GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: SWITCHGEAR & PROTECTION
(COURSE CODE: 3360901)

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

1. RATIONALE

An electrical power system consists of generators, transformers, and 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 essential that the diploma pass out students should develop skills of operating various controls and switchgear in power system. They are also required to carry out remedial measures for faults/abnormalities in machines/equipment in power system using appropriate diagnostic instrument/devices. This course attempts to develop these skills in students and hence it is a core course for all electrical engineers.

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 various controls and switchgear in power systems.**

3. COURSE OUTCOMES (COs)

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. Identify various types of faults in Power system
ii. Explain working of different types of circuit breakers in power system.
iii. Explain working of different types of relays in power system.
iv. Maintain the protection of transmission line and feeder from various faults
v. Protect transformer, alternator, motor and bus bar
vi. Protect power system against over voltages

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**ESE**	**PA**	**ESE**	**PA**	
4	0	2	6	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 DETAILS

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
Unit – I Elements of Protection	1a. Describe the functions of basic elements of a protective system 1b. Describe the various types of faults and abnormalities occurring in a power system. 1c. Explain the concept of the Backup protection 1d. Explain the use of Current Transformer (CT) and Potential Transformer(PT) in protection system. 1e. Describe the working of current limiting reactors and their arrangements 1f. Describe various methods of neutral Earthing.	1.1 Need of protective system 1.2 Functions of basic elements of a protective system. 1.3 Types, causes and effects of various Faults. 1.4 Protection zones : Backup protection zones 1.5 Protective Transformers: Specifications and Connection diagram of Current Transformer and Potential Transformer (single phase and 3 phase) 1.6 Current limiting reactors. 1.7 Neutral Earthing
Unit– II Circuit Interrupting Devices	2a. Describe protective system showing different circuit interrupting devices using a line diagram 2b. Explain the sequence of operation of and interlocking of interrupting devices. 2c. Explain the terms associated with fuse and circuit breaker. 2d. Explain characteristics of fuse and circuit breakers. 2e. Explain arc formation and zero current interruption. 2f. Compare arc quenching in A.C. and D.C. Circuit Breaker. 2g. Explain the resistance switching.	2.1 Interrupting devices: Sequence of operation and interlocking 2.2 Fuse, types, characteristics, testing and applications 2.3 Isolators. 2.4 Circuit breaker: Arc phenomena and arc extinction, Construction, working principle of Oil circuit breakers, Air break, Air Blast, Sulphur Hexa Fluoride (SF_6) and vacuum circuit breakers. 2.5 Auto-reclosure 2.6 Testing of circuit breaker 2.7 Resistance switching 2.8 Working principle of arc quenching in HVDC circuit breaker
Unit– III Protective Relays	3a. Describe need for different types of relays. 3b. State the terms related to relays. 3c. Explain concept of over current and directional relays. 3d. Explain setting of relays. 3e. Describe the testing procedure of various relays.	3.1 Protective relay, classification and selection: Terms related to relay 3.2 Principle of working, construction and operation of electromagnetic induction(shaded pole,watt-hour meter and induction cup),Thermal relay 3.3 Settings of various types of relays 3.4 Directional relay 3.5 Distance relay(impedance,

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
		reactance and mho) 3.6 Negative phase sequence relay 3.7 Static relay, Construction and types 3.8 Principle and working of Microprocessor based relay 3.9 Maintenance and testing of relays
Unit–IV Protection of Transmission Line and Feeder	4a. Compare various protection scheme of transmission line. 4b. Describe the criteria to selection the protection scheme 4c. Explain simple Impedance relay. 4d. Explain need of carrier aided protection. 4e. State the types of auto reclosing. 4f. Explain protection of feeders and ring mains and Bus bar.	4.1 Transmission line protection scheme 4.2 protection scheme -Overload protection, Over-current and earth fault protection, Time graded and current graded protection, Current balance differential protection 4.3 Carrier aided protection, Carrier inter-tripping, acceleration and blocking scheme 4.4 Distance /Impedance protection 4.5 types of Auto reclosing 4.6 Protection of parallel feeders and Ring Mains
Unit-V Protection of Transformer, Alternator, Motor and Busbar	5a. Explain various protection scheme for transformer. 5b. Describe the inrush current phenomenon in transformer. 5c. Explain the protection offered by Buchholz Relay.	5.1 Over current, Percentage differential and restricted earth fault protection of Transformers 5.2 Inrush phenomenon and over fluxing phenomenon in Transformer 5.3 Buchholz Relay, analysis of trapped gases
	5d. Explain the faults and abnormalities in alternator. 5e. Explain various faults occurring in motor and their protection schemes. 5f. Explain Differential protection of Bus bars.	5.4 Various faults and abnormal operating conditions in Alternator and its protection schemes 5.5 Various faults and abnormal occurring in the Motor and its protection schemes 5.6 Differential Protection of Bus bars
Unit-VI Over Voltage Protection	6a. State the causes of over voltage. 6b. Explain the characteristics of Lightning Arrestor. 5g. Describe the Insulation co-ordination and basic impulse insulation Level	6.1 Causes of over voltages 6.2 Methods of reducing over voltages 6.3 Operating principles, construction and applications of lightning arrester 5.7 Insulation co-ordination, volt- time characteristic and basic impulse insulation level

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	Elements of Protection	08	04	02	02	08
II	Circuit interrupting Devices	10	05	06	04	15
III	Protective Relays	12	05	06	04	15
IV	Protection of Transmission Line	12	04	08	03	15
V	Protection of Transformer, Alternator, Motor and Bus Bar	10	04	06	02	12
VI	Over Voltage Protection	04	03	02	00	05
	Total	**56**	**25**	**30**	**15**	**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 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. However, if these practical 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	Check the Polarity of Current Transformer and Potential Transformer and connect it with the relay.	02
2	II	Identify various switchgear equipment available in the lab and write its specification and symbols.	02
3	II	Identify parts of various circuit breakers and their specification	02
4	II	Find the fusing factor of a given fusing material.	02
5	II	Dismantle a Vacuum circuit breaker.	02
6	II	Identify the various components of SF_6 circuit breaker.	02
7	III	Test overload relay and plot Time-Current characteristic	02
8	III	Use Buchholz relay for transformer protection.	02
9	III	Test thermal overload relay for protection of motor and set the relay properly.	02
10	III	Test static relay for the protection of motor	02
11	IV	Apply balance current protection scheme using appropriate switch gear	02

S. No.	Unit No.	Practical Exercises (Outcomes in Psychomotor Domain)	Approx. Hours. Required
12	IV	Interpret various protective scheme used for transmission lines and feeders (from Blue print and visit).	04
13	IV	Draw schematic diagram of protective schemes for 66 KV/ 132 KV/220 KV Substation nearby area. (after visit)	04
14	IV	Visit a substation and prepare its technical report emphasizing on control side	04
15	V	Interpret the protection scheme for an alternator in power station (from Blue print and visit).	04
16	V	Interpret different protective scheme for transformer.	02
17	VI	Set up a Horn gap lightning arrester.	02
Total			**42**
Note :Perform any of the practical exercises from above list for a minimum of 28 hours depending upon the availability of resources so that skills matching with the most of the outcomes of every units are included.			

