Department of Electrical & Electronics Engineering

COURSE MODULE OF THE COURSE TAUGHT FOR THE SESSION AY: 2025-26

Faculty Name **: Praveen Kumar M**			Academic Year: 2025-26				
Department: Electrical & Electronics Engineering							
Course Code	Course Title	Core/Elective	Pre requisite	Number of Lecture Hours/Week			Total Hrs/ Sessions
				L	T	P	
BEE701	Switchgear and Protection	IPCC	Subject knowledge of Basic Electrical, Power System Analysis	3	-	2	40 hours Theory + 10 Lab slots

Course objectives:

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- To discuss performance of protective relays, components of protection scheme and relay terminology.
- To explain Over current protection using electromagnetic and static relays and Over current protective schemes and microprocessor -based Protective Relays.
- To discuss pilot protection; wire pilot relaying and carrier pilot relaying differential protection, protection of generators, motors, Transformer and Bus Zone Protection.
- To explain the principle of circuit interruption and different types of circuit breakers.
- To describe the construction and operating principle of different types of fuses and to give the definitions of different terminologies related to a fuse.
- Experimentally verify the characteristics of over current, over voltage, under voltage using electromagnetic, static, distance and impedance relays.
- To discuss protection Against Over voltages and Gas Insulated Substation (GIS).
- To discuss the construction, operating principles and performance characteristics of protective devices.
- To conduct experiments and verify the characteristics of electromechanical and microprocessor based relays.
- To verify the operation of motor protection for different faults

Topics Covered as per Syllabus

Module-1	**Teaching Hours**
Introduction to Power System Protection: Need for protective schemes, Nature and Cause of Faults, Types of Fault, Effects of Faults, Fault Statistics, Zones of Protection, Primary and Backup Protection, Essential Qualities of Protection, Performance of Protective Relaying, Classification of Protective Relays, Automatic Reclosing, Current Transformers for protection, Voltage Transformers for Protection. **Relay Construction and Operating Principles**: Introduction, Electromechanical Relays, Static Relays Merits and Demerits of Static Relays, Numerical Relays, Comparison between Electromechanical Relays and Numerical Relays.	**8**
Module-2	
Overcurrent Protection: Introduction, Time current Characteristics, Current Setting, Time Setting. Overcurrent Protective Schemes, Reverse Power or Directional Relay, Protection of Parallel Feeders, Protection of Ring Mains, Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme, Phase Fault Protective Scheme, Directional Earth Fault Relay, Static Overcurrent Relays, Numerical Overcurrent Relays. **Microprocessor based Protective Relays**: Introduction, Overcurrent relays, Impedance relay.	**8**
Module-3	
Pilot Relaying Schemes: Introduction, Wire Pilot Protection, Carrier Current Protection. **Differential Protection**: Introduction, Differential Relays, Simple Differential Protection, Percentage or Biased Differential Relay, Differential Protection of 3 Phase Circuits, Balanced	**8**

(Opposed) Voltage Differential Protection. **Rotating Machines Protection:** Introduction, Protection of Generators. **Transformer and Bus zone Protection**: Introduction, Transformer Protection, Bus zone Protection, Frame Leakage Protection	
Module-4	
Circuit Breakers: Introduction, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers, Air – Break Circuit Breakers, Oil Circuit Breakers, Air – Blast Circuit Breakers, SF6 Circuit Breakers, Vacuum Circuit Breakers, High Voltage Direct Current Circuit Breakers, Rating of Circuit Breakers, Testing of Circuit Breakers	**8**
Module-5	
Fuses: Introductions, Definitions, Fuse Characteristics, Types of Fuses, Applications of HRC Fuses, Selection of Fuses, Discrimination. **Protection against Over voltages:** Causes of Overvoltages, Lightning phenomena, Wave Shape of Voltage due to Lightning, Over Voltage due to Lightning, Klydonograph and Magnetic Link, Protection of Transmission Lines against Direct Lightning Strokes, Protection of Stations and Sub Stations from Direct Strokes, Protection against Travelling Waves, Insulation Coordination, Basic Impulse Insulation Level (BIL). **Modern Trends in Power System Protection**: Introduction, gas insulated substation/switchgear (GIS).	**8**

