POWER SYSTEM PROTECTION

Subject Code : EE603PC
Regulations : R18 - JNTUH
Class : III Year B.Tech EEE II Semester

Department of Electrical and Electronics and Engineering

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

Ibrahimpatnam - 501 510, Hyderabad

POWER SYSTEM PROTECTION (EE603PC)

COURSE PLANNER

I. OBJECTIVE AND RELEVANCE:

The main objective of this subject is to understand and to know the following concepts:

- To understand the types of Circuit breakers and relays for protection of Generators, Transformers and feeder bus bar from Over voltages.
- To describe the important of neutral grounding for overall protection.
- To analyses the phenomenon of over Voltage and its classification.

II. PREREQUISITES:

The knowledge of following subjects is essential to understand this subject:

- Power Systems – I.
- Power Systems – II.

III. COURSE OUTCOME:

S.No	Description	Bloom's Taxonomy Level
1	Understand the types of Circuit breakers and choice of Relays for appropriate protection of power system equipment.	Knowledge, Understand (Level 1, Level 2)
2	Understand various types of Protective devices in Electrical Power Systems.	Knowledge, Understand, (Level 1, Level 2)
3	Interpret the existing transmission voltage levels and various means to protect the system against over voltages.	Knowledge, Understanding, Applying, Analyzing (Level 1, Level 2, Level 3)
4	Understand the importance of Neutral Grounding, Effects of Ungrounded Neutral grounding on system performance, Methods and Practices.	Knowledge, Understanding, Applying, Analyzing (Level 1, Level 2, Level 3)

IV. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (PO)		Level	Proficiency assessed by
PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	**2**	**Assignments**
PO2	**Problem Analysis:**Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	**2**	**Assignments**
PO3	**Design/Development Analysis:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	**1**	**Assignments**
PO4	**Conduct Investigations of Complex Problems:** Use research-	**1**	**Assignments**

	based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.		
PO5	**Modern Toll Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	**1**	**--**
PO6	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	**1**	**Assignments**
PO7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	**-**	**--**
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	**-**	**--**
PO9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	**-**	**--**
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	**-**	**--**
PO11	**Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	**-**	**--**
PO12	**Life-long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	**2**	**Research**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: None

V. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSO)		**Level**	**Proficiency assessed by**
PSO1	Talented to analyze, design, and implement electrical & electronics systems and deal with the rapid pace of industrial innovations and developments.	**2**	**Lectures, Assignments**
PSO2	Skillful to use application and control techniques for research and advanced studies in Electrical & Electronics Engineering domain.	**2**	**Lectures, Assignments**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: None

VI. SYLLABUS:

JNTUH SYLLABUS

UNIT- I–**Introduction to Circuit Breakers:**

Circuit Breakers: Elementary principles of arc interruption, Recovery, Restriking Voltage and Recovery voltages. - Restriking Phenomenon, Average and Maximum RRRV, Numerical Problems - Current Chopping and Resistance Switching - CB ratings and Specifications: Types and Numerical Problems. – Autoreclosures.
Description and Operation of following types of circuit breakers: Minimum Oil Circuit
breakers, Air Blast Circuit Breakers, Vacuum, and SF6 circuit breakers

UNIT -II – **Electromagnetic and Static Relays:**

Principle of Operation and Construction of Attracted armature, Balanced Beam, induction Disc and Induction Cup relays. Types of Over Current Relays: Instantaneous, DMT and IDMT types.Application of relays: Over current/ under voltage relays, Direction relays, Differential, Relays and Percentage Differential Relays.Universal torque equation, Distance relays: Impedance, Reactance, and Mho and Off-Set, Mho relays, Characteristics of Distance Relays and Comparison. Static Relays: Static Relays verses Electromagnetic Relays.

