Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Subject: Electrical Engineering

Name of the Course: T.Y. B. Tech

(Syllabus to be implemented from w. e. f. June 2025)

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Faculty of Engineering & Technology

B. Tech (Electrical Engineering)

PROGRAMME: BACHELOR OF ELECTRICAL ENGINEERING

PROGRAMME OBJECTIVES

A. PROGRAM EDUCATIONAL OBJECTIVES

1. Deliver fundamental as well as advanced knowledge with research initiatives in the field of electrical engineering with emphasis on state-of-the-art technology.
2. Graduates will demonstrate measurable progress in the fields they choose to pursue.
3. Design and develop technically feasible solutions for real world applications which are economically viable leading to societal benefits.
4. To nurture Graduates to be sensitive for ethical, societal and environmental issues while conducting their professional work.

B. PROGRAMME OUTCOMES

Students attain the following outcomes: -

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

2 **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3 **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and 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 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 work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12 **Lifelong 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.

C. PROGRAMME SPECIFIC OUTCOMES

1 An ability to specify, design, and analyze Power Systems, Electrical Machinery, Electronic Circuits, Drive Systems, Lightning Systems and deliver technological solutions by adapting advances in allied disciplines.

2 Apply knowledge of electrical engineering to meet the desired needs within realistic constraints viz. economical, ethical, and environmental and safety.

3 Apply modern software tools for the design, simulation, and analysis of electrical systems to successfully adapt to multi-disciplinary environments.

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

FACULTY OF SCIENCE & TECHNOLOGY

NEP 2020 Compliant Curriculum

With effect from 2023-2024

Semester I (Common for All Engineering Branches)

Course Type	*Course Code*	*Name of the Course*	*Engagement Hours*		*Credits*	*FA*	*SA*		*Total*
			L	*P*		*ESE*	*ISE*	*ICA*	
BSC	BS-01/ BS-02	Engineering Physics / Engineering Chemistry $	3	2	4	70	30	25	125
	BS-03	Engineering Mathematics-I	3	2	4	70	30	25	125
ESC	ES-01/ ES-02	Basics of Civil and Mechanical Engineering /Basic Electrical & Electronics Engineering $	3	2	4	70	30	25	125
	ES-03	Engineering Mechanics	3	2	4	70	30	25	125
AEC	AE-01	Communication Skills	1	2	2		25	25	50
CC	CC-01	Sports and Yoga or NSS/NCC/UBA (Liberal Learning Course-I)	1	2	2			25	25
SEC	SE-01	Workshop Practices		2	1			25	25
		Total	**14**	**14**	**21**	**280**	**145**	**175**	**600**
		Student Induction Program**							

Semester II (Common for All Engineering Branches)

Course Type	*Course Code*	*Name of the Course*	*Engagement Hours*		*Credits*	*FA*	*SA*		*Total*
			L	*P*		*ESE*	*ISE*	*ICA*	
BSC	BS-01/ BS-02	Engineering Physics / Engineering Chemistry $	3	2	4	70	30	25	125
	BS-04	Engineering Mathematics – II	3	2	4	70	30	25	125
ESC	ES-01/ ES-02	Basics of Civil and Mechanical Engineering / Basic Electrical & Electronics Engineering $	3	2	4	70	30	25	125
		Engineering Graphics and CAD		4	2		25	50	75
SEC	SE-02	Data Analysis and Programming Skills	1	2	2		25	25	50
CC	CC-02	Professional Personality Development (Liberal Learning Course-II)	1	2	2		25	25	50
IKS	IKS-01	Introduction to Indian Knowledge System	2		2		25	25*	50
		Total	**13**	**14**	**20**	**210**	**190**	**200**	**600**
		Democracy, Elections and Good Governance *	**1**			**50**			

***For IKS activity report should be submitted**

BSC- Basic Science Course, ESC- Engineering Science Course, PCC- Programme Core Course,

AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses ,

VSEC-Vocational and Skill Enhancement Course

- Legends used–

L	Lecture	FA	Formative Assessment
T	Tutorial	SA	Summative Assessment
P	Lab Session	ESE	End Semester Examination
		ISE	In Semester Evaluation
		ICA	Internal Continuous Assessment

- **Notes-**

1. $ - Indicates approximately half of the total students at F. Y. will enroll under Group A and the remaining will enroll under Group B.

   Group A will take up the course of Engineering Physics (theory & laboratory) in Semester I and will take up the course of Engineering Chemistry (theory & laboratory) in Semester II.

   Group B will take up the course of Engineering Chemistry (theory & laboratory) in Semester I and will take up the course of Engineering Physics (theory & laboratory) in Semester II.

2. # - For the Course (C113) Basic Electrical & Electronics Engineering, Practicals of Basic Electrical Engineering and Basic Electronics Engineering will be conducted in alternate weeks.

3. @ - For the Course (C113) Basics of Civil and Mechanical Engineering, Practicals of Basics of Civil Engineering and Basics of Mechanical Engineering will be conducted in alternate weeks.

4. In Semester Evaluation (ISE) marks shall be based upon the student's performance in a minimum of two tests & mid-term written test conducted & evaluated at the institute level.

   Internal Continuous Assessment Marks (ICA) are calculated based on student's performance during laboratory sessions/tutorial sessions.

5. *- Democracy, Elections & Good Governance is a mandatory course. The marks earned by students in this course shall not be considered for the calculation of SGPA/CGPA. However, the student must complete the End Semester Examination (ESE) of 50 marks (as prescribed by the university) for fulfillment of this course. This course is not considered a passing head for counting passing heads for ATKT. However, students must pass this subject for the award of the degree.
6. Students must complete an induction program of a minimum of five days before the commencement of the regular academic schedule in the first semester.

** GUIDELINES FOR INDUCTION PROGRAM (C119)

New entrants into an Engineering program come with diverse thoughts, mindsets, and different social, economic, regional, and cultural backgrounds. It is important to help them adjust to the new environment and inculcate in them the ethos of the institution with a sense of larger purpose.

An induction program for the new UG entrant students is proposed at the commencement of the first semester. It is expected to complete this induction program before the commencement of the regular academic schedule.
Its purpose is to make new entrants comfortable in their new environment, open them up, set a healthy daily routine for them, create bonding amongst their peers as well as between faculty and students, develop awareness, sensitivity, and understanding of the self, people around them, society at large, and nature.
The Induction Program shall encompass (but not be limited to) below activities –

1. Physical Activities
2. Creative Arts
3. Exposure to Universal Human Values
4. Literary Activities
5. Proficiency Modules
6. Lectures by Experts / Eminent Persons
7. Visit to Local Establishments like Hospital /Orphanage
8. Familiarization to Department

The Induction Program Course does not have any marks or credits however performance of students for the Induction Program is assessed at the institute level using below mandatory criteria –

1. Attendance and active participation
2. Report writing

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Faculty of Engineering & Technology

NEP 2020 Compliant Curriculum

W.E.F. 2024-25 ***Semester III***

Distribution	*Course Code*	*Theory Course Name*	*Hrs./week*			*Credits*		*Examination Scheme*			
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/POE*	*Total*
PCC	EEPCC-01	Analog Electronics	3			03	70	30			100
PCC	EEPCC-02	Power Plant Engineering and Elements of Power System	3			03	70	30			100
PCC	EEPCC-03	DC Machines and Transformer	3		2	04	70	30	25	25	150
CEP/FP	EEFP-01	Laboratory on Power Plant Engineering and Elements of Power System			2	01			25	25	50
CEP/FP	EEFP-02	Electrical Workshop			2	01			25	25	50
Entrepreneurship	EM-01	Product Development & Entrepreneurship	1	1		02		50	25		75
OE	OE-01	Open Elective -I	2		2	03	70	30	25		**125**
MDM	MDM-01	Multidisciplinary Minor -I	2		2	03	70	30	25		**125**
VEC	VEC-01	Universal Human Values	1		2	02	50*		25		**75**
	Total		**15**	**1**	**12**	**22**	**400**	**200**	**175**	**75**	**850**
	VEC-01	**Environmental Science**	**1**								

***For VEC-01(Universal Human Values) MCQ-based examination to be conducted. The red colour indicates activities that are connected with other programs**

PCC- Programme Core Course, PEC-Programme Elective Course, AEC - Ability Enhancement Course, IKS- Indian Knowledge System,
CC- Co-curricular Courses, VSEC-Vocational and Skill Enhancement Course, FP- Field Project/ CEP – Community Engagement Program
MDM-Multidisciplinary Minor: It should be selected from other UG Engineering Minor programs.

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Faculty of Engineering & Technology

NEP 2020 Compliant Curriculum

W.E.F. 2024-25 ***Semester IV***

Distribution	*Course Code*	*Theory Course Name*	*Hrs./week*			*Credits*		*Examination Scheme*			
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/POE*	*Total*
PCC	EEPCC-04	Electrical Transmission and Distribution	3			03	70	30			100
PCC	EEPCC-05	Network Analysis	2		2	03	70	30	25		125
PCC	EEPCC-06	AC Machines	3		2	04	70	30	25	25	150
SEC	EESEC-01	Computer-Aided Design and Simulation	1		2	02			25	25	50
Economics/ Managements	EM-02	Project management economics	2			02		25	25		50
OE	OE-02	Open Elective -II	**2**		**2**	**03**	**70**	**30**	**25**		**125**
MDM	MDM-02	Multidisciplinary Minor -II	**2**		**2**	**03**	**70**	**30**	**25**		**125**
VEC	VEC-02	Professional Ethics	**1**		**2**	**02**	**50***		**25**		**75**
	Total		**16**		**12**	**22**	**400**	**175**	**175**	**50**	**800**
	Environmental Science		**1**				**40**	**10**			**50**

VEC-02 (Professional Ethics) Examination will be MCQ based

SEC- Skill Enhancement Course, PCC- Programme Core Course, VSEC-Vocational and Skill Enhancement Course

AEC- Ability Enhancement Course, EM Economice/ Managements, CC- Co-curricular Courses,

MDM-Multidisciplinary Minor: It should be from another UG Engineering Minor Programme..

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Faculty of Engineering & Technology

NEP 2020 Compliant Curriculum

W.E.F. 2025-26   ***Semester V***

Distribution	***Course Code***	***Name of the Course***	***Engagement Hours***			***Credits***	***FA***	***SA***			***Total***
			L	***T***	***P***		***ESE***	***ISE***	***ICA***	***OE/ POE***	
PCC	EEPCC-07	Electromagnetic Engineering	3			03	70	30			100
PCC	EEPCC-08	Power System Analysis	3		2	04	70	30	25		125
PCC	EEPCC-09	Linear Control System	3		2	04	70	30	25	25	150
PEC	EEPEC-01	Programme Elective Course-I	3		2	04	70	30	25		125
AEC	AEC-02	Creativity and Design Thinking	1		2	02	50*		25		75
OE	OE-03	Interdisciplinary Mini Project	**1**		**2**	**02**			**25**	**25**	**50**
MD M	MDM-03	MD Minor-III	**2**		**2**	**03**	**70**	**30**	**25**		**125**
		Total	**16**		**12**	**22**	**400**	**150**	**150**	**50**	**750**

* MCQ examinations

PEC- Program Elective Course, PCC- Programme Core Course, VSEC-Vocational and Skill Enhancement Course

AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses,

MDM-Multidisciplinary Minor: It should be selected from other UG Engineering Minor programs.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
Faculty of Engineering & Technology
NEP 2020 Compliant Curriculum

W.E.F. 2025-26 ***Semester VI***

Distribution	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*			*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/POE*	
PCC	EEPCC-10	Electric Traction & Utilization	2			02	70	30			100
PCC	EEPCC-11	Power Electronics & Industrial Drives	3		2	04	70	30	25	25	150
PCC	EEPCC-12	Advanced Control System	2		2	03	70	30	25		125
PEC	EEPEC-02	Program Elective Course-II	3		2	04	70	30	25	25	150
PEC	EEPEC-03	Program Elective Course-III	3	01		04	70	30	25		125
SEC	SEC-04	Mini Project on Industrial Applications			**4**	**02**			**25**	**50**	**75**
MDM	MDM-04	Multidisciplinary Minor-IV	**2**		**2**	**03**	**70**	**30**	**25**		**125**
		Total	**15**	**01**	**12**	**22**	**420**	**180**	**150**	**100**	**850**

PEC- Program Elective Course, PCC- Programme Core Course, SEC- Skill Enhancement Course
AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses,
MDM-Multidisciplinary Minor: It should be selected from other UG Engineering Minor programs.

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Faculty of Engineering & Technology

NEP 2020 Compliant Curriculum

W.E.F. 2026-27 ***Semester VII***

Distribution	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*			*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/POE*	
PCC	EEPCC-13	Power Quality & FACTS	3			03	70	30			100
PCC	EEPCC-14	Switchgear & Protection	2		2	03	70	30	25		125
PEC	EEPEC-04	Programme Elective Course – IV or MOOCS	##4			04	100				100
Project	Project	Capstone Project			8*	04			100	100	200
RM	RM	Research Methodology and IPR	**3**		**2**	**04**	**70**	**30**	**25**		**125**
MD M	MDM-05	Multidisciplinary Minor-V	**2**			**02**	**70**	**30**			**100**
		Total	**14**		**12**	**20**	**350**	**150**	**175**	**125**	**800**

Students should attend MOOCS in that 4 Hrs. * Academic Load based on project groups
PEC- Program Elective Course, PCC- Programme Core Course, SEC- Skill Enhancement Course
AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses,
MDM-Multidisciplinary Minor: It should be selected from other UG Engineering Minor programs.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Faculty of Engineering & Technology

NEP 2020 Compliant Curriculum

W.E.F. 2026-27 ***Semester VIII***

Distribution	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*			*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/POE*	
PCC	PCC-15	Electrical Energy Audit and Management	4#			04	100				100
PEC	PEC-05	Programme Elective Course –V or MOOCS	4#			04	100				100
OJT	OJT	On-Job Training			**24**	**12**			**200**	**100**	**300**
		Total	**8**		**24**	**20**	**200**		**200**	**100**	**500**

Self-learning Technical # Students will practice or attend in Self-Learning mode. *List of MOOC Courses related to Electrical PEC-04 & 05will be provided by BOS time to time

BSC- Basic Science Course ESC- Engineering Science Course, PCC- Programme Core Course,
AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses,
VSEC-Vocational and Skill Enhancement Course

Basket of Programme Elective Course (PEC)

PEC/Sem	Course code and name
EEPEC - 01/ V	EEPEC – 01A: Advanced Microcontroller Systems EEPEC – 01B: Advanced Electrical Machines EEPEC – 01C: Hybrid Electrical Vehicle Design
EEPEC - 02/ VI	EEPEC – 02A: Power System Operation and Control EEPEC – 02B: Electrical Machine Design EEPEC – 02C: Programmable Logic Control and SCADA
EEPEC - 03/ VI	EEPEC – 03A: Smart Grid Technology EEPEC – 03B Extra High Voltage AC Transmission EEPEC – 03C Energy Storage System EEPEC – 03D: Signal & System
EEPEC - 04/ VII OR	EEPEC – 04A: Electrical Estimation, Installation, and Testing EEPEC – 04B Mechatronics EEPEC – 04C: Neural Networks & Fuzzy Logic Control EEPEC – 04D: Digital Signal Processing
EEPEC - 04/ VII	MOOC Courses (As per the list provided by BOS)
EEPEC - 05/ VIII OR	EEPEC – 05A: High Voltage Engineering EEPEC – 05B: Instrumentation Process Control & Robotics EEPEC – 05C: Advanced Applications in Solar Energy Technology
EEPEC - 05/ VIII	MOOC Courses

Please identify two to three-course baskets as above which students will opt for semester-wise PECs to develop expertise in the specific area.

A) Multidisciplinary Minor (MDM) in “Sustainable Energy System “

Semester	Course Code	Course Title
III	EEMDM-01A	Electrical Technology
IV	EEMDM-02A	Advanced Application in Renewable Energy
V	EEMDM-03A	Electrical Installation and Utilization
VI	EEMDM-04A	Energy Audit, Conservation Economics and Policy
VII	EEMDM-05A	Energy Storage Systems

Multidisciplinary Minors are for the students of Other Programs.

B) Multidisciplinary Minor (MDM) in “Electric Vehicle Systems”

Semester	Course Code	Course Title
III	EEMDM-01B	Basics of Electric Vehicle
IV	EEMDM-02B	Electrical Vehicle Motors
V	EEMDM-03B	Electric Vehicle Controls
VI	EEMDM-04B	Electric Vehicle Battery Systems
VII	EEMDM-05B	AI & Cloud Computing in Electric Vehicles

Multidisciplinary Minors are for the students of Other Programs.

