

GOVERNMENT POLYTECHNIC MUMBAI
(Academically Autonomous Institute, Government of Maharashtra)
Teaching and Examination Scheme (P23)

Programme: Diploma in Electrical Engineering (Sandwich Pattern)
Duration of Programme: 6 Semesters

With effect from AY 2023-24
Semester -V

Semester -V																								
Sr. N.	Course Title	Course Type	Course Code	Total IKS Hrs for Sem	Learning scheme				Credits	Paper Duration (Hrs)	Assessment Scheme													Total Marks
					Actual Contact Hrs/Week			Self Learning Hr/Week			Notional Learning Hrs/Week	Theory			Based on LL & TL				Based on Self Learning					
															Practical									
												FA TH		SA TH	Total		FA-PR		SA-PR		SLA			
												T1	T2											
Max	Max	Max	Max	Min	Max	Min	PR	OR	Min	Max	Min													
1	Switch gear & Protection	DSC	EE23 112		4		2		6	3	3	20	20	60	100	40	25	10	25#	-	10			150
2	Testing & Maintenance of Electrical Equipment	DSC	EE23 113		4		2	2	8	4	3	20	20	60	100	40	25	10	25#	-	10	25	10	175
3	Project & Presentation	AEC	EE23 401		-	-	2	4	6	3	-	-	-	-	-	25	10	-	50#	20	25	10	100	
4	Energy Conservation & Audit	DSC	EE23 114		4	-	2	2	8	4	3	20	20	60	100	40	25	10	-	25#	10	25	10	175
5	Industrial Control and Automation	DSC	EE23 115		4	-	2		6	3	3	20	20	60	100	40	25	10	25#	-	10			150
6	Electric Vehicles (Optional)	DSE	EE23 202		4	-	2	-	6	3	3	20	20	60	100	40	25	10	-	25#	10			150
	Electrical Drives and Control (Optional)	DSE	EE23 203		4	-	2	-	6	3	3	20	20	60	100	40	25	10	-	25#	10			150
Total					20		12	8	40	20		100	100	300	500		150		75	100	-	75		900
Abbreviations : CL- Classroom Learning , TL- Tutorial Learning, LL-Laboratory Learning, FA - Formative Assessment , SA -Summative Assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment																								
Legends : @ Internal Assessment, # External Assessment, *# On Line Examination @\$ Internal Online Examination																								
Note : 1. FA, TH represent the hours of Formative Assessment and Theory respectively. 2. The marks in the assessment scheme are for the internal assessment only. 3. The marks in the assessment scheme are for the external assessment only. 4. The marks in the assessment scheme are for the on line examination only. 5. The marks in the assessment scheme are for the internal online examination only.																								

Abbreviations : CL- Classroom Learning, TL- Tutorial Learning, LL-Laboratory Learning, FA - Formative Assessment, SA -Summative Assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends : @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination
Note : 1. FA-TH represents two class tests of 20 marks each conducted during the semester.

- If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
- If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
- Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 16 Weeks
- 1 credit is equivalent to 30 Notional hrs.
- * Self learning hours shall not be reflected in the Time Table.

7. Students must secure a **minimum of 40 marks out of 100** for passing the course, It shall be **mandatory to obtain a minimum of 10 marks out of 60** in the End Term Theory Examination separately.
Course Category : Discipline Specific Course Core (DSC) : 1, Discipline Specific Elective (DSE) : 2, Value Education Course (VEC) : 3, Intern./Apprentice./Project./Community (INP) : 4, Ability Enhancement Course (AEC) : 5, Skill Enhancement Course (SEC) : 6, Generic Elective (GE) / [Inter Disciplinary Elective (IDE) : 7

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Dept. of Electrical Engineering

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Programme: Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code: EE23 112						Course Title: Switchgear & Protection							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30 Hrs.)	FA- PR	SA		SLA	Total
						T1	T2			PR	OR		
4	-	2	-	6	3	20	20	60	25	25#	--	--	150

Total IKS Hrs. for course:

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale:

Electrical power system consists of generators, transformers, transmission and distribution lines. In case of fault, an automatic protective scheme comprising of circuit breakers and protective relays isolate the faulty section providing protection to the healthy section. Safety of machines/equipment and human beings is the major criteria of every protection scheme. It is also necessary at various levels to protect the power system from any electrical abnormalities. Diploma pass out students should develop skills of operating various controls and switchgear in power system to carry out remedial measures for faults/abnormalities in machines/equipment in power system using appropriate diagnostic instrument/devices. It is a core course and will help while working as a supervisor in substations, manufacturing industries & public service utilities.

II. Industry / Employer Expected Outcome: Maintain different types of electrical equipment following safe practices.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Identify various type of faults in power system.
CO2	Select suitable current interrupting device for various applications.
CO3	Explain the working of different protective relays.
CO4	Maintain the protection of alternator & transformer
CO5	Maintain the protection of motor, bus-bar & transmission line.

Course Content Details:

Switchgear and Protection (EE23 112)

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P-23scheme

Unit No.	Learning Outcome	Topics / Sub-topics
1	TLO 1.1 Describe the functions of the given elements of the protective system TLO 1.2 Explain with sketches the given types of faults and abnormalities in a power system TLO 1.3 Explain with sketches the concept of the Back-up protection for the given protection zone TLO 1.4 Calculate the short circuit currents of symmetrical faults for the given generators TLO 1.5 Select suitable current limiting reactors for the given situation with justification.	Topic Title: Fundamentals of Protection. 1.1 Functions of basic elements of a protective system 1.2 Various types of faults and abnormalities occurring in a power system. 1.3 Concept of the Backup protection. 1.4 Short circuit currents of symmetrical faults. (Numerical) 1.5 Outline the working of current limiting reactors and their arrangements. 1.6 Protection zones Course Outcome: CO1 Teaching Hours : 8 hrs. Marks: 8
2	TLO 2.1 Explain the operation with sketches of the given isolators TLO 2.2 Explain with sketches the given terms related to the specified fuse (s). TLO 2.3 Explain the terms related to arc interruption process of the fuse. TLO 2.4 Explain with sketches arc formation, high resistance and zero current interruption in the given type of circuit breaker. TLO 2.5 Calculate the terms related to circuit interruption based on the given data of the circuit. TLO 2.6 Explain the operation with sketches of the given circuit breaker(s). TLO 2.7 Compare the given circuit interrupting devices on the specified parameters. TLO 2.8 Select the relevant switchgear for the given application with justification. TLO 2.9 Describe the general arrangement of Gas insulated switchgear TLO 2.10 Explain the Insulation coordination for the given installation/machine. TLO 2.11 Classify the Ring main unit switchgear parameters based on given criteria	Topic Title: Current Interruption Devices 2.1 Operation of various isolators with Sketches. 2.2 Important Terms related to fuse (Simple & HRC) 2.2.1 Different types of fuses. 2.3 Characteristics of fuse & state their applications. 2.4 Arc formation, methods of arc extinction high resistance & low resistance, related terms. 2.4.1 Comparison of arc quenching in A.C. and D.C. Circuit Breaker. 2.5 Low tension circuit breakers & their applications. 2.5.1 Miniature CB (MCB), Moulded Case CB (MCCB), Residual Current CB (RCCB), Earth Leakage CB (ELCB) & Air CB (ACB) 2.6 High tension circuit breakers & their applications. 2.6.1 Sulphur Hexafluoride CB (SF6CB), Vacuum CB (VCB) & Air Blast CB (ABCB) 2.7 Selection of current interrupting devices on the basis of various parameters. 2.8 Comparison of current interrupting devices on the basis of various parameters. 2.9 Insulation Coordination- Type1 & Type2 2.10 Lightning Arrester & their types 2.11 Ring Main Unit Switchgear: Introduction, classification based on: type of insulation (gas, oil, air), installation (outdoor, indoor). Course Outcome: CO2 Teaching Hours : 14 Marks : 14

3	TLO 3.1 Explain the given terms related to protective relays TLO 3.2 Calculate the relay time based on the given data in the power system. TLO 3.3 Explain with sketches the working of the given protective relay TLO 3.4 Select relevant protective relay for required application with justification	Topic Title: Protective Relays 3.1 Important terms related to protective relays 3.1.1 Fundamental quality requirements 3.1.2 Basic relay terminology 3.1.3 TSM & PSM relay setting (Numerical) 3.2 Need of various types of relays in power system. 3.3 Various types of relays with Sketches. 3.3.1 Electromagnetic disc relay operation 3.3.2 Thermal relay 3.3.3 Over voltage relay 3.3.4 Over current relay 3.3.4.1 Time current characteristic 3.3.5 Block diagram and working of static relay 3.3.6 Distance relay principle 3.3.7 Directional relay operation with block diagram 3.3.8 Differential relay operation (for voltage & current) 3.3.9 Microprocessor based relays 3.3.9.1 Block diagram & working 3.3.9.2 Protection features Course Outcome: CO3 Teaching Hours : 16 Marks: 16
4	TLO 4.1 Describe the causes and remedies of the given faults in the specified alternator and transformer TLO 4.2 Explain with sketches the given protection schemes of the specified alternator and transformer TLO 4.3 Calculate percentage of winding protected for the specified alternator TLO 4.4 Calculate CT ratio of the specified transformer protection scheme.	Topic Title: Protection of Alternators & Transformers 4.1 Causes of faults & remedies occurred in alternators. 4.2 Various types of protective schemes in alternators. 4.2.1 Differential protection: over current, earth fault, overheating & field failure protection. 4.2.2 Reverse power protection 4.3 Percentage of protected winding for the alternator (Simple Numerical). 4.4 Causes of faults & remedies occurred in transformers. 4.5 Various types of protective schemes in transformers. 4.5.1 Differential protection: over current, earth fault & overheating protection. 4.5.2 Limitations of differential protection 4.6 Buchholz relay: construction, operation, merits & demerits. 4.7 CT ratio of the transformer protection scheme (Simple Numerical). 4.8 Introduction to Microprocessor based alternator & transformer protection. Course Outcome: CO4 Teaching Hours: 12 Marks: 12

5 TLO 5.1 Describe the causes and remedies of the given faults in the specified machines TLO 5.2 Explain with sketches the given protection schemes of the specified machines TLO 5.3 Explain the causes and remedies of the given faults in the bus bar and transmission line TLO 5.4 Describe the various types of protective schemes in transmission lines.	Topic Title: Protection of Induction Motors, Bus-bar, Transmission Lines 5.1 Causes of faults & remedies occurred in motors. 5.2 Various types of protective schemes in motors. 5.2.1 Short circuit protection 5.2.2 Over load protection 5.2.3 Single phase preventer 5.3 Causes of faults & remedies occurred in bus-bars. 5.4 Various types of protective schemes in bus-bars. 5.4.1 Differential protection 5.4.2 Fault bus protection 5.5 Causes of faults & remedies occurred in transmission line. 5.6 Various types of protective schemes in transmission lines. 5.6.1 Over current protection 5.6.2 Distance protection 5.6.3 Pilot wire protection Course Outcome: CO5 Teaching Hours : 10 Marks: 10
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IV. List of Laboratory Experiment. (Minimum 10)

Sr No	Laboratory outcomes	Laboratory Experiment	Number of hrs.	Relevant COs
1	LLO 1.1 Identify various switchgears	Identify various switchgears in the laboratory and write their specifications.	02	CO2
2	LLO 2.1 Identify different parts of isolators.	To identify the components of different types of isolators with their specifications. (through visits, video or model).	02	CO2
3	LLO 3.1 Test the performance of rewirable fuse	To plot the inverse time characteristics of rewirable fuse.	04	CO2
4	LLO 4.1 Identify different parts of MCB / MCCB / ELCB	Dismantle MCB / MCCB / ELCB and identify their various parts.	02	CO2
5	LLO 5.1 Explain parts and working operation of SF6 & Vacuum CB	Demonstrate SF6 & Vacuum CB model (if possible, Video)	02	CO2
6	LLO 6.1 Carry out plug and time setting (with PSM, TSM) of Electromechanical IDMT over current relay.	Carry out Plug Setting Multiplier & Time Setting Multiplier of Electromechanical IDMT over current relay.	04	CO3

7	LLO7.1 Test the performance of numerical over current relay by setting the current magnitude	Test numerical over current relay by performing load test (Inverse time current characteristic) using relay testing kit.	02	CO3
8	LLO8.1 Use Differential protection for protecting the Alternator	Simulate differential protection scheme for 3-phase alternator using the available kit. (winding failure, over excitation, under excitation, over load, low & high frequency, phase sequence etc.).	04	CO4
9	LLO 9.11 Use Differential protection for protecting the Transformer	Simulate differential protection scheme for 3-phase transformer using the available kit. (L-G, L-L & Inter-turn faults).	02	CO4
10	LLO10.1 Use Single Phase Preventer for protection of three phase Induction Motor.	Test the working of single phasing preventer for 3-phase induction motor and also simulate various protections available on the kit.	02	CO5
11	LLO11.1 Select relevant protection scheme for the given transmission line.	Simulate transmission line protection using the impedance / distance relay for various faults using the available kit.	04	CO5
12	LLO 12.1 Identify the components of different types of lightning arresters.	To identify the components of different types of lightning arresters with their specifications. (through visits, video or model).	02	CO2