UNIT-III – **Protection of Power Equipment:**
Protection of generators against Stator faults, Rotor faults, and Abnormal Conditions. Restricted Earth fault and Inter-turn fault Protection. Numerical Problems on % Winding Unprotected.
Protection of transformers: Percentage Differential Protection, Numerical Problem on Design
of CT s Ratio, Buchholtz relay Protection.
Protection of Lines: Over Current, Carrier Current and Three-zone distance relay protection
using Impedance relays. Translay Relay.
Protection of Bus bars – Differential protection.

UNIT- IV –**Neutral Grounding:**
Grounded and Ungrounded Neutral Systems. - Effects of UngroundedNeutral on system performance. Methods of Neutral Grounding: Solid, Resistance, Reactance- Arcing Grounds and Grounding Practices.

UNIT- V –**Protection Against Overvoltages:**
Generation of Over Voltages in Power Systems.- Protection against Lightning Over Voltages - Valve type and Zinc-Oxide Lighting Arresters - Insulation Coordination -BIL, Impulse Ratio, Standard Impulse Test Wave, Volt-Time Characteristics.

GATE SYLLABUS:

Power generation concepts, ac and dc transmission concepts, Models and performance of transmission lines and cables, Series and shunt compensation, Electric field distribution and insulators, Distribution systems, Per-unit quantities, Bus admittance matrix, Gauss-Seidel and Newton-Raphson load flow methods, Voltage and Frequency control, Power factor correction, Symmetrical components, Symmetrical and unsymmetrical fault analysis, Principles of over-current, differential and distance protection; Circuit breakers, System stability concepts, Equal area criterion.

- **IES SYLLABUS:**

Basic power generation concepts, steam, gas and water turbines, transmission line models and performance, cable performance, insulation, corona and radio interference, power factor correction, symmetrical components, fault analysis ,principles of protection systems, basics of solid-state relays and digital protection; Circuit breakers, Radial and ring-main distribution systems,

SUGGESTED BOOKS:

TEXT BOOKS:

1. "Badri Ram , D. N Viswakarma", "Power System Protection and Switchgear", TMH Publications, 2011
2. "Sunil S Rao", "Switchgear and Protection", Khanna Publishers, 2008.

REFERENCE BOOKS:

1. "Paithankar and S. R. Bhide", "Fundamentals of Power System Protection", PHI, 2003.
2. "C R Mason", Art & Science of Protective Relaying – Wiley Eastern Ltd, 1966.
3. "C. L. Wadhwa", "Electrical Power Systems", New Age international (P) Limited, Publishers, 6th Edition 2007.

VII. COURSE PLAN (WEEK-WISE):

LESSON PLAN ACADEMIC YEAR 2020-2021 II SEM

Course Instructor : Bipul Krishna Saha /GYANESH SINGH
Class: EEE III (A &B)

Subject: Power System Protection
WEF : 26.3.21

Lecture No.	Unit No.	Topics to be covered	Link for PPT	Link for PDF	Link for Small Projects/ Numericals(if any)	Course learning outcomes	Teaching Methodology	Reference
1	**1**	Introduction, Need for power system protection	https://drive.google.com/open?id=1RgvDgDIS5sxX_VIPR4_d9vhtCBZlJAfd	https://drive.google.com/open?id=1RgvDgDIS5sxX_VIPR4_d9vhtCBZlJAfd	https://electricalprojectsguide.com/power-system-projects/	UNDERSTAND	PPT / WHITE BOARD	**R1,R2**
2		Effects of faults, evolution of protective relays, zones of protection	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	
3		Primary and backup protection	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	
4		Essential qualities of protection	https://drive.google.com/open?id=1-	https://drive.google.com/open?id=1U	**https://electricalprojectsguide.**	UNDERSTAND	PPT / WHITE BOARD	

			rot9h2WQvm6r_qAwWCTStUscyKr5pCT	Nd8Btz426MRlGtXf8jAlK2kZJAAlqox	**com/power-system-projects/**			
5		Classification of protective relays and schemes	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
6		Current transformers,	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
7		Potential transformers,	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
8		Basic relay terminology	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	
9		Revised Basic	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
10		Electromagnetic relays	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
11		Thermal relays,	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	

