

	SJP N Trust's Hirasugar Institute of Technology, Nidasoshi <i>Inculcating Values, Promoting Prosperity</i> Approved by AICTE, New Delhi, Permanently Affiliated to VTU, Belagavi Recognized under 2(f) & 12B of UGC Act, 1956 Accredited at 'A+' Grade by NAAC	EEE Dept. Academic Course Plan 2026-27 (Odd Sem)



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.

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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.

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	Courses	
	BEE701 -Switchgear and Protection (IPCC)	
	BEE702- Industrial Drives and Applications (PCC)	
	BEE703- Power system analysis- II (IPCC)	
	BEE714C- Programmable Logic Controllers (PEC)	
	BEC755D – Sensors & Actuators (OEC)	
	BME755D – Non Conventional Energy Resources (OEC)	

HSMS: -Humanity and Social Science and management Course, **PCC:** Professional Core Course, **IPCC:** Professional Core Course Theory Integrated with practicals, **PCCL:** Professional Core Course laboratory, **AEC:** Ability Enhancement Course, **ESC:** Engineering Science Course, **MC:** Mandatory Course (Non-credit), **PEC:-** Professional Elective Course, **OEC:-** Open Elective Course

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1.0 Student Help Desk

Sl. No	Coordination Work	Contact Person	
		Faculty	Instructor
01	Attestations	Dr. B. V. Madiggond	-
02	Exam forms signature, Overall department administration, Counseling/ interaction with Parents/Students.		
03	Research Centre Coordinator		
04	Project Coordinator, KSCST Coordinator, Hobby & Mini Project Coordinator,	Prof. O. B. Heddurshetti	-
05	Academic Coordinator, Dept. Library Coordinator, Mentorship Coordinator	Prof. H. R. Zinage	-
06	First Year Coordinator, Dept. NBA Coordinator, Alumni Coordinator	Dr. M. P. Yenagimath	-
07	Dept. Association Coordinator, Professional Body (ISTE & IEEE) Coordinator	Prof. S. D. Hirekodi	-
08	AICTE/VTU/NIRF/LIC Coordinator, AICTE Activity Coordinator	Prof. A. U. Neshti	-
09	IA & EMS Coordinator	Prof. S. J. Patil	Shri. G. B. Rendale
10	News letter/Technical Magazine Coordinator, News & Publicity Coordinator, Website Coordinator,	Prof. S. G. Huddar	--
11	TP Cell Coordinator, IIIC Cell, Internship Coordinator	Prof. P. I. Savadatti	--
12	Dispensary	Dr. Arun G. Bullannavar, Contact No.9449141549	
Class Teacher			
13	3 rd Semester	Prof. S. J. Patil	Shri. V.M. Mutalik
14	5 th Semester	Prof. A. U. Neshti	Shri. G. B. Rendale
15	7 th Semester	Prof. P. I. Savadatti	Shri. R. S. Bardol

2.0 Departmental Resources

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

2.1 Faculty Position

S.N.	Category	No. in position	Average experience
1	Teaching faculty	9	20 Y
2	Technical supporting staff	3	29 Y
3	Helper	2	23 Y

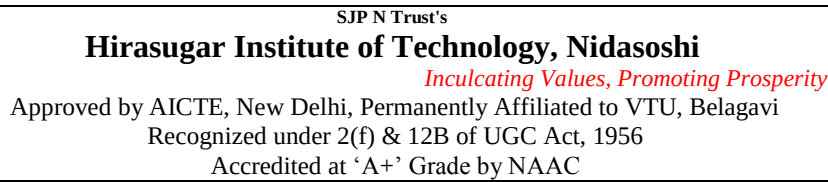
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2.2 Major Laboratories

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	-	33	9343454993
02	Dr. M. P.Yenagimath	Asst. Prof.	Ph.D	VLSI&ES	LMISTE	1	20	9341449466
03	Prof.S.D.Hirekodi	Asst. Prof.	M. Tech.	Power Electronics	LMISTE	1	26	9480849338
04	Prof.H.R.Zinage	Asst. Prof.	M. Tech.	Power System	LMISTE	-	26	9480849335
05	Prof.O.B. Heddurshetti	Asst. Prof.	M. Tech.	Power Electronics	LMISTE	1	19	9448420509
06	Prof. A. U. Neshti	Asst. Prof.	M. Tech.	Digital Electronics	ISTE	-	18	9538223362
07	Prof. S. G. Huddar	Asst. Prof.	M. Tech.	Power System Engg.	LMISTE	-	13	9742066852
08	Prof. P. I. Savadatti	Asst. Prof.	M. Tech.	Digital Electronics	-	-	11	9964315436
09	Prof. S. J. Patil	Asst. Prof.	M. Tech.	Industrial Electronics	-	-	15	9880931802



EEE Dept.
Academic
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VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

B.E. in Electrical & Electronics Engineering**Scheme of Teaching and Examinations 2022**

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the academic year 2023-24)

SCHEME -A-VII SEMESTER (Swappable VII and VIII SEMESTER)

Sl. No	Course and Course Code		Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	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	IPCC	BEE701	Switchgear and Protection	EEE	3	0	2		03	50	50	100	4
2	PCC	BEE702	Industrial Drives and Applications	EEE	4	0	0		03	50	50	100	4
3	IPCC	BEE703	Power system analysis- II	EEE	3	0	2		03	50	50	100	4
4	PEC	BEE714x	Professional Elective Course	EEE	3	0	0		03	50	50	100	3
5	OEC	BEE755x	Open Elective Course	EEE	3	0	0		03	50	50	100	3
6	PROJ	BEE786	Major Project Phase-II	EEE	0	0	12		03	100	100	200	6
										350	350	700	24

Professional Elective Course

BEE714A	Power System Operation and Control	BEE714C	Programmable Logic Controllers
BEE714B	AI Techniques for Electric and Hybrid Electric Vehicles	BEE714D	Big Data Analytics in Power Systems

Open Elective Course

BEE755A	Electric Vehicle Technologies	BEE755C	PLC and SCADA
BEE755B	Energy Conservation and Audit	BEE755D	Optimisation Techniques

PPC: Professional Core Course, **PPCL:** Professional Core Course laboratory, **PEC:** Professional Elective Course, **OEC:** Open Elective Course **PR:** Project Work, **L:** Lecture, **T:** Tutorial, **P:** Practical **S= SDA:** Skill Development Activity, **CIE:** Continuous Internal Evaluation, **SEE:** Semester End Evaluation. **TD-** Teaching Department, **PSB:** Paper Setting department, **OEC:** Open Elective Course, **PEC:** Professional Elective Course. **PROJ:** Project work

Note: VII and VIII semesters of IV years of the program

- (1) Institutions can swap the VII and VIII Semester Schemes of Teaching and Examinations to accommodate research internships/ industry internships 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 the VII or VIII semesters is completed during the beginning of the IV year or the later part of IV years of the program.

Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course. The minimum number of students' strengths for offering professional electives is 10. However, this conditional shall not be applicable to cases where the admission to the program is less than 10.

Open Elective Courses:

Students belonging to a particular stream of Engineering and Technology are not entitled to the open electives offered by their parent Department. However, they can opt for an elective offered by other Departments, provided they satisfy the prerequisite condition if any. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor. The minimum numbers of students' strength for offering Open Elective Course is 10. However, this condition shall not be applicable to class where the admission to the program is less than 10.

PROJECT WORK (21XXP75): 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 install 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 the 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.



Subject Title	SWITCHGEAR AND PROTECTION		
Subject Code	BEE701	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Credits	04	Exam Hours	03

FACULTY DETAILS:

Name: Prof. Amit U. Neshti	Designation: Asst. Professor	Experience: 18 Years
No. of times course taught: 02		Specialization: Digital Electronics

1.0 Prerequisite Subjects:

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

2.0 Course Objectives

The subject aims to provide the student with:

- To discuss performance of protective relays, components of protection scheme and relay terminology.
- To explain over current protection using electromagnetic and static relays and Over current protective schemes and microprocessor -based Protective Relays.
- To discuss pilot protection; wire pilot relaying and carrier pilot relaying differential protection, protection of generators, motors, Transformer and Bus Zone Protection.
- To explain the principle of circuit interruption and different types of circuit breakers.
- To describe the construction and operating principle of different types of fuses and to give the definitions of different terminologies related to a fuse.
- Experimentally verify the characteristics of over current, over voltage, under voltage using electromagnetic, static, distance and impedance relays.
- To discuss protection Against Over voltages and Gas Insulated Substation (GIS).
- To discuss the construction, operating principles and performance characteristics of protective devices.
- To conduct experiments and verify the characteristics of electromechanical and microprocessor based relays.
- To verify the operation of motor protection for different faults

3.0 Course Outcomes

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

	Course Outcome	RBT	POs
C401.1	Discuss the general concepts of power system protection, construction and operation of relays.	L2	PO1,2,3,6,8,9,10,12
C401.2	Explain the construction and operation of different types of over current relays and protection schemes.	L3	PO1,2,3,6,8,9,10,12
C401.3	Discuss pilot protection, construction, operating principles and performance of differential relays and discuss protection of generators, motors, transformer and Bus Zone Protection.	L3	PO1,2,3,6,8,9,10,12
C401.4	Explain the construction and operation of different types of circuit breakers.	L3	PO1,2,3,6,8,9,10,12
C401.5	Outline features of fuse, causes of over voltages and its protection, also modern trends in Power System Protection.	L3	PO1,2,3,6,8,9,10,12
Total Hours of instruction		40 hours Theory + 10 Lab slots	



4.0 Course Content

MODULE-1

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

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

MODULE-2

Overcurrent Protection: Introduction, Time – current Characteristics, Current Setting, Time Setting. Overcurrent Protective Schemes, Reverse Power or Directional Relay, Protection of Parallel Feeders, Protection of Ring Mains, Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme, Phase Fault Protective Scheme, Directional Earth Fault Relay, Static Overcurrent Relays, Numerical Overcurrent Relays. **Microprocessor - based Protective Relays:** Introduction, Overcurrent relays, Impedance relay.

MODULE-3

Pilot Relaying Schemes: Introduction, Wire Pilot Protection, Carrier Current Protection.

Differential Protection: Introduction, Differential Relays, Simple Differential Protection, Percentage or Biased Differential Relay, Differential Protection of 3 Phase Circuits, Balanced (Opposed) Voltage Differential Protection.

Rotating Machines Protection: Introduction, Protection of Generators.

Transformer and Bus zone Protection: Introduction, Transformer Protection, Bus zone Protection, Frame Leakage Protection.

MODULE-4

Circuit Breakers: Introduction, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers, Air – Break Circuit Breakers, Oil Circuit Breakers, Air – Blast Circuit Breakers, SF6 Circuit Breakers, Vacuum Circuit Breakers, High Voltage Direct Current Circuit Breakers, Rating of Circuit Breakers, Testing of Circuit Breakers.

