DIGITAL PROTECTION OF POWER SYSTEMS

Course Code	PEEET631	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET501, PBEET604	Course Type	Theory

Course Objectives:

1. To deliver fundamental concepts to design various electronic circuits to implement various relaying functions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction**: Need for protective systems, Zones of protection, Current transformers and voltage transformers (Electromagnetic and Capacitive voltage transformers), Principle of operation of magneto optic CT/ PT, effect on relaying philosophy. **Relays:** Over current relays - time-current characteristics of over current relays: definite time over current relays, inverse Definite Minimum time - directional over current relays, current setting and time setting - Numerical Problems - Differential relays: Operating and restraining characteristics, types of differential relays, Distance relays: impedance relays, reactance relays, mho relays (basic principles and characteristics only)	9
2	**Protection of Transmission Lines:** Schemes of distance protection, Differential line protection, Phase comparison line protection. **Protection of Bus-bar, Transformer and Generator & Motor**: Types of faults, differential protection: High impedance and low impedance differential protection schemes, harmonic restraint relay, Restricted Earth Fault Protection, frame leakage protection, stator and rotor protection against various types of faults.	9

3	**Digital (Numerical) Relays**: Basic Components of numerical Relays with block diagram, Processing Unit, Human machine Interface, Principle of operation, Comparison of numerical relays with electromechanical and static relays, Advantages of numerical relays - communication in protective relays (IEC 61850), Information handling with substation automation system (SAS) Signal Conditioning Subsystems: Surge Protection Circuits, Anti-aliasing filter, Conversion Subsystem, The Sampling Theorem, aliasing, Sample and Hold Circuit, Concept of analog to digital and digital to analog conversion, Idea of sliding window concept, Fourier, Discrete and fast Fourier transforms	9
4	**Signal processing techniques:** Sinusoidal wave based algorithms, Fourier Analysis based algorithms (half cycle and full cycle), Least squares based algorithm. Digital filters – Fundamentals of Infinite Impulse Response Filters, Finite Impulse Response filters, Filters with sine and cosine windows. **Wide Area Protection and Measurement:** Phasor Measurement Units, concept of synchronized sampling, Definition of wide-area protection, Architectures of wide-area protection, concept of Adaptive relaying, advantages of adaptive relaying and its application, Adaptive Differential protective scheme.	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify the relay protection scheme suitable for overcurrent, differential and distance protection.	**K3**
CO2	Develop the protection scheme for bus bars, transformers, generators, motors and distribution systems using appropriate protective relays	**K3**
CO3	Illustrate the operation of a numerical relay.	**K2**
CO4	Explain signal processing methods and algorithms in digital protection	**K2**
CO5	Infer emerging protection schemes in power systems	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2									
CO2	3		2									
CO3	3		2									
CO4	3		2									
CO5	3		2									

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

		Text Books		
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Protection of Power System	A. T. Johns and S. K. Salman	Peter Peregrinus Ltd, UK	1995
2	Computer Relaying for Power Systems	A. G. Phadke and James S. Thorpe	Research study press Ltd, John Wiley & Sons, Taunton, UK	1988
3	Power System Protection and Switchgear	Badri Ram and D. N. Viswakarma	Tata McGraw Hill Education, Pvt Edition	2011
4	Digital Signal Processing in Power System Protection and Control	Waldemar Rebizant	Springer Publication	2008

	Video Links (NPTEL, SWAYAM…)
Sl No	**Link ID**
1	https://archive.nptel.ac.in/courses/117/107/117107148/ (NPTEL lecture IIT Roorkee)