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities like:

i. Prepare line diagram of substation (any one of 220/132/66 kV)
ii. Prepare chart of basic elements of protective system.
iii. List different types of relays, circuit breakers and collect literature from dealers/Manufactures/users and their websites (such as SEIMENS, BHEL, GE, L&T, Crompton, Power Grid Corporation etc)
iv. Prepare display chart for various types of fuse.
v. Prepare the chart for Combined Earth Fault and Phase Fault Protective scheme.
vi. Download the video of functioning of HVDC circuit breaker, Lightning arrester.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Show video/animation film to demonstrate the working principles, constructional features, testing and maintenance of different types of relays and circuit breakers
ii. Arrange expert lectures by engineers of power distribution companies/suppliers of protection and switchgear equipments.
iii. Arrange a visit to nearby substation and manufacturer site of protection panel
iv. Arrange a visit to a relay testing laboratory.

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1.	Fundamentals of Power System Protection	Paithankar Y. G.and Bhide S. R	PHI, New Delhi (Latest Edition)
2.	Power System Protection and Switchgear	Ram B and Vishwakarma D. N.	TMH, New Delhi (Latest Edition)
3.	Electrical Power	Uppal S.L.	Khanna Publications (Latest Edition)
4.	Electrical Power System	Mehta V. K.	S. Chand Publications (Latest Edition)

S. No.	Title of Book	Author	Publication
5.	Switchgear and Protection	Rao S. S.	Khanna Publications, New Delhi (Latest Edition)
6.	Electrical Power Systems	Rao S. S and Uppal S. L	Khanna Publications (Latest Edition)
7.	Switchgear and Protection	Gupta J. B.	Katariya Pub. New Delhi (Latest Edition)
8.	Power system Protection and Switchgear	Ravindranath B. and M. Chander	Wiley Eastern Ltd, Delhi. (Latest Edition)
9.	Art and Science of Protective relaying	Wadhwa. C. L.	C.R.Mason, John Wiley, New Delhi

B) Major Equipment/ Instrument with Broad Specifications

1. Numerical relay panel with all protection

   Time-overcurrent protection (definite-time/inverse-time/user-def.) , Sensitive earth-fault detection, Inrush restraint, Motor protection(Undercurrent monitoring, Starting time supervision, Locked rotor, Overload protection, Temperature monitoring, Load jam protection

2. Static earth fault relay

   Ratings : 5 A , 50 Hz, VA rating : 3 VA typical
   Setting ranges : Low-set : 0.1 A to 5.0
   High-set : 0.1 A to 50 A

3. VCB with operation simulation panel

   VCB along with variable earth leakage relay, Over voltage / under voltage relay, loading facility, over / under frequency relay, overload relay, to operate under various abnormal conditions.

4. Panel for Biased Differential protection of Transformer

   •Test setup is equipped with single-phase type static relay connected with single- phase auto transformer, provides facility to vary current using a variac and rheostats.

5. Current Transformer (Metering)

   LT Current transformers for metering -ring or window type

1.	Class of Accuracy	0.5
2.	Rated Burden	5.00 VA
3.	Power Frequency Withstand Voltage	3KV
4.	Highest System Voltage	433 V
5.	Nominal System Voltage	400 V
6.	Frequency	50 Hz
7.	Supply System	3 Ph. Solidly grounded Neutral System

   Transformation ratio specified from the following standard ratings as per requirement :

Ratio	**50/5**	**150/5**	**300/5**	**400/5**	**1000/5**

6. Current Transformer (protection)

   Typical specification for a 11 kV CT
   System voltage:11 kV
   Insulation level voltage (ILV) : 12/28/75 kV
   Ratio: 200/1 - 1 - 0.577 A
   Core 1: 1A, metering, 15 VA/class 1, ISF<10
   Core 2: 1 A, protection, 15 VA/5P10

		Core 3: 0.577 A, Class PS, KPV>= 150 V, Imag at Vk/2 <=30 mA, RCT at 75 C<=2 ohms Short time rating:20 kA for 1 second
7.	Potential Transformer	**Typical specification for a 11 kV VT** System voltage: 11 kV Insulation level voltage (ILV) : 12 /28/75 kV Number of phases: Three Vector Group: Star / Star Ratio: 11 kV/ 110 V Burden: 100 VA Accuracy: Class 0.5 Voltage Factor: 1.2 continuous and 1.5 for 30 seconds With provision for fuse
8.	Buchholz Relay	Buchholz Relay set up consisting of following: - Digital AC Ammeter and Voltmeter -Gas actuated Buchholz Relay -Gas compressor for Relay -Duly wired built in control and protection unit -Built in power on indicator trip status indicator -Terminals for all the relay and necessary patch chords required to perform the experiment

C) Software/Learning Websites

i. WWW.nptel.iitm.ac.in
ii. http://electrical-engineering-portal.com/download-center/electrical-software
iii. http://electrical-engineering-portal.com/testing-commissioning-current-transformer#2

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. S. V. Jagani**, Lecturer in Electrical Engineering ,Government Polytechnic, Dahod
- **Prof. T. A. Patel**, Lecturer in Electrical Engineering , Government Polytechnic, Dahod
- **Prof. H. C. Chawda**, Lecturer in Electrical Engineering, R.C. Technical Institute, Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. (Mrs.) C.S. Rajeshwari**, Professor, Department of Electrical and Electronics Engineering.
- **Prof. A.S. Walkey**, Associate Professor, Department of Electrical and Electronics Engineering.

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: INSTALLATION, COMMISSIONING AND MAINTENANCE
(COURSE CODE: 3360902)

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

1. RATIONALE

Electrical Power system consists of a number of transformers, circuit breakers and other equipments which require installation, commissioning and regular maintenance to prevent permanent break down. Many times an engineering diploma holder has to carryout/supervises installation, commissioning and maintenance of various electrical equipments in power stations, substations and industry. This course will enable the diploma pass out student to understand the concepts, principles and acquire basic skills of installation, commissioning and maintenance of electrical equipments in power stations, substations and industry.

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:

- **Undertake installation, commissioning and maintenance of various power system components and equipment**

3. COURSE OUTCOMES (COs):

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Unload the electrical equipments/machines based on scientific procedure
ii. Commission various electrical equipment/machines
iii. Prepare maintenance schedule of different equipment and machines
iv. Prepare trouble shooting chart for various electrical equipment, machines and domestic appliances
v. Carry out different types of earthing
vi. Apply electrical safety regulations and rules during maintenance.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
4	0	2	6	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. Installation of Electrical Equipment	1a. Describe the planning before unloading of heavy electrical equipments at site. 1b. Select appropriate tools for installation of electrical equipment 1c. Explain the procedure for handling, inspection, storage and installation of static and rotating electrical equipment.	1.1 Unloading of electrical equipment at site 1.2 Inspection of electrical equipment at site 1.3 Storage electrical equipment at site 1.4 Foundation electrical equipment at site 1.5 Alignment of electrical machines 1.6 Tools/Instruments necessary for installation 1.7 Technical report, Inspection, storage and handling of transformer, switchgear and motors
Unit– II Commissioning and Testing	2a Describe various commissioning tests on electrical equipment/machines 2b Describe the specific test on electrical equipment/machines 2c Explain the standard tests performed on insulation oil 2d Determine the insulation resistance of electrical equipment/machines 2e Explain the procedure of drying the winding of electrical equipment/machines 2f Explain the various factor affecting the insulation resistance 2g Explain the need for gradual loading of electrical equipment	2.1 Tests before commissioning of electrical equipment- Electrical and Mechanical test, Preparations before commissioning of power transformer, Instruments required for testing 2.2 Specific tests on - Transformer, Induction motor, alternator, synchronous motor 2.3 Commissioning of power transformer, three phase induction motor and switchgear 2.4 Transformer insulation oil: Properties as per IS, sampling, testing and filtering/purifying, standard tests as per IS, classification of insulation resistance 2.5 Measurement of insulation resistance and Polarization Index, Factors affecting the insulation resistance of insulating materials 2.6 Drying the winding of electrical equipment and its record 2.7 Tests after and before commissioning the machine 2.8 Test report on commissioning and test certificate 2.9 Gradually loading of electrical equipment