MODULE-5

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

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

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



PRACTICAL COMPONENT OF IPCC (Any 10 Experiments. But recommended to carryout others experiments)

Sl. No.	Experiments
1	Over Current Relay: (a) Inverse Definite Minimum Time (IDMT) Non - Directional Characteristics (b) Directional Features (c) IDMT Directional.
2	IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical type).
3	Operation of Negative Sequence Relay.
4	IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical type)
5	Operating Characteristics of Microprocessor Based (Numeric) Over –Current Relay
6	Operating Characteristics of Microprocessor Based (Numeric) Distance Relay.
7	Operating Characteristics of Microprocessor Based (Numeric) Over/Under Voltage Relay.
8	Generation Protection: Merz Price Scheme.
9	Feeder Protection against Faults.
10	Motor Protection against Faults.
11	Fuse Characteristics
12	Measurement of Breakdown Strength of Transformer Oil as per IS 1876 :2005
13	Field Mapping using Electrolytic Tank for any one of the following Models: Cable/ Capacitor/ Transmission Line/ Sphere Gap.

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Use of protection schemes against faults in real time projects.

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	Mi Power tool	Simulation of relay coordination

8.0 Books Used and Recommended to Students

Text Books
1. Power System Protection and Switchgear, Badri Ram, D.N. Vishwakarma McGrawHill 2nd Edition.
2. Power System Protection and Switchgear, Bhuvanesh Oza et al McGraw Hill 1st Edition, 2010.
Reference Books



1. Protection and Switchgear Bhavesh et al Oxford 1st Edition, 2011.
2. Power System Switchgear and Protection N. Veerappan S.R. Krishnamurthy S.Chand 1st Edition, 2009.
3. Fundamentals of Power System Protection Y.G.Paithankar S.R. Bhide PHI 1st Edition, 2009.

Additional Study material & e-Books

1. “Switchgear & Protection”, by U.A. Bakshi & M.V. Bakshi.

9.0

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

Website and Internet Contents References

- <https://nptel.ac.in>
- <http://acl.digimat.in/nptel/courses/video/108105017/108105017.html>

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) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures 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.

The IPCC means the practical portion integrated with the theory of the course. CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.

CIE for the theory component of the IPCC

- 25 marks for the theory component are split into 15 marks for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and 10 marks for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for 25 marks).
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- 15 marks for the conduction of the experiment and preparation of laboratory record, and 10 marks for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' writeups are added



and scaled down to 15 marks.

- The laboratory test (duration 02/03 hours) after completion of all the experiments shall be conducted for 50 marks and scaled down to 10 marks.
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for 25 marks.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

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 3 sub-questions), should have a mix of topics under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

- The minimum marks to be secured in CIE to appear for SEE shall be 10 (40% of maximum marks-25) in the theory component and 10 (40% of maximum marks -25) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included. The maximum of 04/05 sub-questions are to be set from the practical component of IPCC, the total marks of all questions should not be more than 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify for the SEE. Marks secured will be scaled down to 50.
- The student is declared as a pass in the course if he/she secures 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.

12.0 Course Delivery Plan

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



2	9	Over current Protective Schemes, Reverse Power or Directional Relay.	20%
	10	Protection of Parallel Feeders, Protection of Ring Mains. Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme.	
	11	Phase Fault Protective Scheme, Directional Earth Fault Relay, Static Overcurrent Relays, Numerical Overcurrent Relays.	
	12	Distance Protection: Introduction, Impedance Relay.	
	13	Reactance Relay, Mho Relay.	
	14	Angle Impedance Relay, Effect of Arc Resistance on the Performance of	
	15	Reach of Distance Relays. Effect of Power Surges on Performance of Distance	
3	16	Effect of Line Length and Source Impedance on Performance of Distance Relays.	20%
	17	Pilot Relaying Schemes: Introduction, Wire Pilot Protection, Carrier Current Protection.	
	18	Differential Protection: Introduction, Differential Relays.	
	19	Simple Differential Protection, Percentage or Biased Differential Relay,	
	20	Differential Protection of 3 Phase Circuits, Balanced (Opposed) Voltage Differential Protection.	
	21	Rotating Machines Protection: Introduction, Protection of Generators	
	22	Transformer and Buszone Protection: Introduction, Transformer Protection	
4	23	Buszone Protection	20%
	24	Frame Leakage Protection	
	25	Circuit Breakers: Introduction, Fault Clearing Time of a Circuit Breaker	
	26	Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage,	
	27	Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers.	
	28	Air – Break Circuit Breakers, Oil Circuit Breakers	
	29	Air – Blast Circuit Breakers, SF6 Circuit Breakers,	
5	30	Vacuum Circuit Breakers,	20%
	31	High Voltage Direct Current Circuit Breakers	
	32	Rating of Circuit Breakers, Testing of Circuit Breakers	
	33	Fuses: Introductions, Definitions, Fuse Characteristics, Types of Fuses,	
	34	Applications of HRC Fuses, Selection of Fuses, Discrimination.	
	35	Protection against Over voltages: Causes of Over voltages, Lightning phenomena.	
	36	Wave Shape of Voltage due to Lightning, Over Voltage due to Lightning.	
	37	Klydonograph and Magnetic Link, Protection of Transmission Lines against	20%
	38	Protection of Stations and Sub – Stations from Direct Strokes, Protection against Travelling Waves, Insulation Coordination.	
	39	Basic Impulse Insulation Level (BIL).	
	40	Modern Trends in Power System Protection: Introduction, Gas insulated substation/switchgear (GIS).	

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl. No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1,2 & 3.	8	Individual Activity. Written solution is expected.	Book 1 of the reference list. Website of the Reference list



2	Quiz	Students study the Topics and write the Answers. Get practice to solve university questions.	All Modules	12	Individual Activity.	Book 1 of the reference list. Website of the Reference list
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14.0 QUESTION BANK

Module No. 1:

1. Explain need of protection schemes?
2. Mention different types of faults?
3. With neat sketch explain primary and backup protection?
4. Explain the classification of protective relays?
5. Mention merits and demerits of static relays?
6. Compare electromechanical and Numerical relays?
7. With a neat diagram, explain zones of protection in a power system.
8. Explain the various methods of back up protection.
9. Briefly explain essential qualities of protective relay.
10. Draw the schematic diagram of Numerical relay and briefly describe its various components.

Module No. 2:

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

Module No. 3

1. Explain carrier current protection?
2. With neat sketch explain the operation of differential relay?
3. With neat diagram explain the operation of percentage or biased differential relay?
4. Explain differential protection of 3 phase circuits?
5. Explain the operation of balanced voltage differential protection?
6. Explain the protection of Generators?
7. Explain transformer protection?
8. Explain buszone protection?
9. Explain the term Pilot with reference to power line protection.
10. Describe the balanced (opposed) voltage differential protection scheme.
11. With a neat diagram. Explain the working of Buchholz relay.

Module No. 4

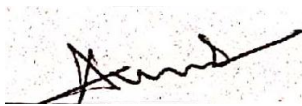
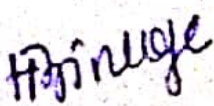
1. Explain the basic principle of operation of Circuit breaker?
2. Explain arc interruption in circuit breaker?
3. Define restriking & recovery voltage?
4. With neat sketch explain interruption of capacitive current?
5. With neat sketch the operation of following circuit breakers?
 - Air-break circuit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



- SF6 circuit breaker
 - Vacuum circuit breaker
 - High voltage direct current circuit breaker
6. Explain the ratings of circuit breaker?
 7. Explain various methods of testing of circuit breakers?
 8. Explain how interruption of capacitive current takes place in AC circuit breaker.
 9. With a neat sketch, explain the construction and working of Non-Puffer type of SF6 Circuit breaker.
 10. With the help of Schematic diagram, explain the working of short circuit test plant.

Module No. 5

1. Mention different types of fuses?
2. With neat sketch explain the operation of HRC fuse?
3. With neat sketch explain the construction & working of Liquid fuse?
4. Explain the procedure for selection of fuses and define discrimination?
5. Mention the causes of over voltages?
6. Explain the lightning phenomena?
7. Explain the protection of transmission lines against direct lightning strokes?
8. Explain the protection of substations from direct strokes?
9. Explain the basic Impulse insulation level?
10. Explain about Gas insulated substation?
11. Define the fusing factor and Fuse.
12. With a neat sketch, explain the working of Klydonograph.
13. What are the various components of a GIS? Briefly describe their functions.

Prepared by	Checked by		
			
Prof. Amit U. Neshti	Prof. H. R. Zinage	HOD	Principal



Subject Title	INDUSTRIAL DRIVES AND APPLICATION		
Subject Code	BEE702	CIE Marks	50
Teaching hours/week(L:T:P:S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Exam Hours	03
CREDITS – 04			

FACULTY DETAILS:

Name: Prof. O. B. Heddurshetti	Designation: Asst. Professor	Experience: 20 Years
No. of times course taught(including present): 03	Specialization: Power Electronics	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Electrical & Electronics Engineering	IV	Electric Motors
02	Electrical & Electronics Engineering	V	Power Electronics

2.0 Course Objectives

- To define electric drive, its parts, advantages and explain choice of electric drive.
- To explain dynamics and modes of operation of electric drives.
- To explain selection of motor power ratings and control of DC motor using rectifiers.
- To analyze the performance of induction motor drives under different conditions.
- To explain the control of induction motor, synchronous motor and stepper motor drives.
- To discuss typical applications of electrical drives in the industry.

3.0 Course Outcomes

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

	Course Outcome	RBT Level	POs
C402.1	Explain the advantages, choice, dynamics and control of electrical drives.	L2	1,2,3,8,12
C402.2	Discuss the control methods of different types of DC motor drives.	L3	1,2,3,8,12
C402.3	Analyze the performance and control of induction motor drives.	L4	1,2,3,8,12
C402.4	Analyze the operation and control of synchronous motor and stepper motor drives.	L4	1,2,3,8,12
C402.5	Discuss the energy conservation in electrical drives, application of drives in industry & rural areas and solar powered drives.	L3	1,2,3,8,12
Total Hours of instruction		40	



MODULE-1

Electrical Drives: Electrical Drives, Advantages of Electrical Drives. Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and AC Drives.

Dynamics of Electrical Drives: Fundamental Torque Equations, Speed Torque Conventions and Multi-quadrant Operation. Equivalent values of Drive parameters, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy Loss in Transient Operations, Steady State Stability, Load Equalization.

Control Electrical Drives: Modes of Operation, Speed Control and Drive Classifications, Closed loop Control of Drives. Phase locked Loop control (PLL)

MODULE-2

Direct Current Motor Drives: Controlled Rectifier Fed DC Drives, Single Phase Fully Controlled Rectifier Control of DC Separately Excited Motor, Single Phase Half Controlled Rectifier Control of DC Separately Excited Motor, Three Phase Fully Controlled Rectifier Control of DC Separately Excited Motor, Three Phase Half Controlled Rectifier Control of DC Separately Excited Motor, Multi-quadrant Operation of DC Separately Excited Motor Fed From Fully Controlled Rectifier, Rectifier Control of DC Series Motor, Supply Harmonics, Power Factor and Ripple in Motor Current, Chopper Control of Separately Excited DC Motor, Chopper Control of Series Motor

MODULE-3

Induction Motor Drives: Analysis and Performance of Three Phase Induction Motors, Operation with Unbalanced Source Voltage and Single Phasing, Operation with Unbalanced Rotor Impedances, Analysis of Induction Motor Fed From Non-Sinusoidal Voltage Supply, Starting, Braking, Transient Analysis. Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources. Voltage Source Inverter (VSI) Control, Cycloconverter Control, Closed Loop Speed Control and Converter Rating for VSI and Cycloconverter Induction Motor Drives, Variable Frequency Control from a Current Source, Current Source inverter (CSI) Control, Comparison of VSI and CSI, current regulated voltage source inverter control, speed control of single phase induction motors.