A. Honors in **Electrical Vehicle**

Semester	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*		*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	
III	EEHn-01A	Electric Vehicle Technology	3		2	4	70	30	25	125
IV	EEHn-02A	Electric Motors and Controls for Electric Vehicles	3	1		4	70	30	25	125
V	EEHn-03A	Energy Management System for Electric Vehicle	3		2	4	70	30	25	125
VI	EEHn-04A	Testing And Certification of Electric And Hybrid Vehicles	3		2	4	70	30	25	125
VII	EEHn-05A	Mini Project			4*	2			50	50
		Total	**12**	**1**	**10**	**18**	**280**	**120**	**150**	**550**

* Indicates Contact Hours

The honors Course will be for the students of same Program

B. Honors in **Sustainable Power Systems**

Semester	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*		*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	
III	EEHn-01B	Advanced and Sustainable Energy Sources	3		2	4	70	30	25	125
IV	EEHn-02B	Smart Energy Management System	3	1		4	70	30	25	125
V	EEHn-03B	Distributed Energy Integration	3		2	4	70	30	25	125
VI	EEHn-04B	AI Applications To Power Systems Management	3		2	4	70	30	25	125
VII	EEHn-05B	Mini Project			4*	2			50	50
		Total	**12**	**1**	**10**	**18**	**280**	**120**	**150**	**550**

*Indicates Contact Hours

The honors Course will be for the students of same Program

Honors with Research

Semester	***Course Code***	***Name of the Course***	***Engagement Hours***	***Credits***	***SA***		***Total***
			P		***ICA***	***OE***	
VII	EERES-01	Research Project Phase-01	9 #	9	100	100	200
VIII	EERES-01	Research Project Phase-02	9 ##	9	100	100	200
Total			18	18	200	200	400

Along with 9 hours of engagement hours, 4.5 Hrs. Activities for preparation for community engagement and service, preparation of reports, etc.

Along with 9 hours of engagement hours 4.5 Hrs. Activities for preparation for community engagement and service, preparation of reports, etc., and independent reading during Project Phase 2 and preferably related to Project Phase 2 activities.

These Courses are open to students of all the UG Engineering Program. However, Paper setting and evaluation responsibilities are assigned as follows:

<table>
<tr><th>Sr. No.</th><th>List of Open Electives</th><th>Responsible BOS</th><th rowspan="7">Semester III</th></tr>
<tr><td>1.</td><td>OE-01A: Advanced Mathematics and Statistics</td><td>General Engineering</td></tr>
<tr><td>2.</td><td>OE-01B Digital Marketing and E-Commerce</td><td>Mechanical Engineering</td></tr>
<tr><td>3.</td><td>OE-01C Humanities and Social Sciences</td><td>General Engineering</td></tr>
<tr><td>4.</td><td>OE-01D Industrial and Quality Management</td><td>Mechanical Engineering</td></tr>
<tr><td>5.</td><td>OE-01E Mathematics for Software and Hardware Applications</td><td>Electrical Engineering</td></tr>
<tr><td>6.</td><td>OE-01F Soft Skills and Personality Development</td><td>General Engineering</td></tr>
</table>

Sr. No.	**List of Open Electives**	**Responsible BOS**	
1.	OE-02A Entrepreneurship and Innovation	Civil Engineering	**Semester IV**
2.	OE-02B Environmental Sustainability	Civil Engineering	
3.	OE-02C Renewable Energy	Civil Engineering	
4.	OE-02D Measurement, Instrumentation & Sensors	Electrical Engineering	
5.	OE-02 E Operation Research	Mechanical Engineering	
6.	OE-02F Computational Mathematics	General Engineering	
7.	OE-02 G Professional Business Communication	General Engineering	

List of Open Electives 01 (Semester –III)

1. **OE-01A: Advanced Mathematics and Statistics**
2. **OE-01B Digital Marketing and E-Commerce**
3. **OE-01C Humanities and Social Sciences**
4. **OE-01D Industrial and Quality Management**
5. **OE-01E Mathematics for Software and Hardware Applications**
6. **OE-01F Soft Skills and Personality Development**

List of Open Electives 02 (Semester –IV)

1. **OE-02A Entrepreneurship and Innovation**
2. **OE-02B Environmental Sustainability**
3. **OE-02C Renewable Energy**
4. **OE-02D Measurement, Instrumentation and Sensors**
5. **OE-02E Operation Research**
6. **OE-02F Computational Mathematics**
7. **OE-02G Professional Business Communication**

Open Electives 03 (Semester –V)

1. **Interdisciplinary Mini Project**

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Subject: Electrical Engineering

Name of the Course: T.Y. B. Tech

(Syllabus to be implemented from w. e. f. June 2025)

SEMESTER -I

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEPCC-07) Electromagnetic Engineering**

Teaching Scheme	Examination Scheme
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
	ISE- 30 Marks

This course introduces electromagnetic field theory which deals with electric and magnetic field vectors.

Course Prerequisite:

Students shall know circuit theory and shall also have basic knowledge of vectors and the Del operator.

Course Objectives:

1. To make students understand the use of different coordinate systems and, the significance of divergence, gradient, and curl.
2. To introduce to students the basic laws of electrostatics and magnetostatics.
3. To introduce students to boundary conditions for electric and magnetic fields.
4. To make students derive Maxwell's equations under different conditions.

Course Outcomes:

Upon the successful completion of the course, students can

1. Solve numerical problems on different coordinate systems, divergence, curl, and gradient.
2. Derive basic laws of electrostatics and apply them to different fields.
3. Analyze boundary conditions for conductors and dielectric.
4. Derive basic laws of magnetostatics and can apply them to different fields.
5. Analyze magnetic boundary conditions for magnetic materials having different properties.
6. Derive Maxwell's equations under different conditions

SECTION-I

Unit 1- Vector Analysis & Co- ordinate System **No of lectures_ 07**

Scalars & vectors, vector algebra, vector components & vectors, vector field, Dot & cross products, Introduction to Co-ordinate System _ Rectangular _ Cylindrical and Spherical Coordinate System, Introduction to line, Surface and Volume Integrals, Definition of Curl, Divergence and Gradient, AI application in Electromagnetic Engineering.

Unit 2_ Coulomb's Law & Static Electric Fields **No of lectures_08**

Coulomb's Law in vector form, Definition of Electric Field Intensity, Electric field due to continuous charge distribution, Electric Field due to line charge & sheet charge Gauss Law, point form; Divergence theorem, Electric Scalar Potential, Relationship between potential and electric field, Electric Flux Density, Line integral, potential difference & potential, potential gradient.

Unit 3_Conductors & Dielectrics **No of lectures _ 05**

Electric current, Current density, point form of Ohm's law, continuity equation for current, Poisson's and Laplace's equation, Definition of Capacitance, calculation of Capacitance of parallel plate, Electrostatic energy and energy density, Boundary conditions for electric fields

SECTION-II

Unit 4_Static magnetic field **No of lectures _ 07**

The Biot-Savart Law in vector form, Magnetic Field intensity due to a finite and infinite wire carrying a current, Magnetic field intensity on the axis of a circular loop carrying a current, Ampere's circuital law and applications, Magnetic flux density, Curl Stokes theorem, Lorentz force equation for a moving charge, Scalar and Vector Magnetic Potential.

Unit 5-Fields in Magnetic Material **No of lectures _ 06**

Nature of magnetic materials, magnetization, and permeability, Inductance of loops and solenoids, magnetic boundary conditions, Energy in an inductor & energy density

Unit 6-Maxwell's equations **No of lectures _ 07**

Continuity equation for static conditions, displacement current and current density, Maxwell's equations in integral form and point form, Maxwell's equations for static, time-varying field, and harmonically varying field.

Text Books:

1. Electromagnetic Engineering, William Hyte, 7th Edition, Tata McGraw Hill
2. Electromagnetic field theory & Transmission Lines, GSN Raju, Pearson Education
3. Schaum's series in electromagnetic, Edminister McGraw Hill publications, 3rd edition

Reference Books:

1. Problems and solutions in electromagnetic, William Hyte, Tata McGraw Hill
2. Elements of Engineering Electromagnetics, M. N. O. Sadiku, Oxford University Press, 3rd edition.
3. Electromagnetic Corson and Lerrain CBS publications, 2nd edition.

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	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEPCC-08) Power System Analysis**

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Practical– 2 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course Prerequisite:

Students shall know basic knowledge of electrical circuits, network analysis, and fundamentals of electrical machines (transformers, alternators) along with an understanding of phasors, three-phase systems, and matrix algebra.

Course Objectives

1. To draw a single-line diagram model power system components and develop network matrices using the per-unit method.
2. To analyze symmetrical faults and calculate short-circuit currents in power systems.
3. To apply symmetrical component theory to resolve and analyze unbalanced systems.
4. To provide the solution against the different faults occurring in the power system.
5. To enhance their ability to analyze the complete load flow problem of a given sample power network.
6. To get familiar with the complete behavior of the power system network & power system equipment by stability analysis under various conditions.

Course Outcomes: On completion of the course, students will be able to-

1. Draw a single line diagram of a given power system network.
2. Compute fault currents and select circuit breakers appropriately under different fault conditions.
3. Analyze power systems using symmetrical components and sequence networks.
4. Analyze and solve unsymmetrical faults with and without fault impedance.
5. Apply various iterative numerical methods and algorithms for load flow analysis.
6. Analyze the steady state and transient stability of a power system using analytical methods.

SECTION-I

Unit 1– Representation of Power System Components **No. of Lectures – 08**

Power in single phase & three phase circuit, Complex Power, Complex Power Balance, Equivalent circuits – synchronous machines, Transmission line, Transformers and Loads, Single line diagram of power system, reactance/impedance diagram, per unit system, per unit impedance diagram of power system, Per unit representation of transformer.

Introduction of Network Matrices, Formation of Y-BUS by method of inspection and method of singular transformation, formation of modified bus impedance matrix. AI application in power system analysis.

Unit 2 – Symmetrical Faults Analysis **No. of lectures – 05**

Introduction of symmetrical faults, percentage reactance, short circuit KVA, Reactor control of short circuit currents, selection of circuit breaker rating, transients on a transmission line, Short-Circuit currents, and the reactance of synchronous machines with and without load.

Unit 3- Symmetrical Components **No. of lectures – 08**

Introduction, Resolution of unbalanced phasors into their symmetrical components, Power in terms of symmetrical components**,** Analysis of balanced and unbalanced loads against unbalanced 3-phase supply, Sequence impedances, and networks of power system elements like alternator, transformer, and transmission line.

SECTION-II

Unit 4 - Unsymmetrical Faults **No. of lectures – 07**

L-G, L-L, L-L-G faults on an unbalanced alternator with and without fault impedance, Unsymmetrical faults on a power system with and without fault impedance, and Open conductor faults in the power system.

Unit 5– Load Flow Studies **No. of lectures – 08**

Introduction, complex power flow, Power flow equations, Classification of buses, Operating constraints, Data for load flow, Gauss-Seidel Method – Algorithm and flow chart for PQ and PV bus, Acceleration of convergence; Newton Raphson’s Method –Algorithm and flow chart for NR Method in polar coordinates, Algorithm and flow chart for Fast Decoupled load flow method, Comparison of Load Flow Methods.

Unit 6 - Stability Studies **No. of lectures – 06**

Introduction**,** rotor dynamics and the swing equation, Steady-state and transient stability, Equal area criterion for transient stability evaluation and its applications, critical clearing angle and time.

Textbooks:

1. Elements of Power System Analysis, W. D. Stevenson, TMH,4th Edition
2. Modern Power System Analysis, I. J. Nagrath and D. P. Kothari- TMH, 3rd Edition,2003.
3. Symmetrical Components and Short Circuit Studies, Dr. P. N. Reddy, Khanna Publishers
4. Computer Methods in Power System Analysis, Stag, G. W., and EI-Abiad, A. H.-McGraw Hill International Student Edition. 1968.

Reference Books:

1. Power System Analysis, Hadi Sadat, TMH, 2nd Edition.
2. Power system Analysis, R. Bergen, and Vijay Vittal, Pearson publications, 2ndedition, 2006.
3. Computer Aided Power system analysis, G.L., Kusic, PHI. Indian Edition, 2010.
4. Power System Analysis, W. D. Stevenson & Grainger, TMH, First Edition, 2003.
5. Advanced Power System Analysis and Dynamics, Singh, L. P, New Age International (P) Ltd, New Delhi, 2001.
6. Computer Aided Power System Operations and Analysis”- Dhar, R. N, TMH, 1984.

Internal Continuous Assessment (ICA):

ICA shall consist of at least 8 simulations/programs of the following:

1. Y Bus formation for power systems with mutual coupling by singular transformation
2. Y Bus formation for power systems without mutual coupling by singular transformation
3. Y Bus formation for power systems with mutual coupling by inspection Method.
4. Y Bus formation for power systems without mutual coupling by inspection Method.
5. Determination of bus currents, bus power, and line flow for a specified system voltage (Bus) Profile
6. Formation of Z-bus (without mutual coupling) using Z-bus building Algorithm.
7. To obtain a swing curve and to determine critical clearing time and regulation for a single machine connected to an infinite bus.
8. Write a program to perform load flow using the Gauss-Seidel method
9. Write a program to perform load flow using the NR method
10. Write a program to perform load flow using the decoupled method
11. To determine fault currents and voltages in a single transmission line system with star delta transformers at a specified location for LG fault.
12. To determine fault currents and voltages in a single transmission line system with star delta transformers at a specified location for LL fault.
13. To determine fault currents and voltages in a single transmission line system with star delta transformers at a specified location for LLG fault.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEPCC-09) Linear Control System**

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Practical– 2 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks
	OE- 25 Marks

This course covers the fundamentals of Control Systems, types and block diagram representations, and Signal flow graphs. It includes the modelling of electrical and mechanical systems and their transfer functions. It also introduces analysis of linear time-invariant systems in time domain and frequency domain. It includes concepts of stability in the time domain and frequency domain.

- **Course Prerequisite:**

Students should have a mathematical background in differential equations, able to apply Kirchhoff's laws. Also, students should know Laplace transform.

- **Course Objectives**
  1. To understand basic control systems, transfer functions, feedback, and sensitivity concepts.
  2. To calculate transfer functions for electrical and mechanical physical systems.
  3. To simplify complex systems using block diagrams and signal flow graphs.
  4. To study transient and steady-state behaviour of first and second-order systems.
  5. To analyze system stability using Routh-Hurwitz and root locus techniques.
  6. To understand system behaviour through frequency response plots and stability margins.
- **Course Outcomes: On completion of the course, students will be able to**
  1. Explain fundamental concepts of control systems and apply transfer functions effectively to electrical circuits.
  2. Derive a mathematical model of the physical system using different analogies.
  3. Use model reduction techniques to calculate the transfer function of a given system in system simplification.
  4. Apply control system analysis techniques to compute the parameter of time response and explain various controllers.
  5. Explain & examine the stability of a given system using the Routh-Hurwitz criterion.
  6. Analyze the performance and stability of the control system in the time and frequency domain.

SECTION I

Unit 1: Introduction to Control System **No. of Lectures -06**

Definition, basic components & classification of the general control system, Open loop & Closed Loop control systems, advantages & disadvantages, examples, Positive & negative feedback, Transfer

Function of open loop and closed loop control system, Definition of sensitivity, the effect of feedback on sensitivity, AI application in the control system.

Unit 2: Mathematical Models of Physical Systems **No. of Lectures -07**

Introduction, Transfer Function of electrical and mechanical (Translational and Rotational) systems, electrical analogy of mechanical systems (F-V & F-I), Transfer Function of AC & DC Servomotor.

Unit 3: Reduction of Multiple Systems **No. of Lectures -08**

Reduction of multiple systems & feedback characteristics, Block diagram representation, Signal flow Graph (SFG), Mason's Gain formula and its application for SFG, Conversion of Block diagram to SFG.

SECTION-II

Unit 4: Time-Response Analysis **No. of Lectures -07**

Standard test signals, poles, zeros & system response, the response of first-order and second-order systems to standard input, Transient response specifications, Steady state errors & definitions of error constants Kp, Kv, and Ka, P, PI, PD, and PID Controller.

Unit 5: Stability & Root Locus Techniques **No. of Lectures -07**

Concept of stability & necessary condition, Routh-Hurwitz criterion with special cases, location of roots in s-plane, concept of root locus diagram, properties, and rules for construction of root locus, Determination of stability from root locus.

Unit 6: Frequency Response Analysis **No. of Lectures -07**

Introduction to frequency response of system, Frequency domain specifications, Correlation between Time domain and Frequency domain, polar plot & bode plot for frequency function. Minimum phase function, gain margin & phase margin, determination of stability using Bode Plot.

Text Books:

1. Control System Engineering, I. J. Nagrath, M. Gopal,. New Age International Publishers, 5th Edition.
2. Control System Engineering by R. Anandanatrajan, P Ramesh Babu, Scitech publications, 2nd Edition.
3. Automatic Control Engineering, Benjamin C. Kuo, Prentice Hall of India Pvt. Ltd.
4. Modern Control Engineering, K. Ogata, Prentice Hall of India Pvt. Ltd.
5. Control system principles and design, M. Gopal, TMH publication, 3rd edition, 2008.

