GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: MAINTENANCE OF TRANSFORMER AND CIRCUIT BREAKER
(COURSE CODE: 3360907)

Diploma Programme in which this course is offered	Semester in which offered
Electrical Engineering	Sixth

1. RATIONALE

Power system consists of a number of transformers, circuit breakers installed at substations including poll mounted distribution transformers whose numbers are in thousands only in Gujarat. These require regular maintenance to prevent permanent break down. Most of the industries and big commercial installations such as big institutes/hotels/complexes/hospitals that have their own substation also require maintenance of transformers and circuit breakers on regular basis. Most of the big cities are now establishing their own Metro railways. Indian Railways and city metros also have their own substations where transformer and circuit breakers are installed. Power companies also off load their maintenance work of distribution transformers and circuit breakers to private agencies. Thus there is huge demand for maintenance of transformers and circuit breakers.

Transformer and Circuit Breakers are one of the two electric equipment who operate at highest possible voltage i.e up to the level of 400 KV (generators and motors normally operate up to 33 KV Class). Moreover in transformers and circuit breakers current breaking and making takes place with full power (In transformer it happens in on load tap changer). Because of these conditions of very high voltage operations and breaking and making of full power current, insulating oil of transformers and circuit breakers is subjected to deterioration. Contacts of the circuit breaker are also subjected to deterioration due to formation of arcs. Because of these reasons these equipment require regular maintenance.

This course will enable the diploma pass out student to understand the concepts, principles and acquire basic skills of testing and maintenance of transformers and circuit breakers. There is a huge scope of self employment in this area with very less investment of capital.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Maintain transformers and circuit breakers.**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Undertake /apply preventive maintenance
ii. Maintain power and distribution transformers.
iii. Commission different types of transformers
iv. Maintain different types of circuit breakers

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme1				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I. Preventive Maintenance	1a. State the types of maintenance. 1b. Explain the significance of Preventive maintenance. 1c. Describe the economy of maintenance.	1.1 Maintenance and its types - Preventive and Breakdown 1.2 Advantages of preventive maintenance 1.3 Scope of preventive maintenance 1.4 Economics of preventive maintenance
Unit– II Maintenance of Transformers	2a. Describe maintenance of different parts of power transformer. 2b. Explain the different factors affecting the life of transformer. 2c. Prepare maintenance schedule of different types of transformer. 2d. Explain the importance of quality of transformer oil. 2e. Describe the transformer oil filtration procedure 2f. List the parameters for quality of oil. 2g. Describe Trouble shooting procedure of power transformer. 2h. Inspect and maintain distribution and power transformer. 2i. Describe the causes of failure of transformers 2j. Describe the methods to reduce the noise level in transformer. 2k. Describe how from analyses of	2.1 Significance of transformer maintenance 2.2 Parts of transformer- tank. Core, winding, conservator, radiators, bushings, terminals, temperature measurement system, safety valves, tap changers and accessories/ fittings etc. 2.3 Factors affecting the life of transformer-moisture, water oxygen, solid impurities, varnish, slackness of windings and dust. 2.4 Inspection-sensory, records and electrical test. 2.5 General/Typical maintenance schedule of power transformers-up to 1000 kVA and above 1000 kVA 2.6 Maintenance of transformer oil-characteristic, interpretation of tests, procedure of testing BDV, filtering plant.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	gas collected in Buchholz relay, condition of transformer may be ascertained. 2l. State procedure for measuring of insulation resistance of transformers. 2m. Sate safety precautions to be absorbed during maintenance of transformers.	2.7 Causes of failures of power transformers and preventive actions. 2.8 Detective devices-Buchholz relay, Pressure relief device, Differential relay, Dial thermometer alarm contact, Over current relay, ground fault relay, voltmeter, ammeter, Human senses 2.9 Check list of maintenance of power transformers 2.10 Causes and methods to reduce Audible Noise (AN) from transformer 2.11 Maintenance of distribution transformer i. Reasons for failure of Distribution Transformers and the remedial measures thereof ii. Inspection & Maintenance Schedule for Distribution Transformers: iii. Inspection & Maintenance of transformer and accessories within the sub-station and its proximity. 2.12 Procedure of measuring the insulation resistance of transformer windings.
Unit– III Commissioning and Recharging of Transformers	3a. Understand the procedure of commissioning of power transformer. 3b. Perform required test after commissioning of transformer. 3c. State do's and don'ts for power transformer. 3d. Describe the procedure of loading the transformer.	3.1 Concept of commissioning and recharging of transformer. 3.2 General checks 3.3 Insulation resistance test 3.4 Measurement of oil characteristics 3.5 Off circuit tap switch 3.6 Continuity test 3.7 Measurement of winding resistance 3.8 Voltage ratio tests 3.9 Magnetizing current 3.10 Charging of the transformer 3.11 Do's and Don'ts for transformer 3.12 Various commissioning tests on a power transformers