I. List of Tutorial

NIL

II. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): (Minimum 5)

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Specification Table:

Unit No	Topic Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1	Fundamentals of Protection	08	02	02	04	08
2	Current Interruption Devices	14	04	10	00	14
3	Protective Relays	16	04	08	04	16
4	Protection of Alternators & Transformers	12	02	06	04	12
5	Protection of Motors, Bus-bars & Transmission Lines	10	04	06	00	10
Total		60	16	32	12	60

III. Assessment Methodologies/Tools

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on process and product related performance indicators (25 marks)

Summative Assessment (Assessment of Learning)

- End term examination, Viva-voce (25 marks)

IV. Suggested COs - POs Matrix Form

Course Outcome s (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	3	1	2	2	1	3	2	1	3
CO2	3	2	1	3	2	1	3	2	1	3
CO3	3	2	1	3	3	1	3	2	1	3
CO4	1	2	1	3	3	1	3	3	1	3
CO5	1	2	1	3	3	1	3	3	1	3

Legends: - High:03, Medium:02, Low:01, No Mapping: --

V. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Principles of Power System	Mehta V.K.; Rohit Mehta., S. Chand and Co. Ltd., New Delhi. 2016	ISBN: 978-81-2192-496-2.
2	Switchgear and Protection	Rao Sunil S. Khanna Publishers, New Delhi, 2015	ISBN: 978-81-7409-232-3.
3	Switchgear and Power System Protection	Singh R. P., PHI Learning, New Delhi, 2015	ISBN: 978-81-203-3660-5.
4	Switchgear and Protection	Gupta J. B., S.K. Kataria & Sons, New Delhi, 2015	ISBN: 978-93-5014-372-8.
5	Power System Protection and Switchgear	Ram Badri. Viswakarma D. N., McGraw-Hill, New Delhi, 2015	ISBN: 978-07-107774-X.
6	Switchgear and Protection	Veerapan, N., Krishnamurthy D. N., S. Chand and Co. Ltd., New Delhi. 2014	ISBN: 978-81-2193-212-7.
	Electrical Power Systems	Wadhwa C.L., New Age International, 2009	ISBN: 8122424686, 9788122424683
	Power System Protection and Switchgear	Ravindranath B. Chander, M. New Age International, Second	ISBN-10: 8122430325; ISBN-13: 978-8122430325

VI. Learning Websites & Portals

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E-References:

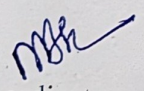
1. www.nptelvideos.in/electricalengineering/relays
2. www.cgglobal.com
3. www.dreamtechpress.com/eBooks
4. www.youtube.com/switchgears
5. www.electrical4u.com
6. www.en.wikipedia.org
7. www.abb.co.in/ProductGuide/

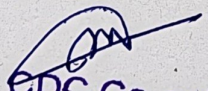
Sr. No.	Link / Portal	Description
1	www.cgglobal.com	Different types of Switchgears
2	https://nptel.ac.in/courses/108101039	NPTEL course on Power System Protection (Fundamentals of Power System Protection, Fault Analysis, Over current Protection, Directional Overcurrent Protection, Distance Protection, Numerical Relay Fundamentals, Differential Protection of Busbar, Transformer and Generator)
3	https://new.abb.com	Different types of Switchgears, Ring Main Unit (RMU) Switchgears, Relays.
4	https://www.elecspare.com	Different types of Switchgears, Ring Main Unit (RMU) Switchgear

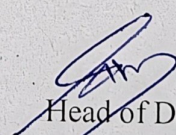
VII. Academic Consultation Committee/Industry Consultation Committee:

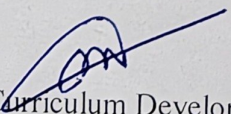
Sr. No	Name	Designation	Institute/Organisation
1	Mr. Kuldeep Singh Rajput	Deputy Executive Engineer	400 KV Receiving Station and Operation and Maintenance Khargar
2	Mr. S.N. Jawarkar	Selection Grade Lecturer	KJ Somaiya Polytechnic, Mumbai
3	Mrs. R.U. Patil	HOD Electrical Engineering	VPM Polytechnic, Thane
4	Dr. P.N. Padghan	Selection Grade Lecturer	Govt. Polytechnic, Mumbai
5	Miss Ashwini V Patil	Lecturer, Electrical Engineering	Government Polytechnic Mumbai

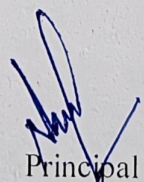
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EDC Co-ordinator
G. P. Mumbai


Head of Department
Department of Electrical Engineering


I/C, Curriculum Development Cell


Principal

Programme: Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code:EE23 113						Course Title:Testing & Maintenance of Electrical Equipment							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30 Hrs.)	FA- PR	SA		SLA	Total
						T1	T2			PR	OR		
4	-	2	2	8	4	20	20	60	25	25#	--	25	175

Total IKS Hrs. for course:

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale:

The electrical engineering technologist is required to carry out the maintenance of the electrical machines and equipment, which includes installation and testing. S/he is thus expected to use the relevant skill-sets while working in the industry, commercial establishments, and public utility departments such as PWD, irrigation, electricity supply agencies, and water supply and sewage board. This course arms the student with the skills to inspect various types of installations and test electrical machines as per prevailing standards. S/he will also be able to carry out different types of maintenances of electrical equipment. S/he will follow the relevant safety practices during such activities

II. Industry / Employer Expected Outcome: Maintain different types of electrical equipment following safe practices.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Explain safety measures and precautions
CO2	Test electrical machines / Earthing as per IS code of practice
CO3	Identify common troubles in electrical machines
CO4	Prepare maintenance schedules for electrical equipment/ machine
CO5	Maintain insulation systems of electrical equipment.

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Course Content Details:

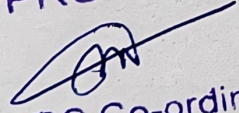
Unit No.	Learning Outcome	Topics / Sub-topics
1	TLO 1.1 Explain the safety actions for the given situation TLO 1.2 Explain the hazards involved for The given situation and action. TLO 1.3 Explain the responsibilities of the supervisor in the given hazardous or accident situation.	Safety & Prevention: 1.1 Definition of terminology used in safety: safety, hazard, accident, major accident, risk assessment, competency, responsibility, authority, accountability, monitoring. General Electrical Safety precautions(Dos & don'ts) for electrical supervisor 1.2 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 CPR and AED, PPE used in the testing and maintenance 1.3 Precautions to be taken to avoid fire due to electrical reasons, Types of fire extinguishers. operation of fire extinguishers Course Outcome: CO1 Teaching Hours : 6hrs Marks: 8 (R- 2, U-4, A-2)
2	TLO 2.1 Describe objective of Testing. TLO 2.2 Explain the need for maintenance for the given type of electrical equipment. TLO 2.3 Explain method of Testing TLO 2.4 State the principal characteristics and related precautions for safety of equipment earthed by the specified class.	General Introduction: 2.1 Objectives of testing, Significance of Indian Standards, Concept of: tolerance, routine test, type test, special test and supplementary tests 2.2 Concept of routine, preventive, breakdown & predictive maintenance. Condition monitoring techniques. Advantages of preventive maintenance, procedure for developing preventive maintenance schedule. Factors affecting preventive maintenance schedule. Concept of TPM, Pillars of TPM 2.3 Methods of Testing: direct, indirect and regenerative with advantages and applications 2.4 Concept of Bathtub curve 2.5 Earth resistance and earth resistivity. factors affecting earth resistance. earth resistivity of different soil composition, methods for reducing soil resistance 2.6 Testing of earth resistance and earth pit electrode: Four terminal method, three terminal method, permissible resistance of the earthing required for different electrical installations, methods of reducing effective earthpit resistance. 2.7 Earthing of electrical equipment as per IS code- IS 3043-1987: Objectives, classification of equipment according to degree of protection against electric shock.

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		Course Outcome: CO2 Teaching Hours : 14 Marks : 12
3	TLO3.1 Explain the specified test with its purpose on the given type of transformer. TLO3.2 Explain the causes of failure of the specified type of transformer from the given symptoms. TLO3.3 Explain the steps in preparing troubleshooting chart for the given type of transformer. TLO 3.4 Explain the remedies for the specified fault in the given transformer	Testing and Maintenance of Transformers : 3.1 Enlist of type test, routine test & special test as per I.S. 1980 -1989. 3.2 Procedure for conducting following tests: Measurement of winding resistance, voltage ratio, polarity, no load losses, & no load current. Impedance voltage, load losses, Insulation Resistance test, Temperature rise test of oil & winding 3.3 Preventive maintenance & routine maintenance of distribution transformer as per I.S10028 (part III): 1981. 3.4 Periodic checks for replacement of oil, silica gel 3.5 Causes of failure of transformer. Various types of faults (mechanical, electrical & magnetic) and reason for occurrence 3.6 Trouble shooting of three phase transformer and remedial measures 3.7 Checklist of Transformer Course Outcome: CO2, CO3 Teaching Hours : 14 Marks: 14
4	TLO 4.1 Explain the objectives of testing the given type of electrical machine. TLO 4.2 Explain the need for the given type of test/s on the specified machine TLO 4.3 Explain the purpose of the specified test on the given type of rotating machine. TLO 4.4 Explain the steps in preparing trouble shooting chart for the given type of rotating machine.	Testing and Maintenance of Rotating Machines: 4.1 List of type tests, routine tests & special tests pertaining to 1 & 3 phase Induction motors. 4.2 Procedures of routine test on single phase (IS7572:1974 (R2017) and three phase induction motors as per (IS code 4029:2010)-Measurement of dc resistance of windings (1&3 phase). measurement of insulation resistance (1&3 phase). No load test (1&3 phase), High voltage test (1 phase), reduced voltage starting and running test (3 phase), temperature rise test (3 phase or three phase) 4.3 Routine, Preventive, & breakdown maintenance of 1 & 3 phase Induction motors as per IS900:2019 latest updated. 4.4 Maintenance schedule of alternators & synchronous Machines. 4.5 Causes of failure of induction motor. Various types of faults (mechanical, electrical & magnetic) and reason for occurrences. 4.6 Trouble shooting of 1 phase & 3-phase induction motor with remedial measures. 4.7 Checklist of 1 phase and 3 phase induction motor.

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		Course Outcome: CO3, CO4 Teaching Hours: 14 Marks: 14
5	TLO5.1 Suggest the insulation material for the given application TLO 5.2 Explain with sketch the procedure to measure the insulation resistance of the given type of machine TLO5.3 Interpret the insulation value acceptability from the given set of readings. TLO 5.4 Explain the reasons for weakening of given type of insulation.	Maintenance of electrical machine insulation: 5.1 Factors affecting life of insulating materials, classifications of insulating materials as per IS:1271-2012 5.2 Measuring insulation resistance, Dielectric Absorption Ratio, Polarization Index, interpretation of the of insulation condition from measurement data. 5.3 Insulating oil – Electrical and thermal properties of insulating oil, causes of deterioration of oil, testing of transformer oil as per IS 1866 : 2017/IEC 60422 : 2013, purification of insulating oil 5.4 Reconditioning of insulation medium: weakening agents which deteriorate properties of insulation medium, cleaning and drying, baking, revarnishing, vacuum impregnation. 5.6 Measures to be taken to maintain the insulation resistance of electrical machines to healthy level during operation and non-operation period Course Outcome: CO5 Teaching Hours : 12 Marks: 12

IV. List of Laboratory Experiment. (Minimum 10)

Sr No	Laboratory outcomes	Laboratory Experiment	Number of hrs.	Relevant COs
1	LLO 1.1 Explain artificial respiration technique after electrocution	Demonstration of artificial respiration technique after electrocution	02	CO1
2	LLO 2.1 State routine test on transformer as per latest IS code 2026-1981	Perform routine test on transformer as per latest IS code 2026-1981 (minimum two test)	04	CO2
3	LLO 3.1 Explain trouble-shooting chart for three phase transformers	Prepare trouble-shooting chart for three phase transformers	02	CO3
4	LLO 4.1 Explain maintenance schedules and carry out routine & preventive maintenance of electrical machines	Prepare maintenance schedules and carry out routine & preventive maintenance of electrical machines available in the institute	02	CO4
5	LLO 5.1 Describe insulation resistance (IR) test on motor / transformer as per IS code	Perform insulation resistance (IR) test on motor / transformer as per IS code	02	CO2 CO5
6	LLO 6.1 State use of fire extinguisher in case of fire due to electrical abnormal conditions	Demonstration of use of fire extinguisher in case of fire due to electrical abnormal conditions	02	CO1
7	LLO7.1 Explain measurement of resistance of earth pit electrode which is available at institute	Measurement of resistance of earth pit electrode which is available at institute	02	CO2