12		Static relays	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
13		Microprocessor based protective relays.	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	
14		Quiz, Revised Unit1, Solved question papers	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1UNd8Btz426MRlGtXf8jAlK2kZJAAlqox	**https://electricalprojectsguide.com/power-system-projects/**	NUMERICAL	PPT / WHITE BOARD	
15	**2**							
16		Time-current characteristics, current setting	https://drive.google.com/open?id=1RgvDgDIS5sxX_VIPR4_d9vhtCBZlJAfd	https://drive.google.com/open?id=1RgvDgDIS5sxX_VIPR4_d9vhtCBZlJAfd	https://electricalprojectsguide.com/power-system-projects/	KNOWLEDGE	PPT / WHITE BOARD	
17		Over current protective schemes	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
18		Directional relay, protection of parallel feeders	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	**R2**
19		Protection of ring mains, Phase fault and earth fault protection	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
20		Combined earth fault and phase fault protective	https://drive.google.com/open?id=1-	https://drive.google.com/open?id=1nS	**https://electricalprojectsguide.**	UNDERSTAND	PPT / WHITE BOARD	

		scheme	rot9h2WQvm6r_qAwWCTStUscyKr5pCT	PK4j_NdanTcB28wCZgqP2QAzdcceL1	**com/power-system-projects/**			
21		Directional earth fault relay	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
22		Impedance relay, reactance relay, MHO relay	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
23		input quantities for various types of distance relays,	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
24		Effect of arc resistance, Effect of power swings	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
25		effect of line length and source	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	
26		Impedance on the performance of distance relays	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	
27		selection of distance relays, MHO relay with blinders, Reduction of measuring units	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	

28		Switched distance schemes, auto re-closing	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
29		Quiz, Revised Unit 2, Solved question papers	https://drive.google.com/open?id=1-rot9h2WQvm6r_qAwWCTStUscyKr5pCT	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	NUMERICAL	PPT / WHITE BOARD	
I Mid Examinations								
30	**3**	Wire Pilot protection	https://drive.google.com/open?id=1RgvDgDIS5sxX_VIPR4_d9vhtCBZlJAfd	https://drive.google.com/open?id=1RgvDgDIS5sxX_VIPR4_d9vhtCBZlJAfd	https://electricalprojectsguide.com/power-system-projects/	UNDERSTAND	PPT / WHITE BOARD	R2,R3
31		Carrier current protection.	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
32		AC Machines and Bus Zone Protection	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
33		Protection of Generators	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
34		Protection of Generators	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
35		Buszone protection	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-	https://drive.google.com/open?id=1nSPK4j_Ndan	**https://electricalprojectsguide.com/powe**	UNDERSTAND	PPT / WHITE BOARD	

			31JGcenH6Ej	TcB28wCZgqP2QAzdcceL1	**r-system-projects/**			
36		frame leakage protection	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
37		Revised Basic	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
38		Project discuss	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
39		Discuss privious year question paper	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
40		Quiz, Revised Unit 2, Solved question papers	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
41		Static Relays	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
42	**4**	Amplitude and Phase comparators	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	**R2**
43		Duality between AC and PC, Static amplitude	https://drive.google.com/open?id=1BSG94qEWr	https://drive.google.com/open?id=1nS	**https://electricalprojectsguide.**	UNDERSTAND	PPT / WHITE BOARD	

		comparator	JDCHjxJZLnS-31JGcenH6Ej	PK4j_NdanTcB28wCZgqP2QAzdcceL1	**com/power-system-projects/**			
44		Integrating and instantaneous comparators, static phase comparators	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
45		Coincidence type of phase comparator	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
46		Static over current relays, static directional relay	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
47		Static differential relay, static distance relays, Multi input comparators,	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
48		Advantages, over current relays, directional relays, distance relays.	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	https://electricalprojectsguide.com/power-system-projects/	UNDERSTAND	PPT / WHITE BOARD	
49		Revised Basic	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	
50		Discuss privious year question paper	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	

