

GUJARAT TECHNOLOGICAL UNIVERSITY

SUBJECT NAME: Switch Gear and Protection

SUBJECT CODE: 2170908

B.E. 7th SEMESTER

Type of course: Engineering

Prerequisite: Electrical Power Systems II

Rationale: This subject is a core subject and very important for any practicing electrical engineer. The electrical engineer has to deal with many switchgears and protection systems of various elements of power systems. The subject curriculum focuses on the study of fundamentals of power system protection, electromagnetic relays which are important one. It also covers the protection of feeders, transmission lines, transformers, generators and induction motors. The subject deals with the principles of circuit breaking and circuit breaker fundamentals. It also covers the working principle of protective switch gears like CT and PT. The topics covered in the curriculum are chosen in such a way that the students get a very good idea of the underlying principles of switchgear and protection.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
4	00	02	06	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	%Weightage
1	Introduction to Protective Relaying and electromagnetic relays Faults, Causes and Effects, Protective Zones, Primary and Backup Protection, Desirable Qualities and Terms of Protective Relaying, Basic Connection of Trip Circuit, Types of Relay Units, Relay Pick up, Reset or Drop out, Pick up/ Drop off Ratio, Construction and Working of Different Electromagnetic Relays [3]	3	4
2	Over Current Protection of Transmission line Introduction, Fuse, Thermal Relays, Over Current Relays, Application of Definite Time & IDMT O.C. Relays for Protection of Feeder, Directional Over Current Relay, Limitations of O.C. Relays [1]	3	5

3	Differential Protection Simple Differential Protection, Zone of Protection and Actual Behavior of Simple Differential Protection, Percentage Differential Protection, Earth Leakage Protection[1]	2	4
4	Transformer Protection Types of Faults, Over Current Protection, Percentage Differential Protection, Inrush Phenomenon, High Resistance Ground Faults in Transformers, Inter-turn Faults, Incipient Faults, Over-fluxing Phenomenon[1]	4	7
5	Distance Protection of Transmission line Drawbacks of O.C. Protection, Introduction to Distance Protection, Types of Distance Relay, Impedance, Reactance, MHO Relay, Performance of Distance Relay During Normal Load and Power Swing, Effect of Arc Resistance on Reach of Distance Relays, Comparison of Distance Relays, Distance Protection of Transmission line, Reasons for Inaccuracy of Distance Relay Reach, Three Step Protection, Trip contact configuration, 3-step protection of double and fed lines. [1]	5	10
6	Carrier aided protection of transmission lines Need for carrier aided protection of transmission lines, various options for carrier, Coupling and trapping the carrier into the desired line section, single line to ground coupling, line to line coupling, unit type carrier aided directional comparison relaying, carrier aided distance scheme for acceleration of zone II, transfer trip or inter trip, permissive inter trip, acceleration of zone II, pre-acceleration of zone II, phase comparison relaying (unit scheme) [1]	5	10
7	Generator protection Various faults & abnormal operation conditions, stator & rotor faults, transverse differential protection, unbalanced loading, over speeding, loss of excitation, loss of prime mover [1]	5	10
8	Induction motor protection Various faults & abnormal operation conditions, starting of induction motor, protection of small & large induction motor. [2]	5	10
9	Numerical protection Introduction, block diagram of numerical relay, numerical over current protection, numerical transformer protection, numerical distance protection of transmission line [1]	5	10
10	Theory of circuit Interruption	3	5

	Introduction, Physics of arc phenomena, Maintenance of the arc, Losses from plasma, Essential properties of arc, Arc interruption theories. [4]		
11	Circuit Constant in Relation to Circuit Breaking Introduction, Circuit breaker rating, Circuit constants & circuit conditions Re-striking voltage transient Characteristics of re-striking voltage, Interaction between the breaker & circuit, Current chopping, duties of switchgear.[4]	4	5
12	Theory & Practice of Conventional Circuit Breaker and modern circuit breakers Automatic switch, Air-break circuit breakers, Oil circuit breakers, Single and multi break Construction, Air-blast circuit breaker, Performance of circuit breakers and system requirements, Modification of circuit breaker duty by shunt resistors, Power factor correction by series resistance, Comparative merits of different types of conventional circuit breakers, Modern trends, Vacuum circuit breakers, Sulphur hexafluoride (SF ₆) circuit breakers D.C. circuit breaker, auto-reclosing - definitions & features, 3-Phase versus 1-Phase auto-reclosing [4]	8	15
13	Protective current transformer and potential transformer Magnetization curve of CT, Difference between measurement & protective CT, CT errors, calculation of CT accuracy, selection of CT, CT requirements for differential protection, specifications of CT, specifications of PT, CVT. [2]	4	5

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	25	25	20	5	5

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.

Self Study: Protection using Fuses, MCB, MCCB & ELCB [2]

Reference Books:

1. Fundamentals Of Power System Protection – Y. G. Parithankar & S. R. Bhide, 2nd edition, PHI [2],[3],[4],[5],[6],[7],[9]
2. Power system protection and switchgear by Oza, Nair, Mehta, Makwana :[8],[13],[Self Study]
3. Switchgear And Protection – S. S. Rao, Khanna publication : [1],
4. Power System Protection And Switchgear – B. Ravindranath and M. Chander: [10],[11],[12]
5. Art And Science Of Protective Relaying – Masson
6. A Web Course on Digital protection of power system by Prof. Dr. S.A.Soman, IIT Bombay.
7. Computer relaying for power systems by A.G.Phadke, J.S.Thorp-research studies press ltd. England John Wiley & sons Inc. New York.
8. Protection of power systems by Blackburn.
9. Protection and switchgear ,By Bhavesh Bhalja, R.P.Maheshwari, Nilesh hotani, 1st edition, 2011, Oxford Publication
10. Power System Protection – B. Ram , TMH Publication
11. Modern Power System Protection – Divyesh Oza, TMH Publication

Course Outcome:

After learning the course the students should be able to:

1. Explain the purposes of protection, in relation to major types of apparatus, protection principle, dangers and criteria.
2. Choose and justify a suitable protection system for a specified application.
3. Analyze and compare specified protection systems
4. Compare merits of various principles, relay hardware and interrupting devices.
5. Compare the different type of circuit breakers performance based on which selection of circuit breaker can be made for a given application

Suggested list of Experiments:

1. To study Micro controller based 3-Phase Differential Relay.
2. To study Micro controller based over current Relay.
3. To study the Numerical Protection of induction motor.
4. To obtain the operating characteristics of an IDMT relay.
5. To study the operating characteristics of directional over current relay.
6. To study the operating characteristics of the transformer percentage differential relay.
7. To study the magnetic inrush current in a transformer and its protection.
8. To study radial feeder protection using two overcurrent and one Earth fault relay.
9. TO obtain and study the magnetization characteristic of CT.
10. To study transformer differential protection.
11. To study the protection schemes for different abnormal conditions in an alternator.
12. To study Buchholz relay for transformer protection.
13. To study Generalized block diagram of Numerical Relay

Design based Problems (DP)/Open Ended Problem:

The students can be asked to collect the data of a small power system network. Then the student is asked to design complete protection scheme of the component of power system like a feeder, a transmission line, transformer and a generator. The design should include the selection of circuit breaker rating and the relay settings wherever applicable.

Major Equipment:

Computers and programming software like C C++ or MATLAB SCILAB

List of Open Source Software/learning website:

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.