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Testing and Maintenance of Electrical Equipment

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P-23scheme

8	LLO8.1 Describe routine test on 1- phase induction motor as per code IS7572(R2017)	Perform routine test on 1- phase induction motor as per code IS7572: (R2017)(minimum two test, other than IR test)	04	CO2
9	LLO 9.1 Explain routine test on 3- phase induction motor as per code IS 4029:2010	Perform routine test on 3- phase induction motor as per code IS 4029:2010 (minimum two test, other than IR test)	04	CO2
10	LLO10.1 State temperature rise test on transformer as per IS code	Perform temperature rise test on transformer as per IS code	02	CO2
11	LLO11.1 State temperature rise test on motor as per IS code	Perform temperature rise test on motor as per IS code	02	CO2
12	LLO 12.1 Measure breakdown strength of transformer oil	Determine breakdown strength of transformer oil.	02	CO2 CO5
13	LLO 13.1 Measure earth resistivity and locate best spot for earthing pit	Measurement of earth resistivity and locate best spot for earthing pit	04	CO2
14	LLO 14.1 Prepare Troubleshoot the electrical motors available in the institute	Troubleshoot the electrical motors available in the institute	02	CO3

I. List of Tutorial: NIL

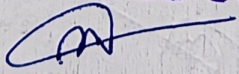
II. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): (Minimum 5)

- Carry out preventive maintenance on any one machine in lab and prepare report on it.
- Prepare power point presentation on testing of Induction motor as per IS.
- Prepare power point presentation related to foundation of transformers.
- Collect sample of various class of insulating materials and prepare a chart of it.
- Collect information on safety signs used for electrically hazardous areas.
- Collect information of specifications, uses, cost of various tools and equipment needed for maintenance of different electrical machines.
- Prepare a report on faulty electrical machine in institute campus through inspection, conduction of tests, troubleshoot and remedial actions needed.

Specification Table:

Unit No	Topic Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1	Safety and Prevention	06	02	04	02	08
2	General Introduction	14	04	04	04	12
3	Testing and troubleshooting of Transformers	14	04	06	04	14
4	Testing and maintenance of rotating machines	14	04	06	04	14
5	Maintenance of electrical machine insulation	12	04	04	04	12
Total		60	18	24	18	60

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Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on process and product related performance indicators (25 marks)

Summative Assessment (Assessment of Learning)

- End term examination, Viva-voce (25 marks)

IV. Suggested COs - POs Matrix Form

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CO1	3	3	2	2	3	3	3	3	3	3
CO2	3	2	2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	3	3	3	3	3	3	3	3
CO5	3	2	3	3	3	3	3	3	3	3

Legends: - High:03, Medium:02, Low:01, No Mapping: --

V. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Operation & Maintenance Of Electrical Machines (Volume I and II)	B.V.S., Rao, Media Promoters & Publishers Ltd. Mumbai	9788185099194
2	Electrical Equipment Handbook: Troubleshooting and Maintenance 1st Edition	Philip Kiameh, McGraw Hill, 1 st edition, 2003	13: 9780071396035
3	Industrial safety , Concepts And Practices	K. T. Kulkarni, Pune Vidyarthi Griha	----
4	Design & Testing of Electrical Machines	M. V. Deshpande. PHI Learning Pvt. Ltd., 2010	8120336453. 9788120336452
5	Installation, Maintenance and Repair of Electrical Machines	M. Gupta, S.K. Kataria & Sons, Edition 2014	978-93-5014-546-3
6	Maintenance & Repairs	Rosenberg, Mc GRAW-HILL, 1 st Edition, May 2003	9780071396035

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E-References:

1. www.howstuffworks.com 2. www.nptel.iitm.ac.in
www.philips.com

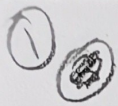
Sr.No	Link / Portal	Description
1	i) w4jHpHoYZhk ii) leRoRx4mobl iii) nkbVC0FnMUU iv) epGGwjjoISM	Fire safety and Fire Extinguisher Operation
2	i) https://youtu.be/TbyV6Z_WQJQ ii) wfpQuYeyG78 iii) OaSovqEimyA	CPR technique
3	https://www.youtube.com/watch?v=_OzBMX84jTA	Tests on transformer
4	https://www.youtube.com/watch?v=4L0ch0-Paq8	Testing of power transformer
5	https://electrical-engineering-portal.com/	i) transformer-maintenance-inspection-repair#energized-condition ii) troubleshooting-transformer-failure iii) testing-and-commissioning-procedure-for-motors iv) regular-motor-maintenance-to-avoid-failure-and-prolong-its-lifespan v) maintenance-practice-electric-motors-generators
6	https://www.youtube.com/watch?v=ZbzYWLCzttk	vaccum dehydration system
7	https://www.youtube.com/watch?v=4-Jnh3fkmiI	Vaccum impregnation process.

VII. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organisation
1	Mr. Prakash Kadam	Unit Head	Pragati Electricals Thane
2	Prof. Dr. Dilip Lulekar	HOD, Electrical Engineering	Govt. polytechnic Nashik
3	Miss. Urvi Sawant	Lecturer, Electrical Engineering	SBM Polytechnic Vile Parle
4	Miss Ashwini V Patil	Lecturer, Electrical Engineering	Government Polytechnic Mumbai

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Government Polytechnic, Mumbai

Diploma in Electrical Engineering

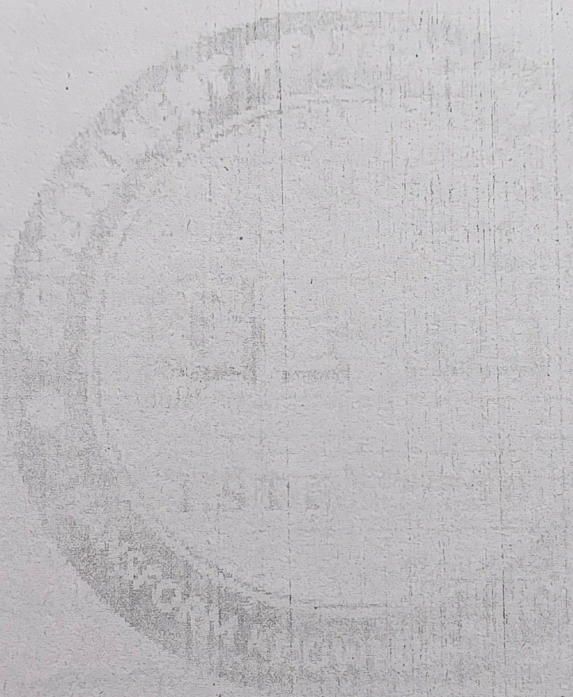
Coordinator,
Curriculum Development,
Department of Electrical Engineering

CBC Co-ordinator
G. P. Mumbai

Head of Department
Department of Electrical Engineering

I/C, Curriculum Development Cell

Principal



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Program: Diploma in Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code: EE23 401						Course Title: Project & Presentation							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (3Hrs.)	FA- PR	SA		SLA	Total
						T1	T2			PR	OR		
-	-	4	2	6	3	-	-	-	25	-	50#	25	100

Total IKS Hrs. for course: 1

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH- Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *#On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 30 marks each conducted during the term.
2. SA-TH represents the end term examination.

Rationale:

The aim of the project is to provide an opportunity to the students to work on an open ended engineering problem. The students will be able to apply knowledge from different areas or courses, which they have studied in their curriculum to a real-world scenario. The scientific way of solving the problems and ability to apply it to find alternative solutions for the problems will help them in their professional life. This course will help to inculcate leadership skills, decision making, participative learning, resource management, cost considerations, documentation and reporting skills with effective communication

Course Outcomes: Student should be able to

EE19401.1	Propose projects with innovative ideas in a clear and concise manner
EE19401.2	Identify and summarize an appropriate list of literature review, analyze previous work done and relate them to current project
EE19401.3	Plan and coordinate work in a group.

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EE19401.4	Implement the skills acquired in the previous semesters to solve complex engineering problems.
EE19401.5	Test the designed project model and evaluate its performance.
EE19401.6	Communicate effectively in oral/written format to present the working of their project/product.

Course Content Details:

Each student of the project batch (maximum five) shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Area of selection for project:

These are only guidelines; any project related to Electrical Engineering depending upon the availability of projects may be included. Preference should be given to projects according to the local needs, practical oriented/industry sponsored/ solutions of society/industry/national/international interest. Projects may be interdisciplinary.

1) Illumination Engineering, 2) Green building Codes, 3) Hybrid Vehicles, 4) Variable Voltage Variable frequency drives, 5) Traction new trends, 6) EHV Transmission, 7) Smart Grid Applications, 8) Computer application in testing and maintenance of electrical equipment, 9) Energy Conservation, Energy Audits, 10) Smart Metering, Electricity Theft Reduction, 11) Power Quality, 12) Renewable Energy, 13) Industry 4.0, 14) IOT, 15) Electrical Mobility, 16) Fuel Cells, 17) Lithium batteries and charging stations, 18) energy efficiency retrofitting of equipment, 19) Electrical Installations, 20) Latest electrical machines, 21) Any other topics related to Electrical Engineering

Project Presentation (Term Work) :25 marks. Each student of the project batch shall present the topic of Project orally and/or through power point slides.

The Project Presentation marks of the Project shall be awarded by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairman. The student shall be evaluated based on:

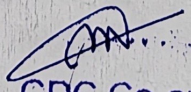
Technical report: 10 marks

Presentation skill: 5 marks

Ability in the Question-and-Answer session: 5 marks.

Attendance and punctuality: 5 marks

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Project & Presentation (EE 23 401)

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(P23 Scheme)

1. Activity plan

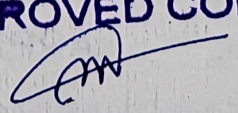
Sr.No.	Activity	Week No
1	Formation of group, Allocation of work responsibility to individual/team	1
2	Visits to Industries / Institutions / Market/field work/sites, Collection of Data /Survey/Analysis	2
3	Finalization of project idea/title and its synopsis submission	3
4	Planning of execution of project activities with time frame	4
5	Design of Components, preparation of drawing, estimates wherever required, printed circuits design, its checking,	5,6
6	Fabrication, Assembling, Model/Prototype development, Testing as per project requirements	7,8,9,10
7	Consolidation of work allotted to individual or team	11
8	Presentation of initial draft: pre submission draft	12
9	Final Project Report: Printed: Submission: soft & Hard copy	13
10	Group presentation of project work at the time of final evaluation	15

The project work along with the project report should be submitted as part of term work in third year fifth semester on or before the term end date.

2. Project Execution:

1. Guide shall monitor the work and help the students from time to time.
2. A project diary is to be maintained by each student, giving details of planning, work executed, information collected etc., on a weekly basis and the same should be validated from the guide on a regular basis.
3. The guide should maintain a record of progressive / continuous assessment of project work and observe the progress of each group member on a weekly basis.
4. The same shall be kept ready for submission to the external examiner before the final examination.

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3. Project Report:

1. The student shall get the initial draft copy of the project approved from the Project Guide.
2. Structure: It shall be as follows

Project report structure

- Title page
- Inner title page (white)
- Certificate
- Certificate from Industry/winner in the competition
- Index/Content/Intent
- List of Abbreviations/Symbols
- List of Figures
- List of Graphs
- List of Tables
- List of if any other inclusion
- Abstract
- Introduction
- Literature Survey/Review
- System Development
- Performance Analysis
- Conclusion
- References
- Appendices
- Acknowledgement

1. Introduction (2-3 pages)

- 1.1 Introduction
- 1.2 Need/Necessity/Motivation
- 1.3 Objectives

2. Literature survey/review (5-10 pages)

Related information available in standard Books, Journals, Transactions, and Internet Websites.

3. System development (20-25 pages)

- The reporting shall be presented in one or more chapters with appropriate chapter titles.
- Experimental setups, procedures adopted, techniques developed, methodologies adopted. Important derivations/formulae
- Figures and tables should be presented immediately following their first mention in the text.