MODULE-4

Synchronous Motor Drives: Operation from fixed frequency supply-starting, synchronous motor variable speed drives, variable frequency control of multiple synchronous motors. Self-controlled synchronous motor drive employing load commutated thyristor inverter, Starting Large Synchronous Machines, Permanent Magnet ac (PMAC) Motor Drives, Sinusoidal PMAC Motor Drives, Brushless DC Motor Drives.

Stepper Motor Drives: Variable Reluctance, Permanent Magnet, Important Features of Stepper Motors, Torque Versus Stepping rate Characteristics, Drive Circuits for Stepper Motor

MODULE-5

Energy conservation in Electrical Drives: Losses in electrical drive system, Measures for energy conservation in Electrical drives, Energy efficient operation of drive, use of right rating motors, improvement of quality of supply.

Solar powered Drives: Solar powered pump drives, solar powered Electric vehicles.

Industrial Drives: Textile Mills, Steel Rolling Mills, Cranes and Hoists, Machine Tools, use of single to three phase semiconductor converters in rural applications



5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
1	VII	Project	Projects based on Electrical drives & its applications

6.0 Relevance to Real World

Sl No	Real World Mapping
01	Used in manufacturing industries to regulate and control rotating equipment such as fans, conveyors, machine spindles, and pumps.
02	Used in process industries to increase the efficiency of equipment.

7.0 Gap Analysis and Mitigation

Sl No	Delivery Type	Details
01	Industrial visits	Theoretical concept and applications of drives can be understood by visiting Textile Mills, Steel Rolling Mills and different production industries.

8.0 Books Used and Recommended to Students

Text Books

1. 'Fundamentals of Electrical Drives', by Gopal K. Dubey, Narosa Publishing House 2nd Edition, 2001.
2. 'Electrical Drives: Concepts and Applications' by Vedum Subrahmanyam McGraw Hill 2nd Edition, 2011.

Reference Books

1. 'Electric Drives' by N.K De, P.K. Sen, PHI Learning 1st Edition, 2009

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

Website and Internet Contents References

<https://nptel.ac.in/courses/108108077/>
www.srmuniv.ac.in/sites/.../EI03INDUSTRIALDRIVESCONTROL_EIE6thsem.pdf

10.0 Magazines/Journals Used and Recommended to Students

Sl. No	Magazines/Journals	Website
1	AEÜ - International Journal of Electronics and Communications	www.journals.elsevier.com/aeu

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 marks for the CIE is 40% of the maximum marks (20 marks out of 50)



and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures 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(CIE):

There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.

Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks

Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)

The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks. Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination (SEE):

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 3 sub-questions), should have a mix of topics under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

11.0 Course Delivery Plan

Module	Lecture No.	Content of Lecture	% of Portion coverage
I	1.	Electrical Drives, Advantages of Electrical Drives. Parts of Electrical Drives.	20
	2.	Choice of Electrical Drives, Status of DC and AC Drives.	
	3.	Fundamental Torque Equations, Speed Torque Conventions and Multi-quadrant Operation.	
	4.	Equivalent values of Drive parameters, Components of Load Torques	
	5.	Nature and Classification of Load Torques, Calculation of Time and Energy Loss in Transient Operations	
	6.	Steady State Stability, Load Equalization.	
	7.	Modes of Operation, Speed Control and Drive Classifications	
	8.	Closed loop Control of Drives. Phase locked Loop control (PLL)	
II	9.	Controlled Rectifier Fed DC Drives, Single Phase Fully Controlled Rectifier Control of DC Separately Excited Motor	20



	10.	Single Phase Half Controlled Rectifier Control of DC Separately Excited Motor	
	11.	Three Phase Fully Controlled Rectifier Control of DC Separately Excited Motor	
	12.	Three Phase Half Controlled Rectifier Control of DC Separately Excited Motor,	
	13.	Multi-quadrant Operation of DC Separately Excited Motor Fed From Fully Controlled Rectifier	
	14.	Rectifier Control of DC Series Motor, Supply Harmonics	
	15.	Power Factor and Ripple in Motor Current,	
	16.	Chopper Control of Separately Excited DC Motor, Chopper Control of Series Motor.	
III	17.	Analysis and Performance of Three Phase Induction Motors	20
	18.	Operation with Unbalanced Source Voltage and Single Phasing, Operation with Unbalanced Rotor Impedances,	
	19.	Analysis of Induction Motor Fed From Non-Sinusoidal Voltage Supply, Starting, Braking, Transient Analysis	
	20.	Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources	
	21.	Voltage Source Inverter (VSI) Control, Cycloconverter Control, Closed Loop Speed Control	
	22.	Converter Rating for VSI and Cycloconverter Induction Motor Drives	
	23.	Variable Frequency Control from a Current Source, Current Source inverter (CSI) Control, Comparison of VSI and CSI	
	24.	Current regulated voltage source inverter control, speed control of single phase induction motors.	
IV	25.	Operation from fixed frequency supply-starting, synchronous motor variable speed drives,	20
	26.	Variable frequency control of multiple synchronous motors	
	27.	Self-controlled synchronous motor drive employing load commutated thyristor inverter	
	28.	Starting Large Synchronous Machines, Permanent Magnet ac (PMAC) Motor Drives	
	29.	Sinusoidal PMAC Motor Drives, Brushless DC Motor Drives	
	30.	Variable Reluctance, Permanent Magnet	
	31.	Permanent Magnet, Important Features of Stepper Motors	
	32.	Torque Versus Stepping rate Characteristics, Drive Circuits for Stepper Motor	
V	33.	Losses in electrical drive system, Measures for energy conservation in Electrical drives,	20
	34.	Energy efficient operation of drive, use of right rating motors	
	35.	Improvement of quality of supply.	
	36.	Solar powered pump drives	
	37.	Solar powered Electric vehicles	



	38.	Textile Mills, Steel Rolling Mills	
	39.	Cranes and Hoists, Machine Tools	
	40.	Use of single to three phase semiconductor converters in rural applications.	

12.0 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: As per university question paper pattern to attain Cos & POs	Students will be able to explain the basics of electrical drives, control of AC and DC drives.	Module 1,2 & 3 of the syllabus	08	Individual activity	Books 1 and 2 of the text book list.
2	Quiz: Online quiz covering all modules to attain Cos & POs	Students will be able to explain the basics of electrical drives, control of AC and DC drives, energy conservation of drives industrial drives and solar powered drives.	Module 1,2,3,4 & 5 of the syllabus	12	Individual Submission through Online Google link.	Books 1 and 2 of the text book list.

13.0 QUESTION BANK

MODULE-1

1. What is an Electric Drive? Explain the classification of Electric Drives with merits and demerits of each.
2. Discuss the various factors governing selection of motors for a drive system.
3. Distinguish between an electric motor and an electric drive. What are the methods by which power is transmitted from the motor to the driven unit?
4. Compare the advantages of individual drive with group drive.
5. Differentiate between passive and active torques with illustration. Establish the criteria for steady state stability of electric drives.
6. What are advantages of electrical drives?
7. State essential parts of electrical drives. What are the functions of power modulator?
8. Write a brief note on the motors employed in variable speed drives.
9. State and explain the functions of various converters.
10. Write a brief note on the sources employed in electric drives.
11. What are main factors which decide the choice of electric drive for a given application?
12. What is the current status of dc and ac drives?
13. Explain what do you understand by the steady state stability? What is the main assumption?
14. Explain that the steady state stability of a drive depends on relative characteristic of the motor and load and not just on motor (or load) characteristic.
15. What are the reasons for using load equalization in electric drive?



16. Explain the operation of a hoist motor driving a hoist motor with four quadrant speed – torque diagram

MODULE-2

1. With usual notations find an expression for the temperature rise of a machine. Sketch the temperature rise Vs time curve.
2. Explain how the rating of a motor can be selected for a continuous duty variable load based on the equivalent current method.
3. What is heating & cooling time constants? Explain how the rating of a motor is affected by the temperature rise.
4. What is meant by rating of motors? Discuss how the type and size of motors for intermittent loads is determined.
5. Derive the expression used for the short time rating of a machine. Sketch the temperature rise Vs time curve.
6. Explain the classification of duty for motors with load diagrams. Mention one example in each case.
7. Derive the expression used for the short time rating of a machine. Sketch the temperature rise Vs time curve.
8. Derive the expression used for the intermittent rating of a machine. Sketch the temperature rise Vs time curve.
9. Derive the expression used for the moment of inertia of a flywheel.
10. Develop expression to determine power ratings of electric motors under the following applications.
 - i. Continuous duty and constant load, ii. Continuous duty and variable load
11. Explain how the rating of a motor can be selected for a continuous duty variable load based on the equivalent torque and power method.
12. Explain how the rating of a motor can be selected for a continuous duty variable load based on the average losses method.
13. A fully controlled rectifier is feeding separately excited dc motor is required to operate in motoring and braking operations in the forward direction. Only one fully controlled rectifier is available. What switching arrangement will be required? Explain.
14. A fully controlled rectifier is feeding a separately excited motor driving a friction load. Motor is operating in a steady state with a rectifier firing angle is 30 deg. Firing angle is now changed from 30 deg to 60deg. Explain how motor current and speed will change with time.
15. Describe relative merits & demerits of four quadrant dc drives employing non circulating and circulating current dual converters.

MODULE-3

1. Explain the stator voltage control of 3 phase induction motors.
2. Explain star- delta starting of 3 phase induction motors with the help of neat diagram.
3. Explain variable frequency control of 3 phase induction motors.
4. Explain regenerative braking of 3 phase induction motors.
5. A 3 phase wound rotor IM with external resistors in the rotor is running at light load. The supply to one of the 3 phases is disconnected. Whether the motor continues to run or stops will depend on the value of rotor resistance why?
6. Explain cycloconverter control of 3 phase induction motors.
7. Explain current source inverter control of induction motor.
8. Explain current source inverter control of induction motor.
9. When plugging is employed for stopping an IM, why is it necessary to disconnect it from supply when the speed reaches close to zero?



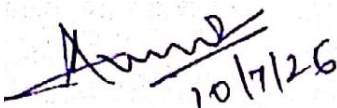
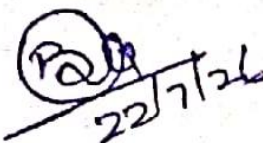
10. Why stator voltage control is suitable for speed control of IM in fan and pump drives?
11. Why stator voltage control is an inefficient method of IM speed control.
12. Why is the p.f of the slip power recovery scheme of speed control of IM low?
13. Why single winding single phase IM does not have starting torque.

