GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering (Part Time)
Subject Code: 2970901

Semester – VII
Subject Name: Switchgear and Protection

Type of course: Professional Core Course

Prerequisite: Power System – I
Power System – II

Rationale: An electrical power system consists of generators, transformers, and transmission and distribution lines. In the case of an event of a fault, an automatic protective scheme comprising of circuit breakers and protective relays isolate the faulty section protecting the healthy part of the system. The safety of equipment and human beings is the major concern for every protection scheme. Moreover, students must develop skills for operating various controls and switchgear in the power system. They are also required to carry out remedial measures for faults/abnormalities in machines/equipment in the power system using appropriate diagnostic instruments/devices. This course attempts to develop these skills in students and hence it is a core course for all electrical engineers.

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)	
4	0	2	5	70	30	30	20	150

Sr. No.	Content	Total Hrs
1	**Fundamentals of Power System Protection:** Introduction to Protective Relaying, Function of the Protective Relaying, Faults and Abnormal Operating Conditions, Desirable Qualities and Terms of Protective Relaying, System Transducers, Basic Tripping Mechanism of a relay, Types and operating principles of various protective relays, Simple Differential Protection, Zone of Protection and Actual Behavior of Simple Differential Protection, Percentage Differential Protection, Earth Leakage Protection [1, 3, 4].	**06**
2	**Overcurrent Protection of the Transmission Line:** Introduction, Thermal Relays, Over Current Relays, Types of Relay Characteristics, Application of Definite Time & IDMT O.C. Relays for Protection of Feeder, Relay Coordination, Directional Over Current Relay, Limitations of O.C. Relays [1].	**05**
3	**Distance Protection of Transmission Line:** 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	**07**

	Reach, Three Step Protection, Trip contact configuration, 3-step protection of double end fed lines [1].	
4	**Transformer Protection:** Faults and Abnormal Conditions in Transformer, Non-electrical Protection, Overcurrent Protection, Earth Fault Protection, Inter-turn Protection, Differential Protection [4].	**06**
5	**Bus-zone Protection:** Non-Unit Protection by Back-up Relays, Differential Protection of Busbars, External and Internal Fault, Protection of Three-phase Busbars [1,4]	**05**
6	**Generator Protection:** Various faults & abnormal operation conditions in a Generator, Stator & rotor faults, Transverse differential protection of a Generator, Unbalanced loading, Over speeding, Loss of excitation, Loss of prime mover [1].	**06**
7	**Induction Motor Protection:** Various faults & abnormal operation conditions in an Induction Motor, Starting of induction motor, Protection of small & large induction motor [2].	**06**
8	**Current and Voltage Transformer:** Construction of Current Transformers, Difference Between CT Cores Used for Measurement and those Used for Protective Relays, Calculation of CT Accuracy, Factors to be Considered while Selecting a CT, Construction of Potential Transformer, Specifications of Voltage Transformer, Capacitor Voltage Transformer.	**05**
9	**Circuit Breaker:** Classification of switchgear and fields of application and relative merits. Theories of current interruption, Energy balance and recovery rate theories, Air Circuit Breaker(ACB), Air Blast Circuit Breaker (ABCB), Practical systems of arc quenching in oil circuit breakers, Construction and operation of bulk oil, Minimum Oil Circuit Breakers, Recent trends in H.V. Circuit Breakers, Sulphur Hexafluoride Circuit Breaker (SF6), Vacuum Circuit Breaker (VCB), Rating of Circuit Breakers, Testing of Circuit Breakers, Miniature Circuit Breakers, Earth Leakage Circuit Breakers [3].	**07**
10	**Modern Trends in Power System Protection** Introduction to static and digital relays, Introduction to adaptive relays. [6]	**03**

Suggested Specification table with Marks (Theory): (For PDDC only)

Distribution of Theory Marks

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R Level	U Level	A Level	N Level	E Level	C Level
20	**20**	**30**	**15**	**10**	**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 the above table.

Reference Books:

1. Fundamentals of Power System Protection –Y. G. Parithankar & S. R. Bhide, 2nd edition, PHI
2. Power System Protection and Switchgear by Badari Ram , D.N Viswakarma, TMH Publications
3. Power system protection and switchgear by Oza, Nair, Mehta, Makwana
4. Protection and switchgear, by Bhavesh Bhalja, R.P.Maheshwari, Nilesh hotani,1st edition, 2011, Oxford Publication
5. Power System Protection and Switchgear –B. Ravindranath and M. Chander
6. Power System Protection & Switchgear by B. Ram, McGraw Hill
7. Power System Protection- Static Relays by T.S.M. Rao Tata McGraw Hill
8. Art and Science of Protective Relaying –Russel Masson

Course Outcomes:

S. No	CO STATEMENT	Bloom's taxonomy level	Marks % weightage
CO1	Acquire the knowledge of various abnormal conditions that could occur in electrical system and protective relays	**Remember L1 , Understand L2, Evaluate L5,**	**15%**
CO2	Knowledge of various conventional relays, their design and latest developments	**Remember L1 , Understand L2, Evaluate L5,**	**25%**
CO3	Ability to understand and design various protective devices in power system for protecting equipment and personnel.	**Remember L1 , Understand L2, Evaluate L5 Create L6**	**40%**
CO4	Knowledge of various types of instrument transformers, circuit breakers with their design and constructional details.	**Remember L1 , Understand L2, Evaluate L5 Create L6**	**20%**

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CO' s	Program Outcomes (PO's)

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	2	2	2	1			1			1	1
CO2	3	1	3	2	2	1						2
CO3	1	3	3	2							1	
CO4	2	2	1	1							1	1

1: Slight (Low) **2: Moderate (Medium)** **3: Substantial (High)** **: None**

Suggestive List of Experiments:

1. To check performance/ study of a 3-Phase Differential Relay.
2. To check performance/ study of an over current Relay.
3. To check performance/ study of 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 check performance/ study of 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 the protection schemes for different abnormal conditions in an alternator.
11. To study Buchholz relay for transformer protection.
12. To study generalized block diagram of Numerical Relay

Design based Problems (DP)/ Open Ended Problem:

1. The students can be asked to collect the data of a small power system network. Then the student is asked to design a complete protection scheme of the component of the 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.

2. Students can study and verify various settings of a generator.

3. Students simulates various system and explore how to source impedance and fault location affect the performance of protective relays.

4. With appropriate simulation explain the selectivity of a protective relay.

5. Study and verify factors that will affect CT accuracy and corrective measures.

Major Equipments:

Electromechanical Relay, Static / Numerical Relay, Testing Panels, CT, PT, Timers, Circuit Breakers.

List of Software/learning website:

- MATLAB
- PSCAD
- EMTP
- NPTEL https://nptel.ac.in/courses/108/101/108101039/
- SWAYAM https://onlinecourses.nptel.ac.in/noc20_ee80/preview