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Project & Presentation (EE 23 401)

(P23 Scheme)

4. **Performance analysis (5-15)**
 - **Test results**
5. **Conclusions (1 page)**
 - 5.1. Conclusion
 - 5.2. Future Scope
 - 5.3. Applications/Utility
6. **References (1-2 pages)**
 - Author, "Title", Name of Journal/Transactions/ Book, Edition/Volume, Publisher, Year of Publication, pp. __.
 - In case of web pages, the complete web page address with assessing date must be enlisted
 - The list of references should be used in the text of the report
7. **Appendices (5-7 pages)**
 - Related data or specifications or referred charts, details computer
 - Code/program, etc.
8. **Acknowledgement(1 page)**
 - Expression of gratitude and thankfulness for helping in completion of the said task with names starting from Guide, HOD, Principal and related people Signed by the candidate.
9. **General Guidelines**
 - Text should be printed on front and correct side of the watermark on quality white bond paper
 - Paper size-A4
 - Font : Times new roman
 - Report heading :- All capital—16 font
 - Chapter heading :- All capital—14 font
 - Subchapter :- Title case-12 font
 - Sub-subchapter :- First alphabet capital case-12 font
 - Content :-Sentence case-12 font
 - Title of the Report should not be more than two lines
 - Spacing between lines-1.5
 - Left Margin-1.5"
 - Right Margin-1/2"
 - Top Margin-1"
 - All text should be justified. (Settings in the Paragraph)
 - Different colours text/diagrams /tables may be used
 - The name of the candidate, diploma (department), year of submission, name of the institute shall be printed on the first page.

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10 Flap

Suitable flap with name of the candidate, Department, Institute. symbol of can be used with nylon strip

4. Criteria of Assessment /Evaluation of Project**A. Formative Assessment (FA) criteria**

The assessment of the students in the fifth semester Formative Assessment (FA) for 25 marks is to be done based on following criteria.

- Project Presentation (Term Work) :25 marks. Each student of the project batch shall present the topic of Project orally and/or through power point slides.
- The Project Presentation marks of the Project shall be awarded by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairman.

a. Suggestive RUBRICS for assessment

S.N.	Criteria	Marks
1	Selection Topic/Theme of project	5
2	Literature review and data presentation	5
3	Quality of Preparation and innovativeness	5
4	Q-A handling	5
5	Time Management	5

B. Summative Assessment criteria

The assessment of the students in the fifth semester Summative Assessment (SA) for 50 marks is to be done based on following criteria.

- Project Presentation (Oral) :50 marks. Each student of the project batch shall present the topic of Project orally and/or through power point slides to External Examiner along with project guide.
- The Project Presentation marks of the Project shall be awarded by the External Examiner

a. Suggestive RUBRICS for assessment

S.N.	Criteria	Marks
1	Quality of Technical report	10
2	Creativity, Innovation in presentation	5
3	Response to the question during presentation	10

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**I. Suggested Activities for Specific Learning / Skills Development (Self Learning):
(Minimum 5) (* mark activities are compulsory)**

- a) Collect information of specifications, uses, cost , etc of anyone of different electrical machines, meters, relays, contactors, ICs, microcontrollers, circuit breakers, power electronic devices, etc.
- b) Carry out survey on latest technology available in Electrical Engineering.
- c) Prepare power point presentation on synopsis of allotted project.
- d) * Prepare power point presentation on completion of allotted project.
- e) * Prepare a technical paper based on completion of allotted project in IEEE format.
- f) * Prepare power point presentation based on above technical paper.
- g) Collect information on safety signs used for electrically hazardous areas.
- h) Collect information of specifications, uses, cost , etc of anyone of different electrical machines, meters, relays, contactors, ICs, microcontrollers, circuit breakers, power electronic devices, etc.

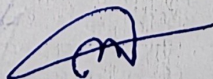
References/ Books:

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Projects in Electrical, Electronics, instrumentation and Computer Engineering	S Chatterjee & S K Bhattacharya S Chand Publishing	9788121930901
2	Project Engineering: The Essential Toolbox for Young Engineers	Frederick B. Plummer Jr. Butterworth Heinemann ,UK, 1 st Edition, 2007	978-0750682794

E-References:

1. <https://innovationenglish.sites.ku.dk/model/double-diamond-2/> The Double Diamond: Strategy + Execution of the Right Solution

2. <https://www.mic.gov.in/> Institution's Innovation Council (IIC). Ministry of Human Resource Development (MHRD), Govt. of India

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Project & Presentation (EE 23,401)

(P23 Scheme)

CO Vs PO and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
EE19401.1	3	3	3	2	2	2	3	3	2	3
EE19401.2	3	3	3	3	3	3	3	3	3	3
EE19401.3	2	2	2	2	2	3	3	3	2	2
EE19401.4	3	3	3	3	3	3	3	3	3	3
EE19401.5	3	3	3	3	3	3	3	3	3	3
EE19401.6	2	2	2	2	3	3	3	2	2	3

Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organisation
1	Mr. Bharat Kadam	Assistant Engineer	MSEDCL, Bhandup, Mumbai
2	Mr. Nikhil Chavan	Unit Head	Solar Panel Assembly, Dhanu
3	Dr. Dilip Lulekar	HOD, Electrical Engineering	Govt. Polytechnic Nagpur
4	Mrs. Deepali Kirtane	Faculty, Electrical Engineering	Govt. Polytechnic Nasik
5	Mrs. J.D. Waghmare (Curriculum Content Designer)	Faculty, Electrical Engineering	Govt. Polytechnic Mumbai
6	Dr. S.B. Bharatkar (Curriculum Content Designer)	HOD, Electrical Engineering	Govt. Polytechnic Mumbai

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Coordinator,

Curriculum Development,

Department of Electrical Engg.CDC Co-ordinator
G. P. Mumbai

Head of Department

Department of Electrical Engg.

I/C, Curriculum Development Cell

Principal

Project & Presentation (EE 23 401)

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(P23 Scheme)

Programme: Diploma in Electrical Engineering (Sandwich Pattern)													
CourseCode: EE23 114						CourseTitle: Electrical Energy Conservation & Audit							
Compulsory/Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30 Hrs.)	FA-PR	SA		SLA	Total
						T1	T2			PR	OR		
4	-	2	2	8	4	20	20	60	25	--	25#	25	175

Total IKS Hrs. for course:

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH- Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale:

The consumption of energy is increasing day by day which causes imbalance in energy generation and its consumption. Energy conservation is a scientific tool provided to minimize the energy imbalance. For implementing and monitoring effectiveness of the energy conservation methods and proper use of electrical energy, its audit is must. To maintain the growth of development, electricity generation will be required, generation should be increased by proper mix of conventional and non-conventional sources of energy. But at the same time its conservation and audit should be done to increase the efficiency of electrical power system. Hence electrical engineers must have knowledge of various methods of energy conservation and concept of energy audit and its implementation.

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Electrical Energy Conservation & Audit (EE23114)

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(P23Scheme)

II. Industry/Employer Expected Outcome: Implement various techniques and methods of energy conservation. Also perform energy audit and its implementation.

III. Course Outcomes: Student should be able to

EE23114.1	Interpret energy conservation policies in India.
EE23114.2	Implement energy conservation techniques in electrical machines.
EE23114.3	Apply energy conservation techniques in electrical installations.
EE23114.4	Use Co-generation and relevant tariff for reducing losses in facilities.
EE23114.5	State the environment problems due to global warming.
EE23114.6	Carryout energy audit for electrical system.

Course Content Details:

Unit No	Learning Outcome	Topics/Sub-topics
1	TLO1.1 State present energy scenario. TLO 1.2 State need of energy conservation and energy audit. TLO1.3 State the relevant clauses of conservation from EC Act 2001. TLO1.4 State the role of BEE and MEDA TLO1.5 State the benefits of Star labeling.	Topic Title: Energy Conservation Basics. Energy scenario: Primary and Secondary Energy, Energy demand and supply, National and Maharashtra scenario. Energy conservation and Energy audit; concepts and difference. Energy Conservation Act 2001; relevant clauses of energy conservation. BEE and its Roles MEDA and its Roles Star Labeling: Need and its benefits. Course Outcome: EE23114.1 Teaching Hours :04 hrs
2	TLO2.1 Describe different energy conservation methods / techniques for electrical motors TLO2.2 State opportunities for energy conservation in transformer TLO2.3 Describe different energy conservation methods/techniques for transformers	Topic Title: Energy Conservation in Electrical Machines. Need for energy conservation in induction motor and transformer. Energy conservation techniques in induction motor by: a) Improving Power quality. b) Motor survey c) Matching motor with loading. (simple numerical) d) Minimizing the idle and redundant running of motor. e) Operating in star mode. f) Rewinding of motor. g) Replacement by energy efficient motor

		i) Periodic maintenance k) Using Energy Conservation Equipment like Soft starters, Automatic star delta convertor, Variable Frequency Drives, Automatic p. f. controller (APFC), Intelligent p. f. controller (IPFC) 2.3 Energy conservation techniques in Transformer. a) Loading sharing b) Parallel operation c) Isolating techniques. d) Replacement by energy efficient transformers. e) Periodic maintenance. f) Using amorphous core for transformers g) Epoxy Resin cast transformer/ Dry type of transformer. Course Outcome: EE23114.2 Teaching Hours: 10hrs
3	TLO3.1 Identify technical and commercial losses of Transmission and Distribution system. TLO3.2 Describe different energy conservation opportunities In Transmission and Distribution Systems. TLO3.3 Define terms related to Illumination. TLO3.4 State procedures for assessing existing lighting System in a facility. TLO3.5 Identify energy conservation techniques / methods in lighting system TLO3.6 Describe energy conservation techniques / methods in lighting system TLO3.7 Calculate payback period of energy efficient luminaries.	Topic Title: Energy conservation in Electrical Installation systems. Aggregated Technical and commercial losses (ATC); Power system at state, regional, National and global level. Technical losses; causes and measures to reduce by: a) Controlling I^2R losses. b) Optimizing distribution voltage c) Balancing phase currents d) Compensating reactive power flow Commercial losses: pilferage, causes and remedies. Energy conservation equipment: Maximum Demand Controller, kVAR Controller, Automatic Power Factor controller (APFC). Energy Conservation in Lighting System a) Recommended Luminance levels b) Replacing Lamp sources. c) Using energy efficient luminaries. d) Using light-controlled gears. e) Installation of separate transformer/ voltage stabilizer for lighting f) Periodic survey and adequate Maintenance programs.

		3.6 Energy Conservation techniques in fans, Electronic regulators. Course Outcome: EE23114.3 Teaching Hours : 10hrs
4	TLO4.1 Define Co-generation TLO4.2 State need for cogeneration TLO4.3 Classify cogeneration systems on the basis of the sequence of energy use TLO4.4 Identify advantages of cogeneration TLO4.5 Find out factor governing selection of cogeneration Systems TLO4.6 State energy cost and Recent MSEDCL tariffs TLO4.7 State application of Tariff System to reduce Energy bill TLO4.8 Describe energy conservation by improving load factor and power factor. TLO4.9. Calculate Energy Conservation by power factor and load factor	Topic Title: Energy conservation through Cogeneration and Tariff. Co-generation and Tariff; concept, significance for energy conservation Co-generation: a) Types of cogeneration on basis of sequence of energy use (Topping cycle, Bottoming cycle) b) Types of cogeneration basis of technology (Steam turbine cogeneration, Gas turbine cogeneration, Reciprocating engine cogeneration). c) Factors governing the selection of cogeneration system. d) Advantages of cogeneration. Tariff: a) Types of tariff structure: Special tariffs; Time-off-day tariff, Peak-off-day tariff, Power factor tariff, Maximum Demand tariff, Load factor tariff and Availability Based Tariff (ABT). Recent MSEDCL tariffs for different consumers. Application of tariff system to reduce energy bill. Course Outcome: EE23114.4 Teaching Hours: 08 hrs
5	TLO5.1 State Relation between energy and environment. TLO5.2 Identify environment and social concerns related to energy utilization in Industry TLO5.3 Describe global environmental issues.	Topic Title: Energy and the Environment Environment and social concerns related to energy utilization The greenhouse effect Global Warming and its effect on Pollution, Acid rains Global Energy and environment Management Course Outcome: EE23114.5 Teaching Hours: 03 hrs

6	TLO6.1 State the need of energy audit TLO6.2 Use of energy audit instruments TLO6.3 State the procedure of Energy audit. 4. State role of energy manager. TLO6.5 Calculate payback period.	Topic Title: Energy Audit of Electrical System. 5.1 Energy audit (definition as per Energy Conservation Act) 5.2 Energy audit instruments and their use. Questionnaire for energy audit projects. Energy flow diagram (Sankey diagram) Simple payback period, Energy Audit procedure (walkthrough audit and detailed audit). Energy Audit report format Course Outcome: EE23114.6 Teaching Hours : 10hrs
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Suggested Specifications Table (Theory):

Unit No	Topic Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1	Energy Conservation Basics.	06	2	4	-	06
2	Energy Conservation in Electrical Machines.	14	4	6	4	14
3	Energy conservation in Electrical Installation systems.	12	4	4	4	12
4	Energy conservation through Co generation and Tariff.	10	2	4	4	10
5	Energy and the Environment	04		4		04
6	Energy Audit of Electrical System.	14	4	4	6	14
Total		60	16	26	18	60

Legends: R-Remember; U-Underst and; A-Apply and above levels (Bloom's revised Taxonomy)

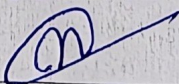
Notes: This specification table shall be treated as a general guideline and actual distribution of marks may slightly vary from table. But the questions from each topic should be asked as per marks weightage. Numerical questions are to be asked only if specified.