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		3.13 Procedure of loading the transformers. 3.14 Transformer grounding.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit–IV Maintenance of Circuit Breaker	4a. Describe the importance of maintenance of circuit breaker. 4b. Describe the procedure for the maintenance of Moulded circuit breaker. 4c. State the frequency of maintenance and its procedure for various Voltage rating of circuit breaker. 4d. Describe the Maintenance of Oil, Air, Air blast, SF_6 and Vacuum circuit breaker. 4e. State the causes of Failure of circuit breaker 4f. Describe the trouble shooting procedure of circuit breaker. 4g. Explain the operating mechanism of circuit breaker. 4h. Describe the procedure for filling SF6 in Circuit Breaker. 4i. State the characteristics of SF6 Gas which makes it useful for CB. 4j. Describe factor effecting life of arcing contacts of CB. 4k. List causes of failure of CB 4l. Describe operating mechanism of HVAC Circuit Breaker. 4m. State safety precautions to be observed during maintenance of CBs.	4.1 Steps in maintenance of CB 4.2 Maintenance of moulded case circuit breakers -Frequency and routine maintenance tests 4.3 Maintenance of low-voltage circuit breakers -Frequency and maintenance procedures 4.4 Maintenance of medium-voltage circuit breakers – Air, Oil and Vacuum circuit breakers - Frequency of maintenance, safety practices and maintenance procedures for each of the above 4.5 Maintenance of high-voltage circuit breakers - frequency of inspections, External and internal inspection guidelines, typical internal breaker problems, Influence of duty imposed, Types of tests performed. 4.6 OIL CB, Post fault maintenance, Steps in maintenance of MOCB 4.7 Maintenance for AIR CB and Frequency of maintenance. 4.8 Maintenance of AIR BLAST CB 4.9 Maintenance of SF6 gas circuit breakers i. Properties of SF6 (sulphur hexafluoride) gas ii. Handling non faulted SF6 iii. Handling faulted SF6 iv. Procedure of filling SF6 gas in single pressure puffer type SF6 CB v. Gas monitoring system and gas handling system for SF6 filled equipment vi. Types and function of SF6 gas handling units. vii. Maintenance of SF6 CB 4.10 Maintenance of VACCUM CB 4.11 Life of arcing contacts in various CB in case of normal

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		current switching and short circuit operation 4.12 Causes of failure of CB, trouble shooting and procedure of failure analysis. 4.13 Typical Record card for maintenance work of CB 4.14 Commissioning tests on HV A.C. CB 4.15 Operating mechanism used in HV A.C. CB 4.16 Safety precautions to be taken in maintenance of CB

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (Theory)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Preventive Maintenance	4	5	2	0	7
II	Maintenance of Transformer	16	8	10	10	28
III	Commissioning and Recharging of Transformers	8	6	4	4	14
IV	Maintenance of Circuit Breaker	14	6	7	8	21
	Total	**42**	**25**	**23**	**22**	**70**

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy)
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.