51		Quiz, Revised Unit 2, Solved question papers	https://drive.google.com/open?id=1BSG94qEWrJDCHjxJZLnS-31JGcenH6Ej	https://drive.google.com/open?id=1nSPK4j_NdanTcB28wCZgqP2QAzdcceL1	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	
52	**5**	Circuit Breakers, Introduction	https://drive.google.com/open?id=1RgvDgDIS5sxX_VIPR4_d9vhtCBZlJAfd	https://drive.google.com/open?id=1RgvDgDIS5sxX_VIPR4_d9vhtCBZlJAfd	https://electricalprojectsguide.com/power-system-projects/	UNDERSTAND	PPT / WHITE BOARD	
53		Arcing in circuit breakers, arc interruption theories	https://drive.google.com/open?id=1O5PHLklAuqf5Wvx5VP8sdNxEiCJgJOT0	https://drive.google.com/open?id=1DooTGCT6rzkf4LwhSVCInMjOOpdJQOis	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
54		Re-striking and recovery voltage	https://drive.google.com/open?id=1O5PHLklAuqf5Wvx5VP8sdNxEiCJgJOT0	https://drive.google.com/open?id=1DooTGCT6rzkf4LwhSVCInMjOOpdJQOis	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
55		Resistance switching, current chopping	https://drive.google.com/open?id=1O5PHLklAuqf5Wvx5VP8sdNxEiCJgJOT0	https://drive.google.com/open?id=1DooTGCT6rzkf4LwhSVCInMjOOpdJQOis	**https://electricalprojectsguide.com/power-system-projects/**	UNDERSTAND	PPT / WHITE BOARD	
56		Interruption of capacitive current, oil circuit breaker, air blast	https://drive.google.com/open?id=1O5PHLklAuqf5Wvx5VP8sdNxEiCJgJOT0	https://drive.google.com/open?id=1DooTGCT6rzkf4LwhSVCInMjOOpdJQOis	**https://electricalprojectsguide.com/power-system-projects/**	KNOWLEDGE	PPT / WHITE BOARD	
57		Discuss privious year question paper	https://drive.google.com/open?id=1O5PHLklAuqf5Wvx5VP8sdNxEiCJgJOT0	https://drive.google.com/open?id=1DooTGCT6rzkf4LwhSVCInMjOOpdJQOis	**https://electricalprojectsguide.com/power-system-projects/**	NUMERICAL	PPT / WHITE BOARD	
58		Quiz, Revised, Solved question papers	https://drive.google.com/open?id=1O5PHLklAuqf5Wvx5VP8sdNxEiCJgJOT0	https://drive.google.com/open?id=1DooTGCT6rzkf4LwhSVCInMjOOpdJ	**https://electricalprojectsguide.com/power-system-projects/**	ANALYSIS	PPT / WHITE BOARD	

				QOis				
II Mid Examinations								

*** Topics beyond Syllabus**

TEXT BOOKS:

1 Protective Relaying Principles and Applications , J. Lewis Blackburn, 3rd Ed, CRC Press, © 2007.

2 *Power System Analysis and Design,* J.D. Glover & M. Sarma, 4th Ed, Thompson Publishing, © 2008. Good intro to relaying in Ch.10. This is also the book used for the pre-req courses EE4221 and EE4222, an excellent reference for power system analysis basics, and understanding the overall behavior of the power system that you are protecting

3 Protective Relay Principles, A.F. Sleva, CRC Press,© 2009. ISBN 978-0824753726.

4 *Electrical Power Equipment Maintenance and Testing*, Paul Gill, 2nd Ed., CRC Press,© 2008. ISBN 978-1574446562

5 *Protective Relaying Theory & Applications*, W.A. Elmore, 2nd Ed, CRC Press, ©2003.

