

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

**COURSE CURRICULUM
COURSE TITLE: SWITCHGEAR AND PROTECTION
(COURSE CODE: 3360901)**

Diploma Programme in which this course is offered	Semester in which offered
ELECTRICAL ENGINEERING DEPARTMENT	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 required to carry out remedial measures for faults/abnormalities in machines/equipment in power system using appropriate diagnostic instrument/devices.

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:

- **Maintain various controls and switchgear in power system**

3. COURSE OUTCOMES:

Student will be able to:

- Identify various types of faults in Power system
- Maintain different types of circuit breakers in power system.
- Maintain different types of relays in power system.
- Protect transmission line and feeder from various faults
 - Protect transformer, alternator, motor and busbar
 - Protect power system against over voltages

4. Teaching and Examination Scheme

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				Total Marks
				Theory Marks		Practical 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	Topics and Sub-topics
Unit – I. Elements of protection	1a Describe the function of basic elements of a protective system 1b State various types of faults and abnormalities occurring in a power system. 1c Describe the operation of the Backup protection 1d Explain the use of Current Transformer and Potential Transformer in protection system. 1e Explain various methods of neutral Earthing.	1.1 Need of protective system 1.2 Functions of basic elements of a protective system. 1.3 Basic functional characteristics of protection system 1.4 Types, causes and effects of various Faults. 1.5 Protection zones 1.6 Backup protection & its types. 1.7 Necessity of Protective Transformers 1.8 Specifications and Connection diagram of Current Transformer and Potential Transformer both single and 3 phase 1.9 Use of current limiting reactors and their arrangements. 1.10 Importance and methods of neutral Earthing

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit– II Circuit Interrupting Devices	2a. Draw line diagram of a protective system showing different circuit interrupting devices 2b. Explain the sequence of operation of and interlocking of the above 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. & D.C. Circuit Breaker 2g. Explain the resistance switching 2h. Describe the Sequence of operation of circuit breaker.	2.1 Necessity and types of interrupting devices 2.2 Sequence of operation and interlocking 2.3 Fuse, types, terms related to fuse, characteristics, testing and applications 2.4 Requirement and types of isolators. 2.5 Arc phenomena and arc extinction in circuit breaker 2.6 Important terms associated with circuit Breaker 2.7 Resistance switching 2.8 Construction, working principle of Air break, Air Blast, Sulphur Hexa Fluoride (SF ₆) and vacuum circuit breakers. 2.9 Circuit breaker ratings 2.10 Auto-reclosure 2.11 Testing of circuit breaker 2.12 Working principle of arc quenching in HVDC circuit breaker
Unit– III Protective relays	3a. Explain the classification and application of relays. 3b. State the basic terms related to relays. 3c. Explain the working of different types of relays. 3d. Explain concept of over current and directional relays. 3e. Explain setting of relays. 3f. Describe the testing procedure of various relays.	3.1 Protective relay, classification and selection 3.2 Basic terms related to relay -Pick up value, reset value and operating current etc. 3.3 Principle of working ,construction and operation of electromagnetic induction(shaded pole, watt-hour meter and induction cup), Thermal relay 3.4 Settings of various types of relays 3.5 Directional relay 3.6 Distance relay(impedance, reactance and mho) 3.7 Negative phase sequence relay 3.8 Need of static relay, Construction and types 3.9 Principle and working of Microprocessor based relay 3.10 Maintenance and testing of relays

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit-IV Protection of transmission line and feeder	4a. Compare various protection scheme of transmission line. 4b. Explain simple Impedance relay 4c. Explain need of carrier aided protection. 4d. State the types of auto reclosing. 4e. Explain protection of feeders and ring mains and Bus bar	4.1 Need of transmission line protection scheme 4.2 Selection of protection scheme - Overload protection, Over-current and earth fault protection, Time graded and current graded protection, Current balance differential protection 4.3 Need of Carrier aided protection, Carrier inter-tripping, acceleration and blocking scheme 4.4 Distance /Impedance protection 4.5 Necessity and types of Auto reclosing 4.6 Protection of parallel feeders and Ring Mains
Unit-V Protection of transformer, alternator, motor and bus bar	5a. Explain various protection scheme for transformer. 5b. Describe the inrush current phenomenon in transformer. 5c. Explain the protection offered by Buchholz Relay 5d. Explain the faults and abnormalities in alternator, 5e. Explain various faults occurring in motor and their protection schemes. 5f. Explain Differential protection of Busbars	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 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. 6c. Describe the Insulation co-ordination and basic impulse insulationLevel	6.1 Causes of over voltages. 6.2 Methods of reducing over voltages. 6.3 Operating principles, construction and Applications of lightning arrester 6.4 Insulation co-ordination, volt-time characteristic and basic impulse insulation level.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & 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	Protective relays	12	05	06	04	15
III	Circuit interrupting devices	10	05	06	04	15
IV	Protection of transmission line	12	04	08	03	15
V	Protection of transformer, alternator, motor & busbar	10	04	06	02	12
VI	Over voltage protection	04	03	02	00	05
	Total	56	25	30	15	70

Legends: R = Remembrance; U= Understanding; A= Application and above levels (Revised Bloom's 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/exercises should be properly designed and implemented with an attempt to develop different types of cognitive and practical skills (**Outcomes in cognitive, psychomotor and affective domain**) so that students are able to acquire the competencies.

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 Programme Outcomes/Course Outcomes in affective domain as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain

S. No.	Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. required
1	I	Check the Polarity of Current Transformer and Potential Transformer and connect it with the relay.	02
2	II	Test overload relay and plot Time-Current characteristic	02
3	II	Test Buchholz relay for transformer protection.	02
4	II	Test thermal overload relay for protection of motor and set the relay properly.	02
5	II	Test static relay for the protection of motor	02
6	III	Determine the fusing factor of a given fusing material.	02
7	III	Test the performance of Vacuum circuit breaker.	02
8	III	Test the performance of SF ₆ circuit breaker.	02
9	IV	Apply balance current protection scheme using appropriate switch gear	02
10	IV	Interpret various protective scheme used for transmission lines and feeders (from Blue print and visit).	04
11	IV	Draw schematic diagram of protective schemes for 66 KV/ 132 KV/220 KV Substation nearby area. (after visit)	04
12	IV	Visit a substation and prepare its technical report emphasizing on control side	04

13	V	Interpret the protection scheme for an alternator in power station (from Blue print and visit).	04
14	V	Interpret different protective scheme for transformer.	02
15	VI	Demonstrate the performance of Horn gap lightning arrester.	02
Total			28

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

- i. Prepare chart for line diagram of power system
- ii. Prepare chart of basic elements of protective system.
- iii. List different types of relays, circuit breakers and collect literature from dealers/Manufactures.
- 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.

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 a visit to nearby manufacturer site of protection panel
- iii. Arrange a visit to relay testing laboratory.

9. SUGGESTED LEARNING RESOURCES

A) List of 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)
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 (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
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B) List of Major Equipment/ Instrument with Broad Specifications

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
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
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.
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.

B) List of Software/Learning Websites

- i. WWW.nptel.iitm.ac.in

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- Prof. S.V.Jagani, Government Polytechnic, Dahod
- Prof. T. A. Patel, Government Polytechnic, Dahod
- Prof. H. C. Chavda, R.C. Technical Institute, Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

- Dr. (Mrs.)C.S. Rajeshwari, Professor, Electrical and Electronics Engineering, NITTTR, Bhopal
- Prof.A.S. Walkey, Associate Professor, Electrical and Electronics Engineering, NITTTR, Bhopal