Reference Books:

1. Feedback Control Systems, C. L. Phillips, R. D. Harbor, PHI publication, 1988
2. Modern Control Systems, Richard C. Dorf, Robert H. Bishop, Pearson Education Eleventh edition.
3. Control systems, Smarajit Ghosh, Pearson Education 2nd Edition

Internal Continuous Assessment (ICA):

ICA consists of a minimum 8 experiments of the following:

1. To verify the potentiometer as a transducer and error detector.
2. To verify Synchro as a transducer.
3. To verify Synchro as an error detector.
4. AC position control system.
5. DC position control system.
6. Time response of the first-order system.
7. Step response of second order system using R, L, and C.
8. To study the effect of P, PI & PID Controller on a 2^{nd}order system.
9. Transient response specifications of second order system using a software program.
10. Root locus plot using a software program.
11. Bode plot using a software program.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
T. Y. B. Tech. Electrical Engineering
Semester-I
(EEPEC-01A) Advanced Microcontroller Systems

Teaching Scheme	Examination Scheme
Theory: - 3Hrs/Week, 3 Credits	**ESE**-70 Marks
Practical: - 2Hrs/Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course Prerequisite:

Students should have a basic understanding of digital electronics, Boolean algebra, number systems, and logic gates, along with foundational knowledge of microprocessors and programming concepts in C or assembly language.

Objectives:

The objectives of this course are

1. To provide an understanding of combinational logic circuits.
2. To provide an understanding of sequential logic circuits.
3. To impart knowledge on the architecture of 8051.
4. To impart knowledge on the instruction set and programming of 8051.
5. To impart knowledge on the interfacing of different peripherals with 8051
6. To use microcontroller 8051 for various applications.

Course outcomes:

On successful completion of the course, the student will be able to

1. Design various combinational logic circuits.
2. Design sequential logic circuits.
3. Understand the architecture of 8051.
4. Develop a program in assembly language and C language for 8051.
5. Interface a microcontroller 8051 to various devices.
6. Develop various applications of 8051 in Electrical Engineering.

SECTION I

Unit-1: Combinational Logic Circuits **No of Lectures -06**

Introduction, standard representation for logic functions in Sum of Product and Product of Sum (SOP and POS), Karnaugh map (K map) representation of logic functions up to 3 and 4 variables, Simplifications of logic functions using K map, Minimization of logic functions specified in Minterm and Maxterm, don’t care conditions, Principle and design of Multiplexing, de multiplexing, Half adder and full adder.

Unit-2: Sequential Logic Circuits **No of Lectures -08**

Flip-flops: Introduction of flip flops, types of flip-flops- SR Flip Flop, JK Flip Flop, D & T flip flops, operation, truth table, and characteristic equation.

Register: Introduction of the shift register, types/modes of shift registers, and applications of shift registers -Ring counter.

Counters: Types of counters, Asynchronous counter- Ripple counter using flip flops, up/down counters, Synchronous Counter-Synchronous counter using T, JK flip flops, modulus of the counter

Unit-3: 8051 Microcontroller Architecture **No of Lectures -07**

Features, the architecture of 8051 Microcontroller, Pin diagram, pin function, alternate function of pins, reset circuit. Buses-Address bus, data bus, control bus, De-multiplexing of address-data bus, Memory classification-RAM, ROM, PROM, EPROM, EEPROM, and FLASH. Memory organization of internal and external data and program memory, Special Function Registers-I/O ports, serial port registers-SCON, SBUF, Timers/counters-TCON, and TMOD SFR map. Interrupts IE and IP SFR map.

SECTION II

Unit-4: Instruction set and programming of 8051. **No of Lectures -07**

Addressing modes, Instruction set, introduction to IDE, Development Tools: Simulators, debuggers, cross compilers, in-circuit Emulators for the microcontrollers. C data types. Programming in assembly and C language.

Unit-5: 8051 Interfacing **No of Lectures -08**

Memory addresses decoding and interfacing of external program (ROM) and data (RAM) memory with 8051. Relay and opto-isolator interface, seven-segment LED interface, 16x2 LCD interface, Matrix keyboard interface, ADC 0809, DAC 0808 interface.

Unit-6: Applications of Microcontrollers. **No of Lectures -06**

Temperature measurement using LM35 temperature sensor, DC motor speed control, Stepper motor speed control, Servo motor speed control, and Fault detection in motors.

Internal Continuous Assessment (ICA):

ICA shall consist of at least 8 simulations/programs of the following:

List of Experiments:

1. To design and verify the truth table of multiplexer and demultiplexer.
2. To Design and verify the truth table of S-R and J-K flip flops.
3. To verify the operation of the shift register.
4. Write an ALP to perform arithmetic operations Using 8051.
5. Write an ALP to perform logical operations Using 8051.
6. Write an ALP to perform block Transfer/block exchange operation using 8051.
7. Write an ALP to generate square waves on the port and port pin using a timer.

8. Write a simple C program to continuously toggle all bits of a port and a particular port pin with some delay.
9. Write a simple C program for bitwise shift operation.
10. Interfacing 16x2 LCD with 8051 Microcontroller.
11. Interfacing DC motor with 8051 Microcontroller.
12. Interfacing stepper motor with 8051 Microcontroller.

Text Books:

1. Modern Digitals Electronic, Jain RP, Tata McGraw Hill, 1984
2. Digital design, Morris M Mano, Prentice Hall International – 1984
3. Digital principal and Application, Malvino & Leach, Tata McGraw Hill, 1991
4. Fundamentals of Digital Circuits, Anand Kumar, Prentice Hall of India
5. Muhammad Ali Mazidi, "The 8051 Microcontroller and embedded systems", Pearson Education.
6. Fundamentals of Microcontrollers and Applications in Embedded Systems with PIC by Ramesh Gaonkar, Thomson and Delmar learning, First Edition.

Reference Books:

1. Digital electronic, Bignell James& Donovan Robert, Delmar, Thomas Learning, 2001
2. The 8051 Microcontroller, Kenneth. J. Ayala, Cengage Learning, 3rd Ed, 2004.
3. The 8051 Microcontrollers, Architecture and Programming and Applications -K. Uma Rao, Andhe Pallavi, Pearson, 2009.
4. Device datasheet- ATMEL, DALLAS.
5. 8051 Manual (Intel).

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEPEC-01B) Advanced Electrical Machines**

Teaching Scheme	**Examination Scheme**
Theory: - 3 Hrs/Week, 3 Credits	**ESE**-70 Marks
Practical: - 2 Hrs/Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

This course introduces different Advanced Electrical Machines in electrical engineering with their construction, working principle, operation, analysis, and control techniques and applications.

Course Prerequisite:

Students shall know all conventional AC and DC machines.

Objectives:

The objectives of this course are

1. To understand the construction, working, and characteristics of synchronous reluctance motors.
2. To study the construction, classification, control, and applications of different stepper motors.
3. To understand the construction, operation, and control circuits of switched reluctance motors.
4. To study construction, working principles, and control circuits of brushless DC motors.
5. To understand the construction, control methods, and characteristics of PMSM motors.

Course outcomes:

On successful completion of the course, the student will be able to

1. Analyze torque-speed characteristics and applications of synchronous reluctance motors.
2. Analyze characteristics and drive systems for various stepper motors.
3. Analyze torque-speed characteristics, switching circuits, and applications of SR and BLDC motors.
4. Apply vector control and self-control methods for PMSM motors.

SECTION I

Unit-1: Synchronous Reluctance Motors **No of Lectures -8**

Introduction, Construction of Synchronous Reluctance Motor, Rotor design and construction, working of synchronous reluctance motor, primary design considerations, Torque-speed characteristics, Phasor diagram, Advantages and disadvantages, Applications.

Unit-2: Stepper Motors **No of Lectures -10**

Introduction, Classification of stepper motors, Single stack variable reluctance stepper motor (Construction, Connection and Principle of Operation), Micro stepping control of stepping motor, Multi-stack variable reluctance stepper motor, Hybrid stepper motor, Single phase stepping motor (Construction, Connection and Principle of Operation), Static and Dynamic characteristics of stepper motor, Torque-speed characteristics, Drive system and control circuitry for stepper motor, Application of Stepper Motor.

SECTION II

Unit-3: Switched reluctance Motor **No of Lectures -06**

Introduction, Construction and operation, Power semiconductor switching circuits, Voltage and torque equations, Control circuits, Torque-speed characteristics, Advantages and disadvantages, Applications.

Unit-4: Permanent Magnet Brushless D.C. Motors **No of Lectures -06**

Introduction, Constructional feature, Principle of operation, Classification, Emf equation, Torque equation, Torque- speed characteristics, Power and control circuit, Advantages and disadvantages, Applications.

Unit-5: Permanent Magnet Synchronous Motors **No of Lectures -06**

Introduction, Construction, and the principle of operation, Emf equation, Torque equation, Phasor diagram, torque-speed characteristics, Self-control, Vector control, Microprocessor based control

Internal Continuous Assessment (ICA):

ICA shall consist of at least 8 practicals based upon the above curriculum not limited to the following list.

1. Experimental Determination of Torque-Speed Characteristics of Switched Reluctance Motor.
2. Starting and Speed Control of Brushless DC Motor Using Hall Sensors.
3. Experimental Study of Construction and Working Principle of Synchronous Reluctance Motor.
4. Measurement and Plotting of Torque-Speed Characteristics of Synchronous Reluctance Motor.
5. Open Loop Speed Control of Stepper Motor Using Pulse Signal Generation.
6. Modeling and Simulation of Synchronous Reluctance Motor in Simulink.
7. Pulse Signal Generation and Stepper Motor Control Simulation in Simulink.
8. Simulation of Micro Stepping Control Technique for Stepper Motor Using Simulink.
9. Modeling and Simulation of Switched Reluctance Motor with Voltage and Torque Equations.
10. Simulation of Speed Control of Brushless DC Motor Using Hall Effect Sensors.
11. Torque-Speed Characteristics Simulation of Brushless DC Motor Under Varying Loads.
12. Vector Control (FOC) Simulation of Permanent Magnet Synchronous Motor (PMSM) in Simulink.
13. Speed Control of PMSM Using PID Controller Simulation in Simulink.
14. Modeling of Back EMF (BEMF) Profiles for BLDC Motor in Simulink.
15. PWM Signal Generation for Motor Control Using Embedded C Simulation in Proteus.

Text Books:

1. Electric Machines, Third Edition, I J Nagrath, D P Kothari Tata McGraw Hill Publication,

2. Electrical Machines, Third Edition, S K Bhattacharya, Tata McGraw Hill Publication,
3. Theory and Performance of Electrical Machines, J B Gupta, S K Kataria& Sons,
4. A Textbook of Electrical Technology Volume II, B L Theraja, S Chand Publications
5. Brushless Permanent Magnet and Reluctance Motor Drives, T. J. E. Miller Clarendon Press, Oxford.
6. Stepping Motors and Their Microprocessor Controls, T. Kenjo, Clarendon Press London.

Reference Books:

1. Electrical Machinery, A E Fitzgerald, C Kingsley, S D Umans, 6th Edition 2002, Tata McGraw Hill,
2. Electrical Machinery, P S Bhimbhra, Khanna Publishers.
3. Electrical Machines, Ashfaq Hussain, Dhanpat Rai & Sons.
4. Theory and Performance of Electrical Machines, J B Gupta, S K Kataria, and Sons
5. Principles of electronic machines & Power electronics, P C Sen, Wiley India,
6. Switched Reluctance Motor Drives–Modeling, Simulation, Analysis, Design and Application, R. Krishnan, CRC Press, New York.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEPEC-01C) Hybrid Electrical Vehicle Design**

Teaching Scheme	**Examination Scheme**
Theory: - 3 Hrs/Week, 3 Credits	**ESE**-70 Marks
Practical: - 2 Hrs/Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course Prerequisite:

Students shall know about Electric vehicles, Electric Vehicle Architecture Design, Control Units, and Energy Storage Solutions (ESS).

Course Objectives

1. To study and understand the history, evolution, components, and structure of electric vehicles (EVs).
2. To analyze the various Motor Torque Calculations for Electric Vehicles.
3. To understand INDIAN and GLOBAL Scenario of Energy Storage Solutions (ESS).
4. To explore various EV classifications and electrification levels.
5. To explain the Electric Drive and controller.
6. To explain the Battery Management System (BMS)/Energy Management System (EMS).

Course Outcomes

After Completion of this Course, the Student will be able to

1. Understand the history, evolution, and key components of electric vehicles.
2. Analyze the various motor torque calculations for different electric vehicles and Compare EVs with internal combustion engine vehicles.
3. Categorize electric vehicles based on electrification levels.
4. Solve various problems related to electric vehicles.
5. Explain the modeling of different electric vehicles.

SECTION-I

Unit-1 Introduction: Electric Vehicle **No of Lectures -07**

History, Components of Electric Vehicle, Comparison with Internal combustion Engine, Technology Comparison with Internal combustion Engine: Benefits and Challenges, EV classification and their electrification levels. EV Terminology.

Unit-2: Motor Torque Calculations for Electric Vehicle **No of Lectures -07**

Calculating the rolling resistance, calculating the grade resistance, calculating the acceleration force finding the total tractive effort torque required on the drive wheel.

Unit-3 Electric Vehicle Architecture Design **No of Lectures -07**

Types of Electric Vehicles and components, Electrical protection and system requirement, Photovoltaic solar-based EV design, Battery Electric vehicle (BEV), Hybrid electric vehicle (HEV), Plug-in hybrid vehicle (PHEV), Fuel cell electric vehicle (FCEV), Electrification Level of EV, Comparison of fuel vs Electric and solar power, Solar Power operated Electric vehicles.

SECTION-II

Unit-4 Electric Drive and Controller **No of Lectures -07**

Types of Motors, Selection, and Sizing of Motor, RPM and Torque calculation of motor, Motor Controllers Component sizing, Physical locations, Mechanical connection of motor, Electrical connection of motor.

Unit-5 Energy Storage Solutions (ESS) **No of Lectures -07**

Cell Types (Lead Acid/Li/NiMH), Battery charging and discharging calculation, Cell Selection and sizing, Battery lay outing design, Battery Pack Configuration, Battery Pack Construction, Battery selection criteria

Unit 6: Battery /Energy Management System (BMS/EMS) **No of Lectures -07**

Need of BMS, Rule-based control and optimization-based control, Software-based high-level supervisory control, Mode of power, Behaviour of motor, advanced features, AI in Electric Vehicle.

Term work:

ICA shall consist of at least 8 practicals based upon the above curriculum not limited to the following list.

1. Evaluation of battery charging and discharging cycle.
2. Motor torque and RPM calculation using a test bench.
3. Solar-powered charging system for electric vehicles.
4. Design and implementation of battery pack for EV.
5. Implementation of a Battery Management System (BMS) on an EV prototype.
6. Simulation of motor performance under different load conditions.
7. Simulation of battery charging and discharging cycle using Simulink.
8. Torque and acceleration force calculation in EVs using simulation.
9. Simulation of energy consumption in various EV configurations (BEV, HEV, PHEV).
10. Design and simulation of battery management system using Simulink.

Textbooks:

1. C. C. Chan and K. T. Chau Oxford University Press.
2. Per Enge, Stephen Zoepf, and Nick Enge McGraw-Hill Education.
3. Beate Müller and Gereon Meyer Springer.
4. L. Ashok Kumar and S. Albert Alexander CRC Press, Taylor & Francis

Reference Books:

1. Tom Denton Routledge, Taylor & Francis.
2. Ali Emadi CRC Press, Taylor & Francis.
3. Shashank Arora, Alireza Tashakori Abkenar, Shantha Gamini Jayasinghe, and Kari Tammi Elsevier
4. Tariq Muneer, Mohan Kolhe, and Aisling Doyle Elsevier

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(AEC-02) Creativity and Design Thinking**

Teaching Scheme	**Examination Scheme**
Theory: - 1 Hrs/Week, 1 Credits	**ESE**-50 Marks
Practical: - 2 Hrs/Week, 1 Credit	**ICA**- 25 Marks

Course Prerequisite:

Students shall have a basic understanding of product development and entrepreneurship and fundamental knowledge of project management and economics.

Course Objectives

1. To introduce students to the concepts of creativity, innovation, and design thinking process.
2. To develop problem-solving skills using divergent and convergent thinking approaches for iterative design methodologies.
3. To familiarize students with prototyping methods and their applications in iterative design methodologies.
4. To emphasize sustainable design principles and their integration into product development processes.

Course Outcomes:

1. Elaborate the critical design thinking skills needed to either improve an existing product or design a new product.
2. Demonstrate the ability to generate and evaluate creative ideas using ideation techniques.
3. Apply Creativity and Prototyping to refine product designs effectively.
4. Analyze and apply sustainable design principles to the engineering design process.

SECTION I

Unit 1: Introduction to Creativity and Design Thinking (4 Hrs)

Creativity and Innovation: Definition, importance, and characteristics, Design Thinking Process, Empathize, Define, Ideate, Prototype, Test, Barriers to Creativity and Techniques to Overcome them.

Unit 2: Ideation and Concept Development (3 Hrs)

Exploring Problem-Solving Approaches: Divergent and convergent thinking, Creative Ideation Methods: Different Methods of Idea Generation such as Brainstorming, SCAMPER, TRIZ, Mind Mapping, Transforming Ideas into Concepts: Concept sketching, storytelling, and visualization techniques.

SECTION II

Unit 3: Creativity and Prototyping **(4 Hrs)**

Creativity in Design: Applying creativity, brainstorming, and concept generation in problem-solving, Prototyping Methods and Strategies: Low-fidelity vs. high-fidelity prototypes, rapid prototyping, and iterative design, Real-Life Applications: Case studies on Real-life applications demonstrating customer-driven designs and meeting product specifications.