MODULE-4

1. Explain starting of synchronous motors from fixed frequency supply.
2. Explain torque- stepping rate characteristics of stepper motor.
3. Explain drive circuits for stepper motors.
4. Explain unipolar drive for variable reluctance motor of low power rating.
5. Why a synchronous motor does not have starting torque?
6. How do you start a synchronous motor?
7. What is basic difference between true synchronous mode and self control made for variable frequency control of synchronous motor?
8. What are the similarities between brushless dc motor and conventional dc motor? Why is it known as brushless dc motor? What are its advantages over a conventional dc motor?

MODULE-5

1. Explain industrial drives for textile mills
2. Explain industrial drives for steel rolling mills
3. What you mean by reversing hot rolling mills & reversing cold rolling mills?
4. What you mean by continuous hot rolling mills & continuous cold rolling mills?
5. Mention types of drives used for paper machine.
6. Compare between line shaft drive and sectional drive.
7. Mention the motors used for different textile mills

Prepared by	Checked by		
			
Prof. O. B. Heddurshetti	Prof. A. U. Neshti	HOD	Principal



Subject Title	POWER SYSTEM ANALYSIS-2		
Subject Code	BEE703	CIE Marks	50
Number of Lecture Hrs / Week	40 hours Theory + 10 Lab slots	SEE Marks	50
Total Number of Lecture Hrs	40	Exam Hours	03
CREDITS – 04			

FACULTY DETAILS:

Name: Prof. S.G.Huddar	Designation: Asst. Professor	Experience: 12 Years
No. of times course taught:-04 (including present)		Specialization: Power System Engineering

1.0 Prerequisite Subjects:

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

2.0 Course Objectives

- To explain formulation of network models and bus admittance matrix for solving load flow problems.
- To discuss optimal operation of generators on a bus bar and optimum generation scheduling.
- To explain symmetrical fault analysis and algorithm for short circuit studies.
- To explain formulation of bus impedance matrix for the use in short circuit studies on power systems.
- To explain numerical solution of swing equation for multi-machine stability.
- To develop admittance and impedance matrices of interconnected power systems.
- To explain the use of suitable standard software package.
- To solve power flow problem for simple power systems.
- To perform fault studies for simple radial power systems.
- To study optimal generation scheduling problems for thermal power plants.

	Course Outcome	RBT Level	POs
CO 403.1	Formulate network matrices and models for solving load flow problems.	L4	1,2,3,8,12
CO 403.2	Perform steady state power flow analysis of power systems using numerical iterative techniques.	L4	1,2,3,8,12
CO 403.3	Solve issues of economic load dispatch and unit commitment problems.	L4	1,2,3,8,12
CO 403.4	Analyse short circuit faults in power system networks using bus impedance matrix. Apply Point by Point method and Runge Kutta Method to solve Swing Equation.	L4	1,2,3,8,12

4.0 Course Content

Module-1

Network Topology: Introduction and basic definitions of Elementary graph theory Tree, cut-set, loop analysis. Formation of Incidence Matrices. Primitive network- Impedance form and admittance form, Formation of Y Bus by Singular Transformation. Ybus by Inspection Method. Illustrative examples.

Module-2

Load Flow Studies: Introduction, Classification of buses. Power flow equation, Operating Constraints, Data for Load flow, Gauss Seidal iterative method. Illustrative examples.

Module-3

Load Flow Studies(continued) Newton-Raphson method derivation in Polar form, Fast decoupled load flow method, Flow charts of LFS methods. Comparison of Load Flow Methods. Illustrative examples.



Module-4

Economic Operation of Power System: Introduction and Performance curves, Economic generation scheduling neglecting losses and generator limits, Economic generation scheduling including generator limits and neglecting losses, Economic dispatch including transmission losses, Derivation of transmission loss formula. Illustrative examples.

Unit Commitment: Introduction, Constraints and unit commitment solution by prior list method and dynamic forward DP approach (Flow chart and Algorithm only).

Module-5

Symmetrical Fault Analysis: Z Bus Formulation by Step by step building algorithm without mutual coupling between the elements by addition of link and addition of branch. Illustrative examples. Z bus Algorithm for Short Circuit Studies excluding numerical. **T1 Power System Stability:** Numerical Solution of Swing Equation by Point by Point method and Runge Kutta Method. Illustrative examples.

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
01	To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault On One of the two Lines. (Using suitable simulation package.)
02	Y-Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation.
03	Y-Bus Formation for Power Systems without Mutual Coupling, by Inspection method
04	Formation of Z-Bus (without mutual coupling) using Z-Bus Building Algorithm.
05	Formation of Jacobian matrix in Polar Coordinates, for a System having less than 4 Buses.
06	Determination of Bus Currents, Bus Power and Line Flows, for a Specified System Voltage.
07	Load Flow Analysis using Gauss Siedal Method for the system with both PQ buses and PV Buses. By simulation
08	Load Flow Analysis using NR Method and Fast Decoupled Method for the system with both PQ buses and PV Buses. (Using suitable simulation package.)
09	Write a program to generate unit commitment schedule for a system with three units using priority listing method (priority based on least cost).
10	Optimal Generation Scheduling for Thermal power plants (Using suitable simulation package.)

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
1	VIII	PSOC	ALL

6.0 Relevance to Real World

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

7.0 Gap Analysis and Mitigation

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



8.0 Books Used and Recommended to Students

Text Books
1. Modern Power System Analysis D P Kothari, I J Nagrath McGraw Hill 4th Edition, 2011
2. Computer Methods in Power Systems Analysis Glenn W. Stagg Ahmed H Ei – Abiad Scientific International Pvt. Ltd. 1st Edition, 2019
3. Power Generation Operation and Control Allen J Wood et al Wiley 2nd Edition, 2016
Reference Books
1. Computer Techniques in Power System Analysis M.A. Pai McGraw Hill 2nd Edition, 2012
2. Power System Analysis Hadi Saadat McGraw Hill 2 nd Edition, 2002
Additional Study material & e-Books
1. http://pdfstuff4u.com/ebook.php?id=1071881
2. http://sjbit.edu.in

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

Website and Internet Contents References
• https://nptel.ac.in/courses/108102047 • https://nptel.ac.in/courses/108105067 • https://nptel.ac.in/courses/108104051

10.0 Magazines/Journals Used and Recommended to Students

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

11.0 Examination Note

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**) and for the SEE minimum passing mark is 35% of the maximum marks (**18 out of 50 marks**). The student is declared as a pass in the course if he/she secures 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.

The IPCC means the practical portion integrated with the theory of the course. CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.

CIE for the theory component of the IPCC

- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks**).
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.



CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of **all** the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write ups are added and scaled down to **15 marks**.
- The laboratory test (**duration 02/03 hours**) after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks**.
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

- Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**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.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

- The minimum marks to be secured in CIE to appear for SEE shall be **10** (40% of maximum marks-25) in the theory component and **10** (40% of maximum marks -25) in the practical component.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify for the SEE. Marks secured will be scaled down to 50.
- The student is declared as a pass in the course if he/she secures 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.

UNIT No.	Lecture No.	Content of Lecture	% of Portion
I	1.	Network Topology: Introduction and basic definitions of Elementary graph theory	20
	2.	Tree, cut-set, loop analysis.	
	3.	Formation of Incidence Matrices.	
	4.	Primitive network- Impedance form and admittance form.	
	5.	Formation of Y Bus by Singular Transformation.	
	6.	Ybus by Inspection Method.	
	7.	Illustrative examples.	
	8.	Illustrative examples.	
II	9.	Load Flow Studies: Introduction	20
	10.	Classification of buses.	
	11.	Power flow equation,	
	12.	Operating Constraints,	
	13.	Data for Load flow,	
	14.	Gauss Seidal iterative method.	
	15.	Gauss Seidal iterative method.	
	16.	Illustrative examples.	



III	17.	Load Flow Studies(continued) Newton-Raphson method derivation in Polar form	20
	18.	Newton-Raphson method derivation in Polar form	
	19.	Newton-Raphson method derivation in Polar form	
	20.	Fast decoupled load flow method	
IV	21.	Flow charts of LFS methods.	20
	22.	Comparison of Load Flow Methods.	
	23.	Illustrative examples.	
	24.	Illustrative examples.	
	25.	Economic Operation of Power System: Introduction and Performance curves.	
	26.	Economic generation scheduling neglecting losses and generator limits	
	27.	Economic generation scheduling including generator limits and neglecting losses.	
	28.	Economic dispatch including transmission losses & derivation of transmission loss formula.	
	29.	Illustrative examples.	
	30.	Unit Commitment: Introduction.	
	31.	Constraints and unit commitment solution by prior list method	
	32.	Dynamic forward DP approach (Flow chart and Algorithm only).	
V	33.	Symmetrical Fault Analysis: Z Bus Formulation	20
	34.	Z bus formulation by Step by step building algorithm without mutual coupling between the elements by addition of link and addition of branch.	
	35.	Z bus formulation by Step by step building algorithm without mutual coupling between the elements by addition of link and addition of branch.	
	36.	Illustrative examples.	
	37.	Z bus Algorithm for Short Circuit Studies excluding numerical.	
	38.	Power System Stability: Numerical Solution of Swing Equation by Point by Point method	
	39.	Numerical Solution of Swing Equation by Runge Kutta Method.	
	40.	Illustrative examples.	

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 test 1: Module 1-5	Students study 3ph-symmetrical faults & get practice to solve university questions.	All 5 Modules syllabus	4	Individual Activity. Written solution expected.	Text Book 1 and reference book 1.
2	Assignment 2: Technical quiz including all 5 modules	Students study the unsymmetrical faults & get practice to solve University question papers	All 5 Modules syllabus	9	Individual Activity. Written solution expected.	Text Book 1 and reference book 1.



Module -1

1. Define the following
 - i. Graph
 - ii. Sub-graph
 - iii. Path
 - iv. Tree
 - v. Co-tree
 - vi. Link
 - vii. Cut set
 - viii. Basic loop
2. Explain the following
 - i. Explain element node incidence matrix
 - ii. Explain bus incidence matrix
 - iii. Explain branch path incidence matrix
 - iv. Explain basic cutset incidence matrix
 - v. Explain augmented cutset incidence matrix
 - vi. Explain basic loop incidence matrix
 - vii. Explain augmented loop incidence matrix
3. Explain about the primitive network in impedance and admittance form.
4. Explain the formation of Y_{Bus} by method of inspection.
5. Explain the formation of Y_{Bus} by method of singular transformation.
6. With usual notations, prove that $Y_{Bus} = A^T [y] A$ using singular transformation.
7. Determine Y_{Bus} by singular transformation for the a system with data as follows

Element No	1	2	3	4	5
Bus code	0-1	1-2	2-3	3-0	2-0
Self admittance	1.4	1.6	2.4	2.0	1.8

Module -2

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

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

The schedule of active and reactive power is

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

Determine the voltage at the end of first iteration Using 1) Gauss – Seidal method, Take acceleration factor = 1.4

6. What is the need for acceleration factor?
7. What is Q-limit of generator?
8. Derive the expressions for power flow equations used in load flow analysis.