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
Unit– III Maintenance of Electrical Equipment .	3a Explain the need of different types of maintenance 3b Explain the reason of failure of electrical equipment due to poor maintenance 3c Prepare maintenance schedule of different equipment 3d State the probable faults due to poor maintenance in various electrical equipment	3.1 Functions of the Maintenance Department; Reasons of failure of electrical equipment 3.2 Preventive maintenance: need, classification, advantages, activities Frequency of maintenance 3.3 Breakdown maintenance: concept, advantages, activities 3.4 Factors for preparing maintenance schedule 3.5 Maintenance schedule of transformer below and above 1000kVA 3.6 Maintenance schedule - induction motor, circuit Breaker, overhead line, storage Battery 3.7 Probable faults due to poor maintenance in transformer, induction motor, circuit breaker, overhead lines and battery

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
Unit–IV Troubleshooting	4a. State various internal and external faults that occur in electrical equipment 4b. State common troubles in various electrical equipment and machines 4c. Prepare trouble shooting chart for various electrical equipment, machines and domestic appliances.	4.1 Causes of faults in electrical equipment (Internal and external) 4.2 Instruments and tools for trouble shooting 4.3 Common troubles in electrical equipment – DC Machines, AC Machines, Transformers, Circuit-breaker, under-ground cable, electrical Installation 4.4 Need of trouble shooting chart, 4.5 Trouble shooting chart for DC Motor, DC Generator, Transformer, Synchronous Motor, Induction Motor, Circuit-breaker 4.6 Trouble shooting chart for Domestic appliances- electrical iron, ceiling fan, Washing machine, Air cooler, Vacuum cleaner, Fluorescent tube light: Construction, working and troubleshooting chart
Unit-V Earthing	5a Explain the need of earthing and the different methods of earthing 5b Explain the various factors affecting the earth resistance 5c Describe the various methods of measuring the earth resistance 5d Differentiate between equipment earthing and system grounding 5e Explain the earthing procedure in different types of electrical installations	5.1 Necessity of earthing 5.2 System earthing : advantage of neutral earthing of generator in power station 5.3 Equipment earthing: Objective 5.4 Types of earth electrodes 5.5 Methods of earthing : plate earthing ,pipe earthing and coil earthing 5.6 Earthing in extra high voltage and underground cable, Earthing resistance-factors affecting, Determination of maximum permissible resistance of the earthing system 5.7 Measurement of earth resistance: voltmeter-ammeter method, earth tester method, ohm meter method and earth loop tester method 5.8 Comparison between equipment earthing and system grounding 5.9 Earthing procedure - Building installation, Domestic appliances, Industrial premises, Earthing of substation, generating station and overhead line.

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
Unit-VI Electrical Accidents and Safety	6a. Explain the causes of electrical accidents 6b. Describe the procedure for shutting down of substation and power lines 6c. Explain the operation of different types of fire extinguishers	6.1 Causes of electrical accidents 6.2 Factors affecting the severity of electrical shock 6.3 Actions to be taken when a person gets attached to live part 6.4 Safety regulations and safety measures 6.5 Indian electricity supply act 1948-1956 6.6 Factory act 1948 6.7 Sub-station shut down Procedure 6.8 certificate of (i) requisition for shut down (ii) Permit to work and (iii) Line clear certificate 6.9 Instruction for the safety of persons working on a job with a permit to work 6.10 Fire extinguishers-Fixed installation and portable devices

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	Installation of Electrical Equipment	6	2	2	4	8
II	Commissioning and Testing	14	4	6	6	16
III	Maintenance of Electrical Equipment	12	4	5	5	14
IV	Trouble Shooting	9	4	5	3	12
V	Earthing	9	2	5	5	12
VI	Electrical Accidents and Safety	6	2	3	3	8
	Total	**56**	**18**	**26**	**26**	**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 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. However, if these practical 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)	Hrs. required
1	I	Prepare layouts of wiring for installation of given machine with specification	2
2	II	Prepare test reports of an electrical machine after commissioning	2
3	II	Perform various tests on insulating oil	2
4	II	Measure insulation resistance of a winding/cables/wiring installation	2
5	III	Prepare maintenance schedule for power transformer	2
6	III	Prepare maintenance schedule for induction motor	2
7	IV	Trouble shoot a ceiling fan	2
8	IV	Dismantle and trouble shoot of fluorescent tube light	2
9	V	Measure earth resistance of installation of building/domestic wiring and appliances by different methods	4
10	V	Prepare plate/pipe earthing as per IS and measure the earth resistance	2
11	V	Interpret IE rules pertaining to safety	2
12	VI	Show the action to be taken when a person comes in contact with a live wire	2
13	VI	Undertake drill operation for using fire extinguisher for safety against fire	2
Total			**28**

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Prepare journals based on practical performed in laboratory.
ii. Solving numerical from different books for practice
iii. List various instruments and tools used for troubleshooting
iv. Find troubleshooting techniques and steps to troubleshoot various electrical equipment and machines
v. Prepare trouble shooting chart for various electrical equipments
vi. Site visit for commissioning of Transformer

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Show video/animation film to demonstrate earthing, grounding
ii. Arrange a visit to nearby industry/substation to observe installation/commissioning and troubleshooting of various electrical equipment and machines.
iii. Use Flash/Animations to demonstrate installation of various electrical equipment and devices.
iv. Arrange expert lectures of the professional engineers involved in installation, commissioning and testing of heavy power equipments/machines.
v. Give Mini projects to students

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1.	Testing Commissioning operation and maintenance of Electrical Equipments.	Rao. S	Khanna Publication (Latest edition), New Delhi
2.	Installation, commissioning and maintenance of Electrical equipment	Singh Tarlok	S.K.Kataria and Sons, New Delhi, Second edition-2012
3.	Electrical power system	Wadhwa C.L.	New Age international Publications, New Delhi
4.	Relevant IS Code for-Installation, maintenance and commissioning of electrical equipments/machines	-	Latest code

B) Major Equipment/ Instrument with Broad Specifications

1. Digital Multimeter — 4 ½ digit hand held 9 V batteries operated, DC Voltage: 0 to 0.001 mV – 1000 V, AC Voltage: 0 to 0.01 mV – 1000 V, AC Current: 0 to 100 nA – 10 A, DC Current: 0 to 100 nA – 10 A,
2. Digital Tachometer — Hand held, battery operated, 5 digit display contact Type, 60 to 50000 r.p.m.,
3. Oil testing kit. — Mains Supply : 230V AC ±10%, 50Hz
Single Phase Variac : 230V/ 0-270V
High Voltage Source : 80kV, 20mA
Voltmeter : 0 to 100kV
4. Megger — Insulation Testing:250V:500V:1000V:
1000 MΩ range, Auto-ranging, Auto discharge

5. Software/Learning Websites

i. http://cercind.gov.in/ElectSupplyAct1948.pdf
ii. www.lce.com/pdfs/The-PMPdM-Program-124.pdf
iii. www.iapa.ca/pdf/prevent.pdf
iv. http://cercind.gov.in/ElectSupplyAct1948.pdf
v. www.pfeiffereng.com/Principals%20of%20Electrical%20Grounding.pdf

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. R D Panchal**, 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

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

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: POWER SYSTEM OPERATION AND CONTROL
(COURSE CODE: 3360903)

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

1. RATIONALE

A diploma engineers working in power sector needs to have awareness of the all major activities related to transmission and distribution of power so that they are able to relate with the jobs assigned to them and appreciate the importance of the activities being performed. For example, they should be aware of active and reactive power control strategies/mechanisms, and methods to ensure power system stability. They should also be aware of load flow studies and how load dispatch is economized. Hence, this course is designed to develop awareness about these concepts in diploma pass outs so that they may appreciate different equipment and techniques being employed to ensure power system stability, to control flow of power and to ensure economic dispatch of load. Thus this course is important for diploma electrical engineers who wish to work in power generation, transmission and distribution companies.