Unit 4: Sustainable Design and Product Development **(4 Hrs)**

Design for Environment Principles: Applying environmental sustainability throughout the product life cycle., Product Development Processes: Selecting and implementing staged, spiral, and agile development models based on project needs. Case Studies: Sustainable product development in the electrical engineering domain.

TERM WORK

Term work should be based on assignments (Case studies) based on the above topics.
1. Presentations — Idea pitching and storytelling exercises.
2. Mini-Projects — Hands-on prototyping and testing (e.g., designing a sustainable electrical product).
3. Group Discussions — Exploring innovative business models and their applications.
4. Participation — engaging in design thinking workshops and brainstorming sessions.

TEXT BOOK

1. Product Design and Development by Karl T. Ulrich and Steven D. Eppinger, Tata McGraw Hill.
2. Design Thinking: Understanding How Designers Think and Work by Nigel Cross.
3. Creative Confidence by Tom Kelley and David Kelley.

REFERENCE BOOKS

1. Product Design for Engineers by Devdas Shetty, Cengage Learning.
2. Product Design by Kevin Otto and Kristin Wood, Pearson Education.
3. Sustainable Design: A Critical Guide by David Bergman.
4. The Art of Innovation by Tom Kelley.
5. Entrepreneurship by Robert D. Hisrich, Michael Peters, Dean Shepherd, Tata McGraw Hill.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(OE-03) Interdisciplinary Mini Project**

Teaching Scheme	Examination Scheme
Theory: - 1 Hrs/Week, 1 Credits	**ICA**- 25 Marks
Practical: - 2 Hrs/Week, 1 Credit	**OE**- 25 Marks

Course Prerequisite:

Students shall have basic knowledge of core engineering disciplines, be familiar with programming languages/CAD design, understanding of project management principles.

Course Objectives

1. To introduce students to foster interdisciplinary collaboration among engineering students to familiarize students with cutting-edge technologies and trends in engineering.
2. To encourage the application of diverse engineering principles to enhance technical, analytical, and problem-solving skills through project-based learning to find innovative solutions.
3. To equip students with the knowledge of ethical considerations and sustainable development principles in engineering.
4. To develop project management, documentation, and presentation skills.

Course Outcomes:

1. Apply interdisciplinary knowledge, teamwork and collaboration skills to design and implement innovative solutions to engineering problems.
2. Develop integration to emerging technologies in engineering and their applications into project design and development.
3. Apply ethical principles and sustainable development goals in engineering design.
4. Produce and present a comprehensive project report with proper documentation.

SECTION I

Unit 1: Introduction to Interdisciplinary Projects (4 Hours)

Definition and significance of interdisciplinary projects, Importance of interdisciplinary projects in engineering, Overview of project management: Planning, execution, and evaluation, Team formation and role allocation.

Unit 2: Problem Identification and Scope Definition (3 Hrs)

Techniques for identifying real-world problems, Defining project scope, objectives, and deliverables, Feasibility analysis: Technical, economic, and environmental considerations.

SECTION II

Unit 3: Design and Development Process (3 Hrs)

System design and architecture, Integration of core engineering disciplines (electrical, mechanical, electronics, computer science), Prototyping and testing methodologies.

Unit 4: Ethics and Sustainability in Engineering Projects (3 Hrs)

Ethical considerations in engineering design and implementation, Sustainable development goals and their relevance to engineering projects.

Unit 5: Project Documentation and Presentation (2 Hrs)

Writing technical reports: Structure and guidelines, Effective presentation techniques, Intellectual property rights, and patent filing basics.

TERM WORK

Students will work in teams of a maximum of 3-4 members to complete a mini-project. The project should integrate at least two engineering disciplines. Assessment can be done on Project Proposal, Mid-Term Review, Presentation, and Viva.

TEXT BOOK

1. Project Management for Engineering and Technology by David L. Goetsch, Pearson Education.
2. Interdisciplinary Engineering Design Education by Michael A. Stylios, Springer.
3. Project Management: A Systems Approach to Planning, Scheduling, and Controlling by Harold Kerzner.
4. Interdisciplinary Research: Process and Theory by Allen F. Repko and Rick Szostak.

REFERENCE BOOKS

1. Product Design for Engineers by Devdas Shetty, Cengage Learning.
2. Engineering Project Management by Nigel J. Smith.
3. Emerging Technologies: From Hype to Impact by Bruno Salgues.
4. Sustainable Engineering: Principles and Practice by David T. Allen and David R. Shonnard.

A. Multidisciplinary Minor in "Sustainable Energy System"

Sem	Course Code	Title
V	EEMDM-03 A	Electrical Installation and Utilization

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
T. Y. B. Tech. Electrical Engineering
Semester-I
(EEMDM-03A) Electrical Installation & Utilization

Teaching Scheme	**Examination Scheme**
Theory: - 2 Hrs/Week, 2 Credits	**ESE**- 70 Marks
Practical: - 2 Hrs/Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course Prerequisite:

Students shall have basic knowledge of electrical circuits, electrical machines, and fundamental concepts in physics such as current, voltage, and power; familiarity with safety practices and elementary mechanical concepts is also beneficial.

Course Objectives

1. To understand electrical safety terminology principles, hazards, and accident prevention measures.
2. To learn machine foundation design, alignment, and earthing techniques for safety.
3. To provide sufficient knowledge of installation & testing of electrical equipment and switch gears
4. To comprehend the different issues related to heating, welding, and illumination.
5. To make the students aware of the importance of maximizing energy efficiency by optimum utilization of electrical energy.
6. To study illumination principles, light sources, and lighting design considerations

Course Outcome: Upon successful completion of this course, a student should be able to:

1. Apply safety regulations, rescue procedures, and fire prevention techniques effectively.
2. Install and align machines correctly while ensuring proper earthing compliance.
3. Select appropriate heating/welding techniques for industrial applications efficiently.
4. To identify/ design efficient lighting schemes for various applications using modern lamps and fittings in use.

SECTION-I

Unit I: Safety and Prevention of Accidents **No of Lectures -07**

Definition of terminology used in safety; safety, hazard, accident, major accident hazard, responsibility, authority, accountability, monitoring, I.E. Act & statutory regulations for safety of persons & equipment working with electrical installation, Meaning & causes of electrical accidents factors on which severity of shock depends, Procedure for rescuing the person who has received an electric shock, methods of providing artificial respiration, Precautions to be taken to avoid fire due to electrical reasons, operation of fire extinguishers

Unit II: Electrical Installation **No of Lectures -07**

Factors involved in designing the machine foundation, Requirement of different dimensions of foundation for static& rotating machines, procedure for leveling & alignment of two shafts of directly & indirectly coupled drives, effects of misalignment, Installation of rotating machines as per I.S.900-1992, earthing, Importance and purpose of earthing, types of earthing.

SECTION: II

Unit III: Electric Heating and Welding **No of Lectures -06**

Electric heating- types, advantages, disadvantages & applications, electric welding- types, advantages, disadvantages & applications

Unit IV: Illumination **No of Lectures -08**

Introduction, terms used in illumination, laws of illumination, factors to be considered for the design of illumination scheme, source of light, discharge lamps, MV and SV lamps, comparison between tungsten filament lamps and fluorescent tubes, basic principles of light control, street lighting, and floodlighting, CFL & LED Lamps.

Text Books:

1. S. Rao "Testing & Commissioning of Electrical Equipment ", Khanna Publishers
2. B .V. S. Rao, "Testing & Commissioning of Electrical Equipment", Media Promoters and Publication Pvt., Ltd.
3. Dr. S.L. Uppal, "Electrical power", Khanna Publishers

Reference Books:

1. 1. E. O. Taylor, "Utilizations of electrical energy", Orient Longman Pvt Ltd.
2. H Partab, "Art & Science of Utilization of Electrical Energy" Dhanpat Rai & Co

ICA:

ICA should consist of a minimum of 6 practicals/ case studies based on the above syllabus but not limited to the following list

1. Inspect a mock electrical panel and identify potential hazards (exposed wires, improper grounding).
2. Demonstrate the correct use of CO_2 and dry powder extinguishers on electrical fires.
3. Measure earth resistance using a Megger and analyze different earthing methods.
4. Heat a metal strip using resistance heating and measure temperature changes.
5. Compare resistance values for plate earthing, pipe earthing, and chemical earthing.
6. Perform a basic welding operation while following safety protocols.
7. Compare illumination levels of LED, CFL, and filament lamps in different settings.
8. Simulate a street lighting layout and calculate optimal pole spacing.
9. Evaluate existing lighting in a lab/workshop and suggest improvements.

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B. Multidisciplinary Minor in "Electric Vehicle Controls"

Sem	Course Code	Title
V	EEMDM-03 B	Electric Vehicle Controls

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEMDM-03B) Electric Vehicle Controls**

Teaching Scheme	Examination Scheme
Theory: - 2 Hrs/Week, 2 Credits	**ESE**- 70 Marks
Practical: - 2 Hrs/Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course prerequisite:

Basics of uncontrolled rectifiers, AC, DC waveforms, and Electrical motors.

Course Objectives

1. To understand the various control strategies applied to the DC motors used in electric vehicles.
2. To understand the various control strategies applied to the AC motors used in electric vehicles.
3. To explain different field-oriented control methods of Electric Vehicle motors.
4. To explain direct torque control methods of Electric Vehicle motors.

Course Outcome: Upon successful completion of this course, a student should be able to:

1. Describe the drive System to be used for the DC motor in Electric Vehicle
2. Describe the drive System to be used for AC motor in Electric Vehicle
3. Explain different field-oriented control methods of Electric Vehicle motors.
4. Explain direct torque control methods of Electric Vehicle motors.

SECTION-I

Unit I: Converter And Chopper Control (08 Hrs)

Principle of phase control – Series and separately excited DC motor with single phase and three phase converters – waveforms, operation with freewheeling diode schemes; Drive employing dual converter. Class A, B, C, D, and E chopper-controlled DC motor – performance analysis, multi-quadrant control.

Unit II: VSI And CSI Fed Induction Motor Control (07 Hrs)

Stator Voltage Control of an induction Motor, VSI fed induction motor drives – V/f operation theory –Slip Power Recovery Theory, Closed loop speed control for VSI & Cyclo-Converter fed Induction motor drives. CSI-fed induction machine Control – Closed loop Speed control of CSI drive.

SECTION: II

Unit III: Field Oriented Control (8 Hrs)

Working Principle of Field oriented control of induction machines – Theory – DC drive analogy, – Direct or Feedback vector control - Indirect or Feedforward vector control –– Flux Vector estimation- Principle of Space Vector Modulation control.

Unit IV: Direct Torque Control (7 Hrs)

Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy – optimum switching vector selection –Torque ripple reduction methods in Induction motor drives.

Text Books:

1. R. Krishnan, “Electric Motor Drives: Modeling, Analysis, and Control”, Prentice Hall of India, 2003
2. Bimal K. Bose, “ Modern Power Electronics and AC Drives”, Pearson Education, 2002.
3. W. Leonhard, “Control of Electrical Drives”, Springer, 3rd edition

Reference Books:

1. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw Hill,2000.
2. R. Krishnan, “Electric Motor Drives – Modelling, Analysis and Control”, Prentice- Hall of India, Pvt. Ltd., New Delhi, 2003.
3. Austin Hughes, “Electric Motors and Drives – Fundamentals, Types and Applications”, Elsevier – a division of Reed Elsevier India Private Limited, New Delhi, 2006.

ICA:

ICA should consist of a minimum of 6 practicals based on the above syllabus but not limited to the following list

1. Simulate a half-wave converter driving a DC motor and find the relation of speed with firing angle.
2. Simulate bidirectional speed control using a dual converter.
3. Simulate open-loop V/f control and plot speed vs. frequency.
4. Simulate torque/flux decoupling using pre-built FOC blocks.
5. Compare power losses in chopper-driven DC motor vs. VSI-driven induction motor.
6. Connect a 3-phase induction motor to a VFD and vary speed using keypad settings.
7. Use a single-phase thyristor kit to vary the motor speed by adjusting a potentiometer (firing angle).

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A. Honors in "Electrical Vehicle"

Sem	Course Code	Title
V	EEHn-03 A	Energy Management System for Electric Vehicle

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEHn-03A) Energy Management System for Electric Vehicle**

Teaching Scheme	**Examination Scheme**
Theory: - 3 Hrs/Week, 3 Credits	**ESE**- 70 Marks
Practical: - 2Hrs/Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course prerequisite:

Basic knowledge of electrical circuits, electrochemical cell fundamentals, electrical machines, and power electronics is required. Familiarity with electric vehicle architecture and simulation tools like MATLAB/Simulink is also recommended.

Course Objectives

1. Make the students aware of different types of energy storage systems.
2. Develop awareness about the battery characteristics & parameters.
3. Develop the various types of battery models.
4. Make the student aware of battery testing, disposal, and recycling.

Course Outcome: Upon successful completion of this course, a student should be able to:

1. Discuss the different types of energy storage systems.
2. Describe the battery characteristics & parameters.
3. Describe the model of different types of batteries.
4. Understand the battery management system.
5. Discuss the battery testing methods.
6. Describe the disposal and recycling of batteries.

SECTION I

Unit-1: Energy Storage System **No of Lectures -06**

Traction Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal-Air Batteries, Zinc Chloride batteries; Ultra capacitors; Flywheel Energy Storage Systems; Comparison of different Energy Storage Systems.

Unit-2: Battery Characteristics & Parameters **No of Lectures -09**

Cells and Batteries- Battery Cell Structure, Chemical reactions, Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters, C rate and Performance criteria of batteries as per C-Rate, Vehicle propulsion factors- Power and energy requirements of batteries.

Unit-3: Battery Modelling **No of Lectures -06**

The general approach to modeling batteries, Basic Battery Model, run time Battery Mode, steps to develop a simulation model of a rechargeable Li-ion battery, Steps to develop a simulation model of a rechargeable NiCd battery, Steps to develop a simulation model of a rechargeable Lead Acid battery.

SECTION II

Unit-4: Battery Pack and Battery Management System. **No of Lectures -09**

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization methods, Heat generation and thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel.

Unit-5: Battery Testing Methods **No of Lectures -06**

Chemical & structure material properties for cell safety and battery design, battery testing methods, Procedure of battery testing, limitations for transport and storage of cells and batteries, Thermal Runway: High discharge rates, short circuits, charging and discharging. Environment and Human Health impact assessments of batteries, Battery Pack Safety Battery Standards & Tests.

Unit-6: Battery Disposal & Recycling **No of Lectures -06**

Recycling, disposal, and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, General recycling issues and drivers, methods of recycling of EV batteries.

Internal Continuous Assessment (ICA):

It should consist of a minimum of 8 experiments based on the above syllabus but not restricted to a list of experiments given below.

List of Experiments:

1. Develop a comparative case Study of different types of batteries with their characteristics &

detailed specifications.

2. Perform Short Circuit Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
3. SOC Estimation by Open-Source voltage for Lead-Acid battery, Ni-MH battery, and Li-ion battery.
4. SOC Estimation by specific gravity for Lead-Acid battery.
5. SOC Estimation by Coulomb counting method for Lead-Acid battery and Li-ion battery.
6. Design a circuit for a Battery monitoring System for Lead acid batteries.
7. Design a circuit for passive cell balancing for Li-Ion battery.
8. Develop a simulation model for lead acid batteries.
9. Develop a simulation model for lithium-ion batteries.
10. Develop a simulation model with a series-parallel combination for lithium-ion battery packs with C-Rate calculation.
11. Develop Battery Pack Modeling for Li-ion cells using the battery builder app in MATLAB.
12. Design a circuit for a Battery monitoring system for Lead acid batteries.

Reference Books:

1. G. Pistoia, J.P. Wiaux, S.P. Wolsky, "Used Battery Collection and Recycling", Elsevier, 2001. (ISBN: 0-444-50562-8)"
2. Guangjin Zhao, "Reuse and Recycling of Lithium-Ion Power Batteries", John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9).
3. T R Crompton, "Battery Reference Book-3rd Edition", Newnes- Reed Educational and Professional Publishing Ltd., 2000.
4. Ibrahim Dinçer, Halil S. Hamut, and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", John Wiley & Sons Ltd., 2016.
5. Chris Mi, Abul Masrur& David Wenzhong Gao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.

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B. Honors in “Sustainable Power System”

Sem	Course Code	Title
V	EEHn-03 B	Distributed Energy Integration

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEHn-03B) Distributed Energy Integration**

Teaching Scheme	Examination Scheme
Theory: - 3 Hrs/Week, 3 Credits	**ESE**- 70 Marks
Practical: - 2Hrs/Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course prerequisite:

Basic understanding of power systems, renewable energy sources (especially solar and wind), electrical machines, and power electronics is essential. Familiarity with grid operations, energy storage, and economic principles of electricity markets is also beneficial.