Module -3

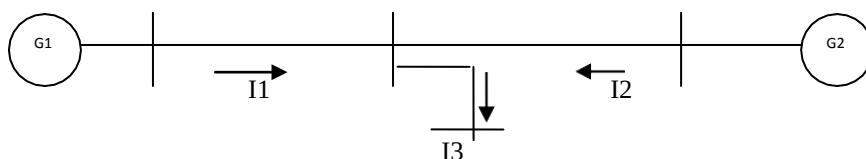
1. Explain the significance of Jacobian matrix of N-R LF analysis.
2. With the help of flow chart, explain the procedure of fast decoupled load flow analysis.



3. What are all the approximations made in fast decoupled load flow solution?
4. With the help of flow chart explain N-R method of load flow analysis
5. Refer question 5 of module 2 and solve by Newton Raphson Method.
6. Derive the expressions for diagonal elements of Jacobian matrices in NR method of load flow analysis.
7. Describe fast decoupled load flow method with a flow chart.
8. Compare different method of load flow solution procedure in respect of the following.
 - i) Time per iteration
 - ii) Total solution time
 - iii) Acceleration of convergence of iterative solution
 - iv) Adaptability for power system calculations

Module -4

1. Explain with reference to economic operation of electric power system, the equal incremental cost criterion. Comment on the same, if the filtration way to include the effect of transmission line losses also.
2. What are transmission line loss coefficients? Obtain the general expression B_{mn} with usual notations.
3. Explain in brief penalty factors & loss co-efficient. Derive the relevant expression.
4. For the system shown in figure, obtain the loss co-efficient. Assume I_1 & I_2 are in phase.



5. Explain problem formulation, solution procedure & algorithm for hydrothermal coordination.
6. Explain the modes of failures of a system.
7. Explain the generating system and its performance,.
8. Define system security and explain major functions involved in the system security.
9. Explain the importance of security assessment in the power system. What are the constraints and how these constraints differ from the normal operating constraints?
10. Distinguish between the normal operating constraints and security constraints of a power system.
11. What are the factors which affect the power system security?

Module-5

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

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



Subject Title	Programmable Logic Controllers		
Subject Code	BEE714C	CIE Marks	50
Number of Lecture Hrs / Week (L:T:P:S)	3:0:0:0	SEE Marks	50
Total Number of Lecture Hrs	40 hours Theory	Exam Hours	03
CREDITS – 03			

FACULTY DETAILS:

Name: Prof. Purnima I Savadatti	Designation: Asst. Professor	Experience: 10
No. of times course taught: 01	Specialization: Digital Electronics	

1.0 Prerequisite Subjects:

Sl.No	Branch	Semester	Subject
01	Electrical and Electronics Engineering	III	Digital logic circuits

2.0 Course Objectives

1. To explain advantages and disadvantages, main parts and their functions, basic sequence of operation of PLC.
2. To describe the hardware components: I/O modules, CPU, memory devices, other support devices and the functions of PLC memory map.
3. To describe program scan sequence, the communication of information to the PLC using different languages, internal relay instruction.
4. To explain identification of common operating modes found in PLCs, writing and entering the ladder logic programs.
5. To define the functions of Relays, Contactors, Motor Starters, Switches, Sensors, Output Control Devices, Seal-In Circuits and Latching Relays.
6. To explain conversion of relay schematics into PLC ladder logic programs and writing PLC programs directly from narrative descriptions.
7. To explain the functions of PLC counter instructions, applying combinations of counters and timers to control systems.
8. To describe the function of selectable timed interrupt and fault routine files and use of temporary end instruction.
9. To explain the execution of data transfer instructions, interruption of data transfer and data compare instructions.
10. To explain the basic operation of PLC closed-loop control system, various forms of mechanical sequencers and their operations.
11. To describe the operation of bit and word shift registers and develop programs that use shift registers.
12. To discuss the operation of various processes, structures of control systems and the method of communication between different industrial processes.

3.0 Course Outcomes

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

	Course Outcome	Cognitive Level	POs
C406.1	Describe the hardware components of PLC: I/O modules, CPU, memory devices, other support devices, operating modes and PLC programming.	L ₁ ,L ₂ ,L ₃ ,L ₄	PO1, PO2, PO8, PO10, PO12
C406.2	Develop Fundamental PLC Wiring Diagrams and Ladder Logic Programs	L ₁ ,L ₂ ,L ₃ ,L ₄	PO1, PO2, PO3, PO8, PO10, PO12
C406.3	Describe the operation of different program control instructions.	L ₁ ,L ₂ ,L ₃ ,L ₄	PO1, PO2, PO3, PO8, PO10, PO12



C406.4	Discuss the execution of data transfer instructions, data compare instructions and the basic operation of PLC closed-loop control system.	L ₁ ,L ₂ ,L ₃ ,L ₄	PO1, PO2, PO3, PO8, PO10, PO12
C406.5	Describe the operation of mechanical sequencers, bit and word shift registers, processes and structure of control systems and communication between the processes.	L ₁ ,L ₂ ,L ₃ ,L ₄	PO1, PO2, PO3, PO8, PO10, PO12
Total Hours of instruction		40	

4.0 Course Content

MODULE – 1

Programmable Logic Controllers: Introduction, Parts of a PLC, Principles of Operation, Modifying the Operation, PLCs versus Computers, PLC Size and Application. PLC Hardware Components: The I/O Section, Discrete I/O Modules, Analog I/O Modules, Special I/O Modules, I/O Specifications, The Central Processing Unit (CPU), Memory Design, Memory Types, Programming Terminal Devices, Recording and Retrieving Data, Human Machine Interfaces (HMIs) Basics of PLC Programming: Processor Memory Organization, Program Scan, PLC Programming Languages, Relay-Type Instructions, Instruction Addressing, Branch Instructions, Internal Relay Instructions, Programming Examine If Closed and Examine If Open Instructions, Entering the Ladder Diagram, Modes of Operation.

MODULE – 2

Developing Fundamental PLC Wiring Diagrams and Ladder Logic Programs: Electromagnetic Control Relays, Contactors, Motor Starters, Manually Operated Switches, Mechanically Operated Switches, Sensors, Output Control Devices, Seal-In Circuits, Latching Relays, Converting Relay Schematics into PLC Ladder Programs, Writing a Ladder Logic Program Directly from a Narrative Description. Programming Timers: Mechanical Timing Relays, Timer Instructions, On-Delay Timer Instruction, Off-Delay Timer Instruction, Retentive Timer, Cascading Timers.

MODULE - 3

Programming Counters: Counter Instructions, Up-Counter, Down-Counter, Cascading Counters, Incremental Encoder-Counter Applications, Combining Counter and Timer Functions. Program Control Instructions: Master Control Reset Instruction, Jump Instruction, Subroutine Functions, Immediate Input and Immediate Output Instructions, Forcing External I/O Addresses, Safety Circuitry, Selectable Timed Interrupt, Fault Routine, Temporary End Instruction, Suspend Instruction.

MODULE-4

Data Manipulation Instructions: Data Manipulation, Data Transfer Operations, Data Compare Instructions, Data Manipulation Programs, Numerical Data I/O Interfaces, Closed-Loop Control. Math Instructions: Math Instructions, Addition Instruction, Subtraction Instruction, Multiplication Instruction, Division Instruction, Other Word-Level Math Instructions, File Arithmetic Operations.

MODULE – 5

Sequencer and Shift Register Instructions: Mechanical Sequencers, Sequencer Instructions, Sequencer Programs, Bit Shift Registers, Word Shift Operations. Process Control, Network Systems, and SCADA: Types of Processes, Structure of Control Systems, On/Off Control, PID Control, Motion Control, Data Communications, Supervisory Control and Data Acquisition (SCADA).

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Automation

6.0 Relevance to Real World

SL. No	Real World Mapping
01	PLCs automate repetitive tasks, improving productivity and reducing manual effort.
02	PLCs monitor equipment and can shut down machines during unsafe conditions.



7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Industry Exposure	Organize industrial visits, internships, guest lectures, and industry-sponsored projects.

8.0 Books Used and Recommended to Students

Text Books: Suggested Learning Resources
1. Programmable Logic Controllers, Frank D Petruzella, McGraw Hill, 4th Edition, 2011
Reference Books
1. Programmable Logic Controllers an Engineer's Guide, E A Parr Newnes, 3rd Edition, 2013
2. Introduction Programmable Logic Controllers, Gary Dunning, Cengage, 3rd Edition, 2006

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

Website and Internet Contents References
1) https://www.plcopen.org/
2) https://inductiveautomation.com/resources/article/what-is-a-PLC

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	PLC Articles, stories & News	https://www.manufacturingtomorrow.com/tag/plc

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) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures 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:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks. Internal Assessment Test 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 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 3 sub-questions), should have a mix of topics under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.



12.0 Course Delivery Plan

Module No.	Lecture No.	Content of Lecture	% of Portion
1	1	Programmable Logic Controllers: Introduction, Parts of a PLC,	20
	2	Principles of Operation, Modifying the Operation, PLCs versus Computers, PLC Size and Application.	
	3	PLC Hardware Components: The I/O Section, Discrete I/O Modules, Analog I/O Modules, Special I/O Modules, I/O Specifications,	
	4	The Central Processing Unit (CPU), Memory Design, Memory Types,	
	5	Programming Terminal Devices, Recording and Retrieving Data, Human Machine Interfaces (HMIs)	
	6	Basics of PLC Programming: Processor Memory Organization, Program Scan, PLC Programming Languages,	
	7	Relay-Type Instructions, Instruction Addressing, Branch Instructions, Internal Relay Instructions, Programming Examine If Closed and Examine If Open Instructions,	
	8	Entering the Ladder Diagram, Modes of Operation.	
2	9	Developing Fundamental PLC Wiring Diagrams and Ladder Logic Programs: Electromagnetic Control Relays, Contactors,	20
	10	Motor Starters, Manually Operated Switches, Mechanically Operated Switches,	
	11	Sensors, Output Control Devices, Seal-In Circuits, Latching Relays,	
	12	Converting Relay Schematics into PLC Ladder Programs,	
	13	Writing a Ladder Logic Program Directly from a Narrative Description.	
	14	Programming Timers: Mechanical Timing Relays,	
	15	Timer Instructions, On-Delay Timer Instruction,	
	16	Off-Delay Timer Instruction, Retentive Timer, Cascading Timers	
3	17	Programming Counters: Counter Instructions, Up-Counter, Down-Counter,	20
	18	Cascading Counters, Incremental Encoder-Counter Applications,	
	19	Combining Counter and Timer Functions.	
	20	Program Control Instructions: Master Control Reset Instruction,	
	21	Jump Instruction, Subroutine Functions,	
	22	Immediate Input and Immediate Output Instructions,	
	23	Forcing External I/O Addresses, Safety Circuitry, Selectable Timed	
	24	Interrupt, Fault Routine, Temporary End Instruction, Suspend Instruction	
4	25	Data Manipulation Instructions: Data Manipulation,	20
	26	Data Transfer Operations, Data Compare Instructions,	
	27	Data Manipulation Programs,	
	28	Numerical Data I/O Interfaces, Closed-Loop Control.	
	29	Math Instructions: Math Instructions,	
	30	Addition Instruction, Subtraction Instruction, Multiplication Instruction, Division Instruction,	
	31	Other Word-Level Math Instructions,	
	32	File Arithmetic Operations	
5	33	Sequencer and Shift Register Instructions: Mechanical Sequencers,	20
	34	Sequencer Instructions, Sequencer Programs,	
	35	Bit Shift Registers, Word Shift Operations.	
	36	Process Control, Network Systems, and SCADA: Types of Processes,	
	37	Structure of Control Systems,	
	38	On/Off Control, PID Control,	
	39	Motion Control, Data Communications,	
	40	Supervisory Control and Data Acquisition (SCADA).	