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:

- **Explain different mechanism/techniques used to ensure power system stability, control of flow of power and economical load dispatch**.

3. COURSE OUTCOMES (COs):

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Represent the power system components p.u. system with single line diagram.
ii. Explain methods for active and reactive power control.
iii. Explain methods for economic load dispatch and unit commitment.
iv. Explain methods to regulate the power for optimum power system stability.
v. Describe importance of load flow analysis for safe power system operation.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				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 Representation of Power System	1a. Calculate the p.u. values of power system parameters. 1b. Derive the kW, kVAr and power factor from complex power. 1c. Represent any balanced three phase system by single phase system.	1.1 Single phase representation of balanced three phase networks 1.2 The single line diagram and impedance of reactance diagram 1.3 Per unit (PU) systems and related examples 1.4 Complex power
Unit– II Active and Reactive Power Control (Voltage Control) Methods	2a. Explain the need to control transmission line voltages 2b. Explain concept of real and reactive power transfer in long distance transmission lines 2c. Describe the conventional methods to control real and reactive power i. AGC ii. Transformer tap changer control iii. Phase shifting transformers iv. Synchronous machine Excitation Control 2d. Explain the following real and reactive power control methods: i. Series and Shunt compensation ii. Load compensation and system compensation iii. FACT controllers, 2e. Describe the application of Series, shunt, series-shunt FACT controllers.	2.1 Transmission line voltages 2.2 Real and Reactive Power Transfer in long distance transmission lines 2.3 Conventional methods to control real and reactive power i. AGC ii. Transformer tap changer control iii. Phase shifting transformers iv. Synchronous machine Excitation Control 2.4 Real and Reactive power control methods: i. Series and Shunt compensation ii. Load compensation and system compensation iii. FACT controllers: Series, shunt, series-shunt. 2.5 Advantages and Disadvantages of FACT controllers,
Unit– III Economic Load Dispatch and Unit Commitment	3a. Describe the criteria for economical dispatch of power 3b. Plan to implement the optimal unit commitment (UC) under various conditions.	3.1 Economical dispatch of power 3.2 Optimal unit commitment(UC)
Unit– IV Power System Stability	4a. Distinguish steady state, dynamic and transient stability. 4b. Explain steam turbine speed	4.1 Turbine speed governing system 4.2 Steady state stability,

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
	governing mechanism. 4c. Describe the factors affecting transient stability 4d. Describe the equal area criterion to maintain steady state stability in inter connected power system.	Dynamic stability, Transient stability 4.3 Equal area criterion
Unit– V Load flow Analysis	5a. Justify the need for load flow analysis in interconnected power system: 5b. Select different types of buses. 5c. Use the GS and NR method to find different parameters (P,Q,Vs,Vr, δ) of transmission lines by using 3 bus power systems. 5d. Use the Concept of graph theory for DC load flow analysis.	5a. Load flow Analysis in interconnected power system: 5b. Different types of buses. 5c. GS and NR method to find different parameters (P,Q,Vs,Vr, delta) of transmission lines

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	Representation of Power System	06	04	04	02	10
II	Real and Reactive Power Control (Voltage Control) Methods	12	06	06	06	18
III	Economic Load Dispatch And Unit Commitment	06	02	06	04	12
IV	Power System Stability	08	04	08	02	14
V	Load flow Analysis	10	04	08	04	16
	Total	**42**	**20**	**32**	**18**	**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 LIST OF EXERCISES/PRACTICALS

The practical 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. However, if these practical 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	Develop a simple programme to calculate the p.u. values of a power system using MiPower/MATLAB software.	4
2	II	Simulate real and reactive power control methods using AGC of long distance transmission line [using 'Power World' simulator (open source)].	4
3	II	Simulate real and reactive power control methods using Transformer tap changer control of long distance transmission line [using 'Power World' simulator (open source)].	4
4	II	Simulate real and reactive power control methods using Phase shifting transformer of long distance transmission line. [Using 'Power World' simulator (open source)].	4
5	II	Simulate real and reactive power control methods using Synchronous machine Excitation Control of long distance transmission line. [Using 'Power World' simulator (open source)].	4
6	III	Determine the economic load dispatch for a given power system [Using software similar to MiPower/MATLAB etc.]	4
7	III	Solve the unit commitment problem for a given power system [Using software similar to MiPower/MATLAB etc.]	4
8	IV	Analyze the steady state stability of the given power system [Using software similar to MiPower/MATLAB etc.]	4
9	IV	Analyze the dynamic stability of the given power system [Using software similar to MiPower/MATLAB etc]	4
10	IV	Analyze the transient state stability of the given power system [Using software similar to MiPower/MATLAB etc]	4
11	V	Develop a simple programme to form the Y – Bus of the given power system[Using software similar to MiPower/MATLAB etc]	4
12	V	Perform Load flow study of given power system by GS and NR method[Using software similar to MiPower/MATLAB etc]	4
Total			**48**
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 units are developed.			

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Visit LDC and prepare detail report on it
ii. Prepare report on case study for cascade tripping
iii. Prepare a report on India's power grids, their power capacities and methods employed to ensure stability even after connecting them with each other.
iv. Prepare flow chart for the GS method and NR method for load flow studies
v. Prepare chart for various FACTs devices

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Arrange Visit to State Load Dispatch centre (SLDC)
ii. Provide as many simulation exercises to students as possible
iii. Arrange expert lecture by some engineers working at load dispatch centers/Power transmission companies.
iv. Discuss some case studies of black outs/grid failures due to power system instability

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1	Modern power system analysis	Kothari D. P. and Nagrath I. J.	Tata McGraw-Hill Publication New Delhi 2012 or latest
2	Electrical power system Design	Deshpande M. V.	Tata McGraw-Hill Publication New Delhi 2012 or latest
3	Electrical power system	Wadhwa C.L.	New Age international Publications New Delhi 2012 or latest
4	A course in Electrical Power	Gupta J.B.	S.K.Kataria and Sons New Delhi 2012 or latest
5	Power system analysis and Design	Gupta B. R.	S.Chand and Co. Ltd. New Delhi 2012 or latest

B) Major Equipment/ Instrument with Broad Specifications

High end computers to run software similar to MiPower/MATLAB/ETAP etc.