List of Tutorials:

Sr. No.	Laboratory Outcomes	Laboratory Experiments	Hours	COs
1	LLO1.1 Identify star labelled electrical apparatus	Identify star labelled electrical apparatus and compare the data for various star ratings.	02	EE23114.1

2	LLO2.1 Determine the '% loading' of Induction motor for various loading.	Determine the '% loading' along with related efficiency for different loads of given Induction motor (30 to 110 percent in steps 10%).	02	EE23114.2
3	LLO 3.1 Determine the reduction in power consumption in star mode operation for induction motor.	Determine the reduction in power consumption in star mode operation of Induction motor compared to delta mode.	02	EE23114.2
4	LLO4.1 Improvement of p.f. of electrical load by APFC.	Use APFC unit for improvement of p.f. of electrical load.	02	EE23114.2
5	LLO5.1 Compare power consumption of different types of tube light.	Compare power consumption of different types of TL with choke, electronic ballast and LED lamps by direct measurements.	02	EE23114.3
6	LLO6.1 Determine the reduction in power consumption by Retrofitting for lamps.	Determine the reduction in power consumption by replacement of lamps in a class room / laboratory.	02	EE23114.3
7	LLO7.1 Determine the reduction in power consumption by Retrofitting for fans.	Determine the reduction in power consumption by replacement of Fans and regulators in a class room / laboratory.	02	EE23114.3
8	LLO 8.1 Interpret electricity bill of an industrial consumer	Collect electricity bill of an industrial consumer and suggest suitable tariff for Energy conservation and its impact on energy bill.	02	EE23114.4
9	LLO 9.1 Interpret electricity bill of an Commercial consumer	Collect electricity bill of a commercial consumer and suggest suitable tariff for conservation	02	EE23114.4
10	LLO 10.1 Interpret electricity bill of an residential consumer	Collect electricity bill of a residential consumer and suggest suitable means for conservation and reduction of the energy bill.	02	EE23114.4
11	LLO11.1 Determine energy saving by improving power factor and load factor.	Estimate energy saving by improving power factor and load factor for given cases.	02	EE23114.4
12	LLO12.1 Prepare energy Audit questionnaire for industrial.	Prepare a sample energy audit questionnaire for the given industrial facility.	02	EE23114.5
13	LLO13.1 Prepare an Energy audit report for phase-I	Prepare an Energy audit report for phase-I	02	EE23114.5

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Electrical Energy Conservation & Audit (EE23114)

(P23 Scheme)

14	LLO14.1 Prepare an Energy audit report for phase-II	Prepare an energy audit report(Phase-II)	02	EE23114.5
15	LLO15.1 Prepare an Energy audit report for phase-III	Prepare an energy audit report(Phase-III)	02	EE23114.5
			30	

References/Books:

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Guide Books No.1 and 3 for National Certification Examination for Energy Managers and Energy Auditors.	Bureau of Energy Efficiency (BEE), Bureau of Energy Efficiency (A Statutory body under Ministry of Power, Government of India) (Fourth Edition 2015).	
2	Energy Technology	O.P. Gupta, Khanna Publishing House, New Delhi	
3	India-The Energy Sector.	Henderson P.D., University Press, Delhi, 2016.	ISBN: 978-0195606539
4	Energy Management Handbook	Turner, W.G., Fairmount Press, 2012.	ISBN: 9781304520708
5	Energy Management and Conservation.	Sharma K.V., Venkateshaiah P., IK International Publishing House Pvt. Ltd; 2011	ISBN: 9789381141298
6	Principles of Power System .	Mehta V.K., S. Chand & Co. New Delhi, 2016.	ISBN: 9788121905947
7	Energy Management.	Singh Sanjeev; Rathore Umesh, S K Kataria & Sons, New Delhi.	ISBN: 13:9789350141014.
8	Efficient Use and Management of Electricity in Industry.	Desai B.G.; Rana J.S.; A. Dinesh V.; Paraman R., Devki Energy Consultancy Pvt. Ltd.	
9	Energy Engineering And Management.	Chakrabarti Amlan, e-books Kindle Edition	

E-References:

1. www.bee-india.nic.in2. www.mnes.nic.in

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Electrical Energy Conservation & Audit (EE23114)

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(P23 Scheme)

3. www.energymanagertraining.com4. www.greenbusiness.com5. www.worldenergy.org6. www.mahaurja.com

COVsPOandCOVsPSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
EE23114	2	3	1	--	3	--	3	1	2	3
EE23114.2	3	3	3	3	1	1	3	2	2	3
EE23114.3	3	3	3	3	1	1	3	2	2	3
EE23114.4	3	3	3	3	3	1	3	2	3	2
EE23114.5	1	2	--	--	3	--	2	--	--	2
EE23114.6	3	3	3	1	3	3	3	2	3	3

Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organisation
1	Mr. Pramod Daspute	BEE Certified Energy Auditor	M/S.ARS Energy Auditors.
2	Prof.S.V. Bhangale	HOD Electrical Engg.	Govt. Polytechnic Pune
3	2. A.K. Dhulshette (Curriculum Content Designer)	HOD Electrical Engg. Selection Grade Lecturer	Govt. Polytechnic Mumbai

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Coordinator,

Curriculum Development,

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CDC Co-ordinator
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Head of Department

Department of

Electrical Engg

I/C, Curriculum Development Cell

Principal

Programme : Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code: EE23 115						Course Title :Industrial Control and Automation							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30Hrs.)	FA-PR	SA		SLA	Total
						T1	T2			PR	OR		
4	--	2		6	3	20	20	60	25	25#			150

Total IKS Hrs. for course: 00

Abbreviations: CL- Classroom Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA - Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents the two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale: Industries rely heavily on automation for economic feasibility, and increased throughput. This course will enable the diploma students to control the process/production using relevant tools like Industrial actuators, Program Logic Controller (PLC), Supervisory Control and Data acquisition (SCADA) and Distributed Control System (DCS).

II. Industry / Employer Expected Outcome::

To automate systems /process/production lines using contactor logic/PLC/SCADA /DCS

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Develop control and power circuits for the given application
CO2	Understand the working of different industrial actuators
CO3	Apply the fundamentals of PLC for effective operation
CO4	Apply the basics of PLC programming for a given application
CO5	Familiarize the SCADA and DCS architecture for process control and data acquisition from the field

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Industrial Control and Automation (EE23 115)

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P-23scheme

IV. Course Content Details:

Unit No.	Learning Outcome	Topics / Sub-topics
1	TLO 1. 1. Interpret the device and its function based on its symbolical representation TLO 1. 2. Describe the working of a given Input/ Output device used in Industrial Control Circuits TLO 1. 3. Differentiate the operation of the control and power circuit for the given motor control circuit TLO 1. 4. Develop control and power circuits for the given process control application(s).	1. Industrial Control Circuits 1.1 Need and benefit of automation, Different Input devices such as push button, selector switch, limit switch, proximity switch and pressure switch. 1.2 Different output devices such as relay, contactor, solenoid valve, solid state relay (SSR) 1.3 Different symbols used in industrial control circuits. Concept of control and power circuit diagram. 1.4 Commonly used motor control circuits - a) DOL starter b) Star-delta starter c) FWD-STOP-REV control and random reversing of induction motor. d) Soft Starters 1.5 Typical control and power circuit diagrams for Skip Hoist, Overhead Crane, conveyor belt (Interlocking of minimum three conveyors), compressor motor Course Outcome : CO1 Teaching Hours : 10hrs Marks: 8
2	TLO 2. 1. Explain the working principle of DC and AC Servo motor. TLO 2. 2. Explain the working principle of PM and Variable DC and AC Servo motor. TLO 2. 3. Differentiate between electrical, hydraulic and pneumatic control systems TLO 2. 4. Explain the construction and working of different types of hydraulic pumps TLO 2. 5. State the need of accumulator and types of filters used in hydraulic circuits. TLO 2. 6. Explain the components of pneumatic system. TLO 2. 7. Explain the working of pneumatic output devices. TLO 2. 8. Explain the construction and working of different types of control valves. TLO 2. 9. Classify direction control valves. TLO 2. 10. Explain the working of different	2. Industrial Actuators 2.1 Servomotor (DC and AC) : Working Principle 2.2 Stepper Motor (PM and Variable Reluctance – Working Principle) 2.3 Brief comparison between electrical, hydraulic and pneumatic control system-merits and demerits. 2.4 Construction and working of different types of Hydraulic pumps Hydrodynamic and Positive displacement (Gear, Lobe, Vane) 2.5 Need of accumulator and types of filters in hydraulic circuits 2.6 Components of Pneumatic system–Types of compressors, FRL unit and it's working. 2.7 Pneumatic output devices- Working of Single acting, double acting cylinder, Gear Motor, Vane motor. 2.8 Hydraulic and pneumatic control devices– Construction and working of different types of control valves (Globe, angle, spool, puppet). Classification and working of direction control valves, working of pressure control valves, working of flow control

	control valves. TLO 2. 11. Explain the working of shaper and sequence circuit	valves (plug, butterfly and ball). 2.9 Examples of application of hydraulic circuit – shaper circuit, sequence circuit. Course Outcome: CO2 Teaching Hours : 14 Marks: 14
3	TLO 3. 1. Describe architecture of PLC with a neat block diagram along with functions of each part. TLO 3. 2. Describe CPU functioning and memory organization of PLC. TLO 3. 3. Describe Redundancy concept in PLC TLO 3. 4. State specifications of given PLC TLO 3. 5. Enlist different brand and model of PLC's available in the market TLO 3. 6. Explain the need and significance of International standard for PLC IEC 61131-1, IEC 61131-2, IEC 61131-3	3. PLC Fundamentals 3.1 Architecture of PLC : Block Diagram and function of each block 3.2 CPU working : PLC scan cycle , speed of execution working modes of CPU (Programming, RUN, REM Modes) 3.3 Redundancy and memory organization of PLC 3.4 Classification of PLCs: According to structure, Size. Advantages of PLC based automation over relay based automation, Specifications of PLC, Different PLCs available in market, PLC comparison with PC 3.5 Digital and Analog IO modules of PLC, Block diagram and specification 3.6 Cloud based PLC : Schematic diagram , advantages 3.7 International standards for PLC IEC 61131-1, IEC 61131-2, IEC 61131-3 Course Outcome: CO3 Teaching Hours : 14 Marks : 16
4	TLO 4. 1. TLO 4.1 State features of PLC programming languages TLO 4. 2. Develop Ladder diagram for different logic gates TLO 4. 3. Develop the PLC ladder programs for the given situations. TLO 4. 4. Describe program scan process for the given type of PLC TLO 4. 5. Describe various types of PLC instructions TLO 4. 6. Develop PLC ladder logic for given Industrial application	4. Basics of PLC Programming 4.1 Binary system , bit , Binary system, bit, byte, word, logic gates, PLC Programming languages : Ladder Logic , Sequential Function Charts (SFC), Function Block Diagram (FBD), Structured Text (ST), Instruction List(IL) - (Only Introduction , Advantages and Disadvantages) 4.2 Programming PLC using ladder diagram, Components of ladder diagram, Program scan process applied to single rung. 4.3 Ladder diagram for different logic gates : AND, OR, NOR and XOR 4.4 PLC Instructions : (i) Bit type instructions- XIC, XIO, OTE, OTL, OUT, OSR (ii) Logical instructions- OR, AND, NOT, XOR (iii) Comparison instructions- EQU, NEQ, LES, LEQ, GRT, GERQ, LIM (iv) Timer instructions- TON, TOFF, RTO (v) Counter instructions- CTU, CTD (vi) Arithmetic instructions- ADD, SUB, MUL, DIV

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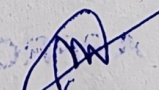
		4.6 System Design, I/O listing, Wiring Diagram and Ladder Logic for Industrial Applications : DOL starter with OLR, Forward reverse control of 3-phase IM, Temperature control (ON/OFF), Bottle filling system, Traffic Light Control Course Outcome: CO4 Teaching Hours : 14 Marks: 14
5	TLO 5. 1.Explain SCADA system architecture used in Industrial Automation with the help of Block diagram. TLO 5. 2.Explain DCS system architecture used in Industrial Automation with the help of Block diagram TLO 5. 3.Compare PLC, SCADA and DCS	5. SCADA and DCS 5.1 Supervisory Control and Data acquisition (SCADA): Basic function, generalized block diagram, function of each block, applications of SCADA 5.2 Distributed Control System: Basic function, generalized block diagram, function of each block, applications of DCS Course Outcome: CO5 Teaching Hours :08 Marks: 08

List of Laboratory Experiments:

The Term work consist of **minimum 10** experiments with approx. number of hours required with corresponding CO's. Care should be taken to include all COs while selecting the practicals.