Course Objectives

1. To introduce the concept of distributed generation, microgrids, electric vehicles, and energy storage.
2. To understand the principles, challenges, and policy aspects of Distributed Generation (DG).
3. To analyze and model wind/PV systems for power flow, stability, and forecasting.
4. To explore technical regulations and standards for DG interconnection with power systems.
5. To study the economic impacts and management of DG systems in power grids.
6. To understand the role of microgrids and energy storage in ensuring grid reliability and stability.

Course Outcome: Upon successful completion of this course, a student should be able to:

1. Explain the technical, economic, and environmental impacts of Distributed Generation.
2. Model and simulate wind/PV systems for power flow, stability, and forecasting.
3. Implement technical solutions for DG interconnection and protection in power systems.
4. Analyze the economic benefits and market value of DG systems.
5. Design and operate microgrids with integrated energy storage for enhanced grid stability.

SECTION I

Unit-1: Distributed Generation **No of Lectures -07**

Reasons for growth, extent of DGs, Issues with DGs, Policy/institutional issues, market/financial issues, social/environmental issues, DG Plant Types, DG Machinery & its control, Integration issues, technical impacts of DGs, Economic impact of DGs, Impact on transmission and generation systems, Security and reliability. International DG Integration Experience.

Unit-2: Wind/PV System Modeling and Handling **No of Lectures -07**

Wind/PV variability and uncertainty. Forecasting methods and applications. Power flow studies, Fault studies, Stability studies, Transient studies, Inertia and Frequency Response studies. Power Quality Issues. System balancing & imbalance handling: Flexibility Issues, Ramping issues, Inertia and Frequency Response Issues, Role of storage and DR and related issues, large-scale storage for grid stability / Backup.

Unit-3: Technical Regulations for the Interconnection of DGs to Power Systems No of Lectures -07

Overview of technical regulations, Active power control, Frequency control, Voltage control, and technical solutions for new interconnection rules. Protection of DGs. Feasibility of integrating Large-Scale Grid Connected DG, Policy, Market and Regulatory Interventions, Regulatory challenges, Viability of DG integration in the deregulated electricity market.

SECTION II

Unit-4: Economics of DG **No of Lectures -07**

Value of power from DGs, Market value of power from DGs, Loss reduction, Investment reduction, Connection costs and charges, Distribution use of system charges, Allocation of losses in distribution networks with DG, Alternative framework for distribution tariff development.

Unit-5: DG Management **No of Lectures -07**

DGs in areas of limited transmission capacity. DGs in distribution networks. Active Management of Distribution Systems. Ancillary Services with DGs, Markets for Ancillary Services. DER Management, Virtual Power Plants

Unit-6: Micro Grids and Energy Storage **No of Lectures -07**

Micro Grids: Concept, Design, Modeling, Operation and Analysis. Role in Energy Reliability, Cold Load Pick Up and Sustainability.

Energy Storage: Type and modeling of storage systems. Scheduling issues, Ancillary services from energy storage, Role in Energy Security, Reliability, and Stability.

Internal Continuous Assessment (ICA):

It should consist of a minimum of 8 experiments based on the above syllabus but not restricted to a list of experiments given below.

List of Experiments:

1. Simulation related to power flow study.
2. Design and modeling of energy storage system.
3. Simulation of PV performance under different forecasting environments.
4. Simulation of wind generation performance under different forecasting environments.
5. Simulation and modeling of steady-state and transient stability analysis of PV generation.
6. Simulation and modeling of steady-state and transient stability analysis of wind generation.
7. Survey on DG Integration – need, growth, policies, technical and financial Impacts.
8. Simulation of power flow analysis in a grid with integrated DG systems.
9. Stability study of wind and solar power systems in a microgrid.
10. Perform fault analysis in a wind/PV integrated grid system.
11. Evaluate the effect of DGs on voltage regulation in a distribution network.
12. Conduct frequency control and power quality analysis for DG integration.
13. Analyze the economic impacts of DG integration using cost-benefit analysis tools.
14. Implement protection schemes for DG systems using simulation tools.
15. Design a microgrid system for energy reliability and sustainability.
16. Model energy storage systems for load balancing in renewable-dominant grids.
17. Simulate large-scale storage and backup solutions for grid stability.
18. Develop an ancillary service market model with DG integration and storage systems.

Reference Books:

1. Math H. Bollen, Fainan Hassan, "Integration of Distributed Generation in the Power System", Wiley IEEE Press, 2011.
2. Willis H. Lee and Scott W. G., "Distributed Power Generation Planning and Evaluation", Marcel Ekker, Inc, New York, 2000.
3. B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson, and D. Milborrow, "Wind Power Integration: Connection and System Operational Aspects" IET, 2007.
4. Loi Lei Lai, Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators" Wiley-IEEE Press, 2007.
5. Komarnicki, Przemyslaw, Lombardi, Pio, Styczynski, Zbigniew , "Electric Energy Storage Systems", Springer, 2017.
6. Garcia-Valle, Rodrigo, Pecas Lopes, Joao A, "Electric Vehicle Integration into Modern Power Networks", Springer, 2012.

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SEMESTER -II

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-II** **(EEPCC-10) Electric Traction & Utilization**

Teaching Scheme	Examination Scheme
Theory– 2 Hrs. /Week, 2 Credits	**ESE**-70 Marks
	ISE- 30 Marks

Course Prerequisite:

Basics of Electrical Engineering, Effects of electric current, Control circuit design basics, awareness about artificial lighting, Characteristics and application of different electric motors, awareness about traction, awareness about energy conservation.

Course Objectives

1. To analyze electric traction systems and speed-time curves of Electrical train movement.
2. To analyze the control and auxiliary equipment for electric traction.
3. To choose electric motors for industrial applications.
4. To understand types of electric heating & welding.
5. To determine lighting systems using illumination principles and various light sources.
6. To use energy-saving principles to develop strategies for various sectors.

Course Outcomes: Upon successful completion of this course, a student should be able to:

1) Analyse electric traction systems, speed-time curves, and energy consumption factors.
2) Understand different controlling methods, and transition methods in traction.
3) Identify motors for different industrial applications.
4) Use suitable electric heating and welding for different applications.
5) Identify/Troubleshoot various lamps and fittings in use.
6) Understand and apply energy efficiency for optimal utilization in professional practice.

SECTION-I

Unit-1 Traction Systems **No of Lectures- 06**

Introduction, systems of electric traction, calculation by trapezoidal and quadrilateral speed time curve, the tractive effort for propulsion of train, determination, and factors affecting specific energy consumption using speed time curve, dead weight, accelerating weight, and adhesive weight, introduction to the metro system, monorail system, AI application in Traction.

Unit-2 Control of Traction Motors and Train Lighting **No of Lectures- 06**

Desirable characteristics of traction motors, suitability of DC series motor, control of traction motors, series-parallel control, shunt and bridge transition, electrical braking, regenerative breaking in traction, control equipment, and auxiliary equipment

Unit-3 Selection of Motors for Industrial Applications **No of Lectures- 04**

Motor selection in textile industries, machine tools, rolling mills, sugar mills, cranes and Lifts

SECTION-II

Unit-4 Electric Heating and Welding **No of Lectures- 06**

Electric heating- types, advantages, disadvantages & applications, electric welding- types, advantages, disadvantages & applications, AI application in utilization.

Unit-5 Illumination **No of Lectures- 05**

Introduction, terms used in illumination, factors to be considered for the design of illumination scheme, source of light, discharge lamps, MV and SV lamps, and comparison between tungsten filament lamps and fluorescent tubes.

Unit-6 Energy Conservation **No of Lectures- 03**

Introduction, Motivation for Energy Conservation, Principles of Energy Conservation, Energy Conservation Planning, Energy Conservation in Industries.

Text Books: -

1. J.B. Gupta, "A course in Electrical Power" by, S K Kataria And Sons
2. Dr. S.L. Uppal, "Electrical power", Khanna Publishers

References Books: -

1. B.R. Gupta, "Generation of Electrical Energy", S Chand
2. E. O. Taylor, "Utilizations of electrical energy", Orient Longman Pvt Ltd.
3. H Partab, "Art & Science of Utilization of Electrical Energy" Dhanpat Rai & Co

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
T. Y. B. Tech. Electrical Engineering
Semester-II
(EEPCC-11) Power Electronics & Industrial Drives

Teaching Scheme	Examination Scheme
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Practical– 2 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks
	POE- 25 Marks

Course prerequisite: Basics of low- power Semiconductor devices, uncontrolled rectifiers, AC, DC waveforms and their equations, Electrical Machines.

Course Objectives

1. To understand the characteristics of power semiconductor devices.
1. To enable students to analyze phase-controlled rectifiers
2. To enable students to analyze Inverter circuits
3. To understand concepts of Electrical Drive.
4. To understand the speed control of DC and AC motors using power electronic converters.

Course Outcome: Upon successful completion of this course, a student should be able to:

1. Understand the operation and characteristics of various power electronic devices.
2. Analyze phase-controlled rectifiers
3. Analyze inverter circuits
4. Apply the concepts of electrical drive
5. Understand the converter-fed DC motor drives.
6. Understand the inverter-fed AC motor drives.

SECTION-I

Unit-1 Silicon Controlled Rectifier and Semiconductor Devices **No of Lectures - 07**

Introduction to PN junction, Principle of operation of Silicon Controlled Rectifier (SCR), Static & Dynamic characteristics, Turn Methods, Firing circuits (using R, R-C only), Commutation Circuits (class C & D only), Protection circuits of SCR (over voltage, over current, dv/dt & di/dt). Principle of operation, V-I characteristics, rating, and applications of Triac, Diac, Gate Turn Off Thyristor (GTO)

Unit-2 Phase Controlled Rectifiers **No of Lectures - 07**

Rectifiers: Introduction, half wave-controlled rectifiers with R, R-L load with and without freewheeling diode. Full Wave controlled rectifiers (Half controlled & fully controlled) with R, R-L load with and

without freewheeling diode, three phase half controlled & fully controlled rectifiers with R load only.
Chopper's: Principle of operation, Classification of choppers, Control Techniques, Step down and Step up choppers, DC-DC switched mode regulators– Buck, Boost, Buck-Boost, and Cuk.

Unit-3 Inverters & AC Voltage Controllers. **No of Lectures - 07**
Inverters: Introduction and Classification of Inverters, Principle of operation, Single phase half and full bridge Inverters with R & R-L load, 3 phase bridge Inverters (120^0 and 180^0 conduction mode) with R load. Voltage control methods of 1- phase inverters.
AC Voltage Controllers - Introduction of AC Voltage Controllers, Principle of On-Off Control, Principle of Phase Control, Single Phase bidirectional control with R load only.

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SECTION: II

Unit-4 Introduction and Dynamics of Electrical Drives **No of Lectures - 07**
Block diagram, Types of electrical drives, parts of electrical drives, criteria for Selections & choice of electrical drives. Dynamics of electrical drives: Fundamental torque equation, speed, torque, connection and Multi-quadrant operation of Drives, Close loop control of drives.

Unit-5 DC Drives **No of Lectures - 07**
Single-phase, three-phase half, and fully controlled converter-fed DC motor drives. Chopper-controlled DC shunt motor drives in single-quadrant and multi-quadrant operation chopper-controlled drives, Braking, and types of Electrical Braking. Brushless DC Motor drives operation & converter circuit, numerical on rectifier fed dc motors only.

Unit-6 AC Drives **No of Lectures – 07**
Basic relations, of 3-phase induction motor, Stator voltage control of 3-phase induction motor by AC regulators fed 3 phase induction motor speed control, variable frequency control by CSI & VSI, comparison between VSI and CSI. VSI fed synchronous motor drives, Variable frequency control of multiple Synchronous motor drives, Stepper motor drives operation & converter circuit, switched reluctance motor drives operation & converter circuit.

Text Books:

1. M H Rashid, "Power Electronics" Prentice-Hall of India
2. P S Bimbhra, "Power Electronics" Khanna Publishers
3. K Hari Babu, "Power Electronics" Scitech Publication
4. Alok Jain, "Power Electronics & its Applications" Penram International Publishing (India) Pvt. Ltd.
5. Vedam Subramanyam, "Power Electronics" New Age International.
6. Gopal. K. Dubey, "Fundamentals of Electrical Drives", Narosa Publication

Reference Book:

1. Landers “Power Electronics”, McGraw Hill
2. M.D. Singh, K.B. Khanchandani, “Power Electronics” Tata McGraw Hill
3. P.C.Sen, “Modern Power Electronics” Wheeler Publication
4. M H Rashid, “Power Electronics Handbook” Academic Press Series in Engineering.
5. N. Mohan T.M. Udeland and W.P. Robbins John, “Power Electronics converter application” Willey & Sons
6. Vedam SuryaVanshi, “Electrical Drives-concept and application” IEEE, 1997
7. B.K. Bose “Modern power electronics & AC drives” Prentice Hall PTR, 2002

Internal Continuous Assessment (ICA):

Minimum five experiments on hardware and three simulations should be performed:

The list of hardware experiments is as follows:

1. V-I Characteristic of SCR
2. Characteristic of any one high switching frequency devices
3. The commutation circuit of SCR
4. Experiments based on controlled rectifiers
5. Experiments based on inverters
6. Experiment based on DC to DC converter
7. Experiment based on AC voltage controller
8. Speed control of DC motor based on controlled rectifiers.
9. Speed control of AC motor using VSI.
10. Speed control of AC motor based on Regulators.

The list of simulations is as follows:

1. Simulations based on AC to DC converter
2. Simulations based on DC to DC converter
3. Simulations based on DC to AC converter
4. Simulations based on AC to AC converter

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-II** **(EEPCC-12) Advanced Control System**

Teaching Scheme	**Examination Scheme**
Theory– 2 Hrs. /Week, 2 Credits	**ESE**-70 Marks
Practical– 2 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

- **Course Prerequisite:**

Students shall know Ordinary differential equations, mathematical modeling of different systems, transient and steady-state response of systems, and stability of systems in the time domain and frequency domain. Students shall also have basic knowledge of linear algebra Laplace and Z- Transform.

- **Course Objectives**
  1. To enhance the analytical ability of the students in facing the challenges posed by growing trends in designing control systems in the time and frequency domain.
  2. To enhance the ability of the students to analyze and design the control system in a modern control approach.
  3. To enhance the ability of the students to understand nonlinear control systems.
  4. To enhance the ability of the students to analyze the Discrete Time Control Systems.
- **Course Outcome:** Upon successful completion of this course, a student should be able to:
  1. **Design** effectively and realize lead, lag, and, lag-lead compensators in the time domain to enhance control system performance.
  2. **Design** various controllers in the frequency domain using a bode plot for desired performance and stability.
  3. **Examine** state space models for effective analysis of system dynamics.
  4. **Design** the state space control system to determine the gain matrix using different methods.
  5. **Use** the concepts of nonlinear systems and **compute** their performance using various techniques.
  6. **Apply** discrete-time mathematical models to derive the pulse transfer function, and **examine** the stability of discrete-time systems.

SECTION I

Unit 1: Design of compensator using Root Locus **No of Lectures- 06**

Introduction of the design problem, Approach & preliminary considerations, Realization of basic compensators with passive and active networks, Design of lead, lag & lag-lead compensators

Unit 2: Design of compensator using Frequency response **No of Lectures- 05**

Design of lag compensation, lead compensation, and lag-lead compensation using Bode Plot

Unit 3: Non-linear Control Systems **No of Lectures- 04**

Introduction, common non-linearity in the control system, Phase plane method. Singular points, Stability of Nonlinear Systems.

SECTION-II

Unit 4: State-Space Analysis and Design **No of Lectures- 08**

Concept of state, state variable & state model, state-space representation of transfer function of electrical and mechanical systems, state transition matrix, its properties, Controllability & Observability. Design of Pole placement, Necessary and sufficient condition for arbitrary pole placement, Determination of K using transformation Matrix, Direct Substitution and Ackermann's Formula, State Observer, Full state observers, Effects of addition of the observer on a closed loop system.

Unit- 5: Discrete-time Control System **No of Lectures- 07**

Basic elements of discrete data control system and its advantages over the continuous time system, Pulse Transfer Function of cascade elements, closed-loop systems, and digital controller, Mapping between s-plane & z-plane, stability analysis of closed-loop systems in z-plane using Juri's Test.

Internal Continuous Assessment (ICA):

A minimum of **eight** programs should be performed in the laboratory based on the entire syllabus but not restricted to the following.

1) Find the poles, Zeroes, and gain of the transfer function and the transfer function of the system whose zeroes and poles by using a software program.

2) Design the lead compensator using the root locus technique using a software program

3) Design the lag compensator by using the root locus technique using a software program

4) Design the lag compensator by using a bode plot using a software program

5) Determine the Eigen Values and Eigenvector of Matrix A by using MATLAB a software program

6) Convert state space to transfer function and transfer function to state space using a software program

7) Conduct the test of controllability using a software program

8) Conduct the test of observability using a software program

9) Converting Continuous time transfer function to discrete-time transfer function using a software program i.e. G(s) to G(z).

10) Demonstrate the effect of the addition of poles and zeros in the given transfer function using a software program

11) Examine the unit state response of the discrete time control system using a software program.

12) Design of pole placement controller using Ackerman's Formula.