C) Software/Learning Websites

i. MiPower software latest version with relevant tool boxes
ii. MATLAB software latest version with relevant tool boxes
iii. ETAP software latest version with relevant tool boxes
iv. www.powergridindia.com
v. www.wrldc.com
vi. www.gseb.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. N N Pandya**, Lecturer in Electrical Engineering, Government Polytechnic, Ahmedabad
- **Prof. R D Panchal**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad
- **Prof. C.T. Patel,** RC Technical Institute, Lecturer in Electrical Engineering, Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. N. P. Patida**r, Professor, Department of Electrical and Electronics Engineering
- **Dr. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM

COURSE TITLE: DESIGN PARAMETERS OF ELECTRICAL EQUIPEMENT AND MACHINES
(COURSE CODE: 3360905)

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

1. RATIONALE

Technical personnel operating any electrical equipment and machines in an industry should be well aware of the basic design principles and key design parameters for better understanding of the functioning of those machines. This knowledge may be used to improve operating efficiency of the machines. Knowledge about design parameters also helps in maintaining those machines in a better way. In case of breakdown, knowledge of design parameters helps in selection of proper replacement materials and components. In some cases if specified components are not available then knowledge of design parameters may help in finding out alternative solutions. This course attempts to create the awareness of these parameters in diploma holders so that they can apply the general principles of design and knowledge of design parameters for better operation and maintenance of electrical equipment and machines. Knowledge so gained would also help students in deciding the specification of the equipment/machines to be purchased for some expansion or new projects. Studying this course will also enable a diploma pass out student to start his/her own business venture independently

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:

- **Apply the general principles of design and knowledge about design parameters for selection, operation and maintenance of electrical equipment and machines.**

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. Analyze the general aspects of design of electrical equipment and machines
ii. Design different types of starter, field regulator, choke and control panel.
iii. Design different types of electromagnets
iv. Design small transformer, understand the procedural steps to design a 3 phase transformers
v. Design capacitor start single phase induction motor and understand the procedural steps to design a 3 phase Squirrel cage induction motor
vi. Calculate various performance parameters for transformers and induction motor.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				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. General Electrical Design Principles	1a. Explain the term design and its limitations in electrical machines. 1b. State the properties of conducting, magnetic and insulating materials used in electrical machines. 1c. Describe the effect of heating and cooling on the performance of electrical machine. 1d. State the factors on which the specific magnetic and electric loadings depends. 1e. State the factors on which the output of an electrical machine depends. 1f. State the factors affecting the size of a rotating machine.	1.1 Design, Limitations of design, modern trends in design of electrical machines 1.2 Electrical properties of conducting, magnetic and Insulating Materials and its Classifications 1.3 Reasons for generation of heat in electrical machines. Concept of load and no load losses. 1.4 Heating and cooling of electrical machines 1.5 Specific magnetic and electric loading and their choice 1.6 Effect of type and quality of insulation on limits of allowed temperature rise and life of machine. 1.7 Output coefficient of DC and AC machine 1.8 Factor affecting size of machines 1.9 Duty cycle and equivalent ratings
Unit– II Design Parameters of Starters , Field Regulator and Control Panel	2a. State the parameters for designing an iron cored choke suitable for 5 amps inductive current. 2b. Derive the calculation of resistance steps of a motor. 2c. Estimate number of resistance section and resistance of each section for a DC shunt and series a motor. 2d. State the parameters for the design of a starter for a 3 phase slip ring induction motor. 2e. State the parameters on which the size of the wire for a particular current carrying capacity of a field regulator depends.	2.1 Design parameters of choke 2.2 Design parameters of A.C. and D.C. motor starters 2.3 Design parameters of Field regulator 2.4 Design of general purpose control panels

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit– III Design Parameters of Electromagnets	3a. Explain the function of an electromagnet. 3b. State the commonly used electromagnets and its applications. 3c. Write four fundamental equations on which the dimensions of various electro-magnets depend. 3d. Explain steps to design electromagnet.	3.1 Electromagnets and its types 3.2 Design of Magnet coils 3.3 Steps to Design small Flat-faced armature type circular magnet 3.4 Steps to Design large-faced armature type circular magnet 3.5 Steps to Design Horse shoe type magnet 3.6 Steps to Design plunger type magnet 3.7 Steps to Design magnetic clutches
Unit–IV Design Parameters of Transformers	4a. State the parameters of small transformer. 4b. Design small transformer. 4c. Compare power and distribution transformer from design point of view. 4d. Write the specifications of power and distribution transformer. 4e. Derive the output equation of a three phase transformer. 4f. Explain the effect of specific magnetic and electric loading on output of a transformer. 4g. Explain the effect of various electrical parameters on the performance of 3 phase transformer. 4h. Write the procedural steps for designing a three phase transformer.	Design of small Transformers 4.1 Core design 4.2 Winding design 4.3 Window area 4.4 Problem design of single phase transformer for 230V 50hz supply to deliver (3 to 5) amp at (12 to 50) volt Design Parameter of Three Phase Transformer 4.5 Power and distribution transformer from design point of view. 4.6 Specifications-Rating and performance expectation. 4.7 Output equation. Choice of Specific magnetic and electric loading. Core losses and copper losses. 4.8 Design of core, winding and main dimensions of frame, Electrical parameter -resistance, reactance, Magnetising current, Design criteria for tank. 4.9 Procedural steps for design of transformer.
Unit-V Design Parameters of Induction Motors	5a. Design the main dimensions of a single phase induction motor. 5b. Explain the basis on which air gap, number of stator and rotor slots are chosen. 5c. Write the procedural steps for designing a single phase capacitor start induction run motor.	5.1 Single phase induction motor -Design considerations and specification. 5.2 Material of core, conductor and insulation. 5.3 Design of core diameter and axial length. 5.4 Choice of air gap, number of stator slots, rotor slots. 5.5 Design of main winding. 5.6 Maximum torque. 5.7 Reactance. 5.8 Procedural steps for designing capacitor start induction run motor. 5.9 Sample examples
	5d. Explain basic considerations for design of a three phase induction motor	5.10 Three phase induction motor (no calculation) - Basic consideration for design.

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
	5e. Design main dimensions of a three phase induction motor 5f. Write procedural steps for designing a three phase squirrel cage induction motor.	5.11 Frame. 5.12 Rating. 5.13 Duty and rating. 5.14 Temperature rise. 5.15 Output equation, choice of specific electric loading. 5.16 Relation between L and D for best power factor. 5.17 Procedural steps for design of a 3 Phase Squirrel Cage Induction Motor.

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	General Electrical Design Principles.	6	4	4	2	10
II	Design Parameters of Starter , Field Regulator & Control Panel	8	4	3	7	14
III	Design Parameters of Electromagnets	8	6	2	4	12
IV	Design Parameters of Transformers	10	7	4	7	18
V	Design Parameters of Induction Motors	10	5	4	7	16
	Total	**42**	**26**	**17**	**27**	**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 PRACTICALS/EXERCISES

The practical 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. However, if these practical 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.	Practicals/Exercises (Outcomes in Psychomotor Domain)	Approx Hours. Required
1	I	Prepare a brief report of various methods of cooling of transformer which are used in industries, power station and substation. (along with their ratings) (different group of students can visit different industries,	4