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	Students explain the architecture, components, and operating principles of a PLC also Compare PLC-based control systems with conventional relay-based control.	All Modules of the syllabus.	8	Individual Activity.	Text book no.1
2	Online Quiz	Students study the topics of all five modules.	All Modules of the syllabus.	12	Individual Activity.	Text book no.1

14.0 QUESTION BANK

Module 1: 8051 Microcontroller Basics

- 1) Explain the construction and working principle of a Programmable Logic Controller with a neat diagram.
- 2) Compare PLCs, computers, and relay logic systems with suitable examples.
- 3) Describe the hardware components of a PLC and explain the function of each component.
- 4) Explain the working of discrete, analog, and special I/O modules with industrial applications.
- 5) Discuss CPU architecture, memory design, and memory organization in a PLC.
- 6) Explain the PLC scan cycle and its significance in industrial automation.
- 7) Describe PLC programming languages according to IEC 61131-3.
- 8) Explain relay-type instructions and branch instructions with ladder diagrams.
- 9) Write ladder logic programs using XIC and XIO instructions for industrial applications.
- 10) Explain PLC operating modes and programming terminal devices.

Module 2:

- 11) Explain various PLC wiring components such as relays, contactors, switches, sensors, and output devices with neat diagrams.
- 12) Describe seal-in circuits and latching relays with ladder logic diagrams.
- 13) Explain the procedure for converting conventional relay wiring diagrams into PLC ladder logic.
- 14) Develop ladder logic from a narrative description for an industrial process.
- 15) Explain the construction and operation of mechanical timing relays.
- 16) Explain different timer instructions available in PLC programming with ladder diagrams.
- 17) Compare ON-delay, OFF-delay, and retentive timers.
- 18) Explain cascading timers with industrial applications.
- 19) Design a ladder logic program for automatic motor start and stop using timers.
- 20) Explain industrial applications of PLC timers with suitable examples.

Module 3:

- 21) Explain different counter instructions used in PLC programming with ladder diagrams.
- 22) Describe the working of Up-Counter and Down-Counter instructions with suitable examples.
- 23) Explain cascading counters and discuss their industrial applications.
- 24) Explain the operation of incremental encoder counters and their applications in automation systems.
- 25) Develop a PLC program combining timer and counter functions for an industrial application.
- 26) Explain program control instructions used in PLCs.
- 27) Describe Master Control Reset, Jump, and Subroutine instructions with examples.
- 28) Explain immediate input/output instructions and their importance in PLC applications.
- 29) Discuss PLC safety circuitry and fault handling mechanisms.
- 30) Explain selectable timed interrupts, Temporary End, and Suspend instructions.

Module 4:

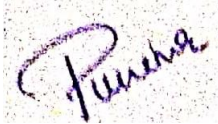
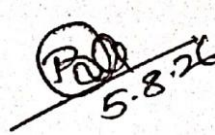
- 31) Explain different data manipulation instructions used in PLC programming with examples.
- 32) Describe data transfer operations and their applications in industrial automation.
- 33) Explain PLC data compare instructions and develop suitable ladder logic examples.
- 34) Discuss data manipulation programs used for industrial control applications.
- 35) Explain numerical data I/O interfaces and their role in PLC systems.
- 36) Explain closed-loop control systems with PLC-based examples.



- 37) Describe PLC math instructions including addition, subtraction, multiplication, and division.
- 38) Explain word-level mathematical operations used in PLC programming.
- 39) Discuss file arithmetic operations with suitable examples.
- 40) Design a PLC-based closed-loop control system using data and math instructions.

Module 5:

- 41) Explain sequencer instructions in PLC programming with suitable examples.
- 42) Describe the operation and applications of mechanical sequencers.
- 43) Develop a PLC sequencer program for an industrial automation process.
- 44) Explain bit shift registers and word shift operations with ladder diagrams.
- 45) Discuss the applications of shift registers in manufacturing systems.
- 46) Explain the structure of process control systems with block diagrams.
- 47) Compare ON/OFF control and PID control systems.
- 48) Explain PID control operation and its applications in industrial automation.
- 49) Describe motion control systems and their applications.
- 50) Explain industrial communication networks used in automation systems.
- 51) Explain SCADA architecture, components, and applications.

Prepared by	Checked by		
			
Prof. Purnima I. Savadatti	Dr. M. P. Yenagimath	HOD	Principal

Subject Title	Sensors & Actuators		
Subject Code	BEC755D	IA Marks	50
Number of Lecture Hrs/ Week	03 L	Exam Marks	50
Total Number of Lecture Hrs	40	Exam Hours	03

FACULTY DETAILS:			
Name: Prof. K.S.Patil.	Designation: Asst. Professor	Experience: 32yrs	
No. of times course taught: 03	Specialization: VLSI & Embedded Systems		

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	ECE	III	Sensors & Instrumentation
02	ECE	III	Electronic Principles & Circuits

2.0 Course Objectives

1. To provide the fundamental knowledge about sensors and measurement system.
2. Understand the working of various actuators suitable in industrial process control systems.
Understand the principle and application of smart sensors.
3. To discuss the principle, design and working of transducers for the measurement of physical time varying quantities.
4. To discuss basics of signal conditioning and signal conditioning equipment

3.0 Course Outcomes

Having successfully completed this course, the student will be able to draw and analyze.

	Course Outcome	Cognitive Level	POs
C411.1	Discuss the fundamental concepts related to sensors and measurement, functional elements of measurement system, I/O Characteristics of measurement system	U	PO1, PO2, PO4 PO5, PO7
C411.2	Interpret and analyze the static and dynamic characteristics of instruments.	U	PO2, PO3, PO5, PO6
C411.3	Elucidate the working principle and usage of different transducers for temperature, and	U	PO2, PO3, PO4 PO5, PO6, PO7
C411.4	.Discuss the principle and working of strain, force and torque measurement	U	PO3, PO4, PO5 PO6, PO7, PO12
C411.5	Analyse the signal conditioning and signal conditioning equipment	U	PO1, PO2, PO10 PO12
Total Hours of instruction		40	

4.0 Course Content

Course Content:

Module	Teaching Hours	Bloom's Taxonomy (RBT) level
Module 1: Sensors and Transducers: Introduction, Definition of Sensors and Transducers, Classification of Transducers, Advantages and Disadvantages of Electrical Transducers Measurement: Introduction to measurement and Instrumentation, Definition, significance of Measurement, Methods of measurement, Modes of measurement, Elements of generalized measurement system with example. Input-output configuration of measuring instruments and measurement systems, Applications of measurement systems	08 Hours	L1, L2,L3
Module 2: Static and Dynamic Characteristics of instruments: Introduction, Definition relating to measuring instruments. Static characteristics - Accuracy, Errors and Correction, Static calibration Range and span. Scale readability Repeatability and Reproducibility, Drift, Accuracy and Precision, Sensitivity, Linearity, Hysteresis, Threshold and Resolution, Dead Zone and Dead Time, Loading Effects and Noise. Dynamic Characteristics – Dynamic Response, Dynamic characteristics of a measurement system, Dynamic analysis of a measurement system, Zero, First and Second order system	08 Hours	L1,L2,L3
Module 3: Measurement of Temperature: Introduction, Temperature measuring instruments, RTD ,Thermistors, Thermocouple Thermometers, Radiation Pyrometers, Optical Pyrometers Measurement of Displacement: Introduction, Principles of Transduction – Variable resistance devices, Variable Inductance Transducer, Induction Potentiometers, Synchros and Resolvers, Variable Capacitance Transducer, Hall Effect Devices, Proximity Devices, Digital Transducer	08 Hours	L1,L2,L3
Module 4: Measurement of Strain: Introduction, Factors affecting strain measurements, Types of Strain Gauges, Theory of operation of resistance strain gauges, Types of Electrical Strain Gauges –Wire gauges, unbounded strain gauges, foil gauges, semiconductor strain gauges, Thin film Guages (principle, types & list of characteristics only), Strain gauge Circuits – Wheatstone bride circuit, Applications Measurement of Force & Torque: Introduction, Force measuring sensor – Load cells – column types devices, proving rings, cantilever beam, pressductor. Hydraulic load cell, electronic weighing system Torque measurement: Absorption type, transmission type, stress type & deflection type.	08 Hours	L1,L2,L3
Module 5:	08 Hours	L1,L2,L3

Signal Condition: Introduction, Functions of Signal Conditioning Equipment, Amplification, Types of Amplifiers, Mechanical Amplifiers Fluid Amplifiers, Optical Amplifiers, Electrical and electronic Amplifiers Data Acquisition Systems and Conversion: Introduction, Objectives and Configuration of Data Acquisition System, Data Acquisition Systems, Data Conversion		
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5.0 Relevance to future subjects

SI No	Semester	Subject	Topics
02	VIII	Projects on VLSI	Projects and Research

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Analyze different types of sensors
02	Design of different types Electrical actuating Systems

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Tutorial	Topic: Measuring Instruments
02	NPTEL	Demonstration and Application

8.0 Books Used and Recommended to Students

Text Books
Text Books: 1. Electrical and Electronic Measurements and instrumentation, R.K Rajput, S. Chand, 4th Edition, 2015 2. Instrumentation: Devices and Systems, C S Rangan, G R Sarma, V S V Mani, 2nd Edition (32 Reprint), McGraw Hill Education (India), 2014.
Reference Books
Reference Books: 1. Electrical and Electronic Measurements and Instrumentation, A K Sawhney, 17th Edition, (Reprint 2004), Dhanpat Rai & Co. Pvt. Ltd., 2004 2. A Course in Electronics and Electrical Measurements and Instruments, J.B. Gupta, Katson Books, 13th Edition, 2008
Additional Study material & e-Books
1. VTU on line notes.

9.0

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

Website and Internet Contents References

<https://www.nist.gov> > how-do-you-measure-it > how-d...

<https://technav.ieee.org> > topic > sensors-and-actuators

<https://apmonitor.com> > pdc > index.php > Main > Feed...

