Approved in 37th BoA Meeting (29-10-2020)

Course Number: EE584
Course Name: Power System Protection
Credits: 3-0-0-3
Prerequisites: EE-303 (Power systems)
Intended for: UG/PG
Distribution: Elective for B. Tech (EE), M.S., M. Tech. & Ph.D.

Preamble: The proposed course is designed to provide the basic concepts of power system protection. System protection deals with detection of proximity of system to unstable operating region and consequent control actions to restore stable operating point and/or prevent damage to equipment. This course focusses on the protective relaying principles, settings and operation during fault condition in power system.

Course Outline: The course will discuss the role of main, back up and redundant relay protection scheme and identification of zones of protection for a given substation. The selection of proper instrument transformer inputs to the relaying schemes and analysis and calculation of currents in a system for various types of fault will be demonstrated. Introduction to the concept of both high impedance and low impedance protection relays to protect power system buses. In addition, protection of rotating machines and distribution networks will also be covered in the syllabus.

Course Modules with Quantitative lecture hours:

Introduction – 3 hours
Fundamentals of protection – Security, selectivity and reliability, measurement principles – unit and non-unit protection, legacy relays, solid state and numerical relays, standards in power system protection

Instrument Transformers – 4 hours
Working principle of current transformers (CT), voltage transformers (VT), dynamic response of CTs and capacitor coupled voltage transformer (CCVT) during faults and its effect on relaying

Fault Analysis using Symmetrical components – 4 hours
Sequence components, sequence modelling of power system components such as transformers, generators, transmission lines, fault analysis

Numerical Relaying – 4 hours
Sampling of analog values, analog to digital conversion, least square method for estimation of phasors, Fourier analysis, discrete Fourier transform: properties, phasor calculation, fast Fourier transform.

Directional Overcurrent Protection – 4 hours
Directional and overcurrent relay principles, directional relay coordination problem associated with multiple loop system.

Transmission line Protection – 6 hours
Distance and non-distance-based protection concepts. Zones of protection and back up protection, distance relay settings, pilot protection with distance relays

Power Swing – 2 hours
Power swing detection, stable and unstable swing, blocking and unblocking of distance relays during power swing, analysis of power swing in multi machine system, operation of relays during out of step condition.

Transformer protection – 3 hours
Inrush phenomenon, Inrush detection methods; Differential and over-excitation protection.
Bus Protection – 3 hours
Bus configurations; High and low impedance protection concepts. External Fault detection methods and remedial measures to account for CT saturation detection.

Rotating Machinery Protection – 4 hours
Motor and generator protection, generator construction and grounding methods, Detection of faults and abnormal operating conditions

Distribution system protection – 2 hours
Feeder protection philosophies, Coordination examples, Power system restoration concepts – Reclosing, Automatic sectionalizing.

Introduction to relay setups and Standards– 3 hours
Distance, overcurrent, over/under frequency relay set up demonstration. Discussion on standards for protection scheme in Indian power grid.

Text book:

1. S. Horowitz and A. G. Phadke, *Power System Relaying (4th ed.)*. Wiley, 2014.
2. A. G. Phadke and J. S. Thorpe, *Computer Relaying for Power Systems*, Wiley, 2009
3. Juan Gers, *Protection of Electricity Distribution Networks (3rd ed.)*, IET press, 2011.

References:

1. P. M. Anderson, *Power System Protection*, Wiley-IEEE press, 1999.
2. J. L. Blackburn, T. J. Domin, *Protection Relaying: Principles and Applications (3rd ed.)*, Taylor and Francis, 2006
3. J. D. Glover, M. S. Saema, T. J. Overbye. *Power System Analysis and Design (5th ed.)*, Cengage Learning, 2010.
4. Bhavesh Bhalja, R. P. Maheshwari and N. Chothani, *Protection and Switchgear*. Oxford University Press, 2nd Edition, New Delhi, India, 2019.

Similarity Content Declaration with Existing Courses:

S. No.	Course Code	Similarity Content	Approx. % of Content
1.	EE303	Sequence components, sequence modelling of power system components such as transformers, generators, transmission lines	7

Proposed by: **Pratim Kundu** School of Computing and Electrical Engineering

Pratim Kundu