S. No.	Unit No.	Practicals/Exercises (Outcomes in Psychomotor Domain)	Approx Hours. Required
		power station and substation and prepare a brief report)	
2	II	Design a control panel for your college. (Electrical Engineering laboratory, workshop, or control panel for complete college)	4
3	II	Design a.c. / d.c. starter for any motor which is present in your laboratory.	4
4	III	Design small flat faced armature type circular magnet using the given data. Also draw the above using AutoCAD.	4
5	III	Design large faced armature type circular magnet using given data. Also draw the above using AutoCAD.	4
6	III	Design Horse shoe type magnet using the given data. Also draw the above using AutoCAD.	4
7	III	Design large faced armature type circular magnet using the given data. Also draw the above using AutoCAD.	4
8	IV	Design single phase transformer for 230V 50hz supply to deliver (3 to 5) amp at (12 to 50) volt. Also draw the above using AutoCAD.	4
9	IV	Design single phase transformer using software.	2
10	IV	Design Distribution Transformer in your college premises or using relevant data. Also draw the above using AutoCAD.	4
11	IV	Prepare Flow chart for designing transformer	2
12	V	Design single phase induction motor used to fill an overhead tank. Also draw the above using AutoCAD	4
13	V	Design single phase induction motor using software.	2
14	V	Design 3-phase induction motor which is present in your laboratory. Also draw the above using AutoCAD	4
15	V	Design 3-phase induction motor using software	2
16	V	Prepare Flow chart for designing induction motor	2
		Total Hours	**54**
NOTE: Perform any of the practical exercises for total minimum of 28 hours from above list depending upon the availability of resources so that skills matching with the most of the outcomes in the all 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, motors etc.
iii. Using internet find different material used for construction of transformer and motors in recent trends.
iv. Survey the market and compare design of induction motors from different manufacturers based on materials used (in winding, insulation, frame, slip rings/squirrel cage, etc.) Losses, efficiency, expected life, temperature rise, type of bearings, noise level, type of cooling, cost etc.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Show video/animation film to demonstrate the working principles, constructional features, testing and maintenance of different electric machines.
ii. Arrange a visit to nearby manufacturer of electrical machines such as motors/transformers
iii. Arrange expert lectures of design engineers working in nearby electric machine manufacturing companies.
iv. Give mini projects to students about design of simple machines.

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1.	Design and testing of electrical machines	Deshpande M. V.	Wheeler Publishing, latest edition
2.	Electrical Machine Design	Mittle V. N. & Mittal Arvind	TMH publications, latest edition
3.	Electrical Machine Design	Shawney A. K.	Dhanpatrai & sons. Pub, latest edition
4.	Electrical Estimating & Costing	Alagappan N. & Ekambaram S. (TTTI, Madras)	Tata McGraw hill Ltd., latest edition
5.	Electrical Estimating & Costing	Surjit Singh	Dhanpat Rai & sons, latest edition
6.	Electrical Design, Estimating & Costing	Raina K.B. & Bhattacharya S.K. (TTTI, Chandigarh)	Wiley Eastern Ltd., latest edition
7.	Electrical Installation, Estimating & Costing	Gupta J.B.	S. K. Kataria & Sons, latest edition
8.	Electrical Machine Design	Agrawal R. K.	S.K.Kataria & Sons, latest edition
9.	Electrical Machine Design	Sen. S. K.	Oxford Publications, latest edition
10.	Electrical Machine Design	Gray A.	McGraw Hill publications, latest edition

B) Major Equipment/ Instrument with Broad Specifications

i. AutoCAD Electrical software : Latest version
ii. MATLAB/SIMULINK : Latest version
iii. Electrical CAD software: Latest version
iv. Venire calipers: Suitable for measuring dimension of motor and transformer
v. Models Showing cross section of different types of motors and transformers.

C) List of Software/Learning Websites

i. www.nptel.iitm.ac.in
ii. www.youtube
iii. www.howstuffworks.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. H. C. Chawda**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad
- **Prof. R. N. Shah**, Lecturer in Electrical Engineering, Govt. Polytechnic Patan.

Coordinator and Faculty Members from NITTTR Bhopal

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

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: ELECTRICAL DRIVES
(COURSE CODE: 3360906)

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

1. RATIONALE

Today's industrial and domestic loads demands precise and smooth variable speed control. The development of compact thyristor power converters has made this possible by smooth speed control of both AC and DC motors which are employed for several applications such as DC/AC drives, Vehicles and renewable energy. This course enables to develop the basics of electric drives and maintain different types of DC/AC drives in industries.

The competency in this area is highly required in diploma pass outs working in most of the industries since these industries employ large number of motors and drives and their smooth operation and maintenance requires lot of competent man power. Thus this course is must for students who want to work in industries.

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:

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

3. COURSE OUTCOMES (COs)

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. Select a drive for a particular application based on power rating.
ii. Select a drive based on mechanical characteristics for a particular drive application.
iii. Operate and maintain solid state drives for speed control of DC machines.
iv. Operate and maintain solid state drives for speed control 3 phase induction motor.
v. Operate and maintain solid state drives for speed control of 3 phase Synchronous motor.
vi. Operate and maintain solid state drives for speed control of various special electrical machines.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				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 **Basics of Electrical Drives** .	1a. Explain the working of an electrical drive with the help of a neat block diagram. 1b. Justify the selection criteria for electrical drive(s) 1c. Select electric drives for a given application.	1.1 Electric drive, types, AC v/s DC drives, choice of electric drives 1.2 Parts of electrical drive-Source, power modulator, electric motor and control unit 1.3 Selection of electric drive for applications: agricultural pumps, steel mills, paper mills, rolling mills, spinning mills, cement industries, chemical industries, refineries, shipping, power stations and automobiles
	1d. Use heating and cooling curve for finding temperature rise in a drive. 1e. Determine power rating for different load curves by equivalent current, torque and power methods. 1f. Select a motor on the basis of duty cycles of motors.	1.4 Heating and cooling curve 1.5 Motor duty class, classification– continuous, short time, intermittent periodic a. Motor power rating for continuous, short time and intermittent duty, equivalent current, torque and power methods for fluctuating and intermittent loads.
Unit– II **Dynamics of Electrical Drives**	2a. Explain the nature of speed torque characteristic of various types of loads and drive motors with the help of neat sketch. 2b. Explain the multi quadrant operation of electrical drive. 2c. Describe different methods of braking used in any electric drive.	2.1 Steady state load Torque speed characteristics 2.2 Multi quadrant operation of drives 2.3 Types of Braking-(a) Plugging, (b) dynamic/rheostat braking and (c) regenerative braking. 2.4 Starters- Typical control circuits for shunt and series motors, Three phase squirrel cage and slip ring induction motors
	2d. Describe the basic concept of various control loops used in electrical drives.	2.5 Close loop control of drives i. Current limit control ii. Close loop torque control iii. Close loop speed control iv. Close loop speed control of multi motor drive
Unit– III **DC Drives** .	3a. Explain conventional speed control technique(s) of DC motors. 3b. Explain various solid state speed controls of single and three phase DC drives. 3c. Describe the speed control of	3.1 Speed control of DC series and shunt motors – armature and field control. 3.2 Solid state speed control of single phase and 3 phase DC drives with the following: i. Half wave converter ii. Semi converter

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	chopper controlled DC drives.	iii. Full converter iv. Dual converter 3.3 Solid state speed control of separately excited shunt and series motor drives 3.4 Chopper controlled drives
Unit– IV **AC Drives - Three Phase Induction Motor Drive**	4a. Explain speed control methods of a 3 phase induction motor. 4b. Explain the working of various 3 phase induction motor drives for precise variable speed control.	4.1 Basic principle of 3 phase induction motor drive. 4.2 Solid state control of 3 phase induction motor: i. Stator voltage control -3 phase AC voltage controller and soft start. ii. Stator variable frequency control- voltage source inverter- PWM drives and current source inverter drives, cycloconverter fed IM drive. iii. Stator voltage and frequency control - Basics of V/f drive, scalar and vector or field oriented control of drives, V/f sensor less flux control drive. iv. Static rotor resistance control v. Slip power control – Static Kramer and Static Scherbius drive.
Unit– V **AC Drives - Three Phase Synchronous Motor Drive**	5a. Explain the principle of two modes of variable frequency control in 3 phase synchronous motor. 5b. Explain the working of self-controlled synchronous motor drive employing load commutated thyristor inverter for high speed and high power applications. 5c. Describe the working of a cycloconverter fed Synchronous motor.	5.1 Control of synchronous motor - Synchronous mode and Self mode. 5.2 Self-controlled synchronous motor drive employing load commutated thyristor inverter, closed loop control 5.3 Self-controlled synchronous motor drive employing cycloconverter
Unit– VI **Drives for Advanced Electrical Machines**	6a. Describe the working of various advance electrical machines drives. 6b. Explain the working of solar powered pump drives. 6c. Explain the working of battery powered electrical vehicles.	6.1 Drive for brushless DC motor 6.2 Stepper motor drive 6.3 Drive for switched reluctance motor solar powered pump drive 6.4 DC drives with chopper control for electrical vehicle. 6.5 Induction motor drive with voltage source inverter control for electrical vehicle.