PRACTICAL COMPONENT OF IPCC (Any 10 Experiments)		**CO**
Sl.No.	**Experiments**	
1	Over Current Relay: (a) Inverse Definite Minimum Time (IDMT) Non - Directional Characteristics (b) Directional Features (c) IDMT Directional	2
2	IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical type).	2
3	Operation of Negative Sequence Relay.	2
4	IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical type)	2
5	Operating Characteristics of Microprocessor Based (Numeric) Over Current Relay	2
6	Operating Characteristics of Microprocessor Based (Numeric) Over/Under Voltage Relay	2
7	Measurement of Breakdown Strength of Transformer Oil as per IS 1876 :2005	2
8	Fuse Characteristics	5
9	Field Mapping using Electrolytic Tank for any one of the following Models: Cable/ Capacitor/ Transmission Line/ Sphere Gap	5
10	Motor Protection against Faults	3
11	Operating Characteristics of Microprocessor Based (Numeric) Distance Relay	3
12	Feeder Protection against Faults	3
13	Generation Protection: Merz Price Scheme.	3

Course outcomes:	At the end of the course the student will be able to: 1. **Interpret** the general concepts of power system protection, construction and operation of relays. [L2] 2. **Interpret** over current protection and analyze the characteristics of electromechanical and microprocessor based relays[L4] 3. Interpret pilot protection scheme, differential protection, protection of generators, Transformer, Bus Zone Protection, **Apply** and verify the operation of motor protection for different faults[L3]

	4. **Apply** the principle of circuit interruption in different types of circuit breakers. [L3] 5. **Explain** features of fuse, causes of over voltages and its protection, modern trends in Power System Protection. [L2]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

The IPCC means the practical portion integrated with the theory of the course. CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.

CIE for the theory component of the IPCC

- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

- The minimum marks to be secured in CIE to appear for SEE shall be 10 (40% of maximum marks-25) in the theory component and 10 (40% of maximum marks -25) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 sub-questions are to be set from the practical component of IPCC, the total marks of all questions should not be more than 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify for the SEE. Marks secured will be scaled down to 50.
- The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Textbook

Power System Protection and Switchgear Badri Ram, D.N. Vishwakarma McGraw Hill 2nd Edition
Power System Protection and Switchgear Bhuvanesh Oza et al McGraw Hill 1st Edition, 2010
Reference Books
1. Protection and Switchgear Bhavesh et al Oxford 1st Edition, 2011 2. Power System Switchgear and Protection N. Veerappan S.R. Krishnamurthy S. Chand 1st Edition, 2009 3. Fundamentals of Power System Protection Y.G.Paithankar S.R. Bhide PHI 1st Edition, 2009
Web links and Video Lectures (e-Resources):
1. https://nptel.ac.in 2. http:// acl.digimat.in/nptel/courses/video/108105017/108105017.html
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning Quizzes, Seminars Visit substations Industries related to manufacturing of relays and circuit breakers

The Correlation of Course Outcomes (CO's) and Program Outcomes (PO's)

Subject Code:	**BEE701**	**TITLE:** Switchgear and Protection						**Faculty Name:**		**Praveen Kumar M**	
Course Outcomes	**Program Outcomes**										
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO-1	3	-	-	-	-	-	-	-	-	-	-	2
CO-2	3	2	2	2	3	2	-	-	3	3	-	2
CO-3	3	2	2	-	3	2	-	-	3	3	-	2
CO-4	3	2	-	-	-	2	-	-	-	-	-	2
CO-5	3	2	-	-	-	2	-	-	3	3	-	2

Note: 3 = Strong Contribution 2 = Average Contribution 1 = Weak Contribution = No Contribution

The Correlation of Course Outcomes (CO's) and Program Specific Outcomes (PSO's)

Subject Code:	BEE701	TITLE: Switchgear and Protection
Course Outcomes	**PSO1**	**PSO2**
CO-1	3	2
CO-2	3	2
CO-3	3	2
CO-4	3	2
CO-5	3	2

Note: 3 = Strong Contribution 2 = Average Contribution 1 = Weak Contribution '-'= No Contribution