6 *Power System Protection*, P.M. Anderson, IEEE Order No.PC5389, McGraw-Hill, ©1999. 1300 pages of insight

7 IEEE Guide for Protective Relay Applications to Transmission Lines, Power Systems Relaying Committee (PSRC), IEEE Std C37.113-1999, ©1999.

8 *Terms Used by Power System Protection Engineers*, IEEE Catalog Number TP130-0-031998-1-0, ©1998.

Useful Web links and other resources:

Public Domain or Royalty-Free Software

ATP - Alternative Transients Program (Royalty Free, Licensing Required)

Educational Software - List of Links Provided by IEEE Power Engineering Education Committee, includes Power World

InterPSS - Open Source Power System Design & Analysis

Available Commercial Software

Aspen - Loadflow, Short-Circuit, Relay Coordination (Academic Version Available)

MatLab with Simulink and SimPowerSystems - Full spectrum of power system analysis and controls (Academic Versions Available)

PSS/E - Loadflow, Short-Circuit, Dynamic Stability (Academic Pricing Available)

CAPE - Loadflow, Short-Circuit, and Relay Coordination (Academic Pricing Available)

V-Flow, V-Net, V-Pro, V-Harm, V-Cap, etc . - Power Verdict Series: Suite of programs by Cooper Power Systems

ETAP PowerStation - Full suite for
power system analysis and design
Transmission 2000 - Loadflow, Short Circuit, Dynamic Stability, and Relay
Coordination (Academic Version Available)
EDSA - Loadflow, Short Circuit, Relaying, AC and DC systems
(mostly industrial, auto, shipboard)

VIII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OFPROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

	Program Outcomes												Program Specific Outcomes	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	**2**	**2**	**1**	**1**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**2**	**2**
CO2	**2**	**2**	**1**	**1**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**2**	**2**
CO3	**2**	**2**	**1**	**1**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**2**	**2**
CO4	**2**	**2**	**1**	**1**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**2**	**2**
AVG	**2**	**2**	**1**	**1**	**-**	**1**	**1**					**2**	**2**	**2**

IX. QUESTION BANK:

UNIT I

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Brief discuss the different methods of arc interruption in case of circuit breakers?	Knowledge	2
2	In a short circuit test on 220 kV, 3-phase system with breaker gave the results as: P.f of the fault is 0.6 and recovery voltage is 0.85 times the full line voltage. The breaking current is symmetrical and restriking transient has a natural frequency of 10kHZ. Calculate the RRR V for i) Grounded fault and ii) Ungrounded fault	Derive	3
3	What is meant by circuit breaker? Discuss the phenomenon of arc formation in a CB.	Knowledge	2
4	Explain the concepts of recovery voltage and restriking voltages?	Knowledge	2
5	Discuss the air blast circuit breakers' ratings and its advantages	Knowledge	2
6	Explain the types of SF6 circuit breakers with neat diagrams?	Knowledge	2
7	List out the merits and limitations of air blast circuit breaker?	Knowledge	2

8	Explain the properties of SF6 gas and how it is used for circuit breakers?	Knowledge	2
9	Explain the concept of resistance switching of a circuit breaker with an equivalent circuit?	Applying	2
10	In a short circuit test on a CB, the following readings were obtained on single frequency transient. i) Time to reach the peak restriking voltage is 50μ sec. ii) The peak restriking voltage is 100kV. Find the average RRRV and iii) Frequency of oscillations	Derive	4
11	Describe the principle of operation of air blast circuit breakers?	Knowledge	2
12	Compare the operation of vacuum circuit breaker with SF6 circuit breaker?	Knowledge	2

UNIT II

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	What is an impedance relay? Discuss its principle of operation. Show its characteristics R-X diagram. List out its merits for transmission line protection.	Derive	4
2	Explain the hinged armature type relay with neat sketch?	Knowledge	2
3	Explain about the principle of operation of biased differential relay with necessary equations?	Applying	3
4	Explain about MHO relay and OFF SET MHO relays with their characteristics?	Applying	3
5	Discuss the operating principle of an impedance relay and the draw its Characteristics on R-X plane?	Knowledge	2
6	Explain functions of induction disc relay with neat diagram?	Knowledge	2
7	Explain the operation of induction cup relay with neat diagram?	Knowledge	2
8	What are the various types of over current relay? Discuss the IDMT relays characteristics	Knowledge	2

