



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Electrical Engineering

Subject Code: DI04009031

Subject Name: Commissioning & Maintenance of Electrical Equipments

w. e. f. Academic Year:	2025-26
Semester:	4 th
Category of the Course:	Professional Elective - II

Prerequisite:	Understanding of basic electrical engineering principles, electrical machines, safety standards and electrical measurements.
Rationale:	Electrical systems in power generation, industrial, and commercial facilities include a wide range of equipment and devices such as transformers, motors, circuit breakers, and other machinery operating at different stages and often situated close to one another. These components must be properly installed, commissioned, and maintained on a regular basis to avoid major failures. Diploma-level engineers are frequently responsible for overseeing or performing these tasks in power plants, substations, and industrial environments. This course is designed to equip students with a thorough understanding of the correct procedures for installation, commissioning, and maintenance of electrical equipment. It also emphasizes key concepts and principles, while providing hands-on experience to develop practical skills necessary for working with electrical systems in real-world settings.

Course Outcomes:

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

No	Course Outcomes	RBT Level*
1	Follow safety procedures with respect to earthing and insulating material.	R, U
2	Install and maintain electrical equipment following standard practices and safety norms	U, A
3	Perform pre-commissioning tests and commissioning of transformer safely and effectively	U, A
4	Perform standard tests and commissioning of rotating machines with adherence to safety standards	U,A
5	Commission switchgear and power cables through standard testing and safety compliance	U,A

*Revised Bloom's Taxonomy (RBT)



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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA(M)	PA (I)	ESE(V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	<p>Unit 1 –Electrical Safety and Insulating Material</p> <p>1.1 Do's and Don'ts Regarding Safety in Substation/ Power Station Operators.</p> <p>1.2 Electrical Safety in Industry/Power Stations/ Substations at the Time of Operation/ Control/ Maintenance.</p> <p>1.3 Factors Affecting Life of Insulating Materials, Classifications of Insulating Materials as Per Indian Standards.</p> <p>1.4 Measuring Insulation Resistance by Different Methods Such As I) Polarization, Ii) Dielectric Absorption, Iii) Megger.</p> <p>1.5 Reconditioning of Insulation-Drying Out Procedures.</p> <p>1.6 Insulating Oil - Properties of Insulating Oil, Causes of Deterioration of Oil.</p>	7	14%
2.	<p>Unit 2-Installation and Maintenance of Electrical Equipment</p> <p>2.1 Requirements of Foundation for Static and Rotating Electrical Machinery.</p> <p>2.2 Concept of Levelling and Aligning- Procedure for Levelling and Aligning, Alignment of Direct Coupled Drive, Effects of Mis-Alignment.</p> <p>2.3 Installation Procedure of Power Transformer as Per I.S.</p> <p>2.4 Installation Procedure of Rotating Electrical Machine (Induction Motor and Alternators) as Per I.S.</p> <p>2.5 Installation Procedure of Switchgear (Circuit Breaker, Isolator and Control Panel) as Per I.S.</p>	12	27%



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	<p>2.6 Devices and Tools Required for Installation of Electrical Equipment.</p> <p>2.7 Concept of Maintenance, Types of Maintenance, Routine, Preventive and Breakdown Maintenance.</p> <p>2.8 Preventive Maintenance-Procedure for Developing Maintenance Schedules for Electrical Machines.</p> <p>2.9 Factors Affecting Preventive Maintenance Schedules.</p> <p>2.10 Maintenance Schedules of Following as Per IS: Power Transformer, Three Phase Induction Motor, Alternator, Circuit Breaker, Batteries, Solar and Wind Power Plants.</p>		
3.	<p>Unit 3 – Commissioning of Transformer</p> <p>3.1 Importance of Commissioning of Transformer.</p> <p>3.2 Difference Between Type Test, Routine Test and Special Test.</p> <p>3.3 Pre-Commissioning Checks- Significance, Procedure and Standard Reference Values for Pre-Commissioning Tests:</p> <p>3.3.1 Insulation Resistance Measurement [Control Wiring, Cooling System Motor and Control Circuit, Main Windings (Polarization Index), Tap Changer Motor and Control]</p> <p>3.3.2 Transformer Oil Break Down Voltage Test (BDV) and Oil Filtering.</p> <p>3.3.3 Polarity and Vector Group Test.</p> <p>3.3.4 Ratio Test on All Taps.</p> <p>3.3.5 Magnetizing Current Test.</p> <p>3.3.6 Magnetic Balance Test. (For 3 Phase Transformer).</p> <p>3.3.7 Capacitance and Tan Delta Measurement of Winding and Bushing.</p> <p>3.3.8 Short Circuit Impedance Test.</p> <p>3.3.9 Contact Resistance Measurement.</p> <p>3.3.10 Measurement of Windings Resistance for all Taps of OLTC.</p> <p>3.4 Final Commissioning Checks.</p> <p>3.5 Procedure-Energization of Transformer.</p> <p>3.6 Faults and Troubleshooting of Transformer and its Auxiliary</p>	10	23%



