Programme Name/s : **Electrical Engineering/ Electrical Power System**

Programme Code : **EE/ EP**

Semester : **Fifth**

Course Title : **SWITCHGEAR AND PROTECTION**

Course Code : **315334**

I. RATIONALE

Switchgear and Protection plays a vital role in maintaining the reliability and stability of the power system. In order to ensure this, operational principles, selection and testing of Switchgear and Protection schemes must be known to the students while performing their duties in electrical sector.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry/employer expected outcome through various teaching learning experiences: "Select and use different switchgears and protection schemes to maintain the reliability and stability of the power system".

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Recognize the different types of faults occuring in power system.
- CO2 - Select the suitable switchgears for different applications.
- CO3 - Test the performance of different protective relays.
- CO4 - Use suitable protection schemes for alternators, motors, transformers, busbars and transmission lines.
- CO5 - Select suitable protection schemes for power system against over voltages.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/ s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315334	SWITCHGEAR AND PROTECTION	SGP	DSC	5	-	2	2	9	3	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the functions of the given elements of the protective system TLO 1.2 Explain with sketches the given types of faults and abnormalities in a power system TLO 1.3 Explain with sketches the concept of the Backup protection for the given protection zone TLO 1.4 Calculate the short circuit currents of symmetrical faults for the given generators TLO 1.5 Select suitable current limiting reactors for the given situation with justification.	**Unit - I Fundamentals of Protection** 1.1 Protective system: Necessity, functions and components 1.2 Normal and abnormal conditions 1.3 Types of faults and their causes 1.4 Protection zones and backup protection 1.5 Short circuit fault calculations for symmetrical fault on busbars fed through generators 1.6 Current Limiting Reactors : Need, types, arrangements , comparative advantages and disadvantages	Lecture Using Chalk-Board Flipped Classroom Demonstration