Sr. No	Laboratory Outcomes	Laboratory Experiment	Number of hrs.	Relevant COs
1	LLO 1. 1 Interpret different symbols used in a given industrial control diagram	Identification of symbols used in industrial control diagrams.	2	CO1
2	LLO 2. 1 Simulate a simple seal-in circuit using PLC simulator. LLO 2. 2 Addressing of Input and output devices	Simulation of a simple seal-in circuit using PLC simulator.	2	CO4
3	LLO 3. 1 Draw logic diagram to create 10 second delay after a push button press using timer instruction block LLO 3. 2 Address properly the input, output devices and timer instruction/block LLO 3. 3 Test the ladder logic	PLC program to create a delay using a timer function	2	CO4

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4	LLO 4.1 Draw logic diagram to count operation of a push button press / toggle switch operation using counter instruction block LLO 4.2 Address properly the input, output devices and counter instruction/block LLO 4.3 Test the ladder logic	PLC program to count the number of operation of switch using a counter function	2	CO4
5	LLO 5.1 Draw ladder logic diagram for controlling the direction of rotation for a 3 phase induction motor LLO 5.2 Address properly the input output devices LLO 5.3 Test the ladder logic program LLO 5.4 Interface the 3 phase induction motor to the PLC with the help of Motor module if available	PLC program for reversal of direction of rotation of 3ph. Induction motor	2	CO4
6	LLO 6.1 Learn the basics and hardware components of PLC LLO 6.2 Understand configuration of PLC system LLO 6.3 Understand various building blocks of PLC	Understand hardware and Software used in PLC. (From Programmable Logic Controller Lab of Electrical Engineering Department from virtual lab portal) https://portal.coepvlab.ac.in/vlab/ Take the print of the output.	2	CO3
7	LLO 7.1 Understand PLC arithmetic instructions	Implementation of PLC arithmetic instructions (By PLC / Programmable Logic Controller Lab of Electrical Engineering Department from virtual lab portal) https://portal.coepvlab.ac.in/vlab/ Take the print of the output.	2	CO4
8	LLO 8.1 Draw ladder logic diagram for controlling the temperature of given process. LLO 8.2 Address properly the input devices (Temperature Sensor) LLO 8.3 Test the ladder logic program LLO 8.4 Interface the Temperature	Control of Temperature with the help of PLC	2	CO4

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	sensor to the PLC			
9	LLO 9.1 Draw ladder logic diagram for controlling the traffic lights. LLO 9.2 Address properly the input and output devices LLO 9.3 Test the ladder logic program	Simulating traffic light control with the help of PLC	2	CO4
10	LLO 10.1 Draw ladder logic diagram to simulate given gate LLO 10.2 Address properly the input and output devices LLO 10.3 Test the ladder logic program (AND, OR, XOR, NOR)	Implementation of Logic gates (By PLC / Programmable Logic Controller Lab of Electrical Engineering Department from virtual lab portal) https://portal.coepvlab.ac.in/vlab/ Take the print of the output	2	CO4
11	LLO 11.1 Draw ladder logic diagram for bottle filling plant. LLO 11.2 Address properly the input and output devices LLO 11.3 Test the ladder logic program LLO 11.4 Interface the input and output devices to the PLC	Logic Implementation for Bottle Filling Application (By PLC / Industrial Automation Laboratory of Electrical Engineering Department from virtual lab portal) https://portal.coepvlab.ac.in/vlab/	2	CO4
12	LLO 12.1 Identify of various features and properties of SCADA system	Identification of various components in library/ Wizard and properties of SCADA software	2	CO5
13	LLO 13.1 Identify hardware and software platform for DCS using virtual lab	Understand hardware and software platforms for DCS (From Industrial Automation Laboratory of Electrical Engineering Department from virtual lab portal) https://portal.coepvlab.ac.in/vlab/	2	CO5
14	LLO 14.1 Identify of various components of a pneumatically operated control valve	Identify various components of a pneumatically operated control valve (From Process Loop Component and Control Valve for Various Applications – virtual laboratory of Electrical Engineering Department from virtual lab	2	CO2

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		portal) https://plccom-coep.vlabs.ac.in/ Take the print of the output.		
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VI. List of Tutorial

NIL

VII. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): (Minimum 2)

1. Write a report on cloud based automation
2. Make a survey of commercially available PLCs in the market
3. Make a survey of Industrial control components based on their ratings.

VIII. Specification Table:

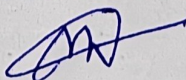
Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Industrial Control Circuits	2	2	4	8
2	Industrial Actuators	0	2	12	14
3	PLC Fundamentals	4	6	6	16
4	Basics of PLC Programming	2	4	8	14
5	SCADA and DCS	2	0	6	8
Total		10	14	36	60

IX. Assessment**Methodologies/Tools****Formative assessment (Assessment for Learning)**

- Rubrics for continuous assessment based on process and product related performance indicators (25 marks)

Summative Assessment (Assessment of Learning)

- End term examination, Viva-voce, Practical performance (25marks)

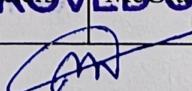
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X. Suggested COs - POs Matrix Form

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	2	2	2	2	1	2	2	2	1
CO2	2	2	2	1	1	1	3	1	1	1
CO3	1	1	1	-	-	-	-	-	-	-
CO4	1	1	1	3	1	1	3	1	-	1
CO5	1	1	1	3	1	-	1	1	1	1
Legends: - High:03, Medium:02, Low:01, No Mapping: --										

XI. Suggested Learning Materials / Books

Sr. No	Author	Title	Publisher
1	Bhattacharya, S.K.; Singh, B.	Control of Machines	New Age International Publishers, New Delhi, 2006, ISBN: 978122418187
2	Eswar, U.S.	Handbook of Electrical Motor Control Systems	McGraw Hill Education, New Delhi, 2013, ISBN : 978-0074601112
3	Madhuchhanda Mitra, Samarjit Sengupta	Programmable Logic Controllers and Industrial Automation: An Introduction	Penram International Publication, New Delhi, 2017, ISBN : 978-8187972631
4	Stuart A. Boyer	SCADA: Supervisory Control and Data Acquisition	ISA, 1999, ISBN : 1556176600, 9781556176609
5	Garry Dunning	Introduction to Programmable logic Controller	Delmer Cengage learning ISBN-13978-1401884260 Edition 3 Publication Date-16 December 2005
6	Boyar S.A	Supervisory control and data acquisition	ISA Publication, USA ISBN: 978-193600709
7	Bhatkar Vijay P.	Distributed computer control system in industrial automation	Routledge 2017 : ISBN 9781351454698
8	Frank D. Petruzella	Programmable Logic Controllers	McGraw Hill ISBN - 13978-9353167271


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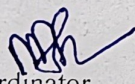
XII. Learning Websites & Portals

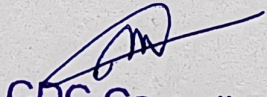
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1	https://portal.coepvlab.ac.in/vlab/auth/home?dept=3&lab=4	Virtual Lab for PLC : from COEP Technological University , Pune
2	https://portal.coepvlab.ac.in/vlab/auth/home?dept=3&lab=2	Virtual Lab for Industrial Automation : from COEP Technological University , Pune
3	https://www.youtube.com/watch?v=PLYosK87D8E	PLC basics
4	https://www.youtube.com/watch?v=Hci-eW5lihM	Basics of PLC Ladder Diagram
5	https://www.youtube.com/watch?v=1pRv-p_HbRk	Controlling Water Level in the PLC Ladder Logic Program
6	https://www.youtube.com/watch?v=3WATUnwCwRA	Mastering PLC Programming: Traffic Light Control
7	https://www.youtube.com/watch?v=8UQOhGp8ggY	Basic PLC bottle filling process
8	https://youtu.be/86uY3TQq2Yk?si=tpM6Rh4CFOMQONJY	Introduction to SCADA Systems What is SCADA?
9	https://youtu.be/DIFOIoFjJwc?si=Zlq8BIzSzxW36kOY	DCS vs PLC Understanding the Differences and Applications

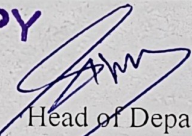
XIII. Academic Consultation Committee/Industry Consultation Committee:

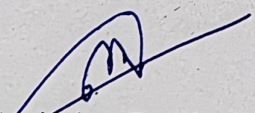
Sr. No	Name	Designation	Institute/Organization
1	Mrs. Asmita M Marathe	Additional Executive Engineer	Executive Engineer ,MSEDCL , Bandra
2	Shri.Kiran Inamdar	Lecturer in electrical Engineering	Pilley COE , Rasayani
3	Dr.Mahesh S. Narkhede	Lecturer in Electrical Engineering	G.P.Mumbai
4	Shri.Rakesh Kumar Shukla	Lecturer in Electrical Engineering	G.P.Mumbai

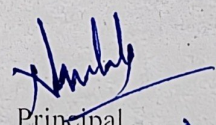
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Coordinator,
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Department of Electrical Engineering


CDC Co-ordinator
G. P. Mumbai


Head of Department
Department of Electrical Engineering


I/C, Curriculum Development Cell


Principal

Programme : Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code: EE23 202						Course Title : Electric Vehicles							
Compulsory / Optional: Compulsory													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2.30Hrs.)	FA-PR	SA		SLA	Total
						T1	T2			PR	OR		
4	--	2		6	3	20	20	60	25	25#			150

Total IKS Hrs. for course: 00

Abbreviations: CL- Classroom Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA - Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents the two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.

I. Rationale: The global movement towards sustainable energy has positioned electric vehicle (EV) technology as a crucial field for electrical engineers. This course is designed to provide students with the essential knowledge and skills to understand, test, and work with EV systems. Through a blend of theoretical instruction and hands-on laboratory experiments, students will develop a thorough understanding of EV technology, equipping them for careers in the rapidly expanding electric vehicle industry.

II. Industry / Employer Expected Outcome:

Test and use different components of EV systems and compliance of policies & preparing for careers in the electric vehicle industry.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Identify components and subsystems used in electric vehicles.
CO2	Select electrical drives for particular EV application.
CO3	Test the performance of batteries and energy storage systems used for EV applications.
CO4	Apply the concept of converters and charging system in EV.
CO5	Implement Indian and State EV policies for EV applications.