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	Basics of Electrical Drives	08	02	04	02	08
II	Dynamics of Electrical Drives	08	02	04	04	10
III	DC Drives	10	04	04	06	14
IV	AC Drives – 3 Phase Induction Motor Drives	10	04	06	08	18
V	AC drives – 3 Phase Synchronous Motor Drives	12	02	04	04	10
VI	Drives for Advance Electrical Machines	08	02	02	06	10
	Total	**56**	**16**	**24**	**30**	**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 PRACTICALS/EXERCISES

The practical 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. However, if these practical 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	III	Test the performance of DC shunt motors.	2
2	III	Test the performance of DC series motors.	2
3	III	Control the speed of DC motor using single phase half wave Converter.	2
4	III	Control the speed of DC motor using single phase semi converter.	2
5	III	Control the speed of DC motor using single phase full converter.	2
6	III	Control the speed of DC motor using single phase dual converter.	2

S. No.	Unit No.	Practical/Exercises (Outcomes in Psychomotor Domain)	Approx. Hours Required
7	III	Control the speed of DC motor using three phase half wave converter.	2
8	III	Control the speed of DC motor using three phase semi converter.	2
9	III	Control the speed of DC motor using three phase full converter.	2
10	III	Control the speed of DC motor using three phase dual converter.	2
11	IV	Test the performance of closed loop speed control of 3 phase induction motor using stator voltage control.	2
12	IV	Test the performance of 3 phase induction motor V/f drive	2
13	IV	Test the performance of vector control drive	2
14	IV	Test the performance of field oriented control drive	2
15	IV	Test the performance of 3- Ø induction motor using VSI drive.	2
16	IV	Test the performance of cyclo converter fed induction Motor drive.	2
17	V	Test the performance of a self-controlled synchronous motor drive employing load commutated thyristor inverter	2
18	V	Test the performance of a self-controlled synchronous motor drive employing cycloconverter	2
19	VI	Test the performance of stepper motor drive	2
20	VI	Test the performance of BLDC motor drive	2
21	VI	Test the performance of switched reluctance motor drive	2
22	VI	Test the performance of solar powered pump drive	2
Total			**44**

Note: Perform any of the practical exercises from above list for a minimum of 28 hours depending upon the availability of resources so that skills matching with the most of the outcomes of every unit are included.

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Prepare journals based on practical performed in laboratory.
ii. Assignments on solving numerical problems
iii. Visit websites of suppliers of electric drives and do a comparative study of different drives provided by different companies.
iv. List various motor controlling parameters and find how they affect the performance of motor and drives.
v. Find troubleshooting techniques and steps to troubleshoot DC drives.
vi. Simulate various DC motor drives.
vii. Analyze the specifications for various types of AC drives.
viii. Find practical applications of AC drives in home appliances and list various Parameters of those applications.
ix. Make comparative table for various drives based on its application and maximum power ratings.
x. Check the performance of at least two different types of drives using simulation software like MATLAB.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Show video/animation film to demonstrate the working principles, constructional features, testing and maintenance of different types of DC motor drives.
ii. Arrange expert lectures by engineers working in electric drive companies.
iii. Arrange a visit to nearby manufacturer of electrical drives.
iv. Use flash/animations to explain the working of different control devices.
v. Give mini projects to students.

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1.	Fundamentals of Electrical Drives	Dubey, Gopal K.	Narosa Publishing House, New Delhi ,2nd Edition
2.	Power Electronics	Bimbhra, P.S.	Khanna Publishers, New Delhi 5th Edition
3.	Power Electronics	Singh M.D., Khanchandani K.B.	Tata McGraw-Hill Education New Delhi
4.	Variable Speed Drives and Power Electronics	Barnes, Malcolm	Newnes, Elsevier ,2003
5.	Power Electronics: Circuits, Devices and Applications	Muhammad, Rashid H.	Pearson, New Delhi, 2003,3rd Edition or latest

B) Major Equipment/ Instrument with Broad Specifications

1. Digital Multimeter: 4 ½ digit hand held 9 V batteries operated, DC Voltage: 0 to 0.001 mV – 1000 V, AC Voltage: 0 to 0.01 mV – 1000 V, AC Current: 0 to 100 nA – 10 A, DC Current: 0 to 100 nA – 10 A,
2. Digital Tachometer: Hand held, battery operated, 5 digit display contact type, 60 to 50000 r.p.m.,
3. Four channel Digital Oscilloscope: Bandwidth :200MHz, Power supply:230V ± 10% tolerance,50 Hz AC supply
4. Various Trainer boards for DC and AC Drives:
   i. 3 phase induction motor for V/f control
   ii. Microcontroller based Slip ring induction motor speed control using Static Kramer Drive
   iii. DC shunt motor speed control using 3 phase fully controlled converter
5. Any one simulation software (Open source software preferred) : Scilab/Matlab and Simulink toolbox, CASPOC

C) Software/Learning Websites

i. http://nptel.iitm.ac.in/video.php?subjectId=108108077
ii. http://www.edumedia-sciences.com/en/a575-speed-controler-for-dc-motor

iii. http://www.engineeringtv.com/video/Texas-Instruments-Brushless-DChttp://www.scribd.com/doc/6883802/AdjustableSpeedDrivesTutorial
iv. SEQUEL (open source)
v. PSIM
vi. ORCAD

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. H I Joshi**, Lecturer in Electrical Engineering, Government Polytechnic, Ahmedabad
- **Prof. C T Patel**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad
- **Prof. R D Panchal**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

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

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

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- **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

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD

COURSE CURRICULUM
COURSE TITLE: ELECTRIFICATION OF BUILDING COMPLEXES
(COURSE CODE: 3360908)

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

1. RATIONALE

With the revolutionary changes in the building construction, advent of new building materials and electrical fittings and accessories there is an increase in demand for specialists in electrification of high rise-multistoried building and commercial complexes. Therefore a limited exposure to electrification of small building is not sufficient and this subject needs to be taught as a specialized subject. This course will provide knowledge about electrification of high rise buildings and complexes. Studying this course will enable the diploma pass outs to plan, design, and estimate and execute the electrification of multistoried buildings and commercial complexes independently and professionally as per IE rules. If proper skills are developed then pass outs may start their own business of electrification of building complexes, which is very profitable and growing business and requires very less investment.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Applying IE rules, undertake the electrification of multistory buildings and commercial complexes.**

3. COURSE OUTCOMES

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Interpret plan and wiring diagrams of electrification of buildings and complexes.
ii. Calculate the average and peak power requirement of building complexes.
iii. Test a given wiring installation of a building and prepare test report.
iv. Test wiring installation of a multistoried building and commercial complexes.
v. Estimate the materials and cost of electrification for different buildings.
vi. Test the safety devices in a multistoried building and commercial complexes.

