of EPR, Challenges in implementation of EPR fore-waste management.	
	15	Impact of EPR, EPR and e-waste management in India.	
	16	**Toxicity and impacts on environment and human health**: Toxicity, recycling, and regulations I:Environmental concerns II: Human health concerns	
3	17.	**Treating e-waste, resource efficiency, and circular economy**: Safe environment, resource use, and circular economy, Circular economy	60
	18	Recycling, resource recovery, and resource efficiency, Potentials of urban mining in circular economy,	
	19	Recycling and resource efficiency related challenges to the circular economy, Urban mining, recycling, resource use, resource efficiency, and circular economy in India.	
	20	**E-waste management through legislations in India**,	
	21	I: Historical backdrop of regulatory regime fore-waste in India	
	22	II: E-waste (management) Rules, 2016 and E-waste (management) Amendment Rules,2018	

	23	III: Analysing performance of EPR and CPCB as regulatory mechanisms	
	24	IV: Legal cases and judicial directives.	
4	25	**Strategies and initiatives for dealing with e-waste in India** I: Overview of pan-India initiatives for dealing with e-waste during 2000 and 2012	80
	26	I: Overview of pan-India initiatives for dealing with e-waste during 2000 and 2012	
	27	I: Overview of pan-India initiatives for dealing with e-waste during 2000 and 2012	
	28	I: Overview of pan-India initiatives for dealing with e-waste during 2000 and 2012	
	29	II: Law-driven e-waste management – initiatives by the government, non-government agencies, and judiciary	
	30	II: Law-driven e-waste management – initiatives by the government, non-government agencies, and judiciary	
	31	II: Law-driven e-waste management – initiatives by the government, non-government agencies, and judiciary	
	32	II: Law-driven e-waste management – initiatives by the government, non-government agencies and judiciary	
5	33	**Moving towards horizons**: I: Legal and judicial domain	100
	34	**Moving towards horizons** :I: Legal and judicial domain	
	35	II: Economic concerns	
	36	II: Economic concerns	
	37	III: Environment concerns	
	38	III: Environment concerns	
	39	IV: Recycling culture/recycling society	
	40	IV: Recycling culture/recycling society	

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 e-waste managements, recycling, reuse etc	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1 of the syllabus	4	Individual Activity. Printed solution expected.	Book 1 of the reference list. Website of the Reference list
2	Assignment 2: University Questions on EPR,E-waste management through legislations in India	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 2& 3 of the syllabus	9	Individual Activity. Printed solution expected.	Book 1 of the reference list. Website of the Reference list

14.0 QUESTION BANK

MODULE -1

1. Explain the importance role of electrical and electronic equipment in a nation's development.
2. Why is e-waste considered a "toxic companion" in the digital era ? Provide relevant examples.
3. Explain life cycle of an e product with neat diagram
4. Compare hazardous & non-hazardous. Substance in e products.
5. Explain the components of e- waste management.
6. Define e-waste & Explain e-waste statistics.
7. Classify e-waste categories.
8. Brief the overview on e-waste Status related to legislation.
9. Explain Tackling e-waste with neat diagram.
10. What on the e-waste partnerships & achieving agenda 2030.
11. Explain e-waste Indian Scenario.
12. With neat diagram explain cohesive e-waste management thinking in India.
13. Explain e-waste flow & recycling Scenario in India with neat sketch.
14. Why is e-waste considered a "toxic companion" in the digital era? Provide relevant example.
15. What are environmental and health impacts of improper e waste disposal? Suggest sustainable solutions to mitigate these impacts.

MODULE -2

1. Define EPR & Explain evolution concept of extended producer responsibility.
2. Explain EPR goals, implementation & challenges for e waste managements.
3. List the role of PRO.
4. Explain key consideration for successful implementation of EPR.
5. Brief about challenges of implementation of EPR for e waste managements.
6. Explain impact on EPR.
7. List EPR past rules 2011 in india.

MODULE -3

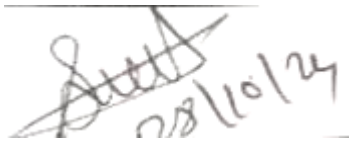
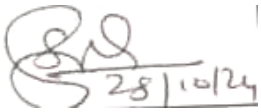
1. Briefly explain the resource use & circular economy for safe environment.
2. Explain the recycling, resource recovery & resource efficiency for circular economy.
3. Explain the Potentials of urban mining in circular economy.
4. What are the challenges to the circular economy related to Recycling and resource efficiency.
5. Explain Significance of recycling technique and technology in e-waste management.
6. Explain the Urban mining, recycling, resource use, resource efficiency, and circular economy in India.
7. Brief explain E-waste Rules, 2011.
8. Explain Historical backdrop of regulatory regime for e-waste in India.
9. What are the Limitations of E-waste Rules 2011 in conception and execution.
10. Explain E-waste (management) Rules, 2016.
11. Explain E-waste (management) amendment rules 2018.
12. What are the Highlights of Rules 2016 and Amendment Rules 2018.
13. What are the Salient changes in Rules, 2016 and Amendment Rules, 2018 compared to Rules, 2011.
14. Explain the performance of EPR and CPCB as regulatory mechanisms.
15. Explain about Legal cases and judicial directives.
16. Compare the Indian legislation with international legislature.

MODULE -4

1. Explain the Overview of pan-India initiatives for dealing with e-waste during 2000 and 2012.
2. Explain the Overview of pan-India initiatives for dealing with e-waste during 2000 and 2010 with neat diagram.
3. What is policy issues for e waste management before 2010 with neat diagram.
4. Explain Law-driven e-waste management related to initiatives by the government, non-government agencies, and judiciary.

MODULE -5

1. Explain the Legal and judicial domain of e waste managements.
2. Explain how way ahead e waste management in india.
3. Explain moving towards horizons related to Economic concerns.
4. Explain moving towards horizons related to Environment concerns.
5. Explain moving towards horizons related to Recycling culture or society.

Prepared by	Checked by		
			
Prof. S. J. Patil	**Prof. S. S. Ittannavar**	**HOD**	**Principal**