GUJARAT TECHNOLOGICAL UNIVERSITY

POWER ELECTRONICS (24)
SWITCHGEAR AND PROTECTION
SUBJECT CODE: 2182407
B.E. 8TH SEMESTER

Type of course: BE

Prerequisite: Basic Power Systems(2142404)

Rationale: "Switch Gear &Protection" subject gives general awareness of different Protective Equipment for Power Systems such as Relays, Circuit Breakers, and Isolators. It also explains about protective system- how it works and where it works? Different applications of the relays for different elements of power system is also discussed in the subject. To introduce students to power system protection and switchgear.
To teach students theory and applications of the main components used in power system protection for electric machines, transformers, bus bars, overhead and underground feeders. To teach students the theory, construction, applications of main types Circuit breakers, Relays for protection of generators, transformers and protection of feeders from over- voltages and other hazards. It emphasis on neutral grounding for overall protection. To develop an ability and skill to design the feasible protection systems needed for each main part of a power system in students.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	20	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1.	Introduction: Substation, Types of Substation, Substation Elements (Symbol, Construction, Function, Application), Types of abnormal Conditions , Trip Circuit & its operation.	04	05
2.	In Circuit Breakers: Elementary principles of arc interruption, Recovery, Restriking Voltage and Recovery voltages. - Restriking Phenomenon, Average and Max. RRRV, Numerical Problems. Current Chopping and Resistance Switching. CB ratings and Specifications: Types and Numerical Problems. – Auto reclosers. Description and Operation of following types of circuit breakers: Oil Circuit breakers, Air Break Circuit Breaker, Air Blast Circuit Breakers, Vacuum and SF6 circuit breakers.	08	20
3.	Principle of Operation and Construction of Attracted armature, Balanced Beam, induction Disc and Induction Cup relays. Relays Classification: Instantaneous, DMT and IDMT types. Application of relays: Over current/ Under voltage relays, Directional relays, Differential Relays and Percentage Differential Relays. Universal torque equation, Distance relays: Impedance, Reactance and Mho and Off-Set Mho relays, Characteristics of Distance Relays and	08	20

	Comparison. Static Relays: Static Relays verses Electromagnetic Relays.		
4.	Protection of generators against Stator faults, Rotor faults, and Abnormal Conditions. Restricted Earth fault and Inter-turn fault Protection. Numerical Problems on % Winding Unprotected.	06	15
5.	Protection of transformers: Percentage Differential Protection, Numerical Problem on Design of CT s Ratio, Buchholtz relay Protection.	06	15
6.	Protection of Lines: Over Current, Carrier Current and Three-Zone distance relay protection using Impedance relays. Translay Relay. Protection of Bus bars – Differential protection.	04	10
7.	Grounded and Ungrounded Neutral Systems. - Effects of Ungrounded Neutral on system performance. Methods of Neutral Grounding: Solid, Resistance, Reactance –Arcing Grounds and Grounding Practices.	03	05
8.	Generation of Over Voltages in Power Systems.-Protection Against Lightning Over Voltages – Valve type and Zinc-Oxide Lighting Arresters. Insulation and Coordination -BIL, Impulse Ratio, Standard Impulse Test Wave, Volt-Time Characteristics and Insulation Co-ordination.	04	05

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks (%)					
R Level	U Level	A Level	N Level	E Level	C Level
10	**40**	**20**	**20**	**10**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create 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.

Reference Books:

1. Sunil S Rao *"Switchgear Protection & Power Systems"*,
2. Badari Ram & D.N Viswakarma *"Power System Protection and Switchgear"*
3. Paithankar and S.R.Bhide, *"Fundamentals of Power System Protection"*
4. T S Madhav Rao, "Power System Protection: Static Relays"
5. C R Mason, "Art & Science of Protective Relaying"
6. Cl Wadhwa, "Electrical Power Systems"
7. Hand Book of Switchgears by BHEL

Course Outcome:

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.

