

## DIGITAL PROTECTION OF POWER SYSTEM

<b>II Semester: EPS</b>																																																		
Course Code	Category	Hours / Week			Credits	Maximum Marks																																												
<b>BPSB11</b>	<b>Core</b>	L	T	P	C	CIA	SEE	Total																																										
		3	0	0	3	30	70	100																																										
<b>Contact Classes: 45</b>		<b>Tutorial Classes: Nil</b>		<b>Practical Classes: Nil</b>			<b>Total Classes: 45</b>																																											
<p><b>I. COURSEOVERVIEW:</b> 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.</p> <p><b>II.COURSE OBJECTIVES:</b> <b>The course should enable the students to:</b> I. Explain the working of numerical relays. II. Develop mathematical approach towards protection. III. Understand algorithms for numerical protection.</p> <p><b>III.COURSEOUTCOMES:</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td colspan="3" style="text-align: center;"><b>After successful completion of the course, students will be able to:</b></td> </tr> <tr> <td style="width: 10%;">CO 1</td> <td style="width: 70%;">Illustrate the significance of protection systems and elements involved in protection of the power system</td> <td style="width: 20%;">Understand</td> </tr> <tr> <td>CO 2</td> <td>Develop the structures, mathematical models and formulae of digital relays for mathematical analysis of the system</td> <td>Apply</td> </tr> <tr> <td>CO 3</td> <td>Identify the basic components of digital relay and signal conditioning subsystems for implementation of digital protection.</td> <td>Apply</td> </tr> <tr> <td>CO 4</td> <td>Develop the mathematical models for analysis of the relying algorithms to address the various types of faults in the power system</td> <td>Apply</td> </tr> <tr> <td>CO 5</td> <td>Categorize the digital relying algorithms to minimize the transient deviations and steady state error to zero</td> <td>Analyze</td> </tr> <tr> <td>CO 6</td> <td>Analyze the various algorithms applicable for protection of Transformers and transmission lines.</td> <td>Analyze</td> </tr> </table> <p><b>IV. SYLLABUS</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;"><b>UNIT-I</b></td> <td style="width: 70%;"><b>MATHEMATICAL BACKGROUND TO DIGITAL PROTECTION</b></td> <td style="width: 20%;"><b>Classes: 09</b></td> </tr> <tr> <td colspan="3">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.</td> </tr> <tr> <td><b>UNIT-II</b></td> <td><b>BASIC ELEMENTS OF DIGITAL PROTECTION</b></td> <td><b>Classes: 09</b></td> </tr> <tr> <td colspan="3">Basic components of a digital relay, signal conditioning subsystems, conversion subsystem, digital relay subsystem, the digital relay as a UNIT.</td> </tr> <tr> <td><b>UNIT-III</b></td> <td><b>DIGITAL RELAYING ALGORITHMS-I</b></td> <td><b>Classes: 10</b></td> </tr> <tr> <td colspan="3">Sinusoidal wave based algorithms: Sample and first derivative methods, first and second derivative methods, two sample technique, three sample technique, an early relaying scheme.</td> </tr> <tr> <td colspan="3">Fourier analysis based algorithms: Full cycle window algorithm, fractional-cycle window algorithms, Fourier-</td> </tr> </table>									<b>After successful completion of the course, students will be able to:</b>			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.	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transform based algorithm. Walsh-function-based algorithms.		
<b>UNIT-IV</b>	<b>DIGITAL RELAYING ALGORITHMS-II</b>	<b>Classes: 08</b>
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-speedwavedifferentialscheme,discriminationfunctionbasedscheme,superimposedcomponenttrajectorybased scheme.		
<b>UNIT-V</b>	<b>DIGITAL PROTECTION OF TRANSFORMERS AND TRANSMISSION LINES</b>	<b>Classes: 09</b>
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- basedscheme.		
<b>Text Books:</b>		
<ol style="list-style-type: none"> <li>1. AG Phadke and J S Thorp, "Computer Relaying for Power Systems", Wiley / Research studies Press, 1<sup>st</sup> Edition, 2009.</li> <li>2. AT Johns and S K Salman, "Digital Protection of Power Systems", IEEE Press, 1<sup>st</sup> Edition, 1999.</li> </ol>		
<b>Reference Books:</b>		
<ol style="list-style-type: none"> <li>1. Gerhard Zeigler, "Numerical Distance Protection", Siemens Public Corporate Publishing, 1<sup>st</sup> Edition, 2006.</li> <li>2. SRB hide "Digital Power System Protection" PHI Learning Pvt. Ltd. 3<sup>rd</sup> Edition, 2014.</li> </ol>		
<b>Web References:</b>		
<ol style="list-style-type: none"> <li>1. <a href="https://www.sciencedirect.com">https://www.sciencedirect.com</a></li> <li>2. <a href="https://www.spinger.com">https://www.spinger.com</a></li> <li>3. <a href="https://www.ieeexplore.ieee.org/Xplore/home.jsp">https://www.ieeexplore.ieee.org/Xplore/home.jsp</a></li> </ol>		
<b>E-Text Books :</b>		
<ol style="list-style-type: none"> <li>1. <a href="https://www.nptel.ac.in/downloads/108105066/">https://www.nptel.ac.in/downloads/108105066/</a></li> <li>2. <a href="https://www.miniorn.tlu.ee/~jaagup/kool/java/kursused/15/robootika/elektriopik.pdf">https://www.miniorn.tlu.ee/~jaagup/kool/java/kursused/15/robootika/elektriopik.pdf</a></li> </ol>		