<https://nptel.co.in>
<https://cti-ct.com> > article_75_Industrial-Valves-Actuato...

https://www.edx.org/school/iitbombayx?utm_source=bing&utm_medium=cpc&utm_term=iit-bombay&utm_campaign=partner-iit-bombay

10.0

Magazines/Journals Used and Recommended to Students

Sl. No	Magazines/Journals	website
1	IEEE Xplorer	http://iee.com
2	International Journal of Science and Technology	http://www.sciencedirect.com/science/journal/00207683
3	Journal of Communication Engineering	http://iee.com

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)**

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**

(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**)

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 scored out of 100 shall be reduced proportionally to 50 marks

12.0 Course Delivery Plan

Course Delivery Plan:

MODU LE	LECTU RE NO.	CONTENT OF LECTURE	% OF PORTIO N
1	1	Introduction, Definition of Sensors and Transducers	20
	2	Classification of Transducers,	
	3	Advantages and Disadvantages of Electrical Transducers.	
	4	Introduction to measurement and Instrumentation Definition	
	5	significance of Measurement	
	6	Methods of measurement, Modes of measurement	
	7	Elements of generalized measurement system with example.	
	8	Input-output configuration of measuring instruments and measurement systems, Applications of measurement systems	
2	9	Introduction, Definition relating to measuring instruments	40
	10	Accuracy, Errors and Correction, Static calibration Range and span	
	11	Scale readability Repeatability and Reproducibility, Drift readability Repeatability and Reproducibility, Drift	
	12	Loading Effects and Noise.	
	13	Dynamic Characteristics– Dynamic Response	
	14	Dynamic characteristics of a measurement system	
	15	Dynamic analysis of a measurement system	
	16	Zero, First and Second order system.	
3	17	Measurement of Temperature: Introduction, Temperature measuring instruments	60
	18	RTD, Thermistors	
	19	Thermocouple Thermometers, Radiation Pyrometers, Optical Pyrometers	
	20	Measurement of Displacement: Introduction, Principles of Transduction	
	21	Variable resistance devices, Variable Inductance Transducer	
	22	Induction Potentiometers, synchro's and Resolvers	
	23	Variable Capacitance Transducer, Hall Effect Devices	
	24	Proximity Devices, Digital Transducer	
4	25	Measurement of Strain: Introduction, Factors affecting strain measurements	80

	26	Types of Strain Gauges, Theory of operation of resistance strain gauges	
	27	Types of Electrical Strain Gauges Wire gauges, unbounded strain gauges, foil gauges, unbounded strain gauges	
	28	semiconductor strain gauges, Thin film Gauges ,Strain gaugeCircuits	
	29	Wheatstone bridge circuit, Applications	
	30	Measurement of Force & Torque: Introduction, Force measuring sensor Load cells – column types devices, proving rings, cantilever beam, pressductor, Hydraulic load cell,	
	31	Electronic weighing system. Torque measurement: Absorption type	
	32	transmission type, stress type & deflection type	
5	33	Signal Condition: Introduction, Functions of Signal Conditioning Equipment	100
	34	Amplification, Types of Amplifiers	
	35	Mechanical Amplifiers Fluid Amplifiers, Optical Amplifiers	
	36	Electrical and electronic Amplifiers	
	37	Data Acquisition Systems and Conversion: Introduction ,Objectives	
	38	Configuration of Data Acquisition System	
	39	Data Acquisition Systems, Data Conversion	
	40	Revision of VTU Questions Papers	

13.0

QUESTION BANK

MODULE -1

1. Define Sensor & transducer.
2. Give the classification of transducers
3. Define, significance of measurement
4. Explain mechanical, electrical and electronic instruments
5. Explain Input-output configuration of measuring instruments and measurement systems
6. Mention Methods of correction for interfering and modifying inputs

MODULE -2

1. Define accuracy , precision
2. Define static error, scale range and scale span, reproducibility
3. Explain signal to noise ratio, sensitivity, linearity, hysteresis
4. Explain Dead Zone and Dead Time
5. Explain loading effects and noise
6. Explain Dynamic response for Zero Order System
7. Explain Dynamic response for First Order System
8. Explain Dynamic response for Second Order System

MODULE -3

1. Mention the instruments for measuring temperature
2. Explain RTD
3. Explain Thermocouple, laws of thermocouple
4. Explain Thermometer, Radiation Pyrometer
5. Write a note Optical Pyrometers
6. Explain Principle of Transduction
7. Explain Hall effects Devices and Digital Transducers

MODULE -4

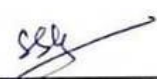
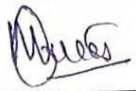
1. Mention factors affecting strain measurements
2. Mention the types of strain Gauges.
3. Mention the types of Electrical Strain Gauges.
4. Explain principle of Thin film Gauges.
5. Explain Wheatstone bridge circuit, with Applications.
6. Mention the applications of resistance strain gauges,
7. Explain Force measuring sensor –Load cells – column types devices
8. Explain Torque measurement by Absorption type.
9. Explain Torque measurement: by transmission type, stress type & deflection type.
10. Explain Torque measurement: by stress type & deflection type.

MODULE-5

1. Explain the functions of Signal Conditioning Equipment.
2. Explain Amplification process. and Types of Amplifier
3. Explain Mechanical amplifier.
4. Explain Fluid amplifier.
5. Explain Optical amplifier
6. Explain Principle of operation Electrical and Electronic Amplifiers.
7. Mention objectives of data acquisition and conversion.
8. Explain configuration of data acquisition System

15.0 University Result

Examination	FCD	FC	SC	% Passing
DEC2024	08	04	---	95.16
DEC2025	12	01	-	100

Prepared by	Checked by		
			
Prof. K.S.Patil	Prof.S.S.Kamate	HOD	Principal

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			Course Plan
			NCER
			AY: 2026-27 (Odd Sem)

Subject Title	NON CONVENTIONAL ENERGY RESOURCES		
Subject Code	BME755D	CIE Marks	50
Number of Lecture Hrs / Week(L:T:P:S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Exam Hours	03
CREDITS – 03			

FACULTY DETAILS:		
Name: Dr. M. M. Shivashimpi	Designation: Associate Professor	Experience: 19
No. of times course taught: 02	Specialization: Thermal Engineering	

1.0 Prerequisite Subjects:

Sl. No.	Branch	Semester	Subject
01	Students should have the knowledge of basic subjects	I/II	Mathematics, Physics and Chemistry & Renewable Energy Sources

2.0 Course Objectives

1. To introduce the concepts of solar energy, its radiation, collection, storage and application.
2. To introduce the concepts and applications of Wind energy, Biomass energy, Geothermal energy and Ocean energy as alternative energy sources.
3. To explore society's present needs and future energy demands.
4. To examine energy sources and systems, including fossil fuels and nuclear energy, and then focus on alternate, renewable energy sources such as solar, biomass (conversions), wind Power, geothermal, etc.
5. To get exposed to energy conservation methods.

3.0 Course Outcomes

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

CO'S	Course Outcome	Cognitive Level	PO's	PSO's
C411.1	Describe the environmental aspects of nonconventional energy resources in Comparison with various conventional energy systems, their prospects and limitations, the need of Renewable energy resources, historical and latest developments.	L1,L2&L3	1,2,3,4, 5,6,7,8,9,10, 11,12	1,2
C411.2	Describe the use of solar energy and the various components used in the energy production with respect to applications like heating, cooling, desalination, power generation, drying, cooking etc.	L1,L2&L3	1,2,3,4, 5,6,7,8,9,10, 11,12	1,2

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C411.3	Understand The Performance Analysis of Liquid Flat Plate Collectors.	L1,L2&L3	1,2,3,4, 5,6,7,8,9,10,	1,2
C411.4	Appreciate the need of Wind Energy and the various components used in energy generation and know the classifications. Acquire the knowledge of tidal power and Ocean Thermal Energy Conversion principles and applications.	L1,L2&L3	1,2,3,4, 5,6,7,8,9,10, 11,12	1,2
C411.5	Acquire the knowledge of fuel cells and geothermal principles and applications. Understand the concept of Biomass energy resources and their classification, types of biogas Plants- applications	L1,L2&L3	1,2,3,4, 5,6,7,8,9,10, 11,12	1,2

4.0 Course Content

Module-1

Introduction: Energy source, India's production and reserves of commercial energy sources, need for nonconventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind Biomass, ocean temperature difference, tidal and waves, geothermal, tar sands and oil shale, nuclear (Brief descriptions); advantages and disadvantages, comparison (Qualitative and Quantitative).

Solar Radiation Measurement of Solar Radiation

Solar Radiation: Extra Terrestrial radiation, spectral distribution of extraterrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. Measurement of Solar Radiation: Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.

Module-2

Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, and zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sun, day length, numerical examples.

Radiation Flux on a Tilted Surface Solar Thermal Conversion

Radiation Flux on a Tilted Surface: Beam, diffuse and reflected radiation, expression for flux on a tilted surface (no derivations) numerical example. Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis); sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, and refrigeration. Distillation (Qualitative analysis) solar pond, principle of working, operational problems.

Module-3

Performance Analysis of Liquid Flat Plate Collectors

General description, collector geometry, selective surface (qualitative discussion) basic energy balance equation, stagnation temperature, transmissivity of the cover system, transmissivity – absorptivity product, numerical examples. The overall loss coefficient, correlation for the top loss coefficient, bottom and side loss coefficient, problems (all correlations to be provided). Temperature distribution between the collector tubes, collector heat removal factor, collector efficiency factor and collector flow factor, mean plate temperature, instantaneous efficiency (all expressions to be provided). Effect

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	Mech. Engg. Dept.	
	Course Plan	
	NCER	
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of various parameters on the collector performance; collector orientation, selective surface, fluid inlet temperature, number covers, dust.

Photovoltaic Conversion

Photovoltaic Conversion: Description, principle of working and characteristics, applications.

Module-4

Wind Energy:

Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis windmills, elementary design principles; coefficient of performance of a windmill rotor, aerodynamic considerations of windmill design, numerical examples.

Tidal Power:

Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations.

Ocean Thermal Energy Conversion:

Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.

Module-5

Hydrogen Energy:

Properties of Hydrogen with respect to its utilization as a renewable form of energy, sources of hydrogen, production of hydrogen, electrolysis of water, thermal decomposition of water, thermo chemical production biochemical production. Storage & Transportation Methods: Gaseous, cryogenic and metal hydrides, application of hydrogen, domestic and industrial safe burning of hydrogen.

Geothermal Energy Conversion:

Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy.

Energy from Biomass:

Photosynthesis, photosynthetic oxygen production, energy plantation, biogas production from organic wastes by anaerobic fermentation, description of biogas plants, transportation of biogas, problems involved with biogas production, application of biogas, application of biogas in engines, advantages.

5.0

Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VII & VIII	Project work	Implementation of renewable energy based projects

6.0

Relevance to Real World

Sl. No	Real World Mapping
01	Electrical power generation using renewable energy sources like wind and solar.
02	Generation of heat energy by using solar and biomass.
03	Conservation of non-renewable energy sources.

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			Course Plan
			NCER
			AY: 2026-27 (Odd Sem)

7.0 Gap Analysis and Mitigation

Sl No	Delivery Type	Details
01	Practical Assignment	Practical assignments could be given to the students to construct a model to demonstrate generation of heat and electricity using solar and wind energy.
02	Industrial visit	To provide practical exposure to the students' industrial visit to solar power plants and wind mills could be arranged.

