FACULTY OF ENGINEERING & TECHNOLOGY

Effective from Academic Batch: 2022-23

Programme: **Bachelor of Technology (Electrical Engineering)**

Semester: **VII**

Course Code: **202050708**

Course Title: **Condition Monitoring of Power Apparatus**

Course Group: **Professional Elective Course-IV**

Course Objectives: This course will enable the students to understand the concepts, principles and acquire basic skills of condition monitoring and diagnostics of electrical equipments in power stations, substations and industry.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
				Theory		J/V/P*		Total
Lecture	Tutorial	Practical		Internal	External	Internal	External	
3	0	0	3	50 / 18	50/17	NA	NA	100 /35

* **J**: Jury; **V**: Viva; **P**: Practical

Detailed Syllabus:

Sr.	Contents	Hours
1	**Maintenance and condition monitoring** Importance and necessity of maintenance, different maintenance strategies like breakdown maintenance, planned maintenance, preventive maintenance and condition based maintenance of transformer, induction motor and alternators, insulation failure modes, concept of condition monitoring of electrical equipment.	04
2	**Various test techniques** Thermal test, acoustic test, vibration analysis, chemical analysis: dissolved gas analysis, Furan analysis, degree of polymerization, electric analysis: current signature analysis, insulation resistance test, loss angle test, partial discharge test, impulse test, frequency response analysis, IIoT and soft computing in condition monitoring.	10

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3	**Condition monitoring of Transformer** Construction and operation of transformer, causes of failure in transformer, winding faults: winding to ground failure, failure across large portion of winding, inter winding breakdown, failure between small portions of winding, diagnostic test techniques for transformer, remaining life estimation, various case studies. **Dissolved Gas Analysis** – Background, transformer diagnosis using individual and total dissolved key gas concentrations, diagnosing a transformer problem using dissolved gas analysis and the Duval triangle, expertise needed. **Oil Physical / Chemical Tests** – Transformer oil tests that should be performed annually with the dissolved gas analysis, dielectric strength, Interfacial Tension (IFT), acid number, furans, oxygen, oxygen inhibitor, oil power factor, moisture.	**12**
4	**Condition Monitoring of Rotating Electrical Machines** Construction, operation and failure modes of electrical machines, structure of electrical machines and their types, machine specification and failure modes, failure sequence and effect on monitoring, typical root causes and failure modes, machine specification and failure modes, insulation aging mechanism – general, thermal aging, electrical aging, mechanical aging, environmental aging, synergism between aging stresses. insulation failure modes – general, stator winding insulation, stator winding faults, rotor winding faults, induction motor faults, diagnostic techniques for rotating electrical machines, case studies. **Temperature Monitoring** – Introduction, local temperature measurement, hot-spot measurement and thermal images, bulk measurement, conclusion. **Vibration monitoring** – Introduction, stator core response – general, calculation of natural modes, stator electromagnetic force wave. stator end-winding response, rotor response – transverse response, torsional response. bearing response – general, rolling element bearings, sleeve bearings. monitoring techniques – overall level monitoring, frequency spectrum monitoring, faults detectable from the stator force wave, torsional oscillation monitoring, shock pulse monitoring.	**14**
5	**Condition-based maintenance and asset management:** Introduction, condition-based maintenance, life-cycle costing, asset management, conclusion	**02**

List of Practicals / Tutorials: NA

Reference Books:

1	S. Chakravorti, D. Dey, B. Chatterjee, Recent trends in the condition monitoring of transformers, Springer.
2	H. Toliyat, S. Nandi, S. Choi, H. Meshgin-Kelk, Electric machines: Modelling, condition monitoring and fault diagnosis, CRC press
3	W. Thomson, I. Culbert, Current signature analysis for condition monitoring of cage induction motors, IEEE press – Wiley.

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4	Peter Tavner, Li Ran, Jim Penman, Howard Sedding, "Condition Monitoring of Rotating Electrical Machines", The Institution of Engineering and Technology, London, United Kingdom, 2008.
5	Kulkarni S. V. and Khaparde S. A., " Transformer Engineering – Design, Technology and Diagnostics" Second Edition, CRC Press, New York

Supplementary learning Material:	
1	1. http://www.bis.org.in/index.asp
2	2. http://www.ieee.org/publications_standards/publications_standards_index.html
3	3. http://www.nema.org/Standards/About-Standards/pages/default.aspx
4	CIGRE working group report: WA2.34, Guide for Transformer maintenance.
5	http://www.ni.com/condition-monitoring/

Pedagogy:

- Direct classroom teaching
- Audio Visual presentations/demonstrations
- Assignments/Quiz
- Continuous assessment
- Interactive methods
- Seminar/Poster Presentation

Internal Evaluation: The internal evaluation comprised of written exam (40% weightage) along with combination of various components such as Certification courses, Assignments, Mini Project, Simulation, Model making, Case study, Group activity, Seminar, Poster Presentation, Unit test, Quiz, Class Participation, Attendance, Achievements etc. where individual component weightage should not exceed 20%.

Suggested Specification table with Marks (Theory) (Revised Bloom's Taxonomy):

Distribution of Theory Marks in %						**R**: Remembering; **U**: Understanding; **A**: Applying; **N**: Analyzing; **E**: Evaluating; **C**: Creating
R	**U**	**A**	**N**	**E**	**C**	
20%	30%	30%	10%	10%	0%	

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

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Course Outcomes (CO):

Sr.	Course Outcome Statements	%weightage
CO-1	Identify and understand the significance of role of condition monitoring.	**20**
CO-2	Assess the condition of various electrical equipments.	**30**
CO-3	Identify amount of damage/deterioration in the electrical equipments.	**20**
CO-4	Check the mechanical integrity of the electrical equipments.	**20**
CO-5	Implement condition monitoring plan for complete electrical system	**10**

Curriculum Revision:	
Version:	2.0
Drafted on (Month-Year):	June-2022
Last Reviewed on (Month-Year):	-
Next Review on (Month-Year):	June-2025

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