Text Books:

1. I. J. Nagrath, M. Gopal “Control System Engineering”, 5th Edition. New Age International Publishers.
2. Control System Engineering by R. Anandanatrajan, P Ramesh Babu, 2nd Edition, SciTech
3. Discrete-time Control Systems by K Ogata, Prentice Hall India, 2nd Ed
4. Digital Control Systems by B.C. Kuo, Saunders College Publishing, 2nd Ed

Reference Books:

1. Benjamin C. Kuo, “Automatic Control Engineering”, Prentice Hall of India Pvt. Ltd.
2. K. Ogata, “Modern Control Engineering”, Prentice Hall of India Pvt. Ltd.
3. M. Gopal, “Digital Control Engineering”, Wiley Eastern, 1988
4. Control system principles and design, M. Gopal, TMH publication, 3rd edition, 2008
5. Feedback Control Systems, C. L. Phillips, R. D. Harbor PHI publication, 1988

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-II** **(EEPEC-02A) Power System Operation and Control**

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Practical– 2 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks
	OE/POE -25 Marks

Course Prerequisite:

Students shall know power systems, generation, power plants, Active and reactive power, voltage stability

Course Objectives

1. To study and understand the operation and control of power systems.
2. To analyze the various load characteristics with load curve and load duration curve.
3. To understand conduction & breakdown in liquids as well as compare between liquids & solids breakdown.
4. To explain the modeling of reactive power-voltage interaction and the control actions.
5. To explain the concept of reactive power control and voltage stability

Course Outcomes

After Completion of this Course, the Student will be able to

1. Understand the operation and control of power systems
2. Analyze the various load characteristics with load curve and load duration curve
3. Solve economic dispatch problems and unit commitment problems in the power system.
4. Explain the modeling of reactive power-voltage interaction and the control actions
5. Explain the concept of reactive power control and voltage stability

SECTION-I

Unit-1 Economic Operation of Power System (07 Hrs.)

Optimal operation of Generators in Thermal Power Stations, heat rate Curve, Cost Curve, Incremental fuel and Production costs, input-output characteristics, Optimum generation allocation with line losses and with line losses neglected, Loss coefficient, Penalty factor, Hydrothermal scheduling

Unit-2: Unit Commitment

(07 Hrs.)

Spinning reserve, thermal unit constraints, Unit commitment solution methods- Priority list, Dynamic programming, Lagrange multiplier

Unit-3 Load Frequency Control

(07 Hrs.)

Necessity of keeping frequency constant, Definitions of Control area – Single area control, Load frequency control of 2-area system, speed governing system

SECTION-II

Unit-4 Reactive Power control

(07 Hrs.)

Overview of Reactive Power control – Reactive Power compensation in transmission systems, advantages and disadvantages of different types of compensating equipment for transmission systems, load compensation – Specifications of load compensator, Uncompensated and compensated transmission lines: shunt and Series Compensation

Unit-5 Power System Security (07 Hrs)

Introduction, system state classification, security analysis, contingency analysis, Sensitivity factors, power system voltage stability

Unit 6: Voltage Stability (07 Hrs)

Introduction, comparison of voltage angle & voltage stability, reactive power flow and voltage, collapse, mathematical formulation of voltage stability problem, voltage stability analysis, prevention voltage collapse, state of the art, future trends & challenges

Textbooks:

1. C. L. Wadhwa, "Electrical Power Systems", Newage International.

2. I. J. Nagrath & D. P. Kothari "Modern Power System Analysis "Tata M Graw Hill

3. Allen. J. Wood and Bruce F. Wollenberg, "Power Generation, Operation and Control", John Wiley& Sons, Inc., 2003

4. Chakrabarti & Halder, "Power System Analysis: Operation and Control", Prentice Hall of India

Reference Books:

1. J Duncan Glover and M. S. Sarma, "Power System Analysis and Design", THOMPSON.

2. O. I. Elgerd, "Electric Energy systems Theory", Tata McGraw-hill Publishing Company Ltd.

3. Grainger and Stevenson, "Power System Analysis", Tata McGraw Hill.

4. HadiSaadat, "Power System Analysis", TMH Edition.

ICA: Minimum Eight simulation experiments based on the above syllabus

1) To analyze the transients on a transmission line and verify
2) Write a program to find the optimum loading of generators with penalty factors
3) Simulink model of single area load frequency control with and without pi controller and without pi controller

4) Write a program to find the optimum loading of generators neglecting transmission losses
5) Write a program for equal incremental cost for optimal dispatch
6) Simulate LFC in a single-area power system to maintain constant frequency under varying loads.
7) Simulink model for two-area load frequency control
8) Simulate and analyze the speed governing system of a thermal plant to maintain grid frequency
9) Simulink model for evaluating the transient stability of a single machine connected to an infinite bus
10) Simulate series compensation and analyze its impact on line performance and voltage stability.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-II** **(EEPEC-02B) Electrical Machine Design**

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Practical– 2 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks
	OE/POE -25 Marks

Course Prerequisite*:*

Knowledge of types, construction, and working of transformers, DC Machines, three-phase induction motors, and Synchronous machines.

Course Objectives*:*

1. To clear the basic concept of the design of the transformer.
2. To get detailed information for designing a DC Machine.
3. To get detailed information for designing a Three-phase Induction machine.
4. To get detailed information for designing a Synchronous machine.

Course Outcomes*:*

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

1. Explain the basic concepts related to the design of Electrical machines.
2. Design the main dimensions & analyze the performance of Single-phase, and three-phase transformers.
3. Estimate the main dimensions & analyze the performance of DC machines.
4. Calculate the main dimensions & analyze the performance of the induction motor.
5. Design the main dimensions & analyze the performance of the Synchronous machine.

SECTION-I

Unit-1: Introduction **No. of Lectures- 04**

Principles of design, design factors, specifications, limitations, modern trends in the design of electrical machines, insulation, and class of insulation

Unit-2: Design of transformers: **No. of Lectures -10**

Types, classification & specifications, output equation, design of core, selection of design constants, design of yoke, design of window, and design of windings, tank design with and without cooling tubes

Unit 3: Design of DC Machines **No. of Lectures -07**

Output equations of DC machine, factors affecting size of rotating machines, Choice of specific loadings, separation of main dimensions, Selection of no. of poles, core length, air gap, design of armature of the field system.

SECTION-II

Unit 4: Design of three-phase induction motors-I: **No. of Lectures 05**

Output equation, Choice of specific loadings, main dimensions, stator design, stator winding, stator core, stator slot design, and selection of stator slots.

Unit 5: Design of three-phase induction motors-II: **No. of Lectures 06**

Rotor design, selection of rotor slots, rotor bars/windings calculation, design of end ring, design of wound rotor, no of rotor turns, area of rotor conductors, rotor tooth density, design of rotor core.

Unit 6: Design of synchronous machines **No. of Lectures 10**

Output equation, specific loadings, design of salient pole machines-main dimensions,
length of air gap, armature design, design of turbo alternator main dimensions,
length of the air gap, stator design, and rotor design.

Internal Continuous Assessment (ICA):

Term work shall consist of at least 4 drawing sheets & 2 experiments based on software.

Text Books:

1. A course in Electrical machine design", Dhanpat Rai & Sons by A.K Sawhney
2. Principles of Electrical machine design", S K Kataria & Sons by R.K Agarwal

Reference Books:

1. "Design of Electrical machines", Standard publications and Distributors by Mittle V.N and Mittle A
2." Performance & design of A.C machines",CBS Publishers & Distributors by M.G.Say
3. "Performance & design of D.C machines", CBS Publishers & Distributors by A.E.Clayton

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-II** **(EEPEC-02C) Programmable Logic Control and SCADA**

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Practical– 2 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks
	OE/POE -25 Marks

Prerequisite:

Basic knowledge of Electronics, computers, logic gates, Relay logic, controllers, parts of SCADA Systems

Course Objectives:

The primary objectives of this course are to:

1. To understand the generic architecture and constituent components of a Programmable Logic Controller.
2. To apply knowledge gained about PLCs and SCADA systems to real-life industrial applications.
3. To develop a software program using modern engineering tools and techniques for PLC.
4. To develop the architecture of SCADA explaining each unit in detail.
5. To explain the evolution of SCADA protocols.

Course Outcome: Upon successful completion of this course, students will be able to:

1. Explain and apply the concept of electrical ladder logic, its history, and its relationship to programmed PLC instruction.
2. Design different process control applications through ladder logic and its industrial applications.
3. Understand desirable properties of SCADA Systems Build.
4. Develop the architecture of SCADA and explain the importance of SCADA in critical infrastructure.
5. Describe various SCADA protocols along with their architecture.

SECTION-I

Unit 1: Introduction to PLC **(No. of Lectures- 07 Hrs.)**

Definition & History of PLC, Overall PLC system, PLC Input & Output modules, central processing unit, CPUs & Programmer/monitors, Solid state memory, the processor, Input modules (Interfaces), Power supplies, PLC advantages & disadvantages, Selection criteria for PLC

Unit-2: Programming of PLC **(No. of Lectures -06 Hrs.)**

Programming equipment, proper construction of PLC ladder diagram, Basic components & their symbols in ladder diagram, Fundamentals of a ladder diagram, Boolean logic & relay logic and analysis of rungs, Input ON/OFF switching devices, Input analog devices, Output ON/OFF devices, Output analog devices, programming ON/OFF Inputs to produce ON/OFF outputs.

Unit-3: Advanced PLC Function **(No. of Lectures -08 Hrs.)**

Analog PLC operation, PID control of continuous processes, simple closed loop systems, problems with simple closed loop systems, closed loop system using Proportional, Integral & Derivative (PID), PLC interface, and Industrial process example, Motors Controls: AC Motor starter, AC motor overload protection, DC motor controller, Variable speed (Variable Frequency) AC motor Drive.

SECTION-II

Unit-4: SCADA Systems **(No. of Lectures -08 Hrs.)**

Introduction and definitions of SCADA, Basic SCADA system Architecture, Human Machine Interface, Master Terminal Unit, Remote Terminal Unit, SCADA data transfer through PLCC, Communication Technologies, Communication system components, SCADA Communication in an electrical power system, SCADA system desirable Properties, Real-Time System, SCADA server, SCADA functions.

Unit-5: SCADA Architecture **(No. of Lectures -06 Hrs.)**

First generation-Monolithic, Second Generation-Distributed, Third generation Networked Architecture, Intelligent Electronic Devices, Operation and control of interconnected power system, Automatic substation control, SCADA configuration, Energy management system, system operating states, system security, State Estimation, SCADA system security issues Overview. SCADA systems in the critical Infrastructure: Petroleum Refining Process, Conventional Electric Power Generation, Water Purification System, Chemical Plant.

Unit-6: Evolution of SCADA Protocols **(No. of Lectures -07Hr)**

Overview of Open systems interconnection (OSI) Model, Functions of OSI Model Layers, OSI Protocols, Functions of Transmission control protocol / Internet protocol (TCP/IP) Layers, TCP/IP protocol, DNP3 protocol, IEC61850 layered architecture, Control and Information Protocol (CIP), Device Net, Control Net, EtherNet/IP, Flexible Function Block process (FFB), Process Field bus (Profibus), The Security Implications of the SCADA protocols

ICA: Minimum Eight experiments

1) Identify and study the components of a PLC system, including CPU, I/O modules, and power supply,
2) Simulate how input and output modules interface with sensors and actuators in an industrial setup.
3) Compare different PLC models based on selection criteria like memory size, speed, and input/ output capacity.
4) Create simple PLC ladder diagrams and simulate operations using software tools like RS Logix or Siemens TIA Portal.
5) Use PLC programming to implement and analyze Boolean logic and relay rungs.
6) Program ON/OFF devices (such as switches) to control output devices like lights or motors.
7) Write PLC code to control analog input and output devices, such as sensors and variable drives.
8) Design and simulate a closed loop system with PLC-based PID control for temperature or flow

regulation.

9) Implement PLC programming for AC motor starters, overload protection, and DC motor controllers.
10) Create a SCADA interface for real-time monitoring and control of parameters like temperature, voltage, or pressure.
11) Use SCADA to simulate automatic substation control and energy management system configurations.

Textbooks:

1. Gary Dunning, “Introduction to Programmable Logic Controllers”, Thomson, 2nd Edition

2. John R. Hackworth, Frederick D., Hackworth Jr., “Programmable Logic Controllers Programming Methods and Applications”

3. John W. Webb, Ronald A. Reis, “Programmable Logic Controllers: Principles and applications”, 5th Edition 4. Ronald L. Krutz, “Securing SCADA System”, Wiley Publishing

5. Stuart A Boyer, “SCADA supervisory control and data acquisition

Reference Books:

1. Batten G. L., “Programmable Controllers”, McGraw Hill Inc., Second Edition

2. Bennett Stuart, “Real Time Computer Control”, Prentice Hall, 1988

3. Doebelin E. O., “Measurement Systems”, McGraw-Hill International Editions, Fourth Edition, 1990

4. Gordan Clark, Deem Reynders, “Practical Modern SCADA Protocols”

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-II** **(EEPEC-03A) Smart Grid Technology**

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Tutorial– 1 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course Prerequisite:

Students shall know the Power generation, transmission, and distribution system.

Course Objectives:

By the end of the course, students will be able to:

1. Understand the fundamentals, architecture, and need for smart grids.
2. Learn about enabling technologies such as AMI, PMUs, and smart appliances.
3. Explore integration techniques and challenges for renewable energy sources.
4. Analyze communication systems and protocols used in smart grid environments.
5. Study monitoring, control, and automation of power networks in a smart grid.
6. Understand global standards, policies, and the role of advanced technologies like AI and blockchain in future smart grids.

Course Outcomes:

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

1. Explain the evolution, architecture, and components of smart grids and differentiate them from conventional grids.
2. Describe key smart grid technologies such as smart meters, PMUs, and EV integration systems.
3. Analyze integration issues of renewable energy sources and evaluate hybrid systems and microgrid operations.
4. Evaluate smart grid communication technologies and apply standard protocols to ensure secure data transmission.
5. Apply control and monitoring techniques such as SCADA and EMS to ensure real-time and efficient grid operation.
6. Discuss national/international standards, policies, and emerging technologies shaping the future of smart grids.

SECTION-I

Unit 1: Introduction to Smart Grid **(6 Hours)**

Evolution of Power Grid to Smart Grid, Concept, need, and benefits of Smart Grid, Smart Grid Architecture and building blocks, Comparison between Conventional and Smart Grids, Challenges and barriers in implementation

Unit 2: Smart Grid Technologies and Components (07 Hrs.)

Introduction, Overview of the technologies required for the Smart Grid, Smart meters: An overview of the hardware used, Evolution of electricity metering, Key components of smart metering, AMI, Smart Meters, Net Metering, Demand-side integration, Substation automation equipment, Switching techniques, Phasor Measurement Units (PMUs) and Wide Area Monitoring Systems (WAMS), Smart appliances and load control, Grid automation and Demand Side Management (DSM), Electric Vehicles (EVs) and integration issues

Unit 3: Renewable Energy Integration (7 Hours)

Integration of Solar PV and Wind systems in Smart Grid, Power electronic interfaces: Inverters, MPPT, charge controllers, Challenges in grid stability and power quality, Hybrid systems, microgrids, and distributed generation (DG), Forecasting and scheduling of RE

SECTION II

Unit 4: Smart Grid Communication Technologies (07 Hrs.)

Communication needs in Smart Grid, SCADA and its role in Smart Grids, Communication protocols: IEC 61850, DNP3, Modbus, Wired and wireless technologies: ZigBee, Wi-Fi, PLC, LTE, 5G, Cybersecurity and data privacy challenges

Unit 5: Smart Grid Monitoring and Control (07 Hrs.)

Real-time monitoring and advanced metering, Load forecasting and energy management systems (EMS), Supervisory Control and Data Acquisition (SCADA), Distributed Energy Resources (DER) control and coordination, Microgrid control techniques and operation

Unit 6: Standards, Policies, and Future Trends (06 Hrs.)

National and international Smart Grid standards (ISGF, IEEE, NIST), Indian Smart Grid policy and initiatives (NSGM, Smart Cities Mission), Business models and regulatory framework, AI and ML in Smart Grids, Future trends: Blockchain, transactive energy, VPPs

Text Books:

1. S. K. Srivastava, “Smart Grid: Fundamentals, Design and Analysis”, Oxford University Press
2. Janardhanan E., “Smart Grid: Concepts and Technologies”, CRC Press India / Universities Press
3. N. K. Sharma, “Smart Grid: Technology and Applications”, McGraw Hill Education India.
4. M. K. Khedkar and G. M. Dhole, “Power System Automation and Smart Grid”, Laxmi Publications.