After learning the course the students should be able to:

1.Student gains knowledge on different Protective Equipment or Power Systems
2. Know about various protective systems- how it works and where it works?
3. Different applications of the relays, circuit breakers, grounding for different elements of power system is also discussed in the subject.
4. Ability to discuss Recovery and Restriking.

5. Ability to express Oil Circuit Breaker, Air Blast Circuit Breakers, SF6 Circuit Breaker.
6.Abiity to identify DMT, IDMT type relays
7. Ability to identify Rotor, Stator Faults, interturn faults and their protection.

List of Experiments:

The list is for guideline only. As far as possible, the term work given should be in digitized form.

1. To study Construction, characteristics and Working of oil circuit breaker
2. To study Construction, characteristics and Working of air blast circuit breaker
3. To study Construction, characteristics and Working of vacuum circuit breaker.
4. To study Construction, characteristics and Working of SF6 circuit breaker
5. To study Construction, characteristics and Working of water circuit breaker
6. To study construction and working principle of different types of fuses.
7. To study construction and working principle of H.R.C fuse.
8. To study construction and working principle of isolators.
9. To study construction and working principle along with application of different types of relays.
10. To study construction and working principle of static switches.
11. To study Micro controller based 3-Phase Differential Relay.
12. To study Micro controller based over current Relay.
13. To study the Numerical Protection of induction motor.
14. To obtain the operating characteristics of an IDMT relay.
15. To study the operating characteristics of directional over current relay.
16. To study the operating characteristics of the transformer percentage differential relay.
17. To study the magnetic inrush current in a transformer and its protection.
18. To study radial feeder protection using two overcurrent and one Earth fault relay.
19. To study transformer differential protection.
20. To study the protection schemes for different abnormal conditions in an alternator.
21. To study Buchholz relay for transformer protection.
22. To study Generalized block diagram of Numerical Relay

Design based Problems (DP)/Open Ended Problem:

1. Develop and analyze different types of circuit breaker in MATLAB like simulation software
2. Develop and analyze different protection scheme in MATLAB like simulation software.
3. Core balance leakage protection of power transformer
4. Combined leakage protection and overload protection of machine.
5. Biased differential protection
6. Harmonic Restrain relay
7. Restricted Earth fault protection for power transformers
8. Generator transformer Protection Units.
9. Pilot wire protection of feeders using Merz-Price System.

Major Equipment:

1. 4 ½ digit hand held Digital Multimeter
2. Digital Hand held Tachometer
3. Four channel Digital Oscilloscope
4. Two Section Radial Feeder Protection (Three-phase setup)
5. Three Section Radial Feeder Protection (Single-phase setup)
6. Parallel Feeder Protection (Numerical relays) (Single-Phase Setup)
7. Numerical Relay Panel for Induction Motor Protection
8. Distance Protection Relay Test Setup
9. Numerical Protection of 3-Phase Generator
10. Differential protection of Transformer (Three-phase Type)
11. Numerical Over voltage and Under Voltage protection

12. Characteristic of Inverse Time Over Current Relay
13. Characteristic of Inverse Time Earth Fault Relay
14. Circulating Current Differential protection of Generator
15. Reverse Power Protection
16. Parallel Feeder Protection (Electromechanical relays)
17. Characteristics of Inverse Time Over and Under Voltage Relays
18. Under Voltage Protection (Electromechanical)
19. Over Voltage Protection (Electromechanical)
20. Test Setup (Single Phase Type) for Characteristics of Fuse and MCB
21. Test Setup (Single Phase Type) for Characteristics of Inverse Time Over Current Relay panel
22. Test Setup for Generator (Three Phase) protection Scheme including all types of protection with panel
23. Test Setup for Transformer (Single phase and Three Phase) protection Scheme including all types of protection with panel
24. Test Setup for Three Induction motor protection Scheme including all types of protection with panel
25. Simulation model of distance protection of transmission line with impedance relay
26. Radial Feeder protection panel
27. Parallel feeder protection panel

List of Open Source Software/learning website:

- Computers and programming software like C C++ or MATLAB, SCILAB, OCTAVE
- NPTEL web courses and video courses

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.