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IV.Course Content Details:

Unit No.	Learning Outcome	Topics / Sub-topics
1	TLO 1.1 Compare electric vehicles and internal combustion engine vehicles on the given points. TLO 1.2 Describe the configuration of given types of EV system. TLO 1.3 Compare given EVs on the basis of given points. TLO 1.4 Describe the function of given EV subsystem	1. Basics of Electric Vehicles 1.1 History and evolution of electric vehicles (EV), need of EV, Electric vehicles and internal combustion engine vehicles: Comparison on the basis of environmental impact, power source, maintenance, gear change, noise level, vibrations level, capital cost, and running cost. 1.2 Electric vehicle architecture, Types of EV: Battery Electric Vehicle(BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle(FCEV). 1.3 Comparison of different electric vehicle types on the basis of Driving Component, Energy Source used, Features, Problems and models available in market. 1.4 Block diagram of EV subsystems: energy source subsystem, propulsion subsystem and auxiliary subsystem. Course Outcome : CO1 Teaching Hours :8 Marks: 8
2	TLO 2.1 Classify Electric Vehicles. TLO 2.2 Interpret the characteristics of the given electric motor(s) used in EV. TLO 2.3 Distinguish between given EV Motors on the basis of given points. TLO 2.4 Select given electrical drives for EV applications of different control valves.	2. Electric Vehicle Drives 2.1 Classification of electric drives used in EV : DC Motor drives, AC Motor drives. 2.2 Brushed DC Motor, Brushless DC Motor (BLDC), Permanent Magnet Synchronous Motor (PMSM), Induction Motor (IM), Switched Reluctance Motor (SRM), PM Assisted Synchronous Reluctance Motor, Axial Flux Ironless Permanent Magnet Motor: Salient features, characteristics, advantages, limitations, and usage of different motor types in EV models. 2.3 Comparison of EV motors based on power to weight ratio, torque-speed characteristic, cost of controllers required and cost of motors. Physical location of motor in EV, Rating of motors, Connections (Mechanical and Electrical), and Selection criteria of various types of EV motors. Course Outcome: CO2 Teaching Hours :6 Marks: 16

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3	TLO 3.1 Describe given terms related to battery parameter. TLO 3.2 Describe the procedure for selection of battery for the given EV. TLO 3.3 Calculate EV battery capacity based on mileage and load. TLO 3.4 Describe the process of given Battery Management System (BMS). TLO 3.5 Compare given type of fuel cells based on given points.	3. Batteries and Energy Storage Systems 3.1 Energy storage technology: EV Batteries. Supercapacitors, flywheel energy storage. Battery Parameters: Cell and Battery Voltages, Charge (or Amphour) Capacity, Energy Stored, Specific Energy, Energy Density, Specific Power, Amphour (or Charge) Efficiency, Energy Efficiency, Self-discharge Rates, Battery Geometry, Battery Temperature, Heating and Cooling Needs, Battery Life and Number of Deep Cycles. 3.2 Batteries: Lead-acid, NiMH (Nickel-Metal Hydride), Li-Ion (Lithium-Ion), Ni-Zn (Nickel-Zinc), Ni-Cd (Nickel-Cadmium), Aluminium-Ion batteries (Al-Ion batteries), Aluminium-air batteries (Al-air batteries)- their basic construction components, life time (cycles), efficiency, advantages and disadvantages. Comparison of various batteries. Factors influencing the operation of battery, and selection of battery. Series and Parallel connection of Batteries, Calculation of battery capacity. 3.3 Battery Management Systems (BMS): Need of BMS, Block diagram of BMS, function of each block, Battery Condition Monitoring, "3R" (Reduce, Reuse, Recycle) process for battery. 3.4 Fuel Cell: Difference between fuel cell and batteries, Fuel Cell Terminology: Anode, Cathode, Electrolyte, Catalyst, Reformer, Direct Fuel Cell, Working principle of fuel cell. Types of Fuel Cells used in EVs: Alkaline Fuel Cell (AFC), Polymer Electrolyte Membrane Fuel Cell (PEMFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel cell (SOFC), Their comparison on the basis of Electrolyte type, Cell voltage, Operating temperature, System output (kW), Efficiency (%) and Applications. Course Outcome: CO3 Teaching Hours : 14 Marks : 14
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4	TLO 4.1 Describe the configuration and functions of the given type of converter. TLO 4.2 Describe given type of EV charging method(s). TLO 4.3 Distinguish between given charging systems. TLO 4.4 Describe given type of charging station. TLO 4.5 Calculate charging time based on given data.	4. Converters and EV Chargers 4.1 Introduction to power electronics used in EV, Block diagram of typical EV: Description and Functions of DC to DC Converter, DC to AC Converter, AC to DC Converter (Rectifier) and filters. 4.2 Charging methods: Home charging, Trickle charging, Household AC charging, Public charging (DC Fast charging). 4.3 Charging System: Classification- Wireless, Onboard and Off board charging, V1G (Unidirectional smart charging), V2B/V2H (Vehicle-to-Building/ Vehicle-to-Home), 2X (Vehicle-to-Everything), V2G (Vehicle-to-Grid, Bi-directional smart charging). 4.4 Charging Stations: Types of charging station, Public charging station: Selection and sizing, components and, single line diagram. Calculation of charging time and concept of battery swapping. Precautions observed while charging. Course Outcome: CO4 Teaching Hours : 14 Marks: 14
5	TLO 5.1 State the given points related to NEMMP. TLO 5.2 Compare incentives policies for the given types of electric vehicle.	5. Electric Vehicle (EV) Policies 5.1 Goal of EV30@30 campaign. Goals of electric vehicles initiative in India. National Electric Mobility Mission Plan 2020 (NEMMP): Objectives, Steps taken by Indian Government for faster adoption of electric vehicles, Barriers to adoption of electric mobility, E-mobility strategy, NEMMP 2020 Implementation structure. 5.2 Maharashtra Electric Vehicle Policy 2021: Objectives, Basic demand incentives for electric vehicles, Vehicle segment-wise scrap page incentives, Incentives for charging infrastructure. Course Outcome: CO5 Teaching Hours : 08 Marks: 08

List of Laboratory Experiments:

The Term work consist of **minimum 10** experiments with approx. number of hours required with corresponding CO's. Care should be taken to include all COs while selecting the practical's.

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Electric Vehicles (EE23 202)

P-23scheme

Sr. No	Laboratory Outcomes	Laboratory Experiment	Number of hrs.	Relevant COs
1	LLO 1.1 Identify components of various types of electric vehicle.	*Identification of electric vehicle components.	2	CO1
2	LLO 2.1 Identify various subsystems of electric vehicles.	*Identification of subsystems of electric vehicles..	2	CO1
3	LLO 3.1 Identify the terminals of Permanent Magnet Synchronous Motor. LLO 3.2 Identify the terminals of Three-phase Squirrel cage Induction Motor. LLO 3.3 Identify the terminals of Synchronous Reluctance Motor. LLO 3.4 Identify the terminals of Brushless DC motor.	*Identification of terminals of motors used in EVs.	2	CO2
4	LLO 4.1 Determine and compare The characteristics of given EV motors.	*Comparison of characteristics of EV motors.	2	CO2
5	LLO 5.1 Measure open circuit voltage of a given battery using multimeter. LLO 5.2 Identify the charged, discharged and dead battery condition. LLO 5.3 Determine Amphour (Ah) capacity of battery.	*Testing of EV batteries.	2	CO3
6	LLO 6.1 Perform Active Lithium-Ion Cell balancing using Plastic Platform Scale.	Battery Cell balancing.	2	CO3
7	LLO 7.1 Design battery pack for specified capacity of EV.	*Design of battery for EV.	2	CO3
8	LLO 8.1 Charge an EV battery using various methods, and record charging times and efficiency.	*Charging of EV battery.	2	CO4
9	LLO 9.1 Develop a charging station layout. LLO9.2 Select appropriate components of charging station. LLO9.3 Draw a single-line diagram of a charging station. LLO 9.4 Simulate the charging process of a charging station using any open-source software.	Public charging station for EV.	2	CO4
10	LLO 10.1 Calculate the charging time for different battery capacities using given formulas.	*Calculation of charging time for different battery capacities.	2	CO4

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11	LLO 11.1 Prepare a report on Indian EV policy. LLO 11.2 Prepare a report on Maharashtra EV Policy, 2021.	*Report on EV policy.	2	CO5
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VI. List of Tutorial

NIL

VII. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): (Minimum 2)**Microproject**

- Build and test simple DC-DC converters and inverters.
- Prepare any micro project on EVs.
- Test sensors and systems for autonomous EVs and submit report on it.
- Perform sub-system simulations of an electric vehicle using any open-source software.
- Design and simulate an electric vehicle system model using any open source software.

Assignment

- Prepare a report on comparative study of various two-wheeler EVs available in market.
- Prepare a report on setting of Fast DC charging station.
- Prepare a report on EV battery swapping technology.
- Prepare a report on comparative study of various four-wheeler EVs available in market.
- Prepare a report on Internet of Things (IoT) /Virtual Reality(VR)/Augmented Reality(AR) related to EV.
- Prepare report on driverless EV car available in the market.
- Prepare a report on the performance analysis of DC-DC converters and inverters in an EV setup.
- Prepare a report on different EV chargers for two wheeler and four wheeler and make comparative study of them which are available in market.
- Prepare a report on Installation of battery charging unit at Residential Places.

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VIII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Basics of Electric Vehicles	2	6	0	8
2	Electric Vehicle Drives	0	8	8	16
3	Batteries and Energy Storage Systems	2	4	8	14
4	Converters and EV Chargers	2	8	4	14
5	Electric Vehicle(EV) Policies	4	4	0	8
Total		10	30	20	60

IX. Assessment

Methodologies/Tools

Formative assessment (Assessment for Learning)

- Rubrics for continuous assessment based on process and product related performance indicators (25 marks)

Summative Assessment (Assessment of Learning)

- End term examination, Viva-voce, Practical performance (25marks)

X. Suggested COs - POs Matrix Form

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	-	-	1	3	2	3			
CO2	3	-	-	3	3	2	3			
CO3	3	2	3	3	3	2	3			
CO4	3	-	3	3	3	2	3			
CO5	1	-	-	-	3	2	3			

Legends: - High:03, Medium:02, Low:01, No Mapping: --

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XI. Suggested Learning Materials / Books

Sr. No.	Author	Title	Publisher
1	Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi.	Modern Electric, Hybrid Electric and Fuel Cell Vehicles.	CRC Press, 2019. ISBN 13:978-0367137465.
2	James Larminie, John Lowry.	Electric Vehicle Technology Explained.	Wiley-Blackwell. 2012, ISBN 13: 978-1119942733
3	Dr. Nitesh Tiwari, Dr. Shekhar Yadav.	Electric Vehicle (Green and Sustainable Transportation).	S.K. Kataria & Sons, 2023, ISBN13:987-81-963589-0-7.
4	Ali Emadi, Mehrdad Ehsani, John M. Miller.	Vehicular Electric Power Systems: Land, Sea, Air and Space Vehicles.	CRC Press, 2003. ISBN 13: 978-0824747510.
5	Sunil R. Pawar	Electrical Vehicle Technology: The Future Towards Eco-Friendly Technology.	Notion Press Publication. 2021.ISBN 0:1685545610.

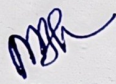
XII. Learning Websites & Portals

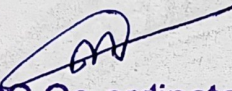
Sr. No.	Link / Portal	Description
1	https://youtu.be/2IgZSDDFW-Y?si=Z1tfZO24ljBppzVA	Identification of terminals of BLDC motor.
2	https://www.niti.gov.in/sites/default/files/2023-02/EV_Handbook_Final_14Oct.pdf	Handbook of electric vehicle charging infrastructure implementation.
3	https://heavyindustries.gov.in/sites/default/files/2023-07/NEMMP-2020.pdf	National Electric Mobility Mission Plan 2020.
4	https://www.cleanenergyministerial.org/initiatives-campaigns/electric-vehicles-initiative/	Goal of EV30@30 campaign.
5	https://maitri.mahaonline.gov.in/PDF/EV%20Policy%20GR%202021.pdf	Maharashtra Electric Vehicle Policy, 2021.
6	https://www.mdpi.com/1996-1073/10/8/1217	Electric vehicle review paper.
7	https://archive.nptel.ac.in/courses/108/103/108103009/	NPTEL electric vehicle course literature.
8	https://onlinecourses.nptel.ac.in/noc22_ee53/preview	NPTEL electric vehicle course videos.
9	https://www.mdpi.com/1996-1073/15/3/1241	DC-AC converters for electric vehicle review paper.
10	https://www.niti.gov.in/sites/default/files/2022-05/Battery_swapping_report_09052022.pdf	Battery swapping.

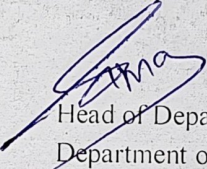
XIII. Academic Consultation Committee/Industry Consultation Committee:

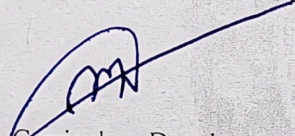
Sr. No	Name	Designation	Institute/Organization
1	Mr. Santosh Patni	Executive Engineer	Executive Engineer, MSEDCL, Prakashgarh, Bandra
2	Shri. Kiran Inamdar	Lecturer in Electrical Engineering	Pilley COE, Rasayani
3	Dr. Sachin S. Bharatkar	Head of Electrical Engineering	G.P. Mumbai
4	Dr. Mahesh S. Narkhede	Lecturer in Electrical Engineering	G.P. Mumbai

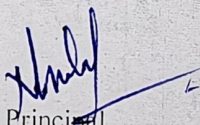
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 Coordinator,
 Curriculum Development,
 Department of Electrical Engineering


CDC Co-ordinator
G. P. Mumbai


 Head of Department
 Department of Electrical Engineering


 I/C, Curriculum Development Cell


 Principal

Programme: Diploma in Electrical Engineering (Sandwich Pattern)													
Course Code: EE23 203						Course Title : Electrical Drives and Control							
Compulsory / Optional: Optional													
Teaching Scheme and Credits						Examination Scheme							
CL	TL	LL	SLH	NLH	Credits	FA-TH		SA-TH (2,30Hrs.)	FA-PR	SA		SLA	Total
						T1	T2			PR	OR		
4	--	2	-	6	3	20	20	60	25	25#	-		150

Total IKS Hrs. for course: NIL

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @\$ Internal Online Examination

Note:

1. FA-TH represents an two class tests of 20 marks each conducted during the term.
2. SA-TH represents the end term examination.
3. FA-PR represents the term work
4. SA-PR represents the end term practical examination.

