DIGITAL PROTECTION OF POWER SYSTEM

II Semester: EPS								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
BPSC13	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	0	0	3	30	70	100
Contact Classes: 45	**Total Tutorials: Nil**	**Total Practical Classes: Nil**				**Total Classes: 45**		

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. COURSE OBJECTIVES:

The students will try to learn:

I. The need of numerical relays and their importance in digital protection of the power system.
II. The mathematical approach towards designing algorithms for the protection of power system.
III. The methods of protection employed for the transformers and transmission lines.

III. COURSE OUTCOMES:

After successful completion of the course, students will be able to:		
CO 1	**Illustrate** the significance of protection systems and elements involved in protection of the power system	Understand
CO 2	**Develop** the structures, mathematical models and formulae of digital relays for mathematical analysis of the system	Apply
CO 3	**Identify** the basic components of digital relay and signal conditioning subsystems for implementation of digital protection.	Apply
CO 4	**Develop** the mathematical models for analysis of the relying algorithms to address the various types of faults in the power system	Apply
CO 5	**Categorize** the digital relying algorithms to minimize the transient deviations and steady state error to zero	Analyze
CO 6	**Analyze** the various algorithms applicable for protection of Transformers and transmission lines.	Analyze

IV. SYLLABUS

MODULE–I: MATHEMATICAL BACKGROUND TO DIGITAL PROTECTION(09)

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 (09)

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(10)

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(09)

Least squares based methods: Integral LSQ fit, power series LSQ fit, multi-variable series LSQ technique, determination of measured impedance estimates; differential equation based techniques: representation of transmission lines with capacitance neglected, differential equation protection with selected limits, simultaneous differential equation techniques; travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's-equation based protection scheme, ultra-high-speed polarity comparison scheme, ultra-high-speed wave differential scheme, discrimination function based scheme, superimposed component trajectory based scheme.

MODULE -V:DIGITAL PROTECTION OF TRANSFORMERS AND TRANSMISSION LINES (09)

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. Text Books:

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

VI. Reference Books:

1. Gerhard Zeigler, "Numerical Distance Protection", Siemens Public Corporate Publishing, 1st Edition, 2006.
2. SRB hide "Digital Power System Protection" PHI Learning Pvt.Ltd. 3rd Edition, 2014.

VII. Web References:

1. https://www.sciencedireect.com
2. https://www.spinger.com
3. https://www.ieeexplore.ieee.org/Xplore/home.jsp

VII. E-Text Books:

1. https://www.nptel.ac.in/downloads/108105066/
2. https://www.minitorn.tlu.ee/~jaagup/kool/java/kursused/15/robootika/elektriopik.pdf