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	Equipment.		
4.	<p>Unit 4 – Commissioning of Rotating Machines(Synchronous Machine, Induction Motor, DC Machine).</p> <p>4.1 Pre-Commissioning Inspection Checks for Rotating Machines.</p> <p>4.2 Pre-Start Tests on Rotating Machines-</p> <p style="padding-left: 20px;">4.2.1 Winding Resistance Measurement</p> <p style="padding-left: 20px;">4.2.2 Insulation Resistance Measurement of Windings</p> <p style="padding-left: 20px;">4.2.3 High Voltage Tests (Power Frequency)</p> <p style="padding-left: 20px;">4.2.4 Trial Start</p> <p style="padding-left: 20px;">4.2.5 No Load Test</p> <p style="padding-left: 20px;">4.2.6 Vibration Measurement</p> <p>4.3 Faults and Troubleshooting of Rotating Machines (Synchronous Machine, Induction Motor, DC Machine).</p>	8	18%
5.	<p>Unit 5 – Commissioning of Switchgear and Power Cable</p> <p>5.1 Pre-Commissioning Checks of Switchgear</p> <p style="padding-left: 20px;">5.1.1 Visual Inspection (Nameplate, Interlocks).</p> <p style="padding-left: 20px;">5.1.2 Insulation Resistance (IR) Measurement.</p> <p style="padding-left: 20px;">5.1.3 Contact Resistance Test of Circuit Breakers and Isolators.</p> <p style="padding-left: 20px;">5.1.4 CTs, PTs, And Protection Relay Connections Verification.</p> <p>5.2 Functional Tests of Switchgear</p> <p style="padding-left: 20px;">5.2.1 Mechanical Operation Test.</p> <p style="padding-left: 20px;">5.2.2 Protection Relay and Control Circuit Testing.</p> <p style="padding-left: 20px;">5.2.3 Interlock Verification (Electrical & Mechanical).</p> <p style="padding-left: 20px;">5.2.4 SF₆ Gas / Vacuum Integrity Test.</p> <p>5.3 On-Site Commissioning Tests of Switchgear</p> <p style="padding-left: 20px;">5.3.1 High-Voltage Withstand Test. (As Per IS/IEC).</p> <p style="padding-left: 20px;">5.3.2 Partial Discharge Test (For GIS).</p> <p style="padding-left: 20px;">5.3.3 Breaker Timing Test</p> <p>5.4 Pre-Commissioning Checks of Power Cable</p> <p style="padding-left: 20px;">5.4.1 Physical Inspection (Joints, Terminations, Bending Radius).</p> <p style="padding-left: 20px;">5.4.2 Conductor Resistance & Continuity Test.</p> <p style="padding-left: 20px;">5.4.3 Insulation Resistance Measurement (Megger Test).</p> <p>5.5 Site Acceptance Tests of Power Cable</p>	8	18%



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	5.5.1 High-Voltage Withstand Test. 5.5.2 Sheath Integrity Test. 5.5.3 Capacitance and Tan δ (Dissipation Factor) Measurement. 5.6 Post-commissioning 5.6.1 Load Test Under Service Conditions. 5.6.2 Temperature Monitoring During Initial Energization. 5.6.3 Documentation of Test Results. 5.7 Faults and Troubleshooting of Switchgear and Power Cable.		
	Total	45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
10 %	40 %	50 %	00	00	00

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Reference Books:

- 1) S. Rao , Khanna Publication, New Delhi ,Testing Commissioning Operation and Maintenance of Electrical Equipments
- 2) Tarlok Singh, S. K. Kataria & Sons, New Delhi, Installation, Commissioning and Maintenance of Electrical equipment
- 3) Deshpande.M. V. PHI Learning Pvt. Ltd., 2010, Design and Testing of Electrical Machines ISBN No 8120336453, 9788120336452.
- 4) Rao, B V S Asia Club House, First Reprint, 2011, Operation and Maintenance of Electrical Equip ment Vol-I, ISBN No 8185099022
- 5) Rosenberg. Mc GRAW-HILL, 1st Edition, May 2003, Maintenance and Repairs, ISBN No 9780071396035
- 6) Sharotri, S.K. Glencoe/ Mcgraw- Hill; 2ndEdition , June 1969; Preventive Maintenance of Electrical Apparatus, ISBN No 10: 007030839X 13: 978-0070308398



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(b) Open-Source Software and Website:

