FACULTY OF ENGINEERING & TECHNOLOGY

Effective from Academic Batch: 2022-23

Programme: **Bachelor of Technology (Electrical Engineering)**

Semester: **VII**

Course Code: **202050703**

Course Title: **Switchgear and Protection**

Course Group: **Professional Core Course-XIV**

Course Objectives: 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 & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
				Theory		J/V/P*		Total
Lecture	Tutorial	Practical		Internal	External	Internal	External	
3	0	2	4	50 / 18	50 / 17	25 / 09	25 / 09	150 / 53

* **J**: Jury; **V**: Viva; **P**: Practical

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Detailed Syllabus:

Sr.	Contents	Hours
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.	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.	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 Reach, Three Step Protection, Trip contact configuration, 3-step protection of double end fed lines.	06
4	**Transformer Protection:** Faults and Abnormal Conditions in Transformer, Non-electrical Protection, Overcurrent Protection, Earth Fault Protection, Inter-turn Protection, Differential Protection.	06
5	**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.	06
6	**Induction Motor Protection:** Various faults & abnormal operation conditions in an Induction Motor, Starting of induction motor, Protection of small & large induction motor.	05
7	**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.	06
8	**Modern Trends in Power System Protection:** Advantages of Numerical (Digital) Relaying, Numerical Relay Hardware.	02

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List of Practicals / Tutorials:

1	Introduction to Various Relays Available in Power System Protection Laboratory.
2	To obtain the operating characteristics of a normal inverse relay.
3	To obtain the operating characteristics of a very inverse relay.
4	To study radial feeder protection with a backup protection scheme.
5	To study parallel feeder protection using directional over current relay.
6	To study the protection schemes for different abnormal conditions in an alternator.
7	To study reverse power protection of generator.
8	To check performance/ study of the Numerical Protection of induction motor during overload condition.
9	To check performance/ study of the operating characteristics of the transformer percentage differential relay.
10	To study Buchholz relay for transformer protection
11	To study the magnetic inrush current in a transformer and its protection.
12	To obtain and study the magnetization characteristic of CT.

Reference Books:

1	Power system protection and switchgear by Oza, Nair, Mehta, Makwana, TMH Publications
2	Fundamentals of Power System Protection by Y. G. Paithankar & S. R. Bhide, PHI Publications
3	Power System Protection and Switchgear by Badri Ram, D. N. Viswakarma, TMH Publications
4	Power System Protection and Switchgear by B. Ravindranath and M. Chander
5	Power System Protection- Static Relays by T.S.M. Rao Tata McGraw Hill
6	Art and Science of Protective Relaying by Russel Mason
7	Protection and switchgear by Bhalja, Maheshwari, Chotani, Oxford Publication

Supplementary learning Material:	
1	https://nptel.ac.in/courses/108/101/108101039/
2	https://onlinecourses.nptel.ac.in/noc20_ee80/preview
3	www.PSCAD.com

Pedagogy:

- Direct classroom teaching
- Audio Visual presentations/demonstrations
- Assignments/Quiz
- Continuous assessment
- Interactive methods
- Seminar/Poster Presentation
- Industrial/ Field visits

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- Course Projects

Internal Evaluation: The internal evaluation comprised of written exam (40% weightage) along with combination of various components such as Certification courses, Assignments, Mini Project, Simulation, Model making, Case study, Group activity, Seminar, Poster Presentation, Unit test, Quiz, Class Participation, Attendance, Achievements etc. where individual component weightage should not exceed 20%.

Suggested Specification table with Marks (Theory) (Revised Bloom's Taxonomy):

Distribution of Theory Marks in %						**R**: Remembering; **U**: Understanding; **A**: Applying; **N**: Analyzing; **E**: Evaluating; **C**: Creating
R	**U**	**A**	**N**	**E**	**C**	
20%	20%	30%	15%	10%	5%	

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.

Course Outcomes (CO):

Sr.	Course Outcome Statements	%weightage
CO-1	Acquire the knowledge of various abnormal conditions that could occur in electrical system and protective relays	**15**
CO-2	Knowledge of various conventional relays, their design and latest developments	**25**
CO-3	Ability to understand and design various protective devices in the power system for protecting equipment and personnel.	**40**
CO-4	Knowledge of various types of circuit breakers with their design and constructional details.	**20**

Curriculum Revision:	
Version:	2.0
Drafted on (Month-Year):	June-2022
Last Reviewed on (Month-Year):	-
Next Review on (Month-Year):	June-2025

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