# EE504: Advanced Power System Protection and Switchgear

| Teaching Scheme | | | Credits | Marks Distribution | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | |
| L | T | P | C | ESE | CE | ESE | CE | |
| 4 | 0 | 2 | 6 | 70 | 30 | 30 | 20 | 150 |

**Course Content:**

| Sr. No. | Topics | Teaching Hrs. |
|---|---|---|
| 1 | **Static Relays:**<br><br>Basic Block diagram, Advantages of Static Relays, Comparators, Phase and amplitude Comparators, General Equations of Comparators, Analysis of Amplitude and Phase Comparators, Operating principles, Static Overcurrent relays, Differential relays, and distance relays. | 04 |
| 2 | **Basic Elements of Digital Protection:**<br><br>Basic Components of a Digital Relay, Signal Conditioning Subsystems, Transducers, Surge Protection Circuits, Analogue Filtering, Analogue Multiplexers, Conversion Subsystem, The Sampling Theorem, Signal Aliasing Error, Sample and Hold Circuit, Digital Multiplexing ,Digital-to-Analogue Conversion, Analogue-to-Digital Conversion, Digital Relay Subsystem, Benefits of digital relays.<br><br>Mathematical basis for protective relaying algorithms:<br><br>Fourier series, Other orthogonal expansions, Fourier transforms, Discrete Fourier transform Fourier algorithms, Fourier algorithms with shorter windows, Recursive forms, Walsh function algorithms, Differential-equation algorithms, Kalman filter algorithms, Removal of the DC offset. | 08 |
| 3 | **Load-Shedding and Frequency Relaying:**<br><br>Introduction, Rate and Frequency Decline, Load-Shedding, Frequency Relays, Induction-Cylinder under frequency Relays, Digital Frequency Relays, microprocessor-Based Frequency Relay, Formulating a Load-Shedding Scheme, Maximum Anticipated Overload, Number of Load-Shedding Step, Size of the Load Shed at Each Step, Frequency Settings, Time Delay, Special Considerations for Industrial System. | 04 |

4 **Reclosing and Synchronizing:** 08

Introduction, Reclosing Precautions, Reclosing System Consideration, One-Shot vs. Multiple-Shot Reclosing Relays, Selective Reclosing, Deionizing Times for Three-Pole Reclosing, Live-Line/Dead-Bus, Live-Bus/Dead-Line Control, Instantaneous-Trip Lockout, Intermediate Lockout, Factors Governing Application of Reclosing Considerations for Applications of Reclosing , Feeders with No-Fault-Power Back-Feed and Minimum Motor Load, Single Ties to Industrial Plants with Local Generation, Lines with Sources at Both Ends, Reclosing Relays and Their Operation, Review of Breaker Operation, Single-Shot Reclosing Relays, Multi shot Reclosing Relays, Synchronism Check, Phasing Voltage Synchronism Check Characteristic, Angular Synchronism Check Characteristic.

5 **Developments in New Relaying Principles** 06

Introduction, Traveling Wave Based Protection of Transmission Lines, Frequency Based Relaying , Series Compensated Line Protection, Introduction, The Degree of compensation, Voltage Profile of Series Compensated Line, Faults with Unbypassed Series Capacitors, Relay Problems Due to compensation, Voltage and Current Inversion, Problems in reach measurement, Protection of Series compensated line, Concept of Adaptive Relaying , Fault Location Algorithms.

6 **Concept of Different Relay Algorithms** 06

Introduction of different techniques, Least square based methods,

Introduction, Integral LSQ fit, Power series LSQ fit, Differential equation based techniques, Basic principles, and Digital harmonic filtering by selected limits, Fourier analysis based techniques, Introduction, The full cycle window algorithm, The half cycle window algorithm.

**Total Hrs. 36**

**Reference Books:**


1. B.A Oza and R.P Mehta, "*Power System Protection*", TMH Publication, 2013.
2. Bhavesh Bhalja and R. P. Mahesheari, "*Protection and Switchgear"* Oxford University Press.
3. Badri Ram and D.N.Vishwakarma, *"Power system protection and Switch gear"*, TMH publication, New Delhi 1995.
4. T.S.Madhava Rao, "*Static relays"*, TMH publication, second edition 1989.
5. C. Christopoulos and A. Wright, "*Electrical Power System Protection"*, Springer International.
6. A. G. Phadke and J. S. Thorp, "*Computer Relaying for Power Systems*", John Wiley and sons.
7. J. L. Blackkburn, *"Protective Relaying (Principles and applications)*", Marcel Dekker,Inc.