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4. TEACHING AND EXAMINATION SCHEME

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

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. Elements of Electrification	1a. Interpret different electrical engineering drawings of an electrical installation. 1b. Measure and verify current, earthing resistance , insulation resistance and continuity of a wiring installation as per IS. 1c. Describe the safety tests as per IS. 1d. Calculate illumination requirements.	1.1 of Electrical installation 1.2 Reading and Interpretation of Electrical Engineering Drawings, diagrams, plans and layout 1.3 Testing of wiring Installation for verification of current, earthing resistance, insulation resistance and continuity as per IS 1.4 Preparation of testing/supervisory report 1.5 Selection of electrical accessories such as main cable, main switches circuit breakers etc. 1.6 Illumination requirements in high rise, Commercial and public Building 1.7 Economical illumination design
Unit– II Electrification of Multistoried Buildings	2a. Prepare wiring layout of Electrical installation. 2b. Calculate total load on electrical distribution work. 2c. Prepare specification of wiring material and accessories required for an electrical installation. 2d. Estimate floor wise electrical material requirements.	2.1 Wiring layout of an electrical installation 2.2 Type of wiring- Concealed /Surface conduit etc 2.3 Calculate number of sub circuits from the total circuit requirement 2.4 Calculation total electrical load on distribution work 2.5 Floor wise estimation of material requirements i. Specification of wiring material and accessories. ii. Estimation of total cost of electrification using schedule of rates (SOR). iii. Case Studies 2.6 Requirements of approval from electrical inspection for high rise-multistoried building 2.7 Load calculation for lifts, escalators, air conditioners: wiring diagram, Case studies(Problems)
Unit– III Electrification of Commercial Complexes and Public Buildings	3a. Interpret Installation drawing and layout of electrical wiring of a commercial complex. 3b. Differentiate between electrification of Residential and commercial Installation. 3c. Calculate Load specification	3.1 Concept of commercial Installation 3.2 Comparison of Residential and commercial Installation 3.3 Fundamental considerations for planning of an electrical installation system for commercial/Public building

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
	for service connection and nature of supply. 3d. Calculate the correct size of cables, bus bar and bus bar chambers. 3e. Select appropriate mounting arrangements and positioning of switchboards, distribution boards, main switch, type of wire and wiring system. 3f. Estimate the cost of electrification of commercial installation.	3.4 Special requirements of hotels, theaters, library and cultural halls etc. from electrification points of view 3.5 Estimating and Costing of material and total cost of electrification of commercial complexes and Public buildings
Unit – IV Distribution System for Multistoried Buildings	4a. Prepare drawing and layout for an underground service connection. 4b. Calculate Load specifications for an underground service connection of multistoried buildings. 4c. Calculate the size of bus bar, cables, panels, wiring system, type of wire 4d. Decide Mounting arrangements and positioning of switchboards, distribution boards main switch etc. 4e. Estimate the cost of multistoried buildings.	4.1 Different Methods of service connection 4.2 Incoming supply to substation for multistoried high rise buildings (building height more than 15m.) 4.3 Distribution panels and bus bar system 4.4 Meter connection-bifurcation of metering-meters as per consumers demand, use of digital – meters for prevention of theft of power 4.5 Cable laying in building, special precautions 4.6 Estimating and costing of electrification of underground service connection of multistoried building.
Unit – V Electrical Safety and IE Rules	5a. Highlight the significance of safety rules to be followed in a Multistoried building. 5b. Conduct safety tests as per IE. 5c. Maintain various safety devices in multistoried buildings. 5d. Maintain Diesel Generator set as a stand by unit.	5.1 Importance of safety rules. 5.2 Safety precaution in electrical installation of multistoried buildings i. Fire alarm system ii. Smoke detection system iii. Safety for lifts and escalators iv. Earthing system (IE rules regarding safety) v. Lightening arrestors arrangements vi. Use of ELCB and MCB in an installation vii. Electronic safety locks at the entrance 5.3 Use of National Building Code

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
		(electrical service) for safety 5.4 Use of D.G. set as a standby power supply in case of emergency. 5.5 IE rules related to Electrical Installation and Testing

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	Elements of Electrification	6	3	3	3	09
II	Electrification of Multistoried Buildings	10	5	6	6	17
III	Electrification of Complexes and Public Buildings	10	5	6	6	17
IV	Distribution System for Multistoried Buildings.	10	5	6	6	17
V	Electrical Safety and I.E. rules	6	3	3	4	10
	Total	**42**	**21**	**24**	**25**	**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 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. However, if these practical 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. Hrs. required
1	II	Draw a complete wiring diagram, of any one of the commercial complexes. (Cinema, hotel, library, cultural hall, hospital etc. A group of 5 students, having one different complex –per group.	4
2	III	Interpret and prepare electrical test report of a large building or complex.	2
3	III	Calculate load, draw wiring diagram and estimate cost of any given high rise building.	4
4	I	Design Economical illumination system for any complex, building.	4
5	V	Testing of safety Devices in electrical installation in a high rise building.	4
6	II	Calculate Load for lift, escalators, air conditioning in high rise building. (A group of 5 students, having one different complex per group.)	4
7	V	Prepare field visit report (Important observations) of any high-rise building or Complex for electrical installation and wiring.	2
8	I and V	Perform electrical tests for commercial and high rise buildings as per IE.	4
Total Hours			**28**

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities:

i. Prepare journals based on practical performed in laboratory.
ii. Assignments on solving numerical
iii. Assignments of case studies
iv. Analyze the standard specifications of various electrical accessories and fittings.
v. Make comparative table of different types of wiring installations.
vi. Prepare a sample test report based on test carried out on an installation
vii. Visit to see the electrification of large multistoried building or commercial building complex

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Arrange lectures by 'A' class contractors engaged in electrification works of building complexes.
ii. Arrange a visit to a complex, multistory building under construction where electrification work is in progress.
iii. Show video/animation film to demonstrate the different types of wiring and installations
iv. Carry out a survey and prepare a report on different type of cables, their sizes and modern electrical accessories and fittings available in local market
v. Use Flash/Animations to explain the working of different electrical safety devices.
vi. Give Mini projects (such as planning and estimating of electrification of given building complex) to students.

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1.	Electrical Design Estimation and Costing	Raina K.B. Bhattacharya S.K.	Willet Estern Ltd., Latest edition
2.	Electrical Estimation and Costing	Uppal S.L.	Khanna Publisher, New Delhi, Latest edition
3.	India Electrical Rules 1956 Hand book	Chudley R.	Butterworth –London New Delhi. Latest Edition, Latest edition
4.	National Building code of India Group 1 and Group 4	Bureau of Indian standard	New Delhi, Book no. 1604,Latest Edition
5.	A Course in Electrical Installation, Estimating and Costing	Gupta J.B.	S.K. Kataria and Sons, Latest edition

B) Major Equipment/Instruments with Broad Specifications

1. Digital Multimeter
2. Clip-on meter
3. MEGGAR
4. EARTH TESTER
5. MULTIMETER
6. Basic wiring tools

Pliers, Screw drivers and nut drivers ,Wire strippers , Utility Knife, Fishing tools, Measuring devices, Labeling machines, Power drills and drivers, hammer/drills, Power saws

C) Software/Learning Websites

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

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. V. R. Kotdawala**, L.E.E, Government Polytechnic, Himmatnagar
- **Prof. A. A. Amin**, L.E.E, Government Polytechnic, Vadnagar

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. (Mrs.) C.S. Rajeshwari**, Professor, Department of Electrical and Electronics Engineering,
- **Prof. A. S. Walkey**, Associate Professor, Department of Electrical and Electronics Engineering,