

# **INSTITUTE OF AERONAUTICAL ENGINEERING**

(Autonomous)

Dundigal - 500 043, Hyderabad, Telangana

# **COURSE CONTENT**

DIGITAL PROTECTION OF POWER SYSTEMS								
II Semester: EPS								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
BPSD13	Core	L	Т	Р	С	CIA	SEE	Total
		3	-	-	3	40	60	100
Contact Classes: 48	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 48		
Prerequisite: Power systems								

# I. COURSE OVERVIEW:

This course will provide the mathematical background of digital protection and understanding the importance of Digital Relays. It will also develop various protection algorithms. It will also cover the application of digital protection.

# **II. COURSES OBJECTIVES:**

# The students will try to learn

- I. The working of numerical relays.
- II. Mathematical approach towards protection.
- III. Algorithms for numerical protection Power flow analysis using various methods.

# **III. COURSE OUTCOMES:**

#### At the end of the course students should be able to:

- CO1 Illustrate the significance of protection systems and elements involved in protection of the power system.
- CO2 Develop the structures, mathematical models and formulae of digital relays for mathematical analysis of the system.
- CO3 Identify the basic components of digital relay and signal conditioning subsystems for implementation of digital protection.
- CO4 Develop the mathematical models for analysis of the relying algorithms to address the various types of faults in the power system.
- CO5 Categorize the digital relying algorithms to minimize the transient deviations and steady state error to zero.
- CO6 Analyze the various algorithms applicable for protection of Transformers and transmission lines.

# **IV. COURSE CONTENT:**

# **MODULE - I: MATHEMATICAL BACKGROUND TO DIGITAL PROTECTION (10)**

Overview of static relays, transmission line protection, transformer protection, need for digital protection; performance and operational characteristics of digital protection, basic structure of digital relays, finite difference techniques, interpolation formulas, numerical differentiation, curve fitting and smoothing, Fourier analysis, Walsh function analysis, relationship between Fourier and Walsh coefficients.

#### MODULE-II: BASIC ELEMENTS OF DIGITAL PROTECTION (10)

Basic components of a digital relay, signal conditioning subsystems, conversion subsystem, digital relay subsystem, the digital relay as a unit.

# MODULE -III: DIGITAL RELAYING ALGORITHMS-I (09)

Sinusoidal wave-based algorithms: Sample and first derivative methods, first and second derivative methods, two sample technique, three sample technique, an early relaying scheme. Fourier analysis-based algorithms: Full cycle window algorithm, fractional-cycle window algorithms, Fourier-transform based algorithm. Walsh-function-based algorithms.

Unbalanced faults: Introduction to symmetrical components, sequence impedances, sequence circuits of synchronous machine, transformer and transmission lines, sequence networks analysis of single line to ground, line to line and double line to ground faults using Thevenin's theorem and Z-bus matrix.

#### MODULE -IV: DIGITAL RELAYING ALGORITHMS-II (10)

Contingency Evaluation: Operating states of a power system, concept of security monitoring, techniques for contingency evaluation, Importance of contingency analysis, addition / removal of one line, construction of a column of bus impedance matrix from the bus admittance matrix, calculation of new bus voltages due to addition / removal of one line, calculation of new bus voltages due to addition / removal of two lines.

#### MODULE -V: DIGITAL PROTECTION OF TRANSFORMERS AND TRANSMISSION LINES (10)

Principles of transformer protection, digital protection of Transformer using FIR filter-based algorithm, least squares curve fitting based algorithms, Fourier-based algorithm, flux-restrained current differential relay; Digital Line differential protection: Current-based differential schemes, Composite voltage- and current- based scheme.

# V. TEXTBOOKS:

- 1. AG Phadke and J S Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 1<sup>st</sup> edition, 2009.
- 2. AT Johns and S K Salman, "Digital Protection of Power Systems", IEEE Press, 1<sup>st</sup> edition, 1999.

# **VI. REFERENCE BOOKS:**

- 1. Gerhard Zeigler, "Numerical Distance Protection", Siemens Public is Corporate Publishing, 1<sup>st</sup> edition, 2006.
- 2. SRB hide "Digital Power System Protection" PHI Learning Pvt.Ltd. 3<sup>rd</sup> edition, 2014.

# **VII. ELECTRONICS RESOURCES:**

- 1. NPTEL Digital Power system protection NOC: Digital protection of Power Systems.
- 2. NPTELDigital Power system protection- NOC: Introduction to protection of Power Systems.
- 3. NPTEL Digital Power system protection- NOC: Power systems protection.
- 4. https://nptel.ac.in/courses/134104085

#### VIII. MATERIALS ONLINE

- 1. Course template
- 2. Tutorial question bank
- 3. Definition and terminology
- 4. Assignments
- 5. Model question paper-I
- 6. Model question paper-II
- 7. Lecture notes
- 8. Early learning readiness videos (ELRV)
- 9. Power point presentations