5. K. S. Manohar, V. Sridhar, “Smart Grid: Challenges, Opportunities and Strategies”, Wiley India
6. Janaka Ekanayake et al., Smart Grid: Technology and Applications, Wiley, 2012.
7. James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley-IEEE Press, 2012.
8. Stuart Borlase, Smart Grids: Infrastructure, Technology and Solutions, CRC Press, 2012.
9. Gil Masters, Renewable and Efficient Electric Power Systems, Wiley, 2013.
10. Clark W. Gellings, The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press, 2009.
11. A. B. M. Shawkat Ali, “Smart Grids Opportunities, Developments, and Trends”, Springer

Reference Books:

1. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley-IEEE Press, 2011.
2. Mini S. Thomas and John Douglas McDonald, Power System SCADA and Smart Grids, CRC Press, 2015.
3. Peter Fox-Penner, Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities, Island Press, 2010.
4. IEEE and CEA Reports on Smart Grid Standardization and Policy Frameworks in India
5. Technical publications from ISGF (India Smart Grid Forum) and NIST Smart Grid Framework

ICA: Minimum Six tutorials based on the above syllabus

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
T. Y. B. Tech. Electrical Engineering
Semester-II
(EEPEC-03B) Extra High Voltage AC Transmission

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Tutorial– 1 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course Prerequisite:

Students should have a fundamental understanding of transmission line theory, electromagnetic field concepts, and basic high-voltage engineering, including inductance, capacitance, and wave propagation principles.

Course Objectives

1. To understand the the need and growth of EHVAC systems.
2. To learn to calculate line parameters for EHV lines.
3. To analyze voltage gradients and corona effects.
4. To understand traveling and standing wave phenomena in transmission lines and analyze their impact under different operating conditions.
5. To evaluate the causes and control of switching surges and voltage control methods.
6. To design EHVAC transmission lines using modern techniques.

Course Outcomes:

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

1. Explain EHVAC system basics and compute line parameters.
2. Analyze corona effects and voltage gradients.
3. Apply wave theory to EHV line analysis.
4. Assess overvoltage causes and mitigation methods.
5. Use voltage control techniques for system stability.
6. Design EHVAC lines considering technical limits.

SECTION-I

Unit -1 Introduction and Calculation of line and ground parameters (08 Hrs.)

Engineering aspects and growth of EHVAC, transmission line trends, and preliminaries, Resistance of conductor, temperature rise properties of bundled conductors, inductance and capacitance calculation, sequence inductance, and capacitance, line parameters for modes of propagation, resistance and inductance of ground return

Unit 2– Voltage gradient of conductors and Losses (07 Hrs.)

Electrostatics, the field of sphere gap, charge potential relations for multi-conductor lines, surface voltage gradients on the conductor lines, surface voltage gradients on sub-conductors of bundle conductors, distribution of voltage gradients on sub-conductors of bundle, I^2R and corona loss, corona loss formula, charge voltage diagram with corona, attenuation of traveling waves due to corona loss, audible noise, corona pulses, their generation and properties, limits for radio interference fields.

Unit 3– Theory of traveling waves and standing waves (07 Hrs.)

The wave at the power frequencies, differential and solution for the general case, standing waves and natural frequencies, open-ended line double exponential response, response to sinusoidal, excitation, line energization with trapped charge voltage, reflection and refraction of traveling waves

SECTION -II

Unit 4 - Over voltage in EHV system covered by switching operations (08 Hrs.)

Over-voltage, their types, recovery voltage and circuit breaker, Ferro-resonance overvoltages and calculation of switching surges- single phase equivalents, reduction of switching surges on EHV systems.

Unit 5- Power frequency voltage control and over voltages (07 Hrs.)

Generalized constants, charging currents, power circle diagram and its use, voltage control using synchronous condenser, sub-synchronous resonance in series capacitors compensated lines, and static reactive compensating systems, Power frequency voltage control and over voltages using AI techniques

Unit 6- Design of EHV-AC lines (06 Hrs.)

Introduction, design factors under steady state, design examples: steady state limits, line insulation design based upon transient over voltages

ICA: Minimum six tutorials based on the above syllabus

Text Books:

1. Rakesh Das Begamudre, “Extra high voltage AC transmission engineering”, New Age Publication

2. S. Rao, “EHV AC and HVDC Transmission Engineering and Practice" Khanna Publishers
3. K. R. Padiyar, “*Power System Dynamics, Stability and Control”*
4. L. Wadhwa – *Electrical Power Systems*
5. S. N. Singh – *Electric Power Generation, Transmission and Distribution*

Reference Books:

1. M. S. Naidu & V. Kamaraju – High Voltage Engineering
2. Ewald F. Fuchs, Mohammad A.S. Masoum – Power Quality in Power Systems and Electrical Machines
3. Narain G. Hingorani & L. Gyugyi – Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems
4. J. Arrillaga & N. R. Watson – Computer Modelling of Electrical Power Systems
5. T. J. E. Miller – Reactive Power Control in Electric Systems

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-II** **(EEPEC-03C) Energy Storage System**

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Tutorial– 1 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

This course aims to introduce the importance and application of energy storage systems and to familiarize with different energy storage technologies.

Course Prerequisite:

Students shall have the importance and application of energy storage systems and familiarize themselves with different energy storage technologies.

Course Objectives:

1. To introduce the role and need for energy storage in power systems and emerging applications.
2. To explain the working principles and modeling of various storage systems.
3. To describe key parameters of electrochemical storage systems including batteries and fuel cells.
4. To analyze thermal, mechanical, and emerging storage technologies.
5. To assess the integration of storage with renewable energy sources.
6. To explore applications of energy storage in smart grids, electric vehicles, and hybrid systems.

Course Outcomes:

Upon the successful completion of the course, students can:

1. Understand the energy balance, modeling, and need for storage in power systems.
2. Explain working principles and configurations of thermal and mechanical energy storage systems.
3. Analyze battery technologies, parameters, fuel cells, supercapacitors, and SMES.
4. Assess storage roles in renewable energy-based isolated and grid-connected systems.
5. Identify practical applications in smart grids, microgrids, and electric vehicles.
6. Compare storage technologies for efficiency, cost, and environmental aspects.

Section-I

Unit 1- Introduction to energy storage in power systems **No of lectures – 06**

Need and role of energy storage systems in power system, General considerations, Types and classification of ESS, Energy and power balance in a storage unit, Mathematical model of storage system: modeling of power transformation system (PTS)-Central store (CS) and charge-discharge control system (CDCS), Econometric considerations.

Unit 2 – Thermal Energy storage technologies **No of lectures – 08**

Thermal energy: General considerations -Storage media- Containment- Thermal energy storage in a power plant, Mechanical Storage, Potential energy: Pumped Hydro-Compressed Air, Kinetic energy: Mechanical- Flywheel, Power to Gas: Hydrogen - Synthetic methane.

Unit 3 – Electrochemical and Electrical Storage Systems **No of lectures – 08**

Battery Technologies: Lead-acid, Li-ion, Flow batteries, Parameters: SoC, DoD, C-rate, Specific Energy & Power (Numericals), Fuel Cells: Working & applications, Supercapacitors and SMES, Comparative analysis & environmental impact

Section-II

Unit 4 – Electrochemical Energy storage technologies **No of lectures – 08**

Electrochemical energy: Batteries- Battery parameters: C-rating -SoC- DoD- Specific Energy-Specific power (numerical examples), Fuel cells, Electrostatic energy (Super Capacitors), Electromagnetic energy (Superconducting Magnetic Energy Storage), Comparative analysis, Environmental impacts of different technologies. Storage role in isolated power systems with renewable power sources, Storage role in an integrated power system with grid-connected renewable power sources.

Unit 5 - Integration with Renewable Energy Sources **No of lectures –6 Hrs**

Storage role in RE systems: Solar, Wind, Hydro, Tidal, Wave, Isolated vs. grid-connected renewable systems, Storage impact on power quality, stability, and reliability

Unit 6- Energy storage Applications **No of lectures – 08**

Smart grid, Smart microgrid, Smart house, Mobile storage system: Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G), Management and control hierarchy of storage systems - Aggregating energy storage systems and distributed generation (Virtual Power Plant Energy Management with storage systems), Battery SCADA, Hybrid energy storage systems: configurations and applications.

Internal Continuous Assessment (ICA)

ICA shall consist of a minimum of Six tutorials based on the above curriculum.

Text Books:

1. Sandeep Dhameja – Electric Vehicle Battery Systems, Elsevier India
2. A.G. Ter-Gazarian – Energy Storage for Power Systems, IET Press
3. Bharat Bhramar – Energy Storage Systems and Power Conversion Electronics, BPB Publications
4. K.R. Padiyar – HVDC Power Transmission Systems, New Age International
5. Chetan Singh Solanki – Renewable Energy Technologies, PHI Learning
6. A.G.Ter-Gazarian, "Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN - 978-1- 84919-219-4),2011.
7. Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt," Energy Storage in Power Systems" Wiley Publication, ISBN: 978-1-118-97130-7, Mar 2016.

Reference Books:

1. R. Rao – Energy Storage Systems, Vijay Nicole Publications
2. James Larminie & John Lowry – Electric Vehicle Technology Explained, Wiley
3. Toshihisa Funabashi – Integration of Renewable Energy Sources with Smart Grid, Academic Press
4. R.M. Dell & D.A.J. Rand – Understanding Batteries, RSC Publishing
5. IEEE/IEC Standards – For battery and hybrid storage integration
6. Electric Power Research Institute (USA), "Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits" (1020676), December 2010.
7. Paul Denholm, Erik Ela, Brendan Kirby and Michael Milligan, "The Role of Energy Storage with Renewable Electricity Generation", National Renewable Energy Laboratory (NREL) -a National Laboratory of the U.S. Department of Energy.
8. P. Nezamabadi and G. B. Gharehpetian, "Electrical energy management of virtual power plants in distribution networks with renewable energy resources and energy storage systems", IEEE Power Distribution Conference, 2011

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur T. Y. B. Tech. Electrical Engineering Semester-II (EEPEC-03D) Signals & Systems

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
Tutorial– 1 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

- **Course Prerequisite:**

Students shall have a mathematical background in differential equations, differentiation, and integration. He /She shall also have basic knowledge of Z transform.

- **Course Objectives**

1. To make students understand mathematical description, graphical representation, transformation, and classification of signals
2. To make students understand the concept of systems, their classification, and properties.
3. To make students understand LTI system analysis in the time domain using convolution and investigation of LTI system properties by Impulse response.
4. To make students understand the use of frequency domain analysis tools like Fourier Transform and Z Transform for LTI systems.
5. To make students understand the concept of Discrete Fourier Transform, need of Fast Fourier Transform and its computation.

- **Course Outcome**

After Completion of this Course

1. Identify basic signals, mathematically and graphically represent, transform, and classify CT and DT signals.
2. Classify different systems and state their properties.
3. Analyze LTI systems in the time domain using convolution and investigate their properties using Impulse response.
4. Use Fourier and Z Transform for analyzing systems in the frequency domain and use their properties.
5. Compute DFT and FFT of DT sequences

SECTION-I

Unit-1. Introduction to Signals & Systems (07 Hrs.)

Definition of signals, Classification of signals, Continuous-time, discrete-time & digital signal, Different types of elementary Continuous and Discrete-time signals (Unit step, Unit Impulse, Exponential, Sinusoidal, Unit ramp), rectangular signal, sine signal, Properties of Unit Impulse, Operations on signals: time shifting, time reversal, Amplitude scaling, time scaling, signal addition & subtraction, signal multiplication, multiple signal transformations, precedence rule, Properties of CT & DT signals

(Periodic, non-periodic, Even and Odd signals, Causal-Non causal, Deterministic & Non-deterministic), energy and power of Continuous-time signal and discrete time signal, Definition of system,

Unit-2 Introduction to Systems **(07 Hrs.)**

Classification of Continuous-time signal and discrete-time systems, lumped and distributed parameter systems, static and dynamic systems, causal and non-causal systems, linear and nonlinear systems, time-variant and invariant systems, stable and unstable systems, invertible & noninvertible systems

Unit-3 Linear Time-Invariant Systems **(06 Hrs.)**

Introduction to system analysis, Representation of discrete-time signals in terms of impulse, Impulse response, Response of DT-LTI system: Convolution sum (Graphical & Analytical method), Response of CT-LTI systems: Convolution Integral, Properties of convolution, Properties of DT-LTI system and CT-LTI system (Dynamicity, invertibility, Causality, stability, unit step response)

SECTION-II

Unit-4 Z Transform **(07 Hrs.)**

Z -transform: Z transform & region of convergence of finite and infinite duration DT signals. Properties of the region of convergence. Properties of Z transform (Statement, Proof, and Numerical): Linearity, Time scaling, Time Shifting, Convolution, differentiation (Multiplication by ‘n’), Initial value theorem, Final value theorem.

Inverse Z transform: Power series method, Partial fraction expansion method, Residue method

Unit-5 Fourier Transform **(07 Hrs.)**

Continuous time Fourier transform:

Introduction to Fourier series & Fourier transforms, Convergence of Fourier transform, phase and magnitude spectrum, Properties (Statement, Proof & Numerical): Linearity, Time shifting, Frequency shifting, time scaling, frequency differentiation, time differentiation, convolution.

Discrete-time Fourier transforms:

Introduction, Relation between Z transform and DT Fourier transform, existence of DT Fourier transform, Properties (Statement, Proof & Numerical): Linearity, Periodicity, Time shifting, Frequency shifting, time reversal, differentiation, convolution in time domain, convolution in frequency domain and Parsevals theorem.

Unit-6 Discrete Fourier Transform **(07 Hrs.)**

Discrete Fourier Transform:

Introduction, 4- & 8-point DFT & IDFT, Properties: Linearity, Time shifting, Shift in K domain, Conjugate symmetry, Time reversal, linear convolution

Fast Fourier Transform:

Need of FFT, 8-point DITFFT algorithm, and 8-point DRIFT algorithm

ICA: -Minimum Six Tutorials based on the above syllabus.

- **Text Books:**

1. Signals and Systems, A.V. Oppenheim, A. S. Wilsky, PHI Publication.
2. Signals and Systems, Simon Haykin, Barry Van Veen, John Wiley & Sons
3. Introduction to Analog and Digital Communications, Simon Hawkins, Wiley India
4. “Signals and Systems”, Dr. D.D. Shah & Prof. A.C. Bhagali, Mahalaxmi Publication Kolhapur

- **Reference Books:**

1. M. J. Roberts and Govind Sharma, “Fundamentals of Signals and Systems”,2nd edition GrawHill,2010
2. Lathi B. P., “Signal & Systems”, Oxford University Press, 2nd Ed. 1998
3. Salivahan S., “Digital Signal Processing”, TMH Publication, 2001.
4. A. Nagoor Kani, “Signals and Systems”, McGraw Hill
5. P. Ramesh Babu & R. Ananda Natarajan, “Signals and Systems”, 4/e- SciTech
6. “Signals and Systems” Ghosh, Pearson Education.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-II** **(EESEC-04) Mini Project on Industrial Applications**

Teaching Scheme	**Examination Scheme**
Theory– 4 Hrs. /Week, 2 Credits	**ICA-** 25 Marks
	POE/OE- 50 Marks

Course Prerequisite:

Students shall have basic knowledge in core engineering disciplines, familiar with programming languages/CAD design, understanding of industrial automation, instrumentation, and project management (from previous semesters).

Course Objectives

1. To provide students with hands-on experience in solving real-world industrial problems fulfilling Sustainable Development Goals (SDGs) using electrical engineering concepts.
2. To familiarize students with industrial applications of electrical engineering, including automation, energy management, and power systems.
3. To enhance technical, analytical, and problem-solving skills through project-based learning.
4. To develop project management, documentation, and presentation skills.

Course Outcomes:

After completing this course, students will be able to:

1. Apply electrical engineering principles to solve industrial problems aligned with Sustainable Development Goals (SDGs).
2. Demonstrate the ability to design, prototype, and test solutions for industrial applications.
3. Analyze and evaluate the feasibility of proposed solutions using technical, economic, and environmental criteria.
4. Develop and present a comprehensive project report with proper documentation.
5. Gain exposure to emerging technologies and their applications in the industrial sector.

Guidelines for Mini Project on Industrial Applications:

Students will form teams of 3-4 members, select a project topic from suggested domains, and follow a structured execution plan: problem identification, system design, prototyping, and final implementation. Each team will be mentored by a faculty member, maintain detailed documentation, and present their project through oral presentations, demonstrations, and peer reviews. The project includes hardware/software development, testing, and reporting.

Domains for Mini Project on Industrial Applications (but not limited to the following):

1. **Industrial Automation:** PLC-based systems, SCADA, HMI, and robotics.
2. **Energy Management:** Smart grids, energy monitoring, smart metering, development of microgrid controllers for isolated communities, and optimization.
3. **Power Electronics:** Drives, converters, and inverters for industrial applications.
4. **Renewable Energy Integration:** Solar, wind, and hybrid systems in industries, development of energy storage solutions for renewable sources.
5. **IoT and Smart Systems:** IoT-based monitoring and control systems, Implementation of predictive maintenance using IoT sensors.
6. **Electric Vehicles and Charging Infrastructure:** Battery management systems, charging stations.
7. **AI and Machine Learning in Industry:** Predictive maintenance, fault detection, and optimization.
8. **Sustainable Development Goals (SDGs):** Projects aligned with SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 13 (Climate Action).