7. SUGGESTED EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes*** *(as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours. required
1	I	Prepare a technical report on the preventive maintenance of transformer which supplies electrical power to your college.	2
2	I	Give comparison analysis between preventive and breakdown maintenance.	2
3	II	Prepare detail specifications data sheet for different transformer.(refer name plate mounted on transformers)	2
4	II	Prepare a technical report on various accessories and fitments on a power transformer in a substation.	4
5	II	Perform various tests applied to insulating oil.	4
6	II	Prepare a technical report on various causes of troubles and failures of power transformer.	4
7	II	Prepare typical maintenance schedule for transformers up to 1000 KVA	4
8	II	Prepare typical maintenance schedule for transformers above 1000 KVA	4
9	II	Prepare a technical report on filtering process and filtering plant for transformer oil filtration.	2
10	III	Prepare test report of a power transformer after commissioning.	4
11	III	Read and interpret I.E. rules pertaining to testing of transformer.	4
12	III	Perform insulation resistance test of transformer.	2
13	III	Perform voltage ratio tests of three phase transformer.	2
14	III	Read and interpret I.E. rules pertaining to commissioning of transformer.	4
15	IV	Prepare detail specifications data sheet for different circuit breaker.(use name plate)	2
16	IV	Prepare a technical report on various types of tests performed on high voltage ac circuit breakers.	4
17	IV	Prepare a technical report on maintenance of air blast circuit breaker.	4
18	IV	Prepare a technical report on maintenance of SF_6 circuit breaker.	2
19	IV	Prepare a technical report on maintenance of Vacuum circuit breaker.	2
20	IV	Prepare test report of tests on HVA.C. Circuit Breaker after commissioning.	2
		Total Hours	**62**

Note: Perform any of the practical exercises for a minimum of 28 hours from above list depending upon the availability of resources so that skills related with the most of the outcomes in all the units are developed.

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Prepare journals based on practical performed in laboratory.
ii. Prepare chart displaying various parts of transformer of different types etc.
iii. List the names, specifications and make of the mountings/accessories used on nearby power transformer.
iv. Prepare a report on various types of oil conservation systems and cooling systems used in power transformers.

v. Survey the market for different type of transformer and circuit breaker oil available and compare their specifications with respect to effect of those parameters on life and functioning of equipment.
vi. Prepare chart displaying various parts of circuit breaker of different types etc.
vii. Visit nearby substation, transformer manufacturing & testing laboratories.
viii. Visit maintenance site / workshop of transformer and circuit breaker.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

(a) Show video/animation film to demonstrate maintenance procedures for transformer/circuit breakers.
(b) Arrange a visit to nearby industry/substation to observe maintenance/installation/commissioning of transformer and circuit breakers.
(c) Arrange expert lectures of the professional engineers involved in maintenance, installation, commissioning and testing of transformers and circuit breakers.
(d) Give Mini projects to students

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1.	Thesis on Self learning package on maintenance of 33 KV class transformers for diploma course in electrical engineering.	Chouhan R.P. Gupta S.K.	TTTI Western Region, Bhopal. (NITTTR)
2.	Testing Commissioning operation and maintenance of Electrical Equipments.	Rao S	Khanna Publication (latest edition)
3.	Transformers	BHEL	TATA McGraw-Hill
4.	Relavent IS Code for-- Maintenance of Transformer, circuit breaker ,switchgears, insulating oil	-	Latest code

B) Major Equipment/ Instrument with Broad Specifications

1.	Oil testing kit.	Mains Supply : 230V AC ±10%, 50Hz Single Phase Variac : 230V/ 0-270V High Voltage Source : 80kV, 20mA Voltmeter : 0 to 100kV
2.	Megger.	Insulation Testing:250V:500V:1000V: 1000 MΩ range, Auto-ranging, Auto discharge
3.	Model of transformer.	Wooden, Plastic, etc material.
4.	Voltage ratio test kit.	For small 3 phase transformer
5.	Model of circuit breaker.	Wooden, Plastic, etc material.

C) List of Software/Learning Websites

i. www.nptel.iitm.ac.in
ii. www.youtube
iii. www.howstuffworks.com
iv. http://electrical-engineering-portal.com/

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. H. C. Chawda**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad
- **Prof. C. T. Patel**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad.

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. (Mrs.) C S Rajeshwari**, Professor and Head Electrical and Electronics Engineering
- **Prof. Joshua Earnest,** Professor, Department of Electrical and Electronics Engineering