UNIT III

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain the restricted earth fault protection by differential system in the protection of an alternator winding?	Understanding	2
2	A 11 kV, 100 MVA alternator is grounded through a resistance of 10 ohms. The current transformers have a ratio of 1000/5. The relay is set to operate when there is an	Solving	3

	out of balance current of 0.5 A. Find the percentage of generator winding protected by percentage differential protection?		
3	Discuss the various faults occurred in the transformer and write the protection scheme for each fault?	Knowledge	3
4	Explain the protection device for a transformer that gives protection from internal Faults.	Applying	3
5	A 3 phase, 11/33KV star delta connected power transformer is protected by differential protection. The CTs on the LV side have a current ratio of 300/5. What must be the ratio of CTs on the HV side? Draw the connection diagram?	Applying, Solving	5
6	Explain how the rotor of an alternator will be protected by field ground fault protection?	Knowledge	3
7	Describe the stator protection of alternator by percentage differential protection with neat sketch?	Knowledge	3
8	plain how the transformer is protected from overheating problem?	Knowledge	3
9	Explain how the transformer is protected from overheating problem?	Knowledge	3
10	A 3ϕ, transformer having line voltage ratio 0.4/11 kV is connected in star delta and protective transformer on the 400 V side have a CT ratio of 500/5. What must be the ratio of the protective transformers on the 11kV side?	Applying, Solving	4
11	Explain transverse percentage differential protection for multi winding generators	Knowledge	3
12	A Star connected 3-ϕ, 25MVA, 11kV generator has a per phase reactance of 12%. It is protected by merz-price circulating current principle which is set to operate for fault current not less than 170 A. Find the value of earth resistance to be provided in order to ensure that only 12% of the generator winding remains unprotected.	Applying, Solving	5
13	Explain the protection against magnetizing inrush current of a transformer?	Knowledge	3
14	Draw and explain the connection of current transformer secondaries for differential protection of star delta connected power transformer?	Knowledge	3

UNIT IV

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain the differences between grounded and un grounded neutral systems?	Solving	4
2	Explaineffects of Ungrounded Neutral on system performance?	Solving	4

3	What are the different methods of Neutral Grounding?	Solving	4
4	Explain Solid Grounding method? Write its merits and demerits?	Applying	4
5	Explain Resistance Grounding method? Write its merits and demerits?	Applying	4
6	Explain Reactance - Arcing Grounds method? Write its merits and demerits?	Solving	4
7	What are the different Grounding Practices?		

UNIT V

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain about the valve type and zinc oxide type lightning arresters?	Applying	3
2	Why is insulation coordination needed in a large power system? What is meant by basic impulse level of equipment?	Solving	3
3	Explain the resistance grounding with circuit diagram and phasor diagrams? List out its merits and demerits.	Solving	3
4	Explain the concept of arcing grounds in the power system and derive the necessary expressions.	Derive	4
5	Draw the volt time characteristics of impulse test wave and mark the flash over voltages?	Applying	3
6	Explain how the over voltages are generated in the power system?	Applying	3
7	what are the methods that are used to give protection against over voltages in the power system?	Applying	3

OBJECTIVE QUESTIONS:

FILL UP THE BANKS:

UNIT-I

1. In a circuit breaker the contact space is ionized by_____.
2. _____should be the value of fusing factor?
3. _____is the relation between the fusing current and the diameter of the wire.
4. The making and breaking currents of a 3 phase ac circuit breakers in power systems are respectively in _____form.
5. _____circuit breaker is preferred to be installed in extra high voltage AC system?