8.0 Books Used and Recommended to Students

Text Books	
1. Non Convention Energy Resources by B H Khan, 3rd Edition, McGraw Hill Education (India) Pvt. Ltd. 2. Non-Conventional Energy Sources by G.D Rai, Khanna Publishers (2003). 3. Solar Energy by Subhas P Sukhatme, 2nd Edition Tata McGraw Hill (1996). 4. Renewable energy sources and Conversion technology by N.K.Bansal, Manfred Kleeman and Michael Meliss, Tata McGraw Hill (2004).	
Reference Books	
1. Principles of Energy conversion, A. W. Culp Jr., McGraw Hill, 1996 2. Non-Convention EnergyResources, Shobh Nath Singh, Pearson, 2018	

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

Website and Internet Contents References	
- E-book URL:https://www.pdfdrive.com/non-conventional-energy-sources-e10086374.html - E-book URL:https://www.pdfdrive.com/non-conventional-energy-systems-nptel-d17376903.html https://www.youtube.com/watch?v=ybZbwKIB1Ic https://onlinecourses.nptel.ac.in/noc23_ge04/preview. https://www.youtube.com/watch?v=LOVZE9WalRE Fundamentals of Photovoltaic https://www.youtube.com/watch?v=BcVzc6IGwS0	

10.0 Magazines/Journals Used and Recommended to Students

Sl. No	Magazines/Journals	website
1	Energy & Environment	https://en.wikipedia.org/wiki/Energy_%26_Environment
2	Journal of Renewable and Sustainable Energy	https://en.wikipedia.org/wiki/Journal_of_Renewable_and_Sustainable_Energy
3	Solar Energy Journal	https://en.wikipedia.org/wiki/Solar_Energy_(journal)
4	Renewable and Sustainable Energy Reviews	https://en.wikipedia.org/wiki/Renewable_and_Sustainable_Energy_Reviews

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	Mech. Engg. Dept.	
	Course Plan	
	NCER	
	AY: 2026-27 (Odd Sem)	

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:

- The CIE is the sum of Average of Two Internal Assessment Tests each of 25 marks and any two Assessment methods for 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assessment methods mentioned in the 22OB4.2, if an assignment is project based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled down sum of two tests and other methods of assessment for a total of 50 marks. (**Duration 01 hours**)

Internal Assessment Test 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 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 3 sub questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

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			Course Plan
			NCER
			AY: 2026-27 (Odd Sem)

12.0 Course Delivery Plan

Module	Lecture No.	Content of Lecturer	Teaching Methodology	% of Portion
1	Introduction:			20
	1	Energy source, India's production and reserves of commercial energy sources	India energy resource maps	
	2	Need for non-conventional energy sources	Chalk and Talk	
	3	Energy alternatives, solar, thermal, photovoltaic. Water power, wind	PowerPoint presentation	
	4	Biomass, ocean temperature difference, tidal and waves, geothermal	PowerPoint presentation	
	5	Tar sands and oil shale, nuclear (Brief descriptions) Advantages and disadvantages, comparison (Qualitative and Quantitative).	PowerPoint presentation	
	Solar Radiation Measurement of Solar Radiation			
	6	Solar Radiation: Extra Terrestrial radiation, spectral distribution of extraterrestrial radiation	PowerPoint presentation	
2	7	Solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data.	PowerPoint presentation	
	8	Measurement of Solar Radiation: Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.	PowerPoint presentation	
	Solar Radiation Geometry:			
	9	Flux on a plane surface, latitude, declination angle	PowerPoint presentation	
	10	surface azimuth angle, hour angle, and zenith angle	PowerPoint presentation	
	11	Solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time.	PowerPoint presentation	40
	12	Apparent motion of sun, day length, numerical examples.	Chalk and Talk	
	Radiation Flux on a Tilted Surface Solar Thermal Conversion			
	13	Radiation Flux on a Tilted Surface: Beam, diffuse and reflected radiation, expression for flux on a tilted surface (no derivations) numerical example.	Chalk and Talk	
	14	Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis)	PowerPoint presentation	
	15	Sensible heat storage, latent heat storage, application of solar energy water heating.	PowerPoint presentation	
	16	Space heating and cooling, active and passive systems, power generation, and refrigeration. Distillation (Qualitative analysis) solar pond, principle of working, operational problems.	PowerPoint presentation	
3	Performance Analysis of Liquid Flat Plate Collectors			60

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			Course Plan
			NCER
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	17	General description, collector geometry, selective surface (qualitative discussion)	PowerPoint presentation	
	18	Basic energy balance equation, stagnation temperature, transmissivity of the cover system	Chalk and Talk	
	19	Transmissivity – absorptivity product, numerical examples.	Chalk and Talk	
	20	The overall loss coefficient, correlation for the top loss coefficient, bottom and side loss coefficient, problems (all correlations to be provided).	Chalk and Talk	
	21	Temperature distribution between the collector tubes, collector heat removal factor, collector efficiency factor and collector flow factor, mean plate temperature, instantaneous efficiency (all expressions to be provided).	Chalk and Talk	
	22	Effect of various parameters on the collector performance	Chalk and Talk	
	23	Collector orientation, selective surface, fluid inlet temperature, number covers, dust.	Chalk and Talk	
	Photovoltaic Conversion			
	24	Photovoltaic Conversion: Description, principle of working and characteristics, applications.	PowerPoint presentation	
	Wind Energy:			
4	25	Properties of wind, availability of wind energy in India	PowerPoint Presentation with Maps and Chart	80
	26	Wind velocity and power from wind;	Chalk and Talk	
	27	Major problems associated with wind power, wind machines;	PowerPoint Presentation	
	28	Types of wind machines and their characteristics, horizontal and vertical axis windmills, elementary design principles;	PowerPoint Presentation	
	29	Coefficient of performance of a windmill rotor, aerodynamic considerations of windmill design, numerical examples.	Chalk and Talk	
	Tidal Power:			
	30	Tides and waves as energy suppliers and their mechanics;	Power Point Presentation	
	31	Fundamental characteristics of tidal power, harnessing tidal energy, limitations.	PowerPoint Presentation	
	Ocean Thermal Energy Conversion:			
	32	Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.	PowerPoint Presentation	
5	Hydrogen Energy:			100
	33	Properties of Hydrogen with respect to its utilization as a renewable form of energy, sources of hydrogen	PowerPoint Presentation	
	34	Production of hydrogen, electrolysis of water, thermal decomposition of water, thermo chemical production biochemical production.	PowerPoint Presentation	
	35	Storage & Transportation Methods: Gaseous, cryogenic and metal hydrides,	PowerPoint Presentation	

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			AY: 2026-27 (Odd Sem)

	36	Application of hydrogen, domestic and industrial safe burning of hydrogen.	PowerPoint Presentation
	Geothermal Energy Conversion:		
	37	Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy.	PowerPoint Presentation
	Energy from Biomass:		
	38	Photosynthesis, photosynthetic oxygen production, energy plantation,	PowerPoint Presentation
	39	Biogas production from organic wastes by anaerobic fermentation, description of biogas plants, transportation of biogas,	PowerPoint Presentation
	40	Problems involved with biogas production, application of biogas, application of biogas in engines, advantages.	PowerPoint Presentation

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: Introduction to Non-conventional energy Resources, Solar Radiation Measurement of Solar Radiation	Students study the Topics and write answer. Get practice to solve university questions.	1,2 module of the syllabus	04	Individual Activity.	Book 1, 2 of the reference list. Website of the Reference list
2	Assignment 2: Wind Energy, Biomass energy, wave energy, tidal energy, OTEC and green energy.	Students study the Topics and write answer. Get practice to solve university questions.	3,4,5 module of the syllabus	09	Individual Activity.	Book 1, 2 of the reference list. Website of the Reference list
3	Quiz: All the module	Students study the Topics and prepare the multiple choice questioner with answer.	5 Module of the syllabus	13	Group Activity.	Book 1, 2 of the reference list. Website of the Reference list

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14.0

QUESTION BANK

Module	Questions
I	1. Enlist and explain the merits and demerits of any 3 non-conventional energy sources. 2. Explain tar sands and oil shale as energy source and mention their limitations. 3. With schematic representation, explain mechanism of absorption, scattering beam and diffuse radiation received at earth's surface. 4. Explain with a neat sketch, explain the working of pyrenometer. 5. Explain briefly the need for alternate energy sources.
II	1. Define the following terms with respect to solar radiation i) hour angle ii) declination angle iii) zenith angle iv) latitude angle v) solar azimuth angle. 2. Calculate the day length of location (latitude 22° 00' W, 73° 10' E) during the month of March 1. 3. With the usual expression for flux explain beam and diffuse radiation on a tilted surfaces 4. With a neat sketch explain working of liquid flat plate collector. 5. Describe solar pond for solar energy collection and storage. 6. Explain how solar energy can be used for drying with a neat sketch.
III	7. Calculate the angle of incidence of beam radiation on a plane surface, tilted by 45° from horizontal plane and pointing 30° west of south located at Mumbai at 1.30 PM (IST) on 15th November . The longitude and latitude of Mumbai are 72°49' E and 18°54' N respectively. The standard longitude for IST 81°44'.
IV	1. List and discuss the various parameters that affect the performance of collector. 2. Explain the heat transfer process in LFPC with neat sketch and write energy balance equation, explaining each terminal. 3. Explain the working principle and I-V characteristics of PV cell. 4. Define i) collector efficiency factor ii) collector heat removal factor of LPFC write expression for the above. 5. What are the applications of solar PV cell? 6. Plot the variation of τ_r, τ_a and τ with the angle of incident for the following cover system Material : glass, Number of covers : 3, Thickness of each cover (δ_c) = 4 mm , Refractive index of glass relative to air (n_2) = 1.52 , extinction coefficient of glass (K)= 15 m⁻¹ and angle of incidence (θ_1) = 15°. Assume n_1 = 1.
V	1. Describe the main consideration in selecting the site for wind generators. 2. Explain With Neat Sketch The Closed Rankine Cycle OTEC System. 3. Explain Briefly The Harnessing Of Tidal Energy. 4. Explain advantages and disadvantages of tidal energy. 5. The wind blows with a velocity of 16m/s and 15°C. Assume 1 standard atmospheric pressure and turbine diameter = 115 m with operating speed = 40 rpm at maximum efficiency, calculate the following i) Total power density in wind stream ii) Maximum obtainable power density iii) Reasonable obtainable power density iv) Total power v) Torque and axial thrust.

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VI	1. What Are Fuel Cells 2. Classify Fuel Cells 3. Explain The Operating Principles Of Fuel Cells 4. Explain Zero Energy Concepts. 5. What Are The Benefits Of Hydrogen Energy 6. Explain Hydrogen Production Technologies Electrolysis Method 7. Describe Hydrogen Energy Storage 8. Give Applications Of Hydrogen Energy 9. What Are The Problems Associated With Hydrogen Energy? 10. State The Environmental Problem Associated With Geothermal Energy Conversion 11. List The Factors Affecting The Biogas Generation 12. Sketch and explain the working of fixed dome type biogas plant used in India
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14.0 University Result

Examination	No. of Students	No. of Students Passed	FCD	FC	SC	Fail	% Passing
Dec./Jan 2026	53	53	43	08	02	Nil	100

Prepared by	Checked by		
			
Dr. M. M. Shivashimpi	Dr. K. M. Akkoli	Dr. S.N. Topannavar	Dr. S.C. Kamate
Course coordinator	Module coordinator	HOD	Principal