Switchgear and Protection

**Course Objective:**  
To present fundamental knowledge on protection system and its associated components in power system

1. **Principle of power system protection(3 hours)**
   1. Protection system components and its terminologies
   2. Basic requirement of protection scheme
   3. Need of protection scheme in power system
   4. Back up protection, coordination , protection zone

1. **Current and Potential Transformers (3 hours)**
   1. Potential transformer: Operation, standard ratios, errors, application
   2. Current transformer : Wound and bar types, operation, standard ratios
   3. Accuracy classification , typical knee point voltage , applications

1. **Fuses (4 hours)**
   1. Types of fuses: Construction, operating characteristic and application
   2. Fuse element, rated fuse current , minimum fusing factor, fusing factor, pre arcing and arcing time
   3. Merits and demerits of various types of fuse

1. **Isolators and Contactors (4 hours)**
   1. Isolators: Construction, operation and uses
   2. Contactors: Construction and operation, normally open (NO) and Normally Close (NC), auxiliary contacts of contactors and application of contactors

1. **System Earthing (6 hours)**
   1. Earthing: Definition, purpose, system earthing and body earthing, methods of earthing, substation earthing, measurement of soil resistivity
   2. Causes of over voltages: Internal cause and external cause
   3. Over voltage protection: Overhead earth wire, angle of protection, horn gap and rod gap lightning arrestor, surge absorbers
   4. Isolated neutral, solid neutral, resistance earthing, reactance earthing, Peterson coil  earthing

1. **Circuit Breaker (12 hours)**
   1. Circuit breaking process: Arc phenomena, arc extinction and its methods, pre-arcing and arcing time, restricting voltage and recovery voltage
   2. Duties of circuit breaker
   3. Classification of circuit breaker:
      1. Miniature circuit breaker: Construction, operating principle and application and various types of MCB such as ELCB
      2. Moulded Case circuit Breaker: Construction, operating principle and application
      3. Air circuit breaker: Construction, operating merits and demerits, arc extinction phenomena and application.
      4. Oil circuit breaker: Construction, operating merits and demerits, arc extinction phenomena and application
      5. Vacuum circuit breaker: Construction, operating merits and demerits, arc extinction phenomena and application.
      6. SF6 circuit breaker: Construction, operating merits and demerits, arc extinction phenomena and application
   4. Circuit breaker rating: Rated voltage , rated current, rated frequency, operating duty, making capacity, short time rating
   5. HVDC circuit breaker
   6. Auto reclosure
   7. Testing of circuit breaker

1. **Protective relays (14 hours)**
   1. Introduction
   2. Classification of relays
   3. Method of earth fault detection
   4. Restricted and unrestricted earth fault protection
   5. Electromagnet attraction relays
   6. Electro magnet induction relays
   7. Buchholz relay
   8. Over current relays
      1. Inverse definite minimum time (IDMT) relay, TDS,PSM
      2. Application of IDMT relay in sectionalized HV feeder, Time-Graded protection/Current   Graded protection
   9. Directional relay (induction type)
   10. Over current and earth fault relay
   11. Unit protection scheme/Differential protection
       1. Advantage of unit protection scheme over non unit protection
       2. Application of unit protection/differential protection scheme to   HV feeders,
       3. Transformers and generators
       4. Biased or percentage relay and its application to transformers and generators
       5. Voltage balance relay
   12. Universal relay torque equation
   13. Distance protection
       1. Impedance, reactance and mho relay
       2. Application of distance protection relay in sectionalized feeder
   14. Carrier current protection
   15. Bus bar protection

1. **Static and digital  Relays (12 hours)**
   1. Need for static relays
   2. Essential components of static relays
   3. Comparison of static and electromagnet relays
   4. Classification of static relays
   5. A review of Electronic Circuit Commonly used in static relays: Auxiliary DC Voltage Supply,
   6. Time Delay Circuit, Level Detectors, Multivibrator, logic circuit, use of operational amplifier in static relay,
   7. Static Over current relays and over volatge/under voltage realy
   8. Directional static over current relays
   9. Static differential relays
   10. Static differential protection scheme applied to transformer
   11. Static distance relays such as impedance relay, reactance relay and mho relay
   12. Static differential protection applied to the generator
   13. Block diagram and Component of digital relay
   14. Block diagram of microprocessor based protective scheme for protection of transformer, generator and transmission line
   15. Block diagram of microprocessor based over voltage /under voltage relay

**Practical**

1. Draw magnetizing curve for a protective CT. Check Knee point voltage
2. Test over current device in an Air Circuit Breaker for operation using primary injection
3. Test an induction disc relay in over current in over current protection scheme for operating characteristics using secondary injection.
4. Test an induction disc relay in residual earth fault protection scheme for operating characteristics and setting using secondary injection.
5. Check connections on a biased differential protection scheme of transformer. Test the scheme for operation and setting values on internal faults using primary injection
6. Measurement of soil resistivity

**References**

1. Sunil S. Rao “Switchgear and protection” Khanna Publishers
2. G. Mason “The art and science of protective realying”
3. J.B Gupta “Switchgear and protection” Kataria and Sons

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

|  |  |  |
| --- | --- | --- |
| **Chapters** | **Hours** | **Marks** **Distribution\*** |
| 1 | 3 | 4 |
| 2 | 3 | 4 |
| 3 | 4 | 6 |
| 4 | 4 | 6 |
| 5 | 6 | 8 |
| 6 | 12 | 16 |
| 7 | 14 | 20 |
| 8 | 12 | 16 |
| **Total** | **58** | **80** |

**\*Note: There may be minor deviation in marks distribution**