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain the operation with sketches of the given isolators TLO 2.2 Explain with sketches the given terms related to the specified fuse (s). TLO 2.3 Explain the terms related to arc interruption process of the fuse. TLO 2.4 Explain with sketches arc formation, high resistance and zero current interruption in the given type of circuit breaker. TLO 2.5 Calculate the terms related to circuit interruption based on the given data of the circuit. TLO 2.6 Explain the operation with sketches of the given circuit breaker(s). TLO 2.7 Compare the given circuit interrupting devices on the specified parameters. TLO 2.8 Select the relevant switchgear for the given application with justification. TLO 2.9 Describe the general arrangement of Gas insulated switchgear TLO 2.10 Explain the Insulation coordination for the given installation/ machine. TLO 2.11 Classify the Ring main unit switchgear parameters based on given criteria. TLO 2.12 Compare Air Insulated Substation (AIS) and Gas Insulated Substation (GIS)	**Unit - II Circuit Interrupting Devices** 2.1 Isolators- Vertical break, Horizontal break and Pantograph type with its advantages and disadvantages 2.2 HRC fuses â€“ Construction, types, working, Inverse time current characteristics,characteristics of fuse element, Fuse current rating, Minimum fusing current, Fusing factor, Prospective current, Cut off Current. 2.3 Terms related to Arc interruption process of fuse â€“ pre-arcing time, cut off value, arcing time, total operating time, peak of prospective current and applications 2.4 Arc formation process, methods of arc extinction (High resistance and Low resistance). 2.5 Arc voltage, Recovery voltage, Re-striking voltage, Rate of rise of restriking voltage (RRRV). 2.6 HT circuit breakers: Vacuum circuit breaker , Sulphur-hexa Fluoride (SF_6) - Working, construction, specifications and applications 2.7 L.T. circuit breaker: Miniature circuit breakers (MCB), Moulded case circuit breakers (MCCB), Motor Protection Circuit Breaker (MPCB) , Residual Current Circuit Breaker (RCCB) and Earth leakage circuit breaker(ELCB), Air circuit breakers (ACB)- Construction, Working and applications 2.8 Selection of LT and HT circuit breakers 2.9 Isolator, fuses and circuit breaker: Comparison 2.10 Gas insulated switchgear 2.11 Insulation Coordination : Type1 & Type2 coordination 2.12 Ring Main Unit Switchgear: Introduction, classification based on: type of insulation (gas, oil, air), installation (outdoor, indoor). 2.13 Air Insulated Substation (AIS) : Concept, Advantages , Disadvantages ; Gas Insulated Substation (GIS) : Concept, Advantages, Disadvantages	Lecture Using Chalk-Board Presentations Flipped Classroom
3	TLO 3.1 Explain the given terms related to protective relays TLO 3.2 Calculate the relay time based on the given data in the power system. TLO 3.3 Explain with sketches the working of the given protective relay TLO 3.4 Select relevant protective relay for required application with justification.	**Unit - III Protective Relays** 3.1 Protective Relay: Fundamental quality requirements (Selectivity, Speed, Sensitivity, Reliability, Simplicity, Economy) 3.2 Basic relay terminology- Protective relay, Relay time, Pick up, Reset current, current setting, Plug setting multiplier, Time setting multiplier. 3.3 Electromagnetic disc relay, Thermal relay, over voltage relay, Over current, Earth fault relay: Operation and its characteristics. 3.4 Static, Digital Relay (Microprocessor based): Block diagram, working, advantages and limitations. Numerical relay: Introduction 3.5 Distance relaying- Principle 3.6 Directional relay: Need and operation with block diagram. 3.7 Current and Voltage differential relay: Operation	Lecture Using Chalk-Board Presentations Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Describe the causes and remedies of the given faults in the specified machine. TLO 4.2 Explain with sketches the given protection schemes of the specified machine TLO 4.3 Calculate percentage of winding protected for the specified alternator TLO 4.4 Calculate CT ratio of the specified transformer protection scheme. TLO 4.5 Explain the causes and remedies of the given faults in the busbar and transmission line	**Unit - IV Protection of Alternators, Motors, Transformers, Busbars and Transmission lines** 4.1 Abnormalities and Faults occurring in alternator 4.2 Differential, Overcurrent , Earth fault Protection: Schemes 4.3 Reverse power protection: Scheme 4.4 Abnormalities and Faults occurring in transformer 4.5 Differential, over current, earth fault, over heating protection. 4.6 Limitations of differential protection. 4.7 Buchholz relay: Construction, operation. 4.8 Motor: Abnormalities and Faults, Short circuit protection, Overload protection, Single phase preventer. 4.9 Busbar: Faults, busbar protection, differential and fault bus protetion. 4.10 Transmission Line: Faults, Over current, Distance and Pilot wire protection.	Lecture Using Chalk-Board Presentations Flipped Classroom

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Test protection system for the earth fault or short circuit fault.	1	*Simulation of Earth Fault/ Short Circuit fault.	2	CO1
LLO 2.1 Test the performance of HRC fuse. LLO 2.2 Validate the performance of HRC fuse by drawing the inverse time current characteristics.	2	*Testing of HRC Fuse.	2	CO2
LLO 3.1 Test the performance of MCB. LLO 3.2 Validate the performance of MCB by drawing the inverse time current characteristics.	3	*Testing of Miniature Circuit Breaker	2	CO2
LLO 4.1 Test Induction type over-current relay by performing load test.	4	*Characteristics of Induction type over-current relay.	2	CO3
LLO 5.1 Carry out plug and time setting (with PSM, TSM) of induction type electromagnetic relay.	5	*Plug Setting and Time setting Multiplier of Induction type relay.	2	CO3
LLO 6.1 Use Differential protection for protecting the Alternator.	6	*Demonstrate/ Simulate differential protection scheme for different types of faults on Alternator.	2	CO4
LLO 7.1 Use Differential protection for protecting the Transformer.	7	*Demonstrate/ Simulate differential protection scheme for different types of faults on Transformer.	2	CO4
LLO 8.1 Use Single Phase Preventer for protection of three phase Induction Motor.	8	*Testing of single phase preventer for protecting three phase induction motor.	2	CO4
LLO 9.1 Select relevant protection scheme for the given transmission line.	9	Demonstrate/Simulate transmission line protection by using the impedance/over current relay for various faults.	2	CO4
LLO 10.1 Identify different parts of the Lightning Arrestor.	10	*Demonstration of Thyrite type lightning arrester using video / Dismantling the same.	2	CO5
LLO 11.1 Describe the step by step procedure to carry out Neutral Earthing.	11	Demonstrate process of carrying out neutral earthing at different substations / locations or with suitable media.	2	CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Installation and commissioning of MCB / ELCB: Calculate load current and finalize the specifications of protection schemes for Electrical Engineering laboratory.
- Alternator/Transformer/Motor/Busbar and Transmission Line protection Relays: Prepare power point presentation on digital and multifunction protection relays used to protect feeder, motor , generator, busbar and Transmission line.
- IEC 61850 communication protocol : Prepare a power point presentation on communication protocol used to provide communication between different equipment located in a substation, such as protection, control, and measurement equipment, as well as (IEDs) intelligent electronic devices.
- Case study of past major grid power failure: Prepare a report after studying the previous power failure in India or abroad

