

# SWITCHGEAR AND PROTECTION

ENEE 305

**Lecture** : 4  
**Tutorial** : 1  
**Practical** : 3/2

**Year** : III  
**Part** : I

## Course Objectives:

The objective of this course is to impart a comprehensive understanding of switchgear and protection in power systems, including the principles, construction, and operation of devices such as current transformer, potential transformer, fuses, isolators, contactors, circuit breakers, and relays. It emphasizes practical skills for testing, analyzing, and implementing protection schemes in real-world power applications. By the end of the course, students will be able to apply these concepts to design, operate, and troubleshoot switchgear and protection systems.

- 1 Fundamental of Power System Protection (4 hours)**
  - 1.1 Need for protective schemes
  - 1.2 Types, causes and effects of faults
  - 1.3 Functions of basic elements of a protective system
  - 1.4 Zones of protection, primary and backup protection
  - 1.5 Essential qualities of protection
  
- 2 Fuses, Isolators, and Contactors (8 hours)**
  - 2.1 Fuses: Characteristics, fusing factor, types and classification, selection, applications, discrimination
  - 2.2 Isolators: Construction, operating principle, classification, types and applications
  - 2.3 Contactors: Constructional features, NO/NC contacts, classifications, operating principles, applications and control circuits
  
- 3 Circuit Breakers (14 hours)**
  - 3.1 Need, importance in power system protection
  - 3.2 Arc extinction methods: High resistance interruption, low resistance interruption
  - 3.3 Arc phenomena, restriking and recovery voltages
  - 3.4 Low voltage (LV) circuit breakers: Construction, operating principle, arc extinction, merits and demerits, application of MCB, MCCB, RCCB, ACB
  - 3.5 High voltage (HV) circuit breakers: construction, operating principle, merits and demerits, arc extinction and application area of ABCB, BOCB, MOCB, VCB, SF<sub>6</sub> circuit breaker

- 3.6 HVDC circuit breakers: Principle, applications, challenges in DC arc extinction
- 3.7 Auto-reclosure in circuit breakers: Importance in transmission lines, single-shot and multiple-shot reclosing
- 3.8 Testing of circuit breakers: Type tests, routine tests and duty cycle test

**4 Earthing and Protection Against Over Voltage (6 hours)**

- 4.1 Earthing: Definition, purpose, system earthing and body earthing
- 4.2 Methods of earthing, earthing resistance, earth loop impedance
- 4.3 Causes of overvoltage in power system, lightning phenomena
- 4.4 Overvoltage protection: Overhead earth wire, angle of protection, horn-gap and rod gap lightning arrestors, surge absorbers.
- 4.5 Neutral earthing: Isolated neutral, solid neutral, resistance earthing, reactance earthing, Peterson coil earthing

**5 Instrument Transformers for Protection (4 hours)**

- 5.1 Current transformers (CTs): Construction, types, operation, ratios, burden, polarity, errors, knee-point voltage, selection, applications
- 5.2 Potential transformers (PTs): Construction, types, operation, ratios, accuracy, applications

**6 Relay and Protection Schemes (14 hours)**

- 6.1 Protective relay: Classification and selection
- 6.2 Distance relay: Impedance, reactance and mho
- 6.3 Electromagnetic attraction relays: Principle and applications
- 6.4 Electromagnetic induction relays: Principle and applications
- 6.5 Universal relay torque equation
- 6.6 Overcurrent protection: Construction and operation of instantaneous overcurrent relay.
- 6.7 Inverse definite minimum time (IDMT) relays
- 6.8 Time graded versus Current graded protection schemes
- 6.9 Directional overcurrent relay: Construction, torque equation, applications.
- 6.10 Distance and carrier aided protection
- 6.11 Unit protection schemes (Differential protection), biased (Percentage) differential protection, voltage balance relay
- 6.12 Protection schemes: Generator protection, transformer protection, busbar protection, feeder protection
- 6.13 Earth fault protection: Restricted and unrestricted earth fault protection

**7 Static and Numerical Relays (10 hours)**

- 7.1 Concept of static relays versus electromagnetic relays
- 7.2 Advantages and limitations of static relays
- 7.3 Comparator techniques

- 7.4 Static relays for protection: Differential relays, directional relays, impedance relays, admittance relays, mho relays
- 7.5 Numerical relays
  - 7.5.1 Description and architecture of numerical relays
  - 7.5.2 Functional blocks: Analog input module, A/D conversion, microprocessor, output relays
  - 7.5.3 Relaying algorithms and applications
  - 7.5.4 Advantages of numerical and microprocessor-based relays
  - 7.5.5 Applications in power system protection

**Tutorial (15 hours)**

1. Design based on fundamentals of power system protection
2. Design based on fuses, isolators, and contactors
3. Numerical related to circuit breakers
4. Numerical related to earthing and overvoltage protection
5. Numerical related to relays and protection schemes

**Practical (22.5 hours)**

1. Perform polarity test, CT ratio test and draw magnetizing curve for a protective CT; Check knee point voltage
2. Test over current and short circuit device in an air circuit breaker for operation using primary injection set
3. Test an induction disc relay in over current in over current protection scheme for operating characteristics using secondary injection set
4. Test an induction disc relay in residual earth fault protection scheme for operating characteristics and setting using secondary injection set
5. Check connections on a biased differential protection scheme of transformer/feeder; Test the scheme for operation and setting values on internal faults using primary injection set
6. Measurement of soil resistivity and earth electrode resistance

**Final Exam**

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1	4	6
2	8	8
3	14	12
4	6	6
5	4	4
6	14	14
7	10	10
<b>Total</b>	<b>60</b>	<b>60</b>

\* There may be minor deviation in marks distribution.

## References

1. Rao, S. S. (1977). Switchgear protection and power systems (Latest Edition). Khanna Publishers.
2. Gupta, J. B. (2013). Switchgear & protection. S. K. Kataria & Sons.
3. Amazon
4. Ram, B., Vishwakarma, D. N. (2011). Power system protection and switchgear. McGraw-Hill Education.
5. Ravindranath, B., Chander, M. (2011). Power system protection and switchgear. New Age International Publishers.
6. Paithankar, Y. G., Bhide, S. R. (2022). Fundamentals of power system protection. PHI Learning Pvt. Ltd.
7. Ingole, A. (2018). Switchgear and protection. Pearson India.
8. Uppal, S. L. (1988). Electrical power (Latest Edition). Khanna Publishers.