

## **EE 511: ADVANCED RELAYING AND PROTECTION (3-0-0: 3)**

### **Introduction**

Basic construction of static relays, Classification of protective schemes, Comparison of Static relays with electromagnetic relays, Amplitude comparator, Phase comparator, Principle of Duality.

### **Amplitude and Phase Comparators**

Rectifier bridge circulating and opposed voltage type-Averaging-Phase splitting type-Sampling type of amplitude comparison, Block spike type-Phase splitting type-Transistor integrating type-Rectifier bridge type-Vector product type phase comparison.

### **Static over Current Relays**

Instantaneous-Definite time-Inverse time-Directional-IDMT-Very inverse Time-Extremely inverse time over current relays, Time current characteristics of over current relays-Applications.

### **Distance Protection**

Impedance Relay: Operating principle-Relay characteristic-Protective Schemes-Static Impedance Relay-Static Reactance relay-Static MHO relay-Effect of arc resistance, Effect of power surges, Effect of line length and source impedance on performance of distance relays-Quadrilateral relay-Elliptical relay-Selection of distance relays.

### **Pilot Relaying Schemes**

Wire pilot protection: Circulating current scheme-Balanced voltage scheme - Translay scheme-Half wave comparison scheme-Carrier current protection: Phase comparison type-Carrier aided distance protection-Operational comparison of transfer trip and blocking schemes-Optical fiber channels.

### **AC Machines and Bus Zone Protection**

Protection of Alternators: Stator protection-Rotor protection-Over voltage protection-Over speed protection-Transformer protection: Earth faults in transformers-Percentage differential protection-Protection against magnetic inrush current-Generator and transformer unit protection-Bus zone protection: Differential current protection-High impedance relay scheme-Frame leakage protection.

### **Microprocessor Based Protective Relays**

Introduction-Over current relays-Impedance relay-Directional relay-Reactance relay.

### **Protection Against Over Voltages**

Protection of transmission lines, stations, and substations against direct lightning strokes-Protection against travelling waves-Insulation coordination.

### **Text Books and References**

1. A. R. Warrington, "Protective Relaying", Chapman and Hall.
2. A. T. John and A. K. Salman, "Digital Protection for Power Systems", IEEE Power Series.
3. P. M. Anderson, "Power System Protection", John and Wiley.
4. T. S. Madhav Rao, "Power System Protection: Static Relays with Microprocessor Applications", TMH.
5. B. Ram and D. N. Vishwakarma, "Power System Protection and Switchgear", TMH.

6. C. R. Mason, "The Art and Science of Protective Relaying", John Wiley.
  7. D. Reimert, "Protective Relaying for Power Generation Systems", Taylor and Francis-CRC Press.
  8. G. Ziegler, "Numerical Distance Protection", Siemens.
  9. M. V. Deshpande, "Switchgear and Protection", TMH.
  10. S. H. Horowitz and A. G. Phadke, "Power System Relaying", John Wiley.
- S. S. Rao, "Switchgear Protection and Power systems", Khanna.