A. Multidisciplinary Minor in "Sustainable Energy System"

Sem	Course Code	Title
VI	EEMDM-04	Energy Audit, Conservation Economics and Policy

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-II** **(EEMDM-04A) Energy Audit, Conservation Economics and Policy**

Teaching Scheme	Examination Scheme
Theory– 2 hrs. /Week, 2 Credits	**ICA**- 25 Marks
Practical– 2 hrs. /Week, 1 Credits	**ISE-** 30 Marks
	ESE-70 Marks

Course Prerequisite:

Awareness about energy sources, Awareness about energy management. Concept of Demand Management, Concept of Tariff

Course Objectives:

1. Understanding the importance of Energy and Energy Security
2. Understand the impact of the use of energy resources on the environment and emission standards, different operating framework
3. Follow the format of energy management, energy policy
4. Learn various tools for demand Control
5. Calculate the economic viability of the energy-saving option

Course Outcomes:

1. Develop strategies to reduce energy consumption while maintaining operational efficiency.
2. Enhance decision-making skills for energy management in industries and organizations.
3. Understand the fundamentals of energy auditing, including types, methodologies, and implementation strategies.
4. Perform real-world energy audits and develop energy conservation plans.
5. Examine global and national energy policies, regulatory frameworks, and sustainability initiatives.

SECTION-I

Unit-1 Energy Scenario **(05 Hrs.)**

Classification of Energy Resources, Conventional and non-conventional, primary and secondary sources, commercial energy production, final energy consumption, Energy needs of a growing economy, short-term and long-term policies, energy sector reforms, distribution system reforms, and up-gradation, energy security, importance of energy conservation, energy and environmental impacts, emission check standard, United nations framework convention on climate change, Global Climate Change Treaty, Kyoto Protocol, Clean Development Mechanism, salient features of Energy Conservation Act 2001 and Electricity Act 2003.Indian and Global Energy Scenario, Introduction to IE Rules, Study of Energy Conservation Building Code (ECBC), Concept of Green Building.

Unit-2 Energy Management: **(05 Hrs.)**

Definition and Objective of Energy Management, Principles of Energy Management, Energy Management Strategy, Energy Manager Skills, key elements in energy management, force field analysis, energy policy, format and statement of energy policy, Organization setup, and energy management. Responsibilities and duties of energy manager under Act 2001. Energy Efficiency Programs and energy monitoring systems.

Unit-3 Demand Management **(05Hrs.)**

Supply-side management (SSM), various measures involved such as the use of FACTS, Generation system upgradation, and constraints on SSM. Demand side management (DSM), advantages and Barriers, implementation of DSM, areas of development of demand side management in agricultural, domestic, and commercial consumers. Demand management through tariffs (TOD), Power factor penalties and incentives in tariff for demand control, Apparent energy tariffs, Role of renewable energy sources in energy management.

SECTION-II

Unit-4 Energy Audit: **(08 Hrs.)**

Definition, need of energy audit, types of audit, procedures to follow, data and information analysis, energy audit instrumentation, energy consumption – production relationship, pie charts. Sankey diagram, Cusum technique, least square method, and numerical based on it. Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options. Benchmarking energy performance of an industry. Energy Audit Report writing as per prescribed format.

Unit-5 Energy conservation in application: **(07 Hrs.)**

a) Motive power (motor and drive system). b) Illumination c) Heating systems (boiler and steam systems) c) Ventilation (Fan, Blower, Compressors) and Air Conditioning systems d) Pumping System e) Cogeneration and waste heat recovery systems f) Utility industries (T and D Sector) g) Diesel generators.

Internal Continuous Assessment (ICA)

ICA consists of a minimum of Six assignments/ Case Studies based above syllabus.

Text Books:

1. Energy Auditing in Electrical Utilities by Rajiv Shankar
2. Energy Management and Conservation by Sharma K V, P. Venkataseshaiah, I K International
3. Handbook on Energy Audit and Environment Management", by Abbi Y.P. and Shashank Jain, The Energy and Resources Institute, TERI
4. Diwan, P., Energy Conservation, Pentagon Press (2008).

Reference Books:

1. Energy Audit and Management 1st Edition 2022 by L. Ashok Kumar and Ganesan, Gokul, CRC Press
2. Handbook of Energy Audits 9th Edition (Hb 2013) by Albert Thumann, Terry Niehus and William J

Younger, Taylor & Francis Publisher
3. Energy Audit Approach for Beginners: A Practitioner's Guide for Energy Manager & Auditors, by S Babu & M Karthik karuppu
4. Energy Efficiency and Management for Engineers, 1st Edition, Mehmet Kanoğlu and Yunus A.Çengel, McGraw-Hill Education

B. Multidisciplinary Minor in “Electrical Vehicle System”

Sem	Course Code	Title
VI	EEMDM-04B	Electric Vehicle Battery Systems

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
T. Y. B. Tech. Electrical Engineering
Semester-II
(EEMDM-04B) Electrical Vehicle Battery System

Teaching Scheme	Examination Scheme
Theory– 2 Hrs. /Week, 2 Credits	**ICA**- 25 Marks
Practical– 2 hrs. /Week, 1 Credits	**ISE-** 30 Marks
	ESE-70 Marks

Course Objective:

1. Understand the fundamentals of electric vehicle battery systems.
2. Learn about different battery chemistries and their characteristics.
3. Design and simulate EV battery systems using software tools.
4. Understand the safety and reliability aspects of advanced EV battery systems.

Course Outcomes: Students will be able to:

1. Understand EV basics, types, and market trends.
2. Compare battery chemistries for EV applications.
3. Design and Analyze EV battery systems.
4. Assess safety and advanced EV batteries.

Section I

Unit I- Introduction to Electric Vehicles and Battery Systems (7 Hrs)

Overview of electric vehicles: history, benefits, and challenges, Battery systems for electric vehicles: types, configurations, and requirements, Market trends and future prospects: industry outlook, government policies, and technological advancements

Unit II- Battery Chemistries and Characteristics (7 Hrs)

Introduction to battery chemistries: principles, materials, and electrochemistry, Lead-acid batteries: characteristics, advantages, and limitations, Nickel-metal hydride (NiMH) batteries: characteristics, advantages, and limitations, Lithium-ion (Li-ion) batteries: characteristics, advantages, and limitations, Comparison of battery chemistries: performance, cost, and environmental impact.

Section II

Unit III- EV Battery System Design and Analysis (8 Hrs)

Battery system architecture: series, parallel, and hybrid configurations, Battery management system (BMS): functions, components, Thermal management system (TMS): functions, components, and strategies, Electrical and mechanical design considerations: wiring, connectors, and packaging, Performance analysis and simulation: modeling, testing, and validation.

Unit IV-Safety and Reliability of Advanced EV Battery Systems (8 Hrs)

Safety considerations for EV battery systems: hazards, risks, and mitigation strategies, Reliability and durability of EV battery systems: testing, validation, and certification, Testing and validation of EV battery systems: standards, protocols, and procedures, Solid-state batteries and Sodium-ion batteries: principles, materials, and applications, Lithium-air batteries: principles, materials, and applications

Textbook:

1. "Electric Vehicle Technology Explained" by James Larminie and John Lowry
2. "Battery Management Systems for Large Lithium-Ion Battery Packs" by Davide Andrea
3. "Electric Vehicle Battery Systems" by SAE International
4. "Lithium-Ion Batteries for Electric Vehicles" by B. Scrosati, K. M. Abraham, W. A. van Schalkwijk, and J. Hassoun
5. "Fundamentals of Electric Vehicle Battery Systems" by C.C. Chan

Reference:

1. "Electric Vehicle Battery Systems" by SAE International
2. "Battery Management Systems for Large Lithium-Ion Battery Packs" by Davide Andrea
3. "Electric Vehicle Implementation" by Kazi Kutubuddin Sayyad Liyakat
4. "Mitigation of High Frequency using ANN " by Kazi Kutubuddin Sayyad Liyakat
5. "Lithium-Ion Batteries for Electric Vehicles" by B. Scrosati, K. M. Abraham, W. A. van Schalkwijk, and J. Hassoun
6. "Fundamentals of Electric Vehicle Battery Systems" by C.C. Chan
7. "Electric Vehicle Technology Explained" by James Larminie and John Lowry
8. "Battery Systems Engineering" by Doberstein, D.
9. "Electric Vehicle Powertrain Engineering" by B. Zhang
10. "Lithium-Ion Battery Materials and Engineering for Electric Vehicles" by Chandra Sekhar

ICA:

ICA should consist of a minimum of five experiments based on the syllabus and one mini-project related to the battery system.

Experiments:

1. Simulation of EV Battery Systems by using MATLAB
2. Battery Management System (BMS) Design by using MATLAB
3. Thermal Modeling of EV Battery Systems by using MATLAB
4. Simulation of EV Battery Charging and Discharging by using MATLAB
5. Design and Simulation of a Solid-State Battery by using MATLAB
6. Advanced Battery Management System (BMS) Design by using MATLAB

A. Honors in “Electrical Vehicle”

Sem	Course Code	Title
VI	EEHn-04A	Testing and Certification of Electric and Hybrid Vehicles

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEHn-04A) Testing and Certification of Electric and Hybrid Vehicles**

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ICA**- 25 Marks
Practical– 2 hrs. /Week, 1 Credits	**ISE-** 30 Marks
	ESE-70 Marks

Course Prerequisite:

Basic knowledge of Electric Vehicle Technology, Components used in Electric Vehicles, and Battery Management Systems.

Course Objective:

1. To understand vehicle specifications, homologation procedures, and testing tracks for EV/HEV.
2. To perform and interpret static vehicle testing for compliance and safety norms.
3. To analyze dynamic testing parameters like acceleration, braking, and range for vehicles.
4. To evaluate vehicle components through standard tests ensuring functional and safety standards.
5. To assess safety aspects in electric vehicles including crash, airbag, and battery tests.
6. To learn hybrid vehicle testing, retrofitment kits, and EV charging station requirements.

Course Outcomes: After the completion of this course, students will be able to:

1. Explain vehicle classification, homologation processes, and testing methods for automotive systems.
2. Demonstrate static testing procedures to evaluate vehicle compliance and component safety.
3. Perform and analyze dynamic vehicle tests for speed, braking, and range efficiency.
4. Conduct component-level testing for automotive parts following industrial testing standards.
5. Evaluate electric vehicle safety tests related to structure, controls, and batteries.
6. Apply hybrid vehicle testing protocols and charging system regulations in practical applications.

SECTION I

Unit I: Introduction **(6 Hrs)**

Specification & Classification of Vehicles (including M, N, and O layout), Homologation & its Types, Regulations overview (AIS, CMVR, FMVSS), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs.

Unit II: Static Testing of Vehicle **(7 Hrs)**

CMVR Physical verification, Tyre Tread Depth Test, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls for M1 Vehicle, The Requirement of Temporary Cabin for Drive–Away–Chassis, Electric vehicle–Safety Norms, Energy consumption and Power test.

Unit III: Dynamics Testing of Vehicle **(7 Hrs)**

Hood Latch, Grade ability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Constant Speed Fuel Consumption, Speedo-meter Calibration, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Electric vehicle–Range Test.

SECTION II

Unit IV: Vehicle Component Testing **(07 Hrs)**

Horn Testing, Rear View Mirror Test, Hydraulic Brakes Hoses, Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tire & Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW<1500 kg), Body block test, Head form test, Driver Field of Vision.

Unit V: Safety Testing of Electric Vehicles **(06 Hrs)**

Safety Glasses Test: Windscreen laminated and toughened safety glass, Crash test with dummies, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, Airbag Test, Accelerator Control System, Safety Requirements of Traction Batteries.

Unit Vi: Tests For Hybrid Electric Vehicles, Retro-Fitment and Charging Station **(07 Hrs)**

Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category (GVW < 3500 kg), Test for Electric Propulsion kit intended for Conversion, Requirements of Electric Vehicle Conductive AC Charging System, and Requirements of Electric vehicle conductive DC charging system.

Reference Books:

1. “Vehicle Inspection Handbook”, American Association of Motor Vehicle administrators
2. Michael Plint& Anthony Martyr, “Engine Testing & Practice”, Butterworth Heinmenn, 3rd ed, 2007
3. Proceedings- Automotive Testing & Certification held on 20th to 24th July 2010 at ARAI PUNE
4. Bosch Automotive Handbook, Robert Bosch, 7th Edition, 2007

ICA:

It should consist of

1. Minimum 2 case studies related to certification and testing
2. Minimum three experiments based on the above syllabus but not restricted to the list given below.
3. Minimum one visit to the electric vehicle manufacturing plant.

List of Experiments:

1. Static testing for Angle & Dimensions Measurement.

2. Range and Acceleration test of electric vehicle.
3. Test for Electric Vehicle Conductive AC Charging System.
4. Test for Electric vehicle conductive DC charging system.
5. Demonstration of Safety Requirement.
6. Brake Performance Testing and ABS Activation Check.
7. Battery Safety Test: Overcharge, Over-discharge, and Short Circuit Handling.
8. Simulate Energy Consumption and Range Testing for EVs.
9. Simulate Coast-down Testing and Resistance Coefficients for a Vehicle.
10. Hybrid System Powertrain Simulation using MATLAB/Simulink.
11. Retrofit Kit Performance Simulation for EV Conversions.
12. Battery SCADA Monitoring and Fault Analysis Simulation.
13. Charging Station AC/DC Simulation Setup and Safety Parameter Testing.

B. Honors in "Sustainable Power System"

Sem	Course Code	Title
VI	EEHn-04B	AI Applications to Power Systems Management

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **T. Y. B. Tech. Electrical Engineering** **Semester-I** **(EEHn-04B) AI Application to Power System Management**

Teaching Scheme	Examination Scheme
Theory– 3 Hrs. /Week, 3 Credits	**ICA-** 25 Marks
Practical– 2 Hrs. /Week, 1 Credits	**ISE-** 30 Marks
	ESE-70 Marks

Prerequisites:

1. Power System Analysis (3rd/4th Semester)
2. Power System Operation and Control (4th Semester)
3. Basics of Artificial Intelligence and Machine Learning (Introductory Course)
4. Programming Skills (Python/MATLAB)

Course Objectives:

1. To introduce students to the application of Artificial Intelligence (AI) techniques in power system management.
2. To equip students with AI tools for solving power system problems such as load forecasting, fault detection, and optimization.
3. To develop skills in implementing AI algorithms for real-time power system monitoring and control.
4. To foster an understanding of the challenges and opportunities of integrating AI into modern power systems.

Course Outcomes:

After completing the course, students will be able to:

1. Understand the role of AI in power system management and its applications in load forecasting, fault detection, and optimization.
2. Apply AI techniques such as neural networks, fuzzy logic, and genetic algorithms to solve power system problems.
3. Design and simulate AI-based solutions for power system monitoring, control, and stability analysis.
4. Analyze the challenges of integrating AI into power systems, including data quality, computational requirements, and cybersecurity.
5. Develop practical AI-based solutions for real-world power system management problems using Python/MATLAB.

Section-I

Unit 1: Introduction to AI in Power Systems **(6 Hours)**

Overview of AI and its relevance to power systems, Challenges in modern power systems: Renewable integration, grid stability, and demand variability, Applications of AI in power system management: Load forecasting, fault detection, and optimization.

Unit 2: AI Techniques for Power Systems (10 Hours)

Machine Learning (ML) basics: Supervised, unsupervised, and reinforcement learning, Neural Networks: Architecture, training, and applications in power systems, Fuzzy Logic: Principles and applications in power system control, Genetic Algorithms: Optimization techniques for power system problems, Case studies: AI applications in load forecasting and fault diagnosis

Unit 3: AI for Power System Monitoring and Control (06 Hours)

Real-time monitoring using AI: Anomaly detection and predictive maintenance, AI-based control strategies: Voltage regulation, frequency control, and stability enhancement

Section-II

Unit 4: AI in Smart Grid (06 Hours)

Smart grid applications: Demand response, energy management, and renewable integration, Challenges: Data quality, computational requirements, and cybersecurity.

Unit 5: AI for Power System Optimization (8 Hours)

Optimal power flow using AI techniques, Unit commitment, and economic dispatch using genetic algorithms and neural networks, AI for renewable energy integration and grid stability, Case studies: AI in microgrid and distributed energy resource management.

Unit 6: Emerging Trends and Future Directions (6 Hours)

AI in IoT-enabled power systems, Role of AI in energy storage management, Ethical and regulatory considerations in AI applications, Future trends: Explainable AI, edge computing, and quantum computing in power systems.

Reference Books:

1. "Artificial Intelligence in Power Systems" by M. E. El-Hawary.
2. "Power System Stability and Control" by P. Kundur.
3. "Machine Learning for Power Systems" by S. N. Singh.
4. "Neural Networks and Fuzzy Logic" by B. Kosko.
5. "Python Machine Learning" by S. Raschka and V. Mirjalili.

ICA:

It should consist of a Minimum of four experiments based on the above syllabus and one visit to the AI Unit of Power Management, but not restricted to the list given below.

List of Experiments:

1. Introduction to Python/MATLAB for AI applications in power systems.
2. Load forecasting using neural networks.
3. Fault detection and classification using machine learning.
4. Optimal power flow using genetic algorithms.
5. Voltage and frequency control using fuzzy logic.
6. Case study: AI-based energy management in a microgrid.
7. Simulation of AI-based predictive maintenance in power systems.
8. Mini-project: Implementing an AI solution for a real-world power system problem.