# Nirma University

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| **Institute:** | **Institute of Technology** |
| **Name of Programme:** | **BTech in Electrical Engineering** |
| **Semester:** | **V** |
| **Course Code:** | **3EE207CC24** |
| **Course Title:** | **Power System Protection and Switchgears** |
| **Course Type:** | **Core** |
| **Year of Introduction:** | **2024 – 2025** |

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**Course Learning Outcomes (CLOs):**

At the end of the course, students will be able to –

1. illustrate the main components and features of protection schemes (BL2)
2. design the protection schemes for power systems (BL6)
3. analyse the characteristics of switchgear during fault condition (BL3)
4. adopt the advances in power system protection (BL4)

| Unit | Contents | Teaching Hours (Total 45) |
|---|---|---|
| **Unit-I** | **Philosophy of Protective Relaying System**<br>Introduction, abnormalities, basic tripping circuit, requirements of protective system, functions of protective relaying schemes, basic relay terminology, relay classification, zones of protection | **03** |
| **Unit-II** | **Instrument Transformers**<br>Current transformer: equivalent circuit, vector diagram, construction, magnetization curve, core material, errors, accuracy class, specifications and testing<br>Potential transformer: equivalent circuit, construction, capacitive voltage transformer, specifications and testing, recent trends in instrument transformers,<br>selection of suitable instrument transformers | **04** |
| **Unit-III** | **Power system Protection Schemes**<br>**Overcurrent Protection Scheme**<br>Working principle, classification, methods of discrimination, directional overcurrent protection, application of overcurrent relays for feeder protection, coordination of overcurrent relays in interconnected systems, earth fault relay<br>**Differential Protection Scheme**<br>Principle of simple differential protection- behaviour during load, during external fault and internal fault, actual behaviour of a simple differential relay, through fault stability percentage differential relay, percentage differential protection of a 3-phase transformer | **13** |

**Distance Protection Scheme**

Impedance relay, Reactance relay, Mho relay, Input quantities for various types of distance relays, Effect of arc resistance, Effect of power swings, Effect of line length and source impedance on the performance of distance relays, Selection of distance relays, Three-stepped impedance protection, Protection of transmission line including principles of pilot wire and carrier protection

**Unit-IV** **Equipment Protection Schemes** **05**

Protective schemes for generator, motor and busbar, neutral grounding, methods of grounding

**Unit-V** **Numerical Protection** **05**

Introduction, numerical relay hardware, numerical overcurrent protection, numerical transformer differential protection, numerical distance protection of transmission line, advantages of numerical protection

**Unit-VI** **Advances in State-of-the-Art in Power System Protection** **05**

Introduction to adaptive relaying, various communication protocols, non-conventional sensors for enhanced protection, protection aspects in smart grid and in DC systems, phasor measurement unit, concepts of wide – area measurements

**Unit-VII** **Switchgear** **10**

Fault clearing and interruption of current, theory of initiation of arc, methods of quenching arc, restriking and recovery voltage, ratings of circuit breaker, construction and principle of different type of circuit breakers, HVDC circuit breakers, IoT in switchgear applications, Post SF6 – eco efficient design, Non-SF6 design, dry pressurised air based design

Self-Study: The self-study contents will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study contents.

Suggested Readings/ References:


- Van A. R. and Warrington C., *Protective relays – Theory and Practice*, Chapman and Hall.
- B. A. Oza, N. C. Nair, R. P. Mehta and V. H. Makwana, *Power System Protection and Switchgear*, Tata McGraw Hill.
- Y. G. Paithankar and S. R. Bhide, *Fundamentals of Power System Protection*, Prentice Hall India.
- B. Ravindranath and M. Chander, *Power System Protection and Switchgear*, New Age International Private Limited.
- B. Bhalja, N. Chothani and R.P. *Maheshwari, Protection and Switchgear*, Oxford Publication.
- B. Ram and D. N. Vishwakarma, *Power System Protection and Switchgear*, Tata McGraw Hill.
- S. S. Rao, *Switchgear and Protection*, Khanna Publications.
- Walter A. Elmore, *Protective Relaying Theory and Applications*, CRC Press.

- Les Hewitson, Mark Brown, Ben Ramesh, *Practical Power System Protection*, Elsevier.
- A. G. Phadke, and J. S. Thorp, *Synchronized Phasor Measurements and Their Applications*, Springer.
- *Research papers and articles from reputed journals.*


Suggested List of Experiments: Laboratory work will be based on the above syllabus with a minimum 10 experiments to be incorporated. The students in a suitable group size will design and perform one experiment as a part of laboratory work.

| Sr. No. | Name of Experiment | Hours |
|---|---|---|
| 1. | To determine the magnetization characteristic of a given current transformer. | 2 |
| 2. | To determine the operating characteristics of a given Electromagnetic type over-current relay. | 2 |
| 3. | To realise feeder protection on a radial transmission system. | 2 |
| 4. | To realise operation of parallel feeder protection. | 2 |
| 5. | To realise the various Time-current characteristics of combined Numerical over-current and Earth fault relay. | 2 |
| 6. | To study operation of various Numerical relays and Interfacing with computer using its software. | 2 |
| 7. | To realise the operation of Percentage Biased Differential protection scheme on transformer. | 2 |
| 8. | To study the operation of Buchholz Relay. | 2 |
| 9. | To realise the operation of auto-reclosure and sectionalizer for the isolation of faulty section and restoring the supply to the healthy section. (Virtual Lab Experiment). | 2 |
| 10. | To analyse the performance of thermal overload relay. | 2 |
| 11. | Relay current analysis<br>C.T. secondary in star and relay in star with common neutral<br>C.T. secondary in delta and relay in start. | 2 |
| 12. | To study operation of $SF_6$ and Vacuum circuit breakers. | 2 |