I. Rationale :

The Electric Drives and Control course is designed to provide students with a comprehensive understanding of electric drives and control. Electric drives and control are critical components of modern industry and technology. and the demand for professionals with expertise in this area is growing rapidly.

II. Industry / Employer Expected Outcome:

The course content should to be taught through the various teaching learning with the aim to help the student to attain the following industry identified competency:

- Operate and maintain different types of DC/AC and special machine drives in the industry.

III. Course Outcomes: Students will be able to acquire required learning outcome in cognitive, psychomotor and affective domain to demonstrate the following COs on completion of course based learning

CO1	Select appropriate electrical drive for a particular application based on power rating
CO2	Operate and Select drive based on Mechanical Characteristics for a particular drive application
CO3	Operate and maintain the functioning of DC drives using choppers and converters
CO4	Operate and maintain the functioning of Induction motor drives
CO5	Operate and maintain the functioning of synchronous motor, BLDC and stepper motor drives

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Electrical Drives & Control (EE23 203)

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IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's	Topics / Sub-topics
1	TLO 1.1 Define electrical drive TLO 1.2 State the advantages of electrical drives TLO 1.3 Draw block diagram of electrical drive TLO 1.4 Explain various parts of electrical drives TLO 1.5 State advantages and disadvantages of AC and DC drives TLO 1.6 State dynamic torque equation of motor TLO 1.7 Explain Multi quadrant operation of motor	1. Basics of Electrical Drives: 1.1 Electrical Drives: Definition Block diagram, components of electrical drives, advantages of electrical drives 1.2 Important factors to be considered while choosing electrical drives 1.3 AC drive, DC drive, Comparison of AC and DC drives 1.4 Dynamic torque equation 1.5 Speed torque convention and Multi quadrant operation. Course Outcome: CO1 Teaching Hours: 12 Hrs Marks: 10 (R-04, U-06, A-00)
2	TLO2.1: Explain the sources of heat generation in electric motors. TLO2.2 : Describe the thermal behaviour of motors during heating and cooling TLO2.3: Explain the concept of motor duty cycles TLO2.4: Classify Motor Duty Types TLO2.5: Apply Duty Cycle Considerations in Motor Sizing and Selection	2. Selection of Motor Power Rating: • Thermal model of motor for heating and cooling • Classes of motor duty as per IS 4722 1968 • Continuous duty • Short time duty • Intermittent periodic duty • Intermittent periodic duty with starting • Intermittent periodic duty with starting and breaking • Continuous duty with intermittent periodic loading • Continuous duty with starting and breaking • Continuous duty with periodic speed changes • Determination of motor rating for • Continuous duty • Short time duty (simple numerical) Course Outcome: CO 2 Teaching Hours: 10 Hrs Marks: 10 (R-02, U-04, A-04)
3	TLO3.1: Explain torque speed characteristic of DC motor TLO3.2: Explain types of braking used in DC motor TLO 3.3: Explain speed control methods used for DC motor TLO 3.4: Explain the working of controlled rectifier fed DC motor drive. TLO 3.5: Explain the working of chopper fed DC motor Drive	3. DC Motor Drive: • Torque speed characteristic and equation of speed • for shunt and separately excited motor • series motor • Types of braking used in Dc Motors • Regenerative • Dynamic and Counter Current braking • DC shunt and series motor • Speed control methods • Armature voltage control • Field flux control • Armature resistance control • Control rectifier fed DC Drive

		• Single phase fully controlled rectifier control of DC separately excited motor • Single phase half-controlled rectifier control of DC separately excited motor • Multi quadrant operation of dc separately excited motor fed from Dual converter • Chopper fed DC drive for separately excited DC motors to obtain • Motor control . Regenerative braking. Motoring and regenerative braking Course Outcome: CO3 Teaching Hours:16Hrs. Marks: 16 (R-04,U-08, A-04)
4	TLO 4.1: Explain Torque speed characteristic of induction motor. TLO 4.2: Describe types of braking used in induction motor. TLO 4.3: Explain speed control methods used for induction motor TLO 4.4: Explain various methods to control induction motor using solid state control	4. Induction Motor Drive 4.1 Torque speed characteristic and equation of torque • For squirrel cage and slip ring induction motor 4.2 Types of Breaking • Regenerative braking • plugging or reverse voltage breaking • AC dynamic braking 4.3 Speed control methods used for induction motor • Pole changing • Stator voltage control • Supply frequency control rotor resistance control 4.4 Solid state control of 3-phase induction motor • Variable voltage variable frequency control from voltage source • Torque and power limitation and modes of operation • Braking and Mult quadrant operation of VSI induction motor drives • Rotor resistance control and static rotor resistance control • Slip power recovery :Static scherbius Drive Course Outcome: CO 4 Teaching Hours:12Hr Marks: 14 (R- 04, U-06, A-04)
5	TLO 5.1: Explain synchronous motor variable speed drive TLO 5.2: Explain BLDC motor drive TLO 5.3: Explain stator motor drive TLO 5.4: Explain Torque VS stepping rate characteristic TLO 5.5: Explain unipolar drive used for stepper motor control	5. Synchronous Motor, BLDC and stepper motor drive 5.1 Synchronous motor variable speed drive • Variable frequency control • Modes of variable frequency control • Variable frequency control of multiple synchronous motor 5.2 Brushless DC motor (Trapezoidal PMAC) motor drives Low cost three phase brushless dc motor drive 5.3 Stepper motor drives. • Single stack variable reluctance motor

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		- Torque VS stepping rate characteristic - Unipolar drive for variable reluctance motor Course Outcome: CO 5 Teaching Hours: 10 Hr. Marks: 10 (R-02,U-04 , A-04)
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V. List of experiments: Total 10 experiments (or turns) out of following experiments (or turns)

Sr. No.	Laboratory Learning Outcome (LLO)	Laboratory Experiment /Practical Titles / Tutorial Titles	No. of hrs.	Relevant COs
1	LLO 1.1 Identify parts of DC drive LLO 1.2 Write the function of each part	Identify various parts of the given Drive.	2	CO1
2	LLO 2.1 Determine torque at different load LLO 2.2 Plot and interpret the Speed torque characteristics	Plot speed torque characteristics of DC shunt motor	2	CO1
3	LLO 3.1 Determine torque at different load LLO 3.2 Plot and interpret the Speed torque characteristics	Plot speed torque on characteristic of DC series motor	2	CO1
4	LLO 4.1 Determine torque at different load LLO 4.2 Plot and interpret the Speed torque characteristics	Plot speed torque characteristics of 3 phase induction motor	2	CO1
5	LLO 5.1 Observe the performance at different speed LLO 5.1 Plot the waveforms	Control the speed of DC shunt motor by single phase full wave-controlled rectifier	2	CO3
6	LLO 6.1 Observe how Counter current braking slows down and stops the DC motor by generating a braking torque.	Perform counter current braking of DC motor	2	CO3
7	LLO 7.1 Observe how Dynamic braking slows down a DC motor by converting kinetic energy into heat energy dissipated in the braking resistor.	Perform dynamic braking of DC motor	2	CO3
8	LLO 8.1 Observe the performance at different speed LLO 8.2 Plot the waveforms	Control the speed of DC motor by chopper	2	CO3
9	LLO 9.1 Observe how dynamic braking slows down a three-phase induction motor by converting its kinetic energy into heat, dissipated in the braking resistor	Perform dynamic braking of 3 phase induction motor	2	CO4

10	LLO 10.1 Observe how regenerative braking allows a three-phase induction motor to convert excess mechanical energy into electrical energy, which is fed back to the power source or an external load.	Perform regenerative braking of 3 phase induction motor	2	CO4
11	LLO 11.1 Observe the performance at different speed LLO 11.2 Plot the waveforms	Control the speed of 3 phase induction motor by variable voltage variable frequency supply	2	CO4
12	LLO 12.1 Observe the performance at different speed LLO 12.2 Plot the waveforms	Control the speed of 3 phase slip ring induction by rotor resistance variation using chopper	2	CO4
13	LLO 13.1 Evaluate motor performance under different operating conditions.	Test the performance of BLDC motor drive		CO5
14	LLO 14.1 Evaluate motor performance under different operating conditions.	Test the performance of stepper motor drive		CO5

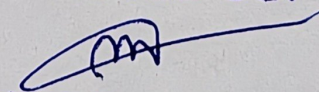
Note: Minimum 10 experiments should be performed in a term for completion of TW

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning): NIL

VII. Specifications Table (Theory):

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Basics of Electrical Drives	4	6	0	10
2	Selection of motor power rating	2	6	2	10
3	DC Motor Drive	4	10	2	16
4	Induction Motor Drive	4	6	4	14
5	Synchronous Motor, BLDC and stepper motor drive	2	6	2	10
Total		16	34	10	60

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VIII. Assessment Methodologies/Tools**Formative assessment (Assessment for Learning)**

- Rubrics for continuous assessment based on process and product related performance indicators(25 marks)

Summative Assessment (Assessment of Learning)

- End term examination, Viva-voce, Workshop performance (25 marks)

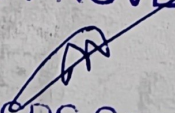
IX. Suggested COs - POs Matrix Form

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO- 1	PSO- 2	PSO- 3
CO1	3	2	3	-	2	-	-	3	2	-
CO2	3	2	3	-	2	-	-	3	2	-
CO3	3	2	3	2	3	-	-	3	2	2
CO4	3	3	3	2	3	2	-	3	3	2
CO5	3	3	3	2	3	2	2	3	3	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --										

X. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year of Publication	ISBN
1	Fundamentals of Electrical Drive	Dubey Gopal K.	Narosa Publishing House, New Delhi, 2nd Edition.
2	Electric Drives Components and Applications	Vedam Subrahmanyam	Tata MC Graw-Hill publishing company Limited, New Delhi
3	A Text Book of Electrical Technology Vol-II	Theraja B.L., Theraja A.K.	S. Chand and Co. Ramnagar, New Delhi.
4	Electrical Machines	M.V. Deshpande	PHI, Learning, New Delhi
5	Electric Motor Drives , Modeling, Analysis, and Control	R. Krishnan	Prentice Hall, Upper Saddle River, New Jersey 07458

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6	Power Electronics	M.D. Singh, K.B. Khanchandani	Tata MC Graw-Hill publishing company Limited, New Delhi
7	A First course on Electrical Drives	S.K. Pillai	New Age International Publisher.

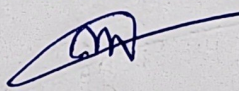
XI. Learning Websites & Portals

Sr.No	Link / Portal	Description
1	www.cesim.com/simulations	
2	www.scilab.org/scilab	
3	www.ni.com/multisim	
4	www.youtube.com /electric circuits/AC-DC DRIVES	
5	www.dreamtechpress.com /ebooks/AC-DC DRIVES	
6	www.nptelvideos.in/electrical engineering/ AC-DC DRIVES	
7	www.learnerstv.com/free-engineering/AC-DC DRIVES	
8	www.orcad.com/resources/orcad-downloads	
9	www.electricaltechnology.org	
10	www.electrical4u.com	
11	www.EasyEngineering.net	

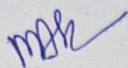
XII. Industry Consultation Committee:

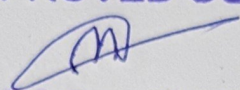
Sr. No	Name	Designation	Institute / Organisation
1	Mr .Nikhil Chavan	Director, Neti Power Solutions	Neti Power Solutions, Dahanu
2	Mrs. Vaishali Bhosale	Lecturer in Electrical Engineering	G.P. Nashik
3	Dr. Mahesh S. Narkhede	Lecturer, Electrical Engg.	Govt. Polytechnic Mumbai
4	Ms. Minakshi B. Shirsat	Lecturer, Electrical Engg. (Curriculum Content Designer)	Govt. Polytechnic Mumbai

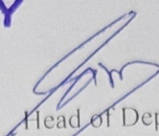
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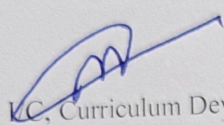

CDC Co-ordinator
G. P. Mumbai

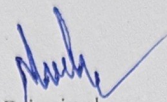
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Coordinator,
Curriculum Development,


CDC Co-ordinator
G. P. Mumbai


Head of Department
Department of Electrical Engineering


VC, Curriculum Development Cell,


Principal



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CDC Co-ordinator
G. P. Mumbai