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|------------------------------|-------------------------|
| <b>Branch Name:</b>          | Electrical Engineering  |
| <b>Program Code:</b>         | ET403                   |
| <b>Course Name:</b>          | SWITCHGEAR & PROTECTION |
| <b>Course Code:</b>          | 2ET4030501              |
| <b>Pre-requisite Course:</b> |                         |

**Course Objectives:**

1. Identify various types of faults in Power system
2. Understand the operation of different types of circuit breakers in power system.
3. Identify types of relays used in power system respect to faults.
4. Maintain the protection of transmission line and feeder from various faults
5. Protect transformer, alternator, motor and busbar

**TEACHING AND EVALUATION SCHEME:**

| Teaching Scheme (Hours per week) |          |           |        | Evaluation Scheme (Marks) |                       |                       |                       |               |
|----------------------------------|----------|-----------|--------|---------------------------|-----------------------|-----------------------|-----------------------|---------------|
| Lecture                          | Tutorial | Practical | Credit | Theory (Marks)            |                       | Practical (Marks)     |                       | Total (Marks) |
|                                  |          |           |        | University Assessment     | Continuous Assessment | University Assessment | Continuous Assessment |               |
| 4                                | -        | 2         | 5      | 60                        | 40                    | 20                    | 30                    | 150           |

**DETAILS OF COURSE CONTENTS:**

| Unit | Topics and Sub-topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Total Hours | % Weightage |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|
| 1    | <b>Elements of Protection</b> <ol style="list-style-type: none"> <li>1.1 Need of protective system</li> <li>1.2 Functions of basic elements of a protective system.</li> <li>1.3 Types, causes and effects of various Faults.</li> <li>1.4 Protection zones: Backup protection zones</li> <li>1.5 Protective Transformers: Specifications and Connection diagram of Current Transformer and Potential Transformer (single phase and 3-phase)</li> <li>1.6 Optical Current Transformer, Optical Potential Transformer.</li> <li>1.7 Current limiting reactors.</li> <li>1.8 Neutral Earthing</li> </ol> | 08          | 10          |



**In Effect from Academic Year 2023-24**

|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |           |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------|
| <b>2</b> | <b>Circuit Interrupting Devices</b><br>2.1 Interrupting devices: Sequence of operation and interlocking<br>2.2 Fuse, types, characteristics, testing and applications<br>2.3 Isolators.<br>2.4 Circuit breaker: Arc phenomena and arc extinction, Construction, working principle of Oil circuit breakers, Air brake, Air Blast, Sulphur Hexa Fluoride (SF <sub>6</sub> ) and vacuum circuit breakers.<br>2.5 Auto-reclosure<br>2.6 Testing of circuit breaker<br>2.7 Resistance switching<br>2.8 Working principle of arc quenching in HVDC circuit breaker | <b>10</b> | <b>20</b> |
| <b>3</b> | <b>Protective Relays</b><br>3.1 Protective relay, classification and selection: Terms related to relay<br>3.2 Principle of working, construction and operation of electromagnetic induction (shaded pole, watt-hour meter and induction cup), Thermal relay<br>3.3 Settings of various types of relays<br>3.4 Directional relay<br>3.5 Distance relay (impedance, reactance and mho)<br>3.6 Negative phase sequence relay<br>3.7 Static relay, Construction and types<br>3.8 Principle and working of Microprocessor based relay                             | <b>12</b> | <b>25</b> |
| <b>4</b> | <b>Protection of Transmission Line and Feeder</b><br>4.1 Transmission line protection scheme<br>4.2 protection scheme -Overload protection, Over-current and earth fault protection, time graded and current graded protection, current balance differential protection<br>4.3 Carrier aided protection<br>4.4 Distance /Impedance protection<br>4.5 types of Auto reclosing<br>4.6 Protection of parallel feeders and Ring Mains                                                                                                                            | <b>12</b> | <b>25</b> |

|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |           |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------|
| <b>5</b> | <b>Protection of Transformer, Alternator, Motor, Bus bar and Over Voltage Protection</b><br>5.1 Over current, Percentage differential and restricted earth fault protection of Transformers<br>5.2 Inrush phenomenon and over fluxing phenomenon in Transformer<br>5.3 Features of numerical differential relay and its advantages, Inrush Current Protection - Harmonic Restraint<br>5.4 Buchholz Relay, analysis of trapped gases<br>5.5 Various faults and abnormal operating conditions in Alternator and its protection schemes<br>5.6 Various faults and abnormal occurring in the Motor and its protection schemes<br>5.7 Differential Protection of Busbars<br>5.8 Causes of over voltages<br>5.8 Methods of reducing over voltages<br>5.9 Operating principles, construction and applications of lightning arrester | <b>14</b> | <b>20</b> |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------|