UNIT-II

1. _____ relay is preferred for phase fault on short transmission line.
2. The under voltage relay can be used for_____.
3. _____ is the purpose of back up protection.
4. The torque produced in induction type relay (shaded pole structure) is inversely proportional to the square of the _____.
5. Induction cup relay is operated due to changes in_____.

UNIT-III

1. Unbalancing of an alternator may occur due to _____.
2. Bias is used in the relay protection to _____.
3. A longitudinal differential protection on _____can detect inter-turn on the stator.
4. We need the biasing of differential relay biased to avoid mal operation when used for transformer protection due to _____.
5. A feeder, in a transmission system, feeds power to _____.

UNIT-IV

1. When the 3-phase system is not grounded and if Single Line to Ground fault occurs, the voltage of the other two healthy phases will_____.

2. Factors on which soil resistance depends_____.

3. Solid grounding is adopted for voltages below_____.

5

UNIT-V

1. Over voltage protection is recommended for_____.

2. Wave trap is used to trap waves of _____.

3. Ungrounded neutral transmission system is not recommended because of system_____.

4. For the protection of power station buildings against direct strokes the requirements are _____.

5. Negative sequence currents is provided for _____.

MULTIPLE CHOICE QUESTIONS:

UNIT-1

1. What is the average rate of rise of restriking voltage upto the first peak?

a. $525 * 10^3$kV / sec b. $453 * 10^3$kV / sec c. $582 * 10^3$ kV / sec d. $467 * 10^3$ kV / sec

Answer. b

2. Circuit breakers usually operate under

a. Steady short circuit current b. Sub transient state of short circuit current

c. Transient state of short circuit current d. None of these

Answer. B

3. What is the making capacity of the circuit breaker?

a. Less than the asymmetrical breaking capacity of the breaker

b. Greater than the asymmetrical breaking capacity of the breaker

c. Equal to the asymmetrical breaking capacity of the breaker

d. Equal to the symmetrical breaking capacity of the breaker

Answer. B

4. SF6 is which type of gas?

a. Electro positive b. Electro negative c. Both (a) and (b) d. None of these

Answer. c

5. A three phase, 33 kV oil circuit breaker is rated 1200 A, 2000 MVA, 3s. What is its symmetrical breaking current?

a. 1200 A b. 3600 A c. 35 kA d. 104.8 kA

Answer. c

UNIT.2

1. What is the actuating quantity for the relays?

a. Magnitude b. Frequency c. Phase angle d. All of these

Answer .d

2. The most efficient torque producing actuating structure for the induction type relays is

a. Shaded pole structure b. Watt hour meter structure c. Induction cup structure

d. Single induction loop structure

Answer. c

3. Plug setting of a electromagnetic relay can be altered by varying

a. Number of ampere turns b. Air gap of magnetic path c. Adjustable back stop

d. None of these

Answer .a

4. On what factor does the operating speed of the relay depend?

a. Rate of flux built up b. Armature core air gap c. spring tension d. All of these

Answer. d

5. Admittance relay is _____ relay.

(a) Impedance (b) directional (c) non-directional (d) none of the above

Answer. b

UNIT-3

1. Protective relays can be designed to respond to _____.

a. Light intensity, impedance b. Temperature, resistance, reactance c. Voltage and current d. All of these

Answer. D

2. A thermal protection switch provides protection against what?

a. Overload b. Temperature c. Short circuit d. Over voltage

Answer. d.

3. What does protective relay provide?

a. Provide additional safety to the circuit breaker in its operation.

b. Close the contacts when the actuating quantity attains a certain predetermined value.

c. Limit the arcing current during the circuit breaker operation.

d. Earth or ground any stray voltage.