- 1) Industrial Safety Engineering - https://onlinecourses.nptel.ac.in/noc20_mg43/preview
- 2) Electrical Safety Simulation- <https://www.osha.gov/electrical>.
- 3) IS 1271 : 2020 – Classification of Insulating Materials -<https://www.services.bis.gov.in>
- 4) Maintenance and Installation Section- <https://www.electrical4u.com>
- 5) <https://electrical-engineering-portal.com>
- 6) <https://cea.nic.in>
- 7) NPTEL Course: High Voltage Engineering –<https://nptel.ac.in>

Suggested Course Practical List:

Sr. No.	Practical Outcome/Title of experiment	Unit/CO	Approx. Hours required
1	Demonstration of electrical safety equipment and PPE	1	2
2	Measurement of insulation resistance using a Megger	1	2
3	Polarization Index (PI) and Dielectric Absorption Ratio (DAR) test	1	2
4	Testing dielectric strength (BDV) of insulating oil	1	2
5	Insulation resistance test of transformer windings (main + control)	3	2
6	Transformer ratio test on all tap positions	3	2
7	Transformer polarity and vector group test	3	4
8	Measurement of winding resistance	3	2
9	No-load and trial run test of induction motor	4	2
10	Measurement of vibration in rotating machine	4	2
11	IR test and contact resistance measurement of circuit breaker	5	4
12	Visual and functional testing of protection relay and interlocks	5	2
13	Insulation resistance test of power cables	5	2
14	Physical inspection and continuity test of LT/HT power cable	5	2

Subject In-charge can add performance experiment only.

List of Laboratory/Learning Resources Required:

1. Digital Multimeter (DMM) — 0–1000 V, 10 A, True RMS
2. Clamp-on Power Meter — for measuring 3-phase current, voltage, and power factor
3. Earth Tester (Megger type) — 0–2000 Ω range



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4. Digital / Analog Insulation Resistance Tester-Range: 0–1000 M Ω ; Test Voltage: 500 V, 1000 V, 2.5 kV, 5 kV
5. Oil BDV Test Set (Automatic / Manual)-Output Voltage: 0–60 kV / 0–100 kV AC; Rate of rise: 2 kV/s; Electrode gap: 2.5 mm
6. Transformer Turns Ratio Tester-Range: 0.8 to 10,000:1; Accuracy: $\pm 0.1\%$
7. AC High Voltage Test Set-Output: 0–5 kV / 0–10 kV / 0–50 kV AC
8. Tan Delta Test Set / Capacitance Meter-Voltage: 0–12 kV; Frequency: 50 Hz
9. Relay Test Set / Secondary Injection Kit-0–250 V AC/DC, 0–20 A, variable output
10. Tachometer (Non-Contact Type)- Range 0–5000 rpm

Suggested Activities for Students:

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be performed to achieve the attainment of the various outcomes of the course: Students should perform following activities individually or in group to accomplish distinct task and prepare reports of about min 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement and may be beneficial during placement interviews:

- I. Visit substation, solar/wind power plant, or industrial switchyard. Observe installation, maintenance, and safety practices.
- II. Prepare standard installation checklist for transformer, induction motor, and circuit breaker as per IS/IEC standards.
- III. Prepare poster/chart showing “Do’s and Don’ts” for substation operators and maintenance engineers.
- IV. Create a sample commissioning report with test results, IR values, BDV, $\tan \delta$, etc.
- V. Students adopt one lab machine (motor/transformer) and perform cleaning, inspection, and IR testing.
- VI. Presentation on topics like “Transformer Drying Methods”, “Cable Testing Procedures”.
- VII. Create flowchart for fault finding in motor, transformer, or cable.
- VIII. Collect and tabulate nameplate details of machines, transformers, breakers, cables used in your Lab.

Suggested Project List: Suggested Project List as given below:

- I. Design posters on substation safety, lockout-tagout, or rescue procedure.
- II. Preparation of Safety Operating Procedures (SOPs).
- III. Preparation of Maintenance Schedule Chart of Any Electrical Equipment.



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- IV. Prepare checklist for transformer, motor, and switchgear before energization.
- V. Preparation of Tool Inventory for Electrical Equipment Installation.
- VI. Prepare Commissioning Test Report of Any Electrical Equipment.
- VII. Maintenance Logbook Preparation for Any Electrical Equipment.
- VIII. Layout design of transformer substation showing earthing and cable routing.
- IX. Prepare report on tests conducted on Insulating oil in laboratory.
- X. Prepare causes of faults along with their trouble shooting chart for any of electrical machines / Equipment.
- XI. Prepare chart with neat diagram for any of earthing methods along its significance.
- XII. Prepare chart for maintenance schedule of solar roof top installed at your institute premises.