**LIST OF REFERENCES:**

| <b>Sr. No.</b> | <b>Title of Book</b>                   | <b>Auth or</b>                 | <b>Publication</b>                              |
|----------------|----------------------------------------|--------------------------------|-------------------------------------------------|
| 1              | Switchgear and Protection              | Rao S. S.                      | Khanna Publications, New Delhi (Latest Edition) |
| 2              | Switchgear and Protection              | Gupta J. B.                    | Katariya Pub. New Delhi (Latest Edition)        |
| 3              | Electrical Power Systems               | Rao S. S and Uppal S. L        | Khanna Publications (Latest Edition)            |
| 4              | Electrical Power System                | Mehta V. K.                    | S. Chand Publications (Latest Edition)          |
| 5              | Power system Protection and Switchgear | Ravindranath B. and M. Chander | Wiley Eastern Ltd, Delhi. (Latest Edition)      |

**LIST OF LEARNING WEBSITES**

1. [www.google.com](http://www.google.com)
2. [www.youtube.com](http://www.youtube.com)
3. [www.nptel.iitm.ac.in](http://www.nptel.iitm.ac.in)
4. <http://electrical-engineering-portal.com>

**LIST OF PRACTICAL:**

| <b>SR NO</b> | <b>PRACTICALS/EXPERIMENTS</b>                                                                               |
|--------------|-------------------------------------------------------------------------------------------------------------|
| 1            | Check the Polarity of Current Transformer and Potential Transformer and connect it with the relay.          |
| 2            | Identify various switchgear/equipment available in the lab and write its specification and symbols.         |
| 3            | Identify parts of various circuit breakers and their specification.                                         |
| 4            | Find the fusing factor of a given fusing material.                                                          |
| 5            | Demonstrate air brake circuit breaker.                                                                      |
| 6            | Dismantle a Vacuum circuit breaker.                                                                         |
| 7            | Identify the various components of SF6 circuit breaker.                                                     |
| 8            | Test overload relay and plot Time-Current characteristic.                                                   |
| 9            | Use Buchholz relay for transformer protection.                                                              |
| 10           | Test thermal overload relay for protection of motor and set the relay properly.                             |
| 11           | Test static relay for the protection of motor                                                               |
| 12           | Apply balance current protection scheme using appropriate switch gear                                       |
| 13           | Interpret various protective scheme used for transmission lines and feeders (from Blue print and visit).    |
| 14           | Draw schematic diagram of protective schemes for 66 KV/ 132 KV/220 KV Substation nearby area. (after visit) |
| 15           | Interpret different protective scheme for transformer.                                                      |

**Course Learning Outcomes (CLO): On completion of this course, the students will be able to:**

| <b>CLO</b> | <b>Description</b>                                                                                                                               | <b>Bloom's Taxonomy Level</b>     |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| CLO1       | Interpret the principles of protection and the different components involved in protection                                                       | 3 Applying, 2 Understanding       |
| CLO2       | Compare the over-current protection, distance protection and carrier-current protection of transmission line                                     | 2 Understanding, 3 Applying       |
| CLO3       | Use and maintain the various protective schemes of transformer                                                                                   | 3 Applying, 4 Analyze, 6 Creating |
| CLO4       | Use and maintain the various protective schemes of Alternator and Induction Motor                                                                | 1 Remembering, 2 Understanding    |
| CLO5       | Interpret working, construction and application of circuit breaker,<br>Interpret insulation coordination and protect system against over voltage | 5 Evaluating, 3 Applying          |

**Mapping of CLOs with Pos & PSOs**

| Course | Program Outcomes (POs) |     |     |     |     |     |     |     |     |      |      |      | Program Specific Outcomes (PSOs) |      |      |
|--------|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|----------------------------------|------|------|
|        | PO1                    | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1                             | PSO2 | PSO3 |
| CLO1   | H                      |     |     |     | H   |     |     | L   |     | L    |      |      | M                                | L    | L    |
| CLO2   | L                      |     |     |     | H   |     |     |     |     |      |      |      | M                                | L    | L    |
| CLO3   | M                      |     |     |     |     | L   |     |     |     |      |      |      | M                                |      | H    |
| CLO4   |                        |     |     |     | L   |     |     | L   |     |      |      |      | M                                |      | H    |
| CLO5   |                        |     |     |     | L   |     |     |     |     |      |      | M    | L                                |      |      |

**H: High, M: Medium, L: Low**