Answer. b

4. Large internal faults are protected by

a. Merz-price percentage differential b. Mho and ohm relays

c. Horn gaps and temperature relays d. Earth fault and positive sequence relays

Answer. a

5. A three phase transformer having a line voltage ratio of 400/33000 V is connected in the star-delta. The CTs on the 400V side have a CT ratio of 1000/5. What will be the current through the pilot wire?

a) $5\sqrt{3}$ A b) $5/\sqrt{3}$ A c) 5 A d) 1/5 A

Answer. a

UNIT-IV

1. Generally grounding is provided for

a. only for the safety of the equipment

b. only for the safety of the operating personnel

c. both (A) and (B)

d. none of the above

Answer .c

2. Ground resistance should be designed such that

a. grounding resistance should be as low as possible

b. grounding resistance should be as high as possible

c. grounding resistance should be always zero

d. none of the above

Answer .b

3. The objective of earthing or grounding is

a. to provide as low resistance possible to the ground

b. to provide as high resistance possible to the ground

c. to provide flow of positive, negative and zero sequence currents

d. none of the above

4. Earth wire or ground wire is made of

a. copper b. aluminium c. iron d. galvanized steel

Answer.d

5. Average resistance of human body is

a. 500 ohms b. 1000 ohms c. 1500 ohms d. 2000 ohms

Answer .b.

UNIT-V

1. Per cent bias for a generator protection lies between

a) 5 to 40 b) 40 to 45 c) 45 to 20 d) None of the above

Answer. a

2. Fault diverters are basically

(a) fuses (b) relay (c) fast switches (d) circuit breakers

Answer. c

3. Which of the following devices will receive voltage surge first travelling on the transmission line?

(a) Lightning arresters (b) Relays (c) Step-down transformer (d) Switchgear

Answer. a

4. To limit short-circuit current in a power system are used.

(a) Earth wires (b) isolators (c) H.R.C. fuses (d) reactors

Answer. d.

5. Fuse in a motor circuit provides protection against

(a) overload (b) short-circuit and overload (c) open circuit, short-circuit and overload

(d) none of the above

Answer.b.

GATE:

1. A negative sequence relay is commonly used to protect (2011)

a. An alternator b. A transformer c. A transmission line d. A busbar

2. In a biased differential relay the bias is defined as a ratio of (2005)

a. Number of turns of restraining and operating coil

b. Operating coil current and restraining coil current

c. Fault current and operating coil current

d. Fault current and restraining coil current

3. The transmission line distance protection relay having the property of being inherently directional is (2006)

a. impedance relay b. MHO relay c. OHM relay d. reactance relay

4. A -phase transformer rated for 33kv/11kv is connected in delta/star as shown in figure. The current transformers on low and high voltage sides have a ratio of 500/5. Find the currents and , if the fault current is 300 A as shown in figure (2015)

a. i 1/1√3 A, i 2 = 0 A b. i 1 = 0 A, i 2 = 0 A c. .i 1 = 0 A, i 2 = A 1√3 d. i 1 =1/1√3 /A, i 2 = 1/1√3 A

5. Consider a stator winding of an alternator with an internal high resistance ground fault. The currents under the fault condition are as shown in the figure. The winding is protected using a differential current scheme with current transformers of ratio 400/5400/5 AA as shown. The current through the operating coil is (2011)

a. 0.1875 A b. 0.2 A c. 0.375 A d. 60 kA

X.WEBITES:

1. https://nptel.ac.in/courses/108/101/108101039/.
2. https://www.vidyarthiplus.com/vp/Thread-EE2402-EE6702-Protection-Switchgear-Hand-Written-Lecture-Notes-All-Units-Lavanya-Edition#.XeYD7YMzbIU

XI. EXPERT DETAILS:

1. Dr. A.Jayalakshmi, Professor, JNTUH
2. Dr. Suryakalaavthi,, Professor, JNTUH

XII. JOURNALS:

1. IEEE Transactions on Industry and General Applications.
2. Springer Protection and Control of Modern Power Systems.

XIII. LIST OF TOPICS FOR STUDENTS SEMINARS:

1. Circuit breakers.
2. Electromagnetic and Static Relays.
3. Generator protection
4. Transmission line protection

XIV. CASE STUDIES/SMALL PROJECTS:

1. Microprocessor based relay protection.
2. Transformer protection.