Assignment

- Write a report on causes of overvoltages in power system.
- Write a report on Lightning phenomena.
- Write a report on Protection of power system against travelling waves.
- Write a report on different types of Lightning arrestors.
- Write a report on arcing ground and Neutral grounding.

All Assignments are mandatory as they will contribute to attainment of CO5.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Fuses (5A), MCB(5A) , Connecting wires.	1
2	Earth tester 500 V, hand driven or digital type.	10
3	HRC Fuses:5A	2
4	MCB : 5A	3
5	Induction Overcurrent Relay : 10A or above	4
6	Alternator Differential Protection Scheme Simulation Kit	5
7	Transformer Differential Protection Scheme Simulation Kit.	6
8	Three phase induction motor with Single phase preventer: 3HP or above.	7
9	Transmission line protection simulation kit using impedance/over current relay.	8
10	Thyrite type/ Metal oxide Type Lightning arrester.	9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals of Protection	CO1	8	2	4	6	12

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
2	II	Circuit Interrupting Devices	CO2	10	2	8	6	16
3	III	Protective Relays	CO3	12	4	4	10	18
4	IV	Protection of Alternators, Motors, Transformers, Busbars and Transmission lines	CO4	20	2	8	14	24
Grand Total				**50**	**10**	**24**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests of 30 marks will be conducted and average of two unit tests considered. For formative assessment of laboratory learning 25 marks. Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment.

Summative Assessment (Assessment of Learning)

- End Semester assessment of 25 marks for laboratory learning. End semester assessment of 70 marks through offline mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO- 1	PSO- 2	PSO- 3
CO1	3	3	3	2	3	2	2			
CO2	3	1	2	2	3	2	3			
CO3	3	1	2	2	3	2	2			
CO4	3	3	3	2	3	2	2			
CO5	3	1	3	2	3	2	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number

Sr.No	Author	Title	Publisher with ISBN Number
1	Mehta V. K ; Rohit Mehta	Principles of Power System	S.Chand and Co., New Delhi., 2016 ISBN: 978-93-5501-077-3
2	Rao.Sunil S.	Switchgear and Protection	Khanna Publishers, New Delhi, 2015 ISBN: 978-93-87394-72-8
3	Gupta. J. B.	Switchgear and Protection	S. K. Kataria and Sons, New Delhi, 2015ISBN: 978-93-5014-372-8.
4	Singh, R. P.	Switchgear and Power System Protection	PHI Learning, New Delhi,2015 ISBN: 978-81-203-3660-5.
5	Ram, Badri Vishwakarma D. N.	Power System Protection and Switchgear	McGraw-Hill, New Delhi. 2015 ISBN : 978-00-7107-774-3
6	Veerapan, N., Krishnamurty, S. R.	Switchgear and Protection	S .Chand and Co., New Delhi. 2014 ISBN: 978-81-2193-212-7.

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	www.cgglobal.com	Different types of Switchgears
2	https://nptel.ac.in/courses/108101039	NPTEL course on Power System Protection (Fundamentals of Power System Protection, Fault Analysis, Over current Protection, Directional Overcurrent Protection, Distance Protection, Numerical Relay Fundamentals, Differential Protection of Busbar, Transformer and Generator)
3	https://new.abb.com	Different types of Switchgears, Ring Main Unit (RMU) Switchgears, Relays.
4	https://www.elecspare.com	Different types of Switchgears, Ring Main Unit (RMU) Switchgear

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students