



SWITCH GEAR AND PROTECTION

Subject Code : A70231
Regulations : R15 - JNTUH
Class : IV Year B.Tech EEE I Semester



Department of Electrical and Electronics and Engineering

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

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**SWITCH GEAR AND PROTECTION (A70231)
COURSE PLANNER**

I. COURSE OVERVIEW:

An electrical power system consists of generators, transformers, and transmission and distribution lines. In case of fault, an automatic protective scheme comprising of circuit breakers and protective relays isolate the faulty section providing protection to the healthy



section. Safety of machines/equipment and human beings is the major criteria of every protection scheme. It is essential that the students should develop skills of operating various controls and switchgear in power system. They are also required to carry out remedial measures for faults/abnormalities in machines/equipment in power system using appropriate diagnostic instrument/devices. This course attempts to develop these skills in students and hence it is a core course for all electrical engineers.

II. PRE REQUISITES:

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

1. Power Systems-I
2. Power Systems-II
3. Computer methods in power systems

III. OBJECTIVE AND RELEVANCE:

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- a. Identify various types of faults in Power system
- b. Explain working of different types of circuit breakers in power system.
- c. Explain working of different types of relays in power system.
- d. Maintain the protection of transmission line and feeder from various faults
- e. Protect transformer, alternator, motor and bus bar
- f. Protect power system against over voltages

IV. COURSE OUTCOMES:

At the end of the course the student will be in a position to

S. No	Description	Bloom's taxonomy level
CO1	Student will be able to Describe circuit breakers, electromagnetic and static relays	REMEMBER L1 , UNDERSTAND L2, EVALUATE L5, CREATE L6
CO2	Student will be able to Illustrate different protection schemes of generator and transformer	REMEMBER L1 , UNDERSTAND L2, EVALUATE L5
CO3	Student will be able to Illustrate different protection schemes of feeder and bus—bar	REMEMBER L1 , UNDERSTAND L2, EVALUATE L5
CO4	Student will be able to Differentiate different grounding practices	REMEMBER L1 , UNDERSTAND L2
CO5	Student will be able to Illustrate different protection schemes against over voltages	REMEMBER L1 , UNDERSTAND L2, EVALUATE L5, CREATE L6
CO6	Student will be able to identify rotor, stator faults, inter turn faults and their protection.	UNDERSTAND L2



V. HOW PROGRAM OUTCOMES ARE ASSESSED

Program Outcomes		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.	3	Assignments, Mock tests
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, Mock tests
PO3	Design/development of solutions: 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.	2	Assignments, Mock tests
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Assignments, Mock tests
PO5	Modern tool 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	Assignments, Mock tests
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, Mock tests
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.	-	-

1: Slight (Low)

2: Moderate (Medium)

3: Substantial (High)

- : None

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		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	1	Assignments, Mock tests
PSO2	Skillful to use application and control techniques for research and advanced studies in Electrical and Electronics engineering domain	1	Assignments, Mock tests

1: Slight (Low)

2: Moderate (Medium)

3: Substantial (High)

- : None

VII. COURSE CONTENT:

JNTUH SYLLABUS

UNIT – I

Circuit Breakers

Circuit Breakers: Elementary principles of arc interruption, Recovery, Restriking Voltage and Recovery voltages. - Restriking Phenomenon, Average and Max. RRRV, Numerical Problems - Current Chopping and Resistance Switching - CB ratings and Specifications: Types and Numerical Problems. – Auto reclosures. 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. **Relays Classification:** Instantaneous, DMT and IDMT types-Application of relays: Over current/ under voltage relays-Direction relays, Differential Relays, Percentage Differential relays-Universal Torque Equation-**Distance Relays:** Impedance Relay-Reactance Mho Relay-Off-set Mho Relays-Characteristics of Distance Relays and Comparison-Static Relays verses Electromagnetic Relays.

UNIT – III



Generator & Transformer Protection

Protection of generators against Stator faults-Rotor faults-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

UNIT –IV

Feeder and Bus-Bar protection & Grounding:

Introduction-Over Current, Carrier Current-Three-zone distance relay protection using Impedance relays-Translay Relay-Protection of Bus bars-Differential Protection

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

UNIT – V

Protection against Over Voltages

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: Principles of over-current, differential and distance protection; solid state relays and digital protection; circuit breakers

IES SYLLABUS: Power system Protection Circuit breakers

VIII. LESSON PLAN-COURSE SCHEDULE:

Lect.No.	Week No.	TOPIC	Course Learning Outcomes	Reference
UNIT – 1				
1.	1	Elementary principles of arc interruption	understand basic theory of arc	Text Book No. 3,7
2.		Recovery, Restriking Voltage and Recovery voltages.	analyse rrrv	
3.		Restriking Phenomenon, Average and Max. RRRV	analyse rrrv	
4.		Numerical Problems , Current Chopping	evaluate rrrv	
5.	2	Resistance Switching, CB ratings and Specifications	understand resistance switching	
6.		Types and Numerical Problems	evaluate	
7.		CB ratings and Specifications , Auto reclosures		
8.		Types of CBs, Description & operation of Minimum Oil Circuit Breakers	distinguish types of circuit breakers	
9.	3	Description & operation of Air Blast Circuit Breakers	discuss operation of air blast circuit breakers	
10.		Description & operation of Vacuum Circuit Breakers	discuss operation of vaccum circuit breakers	



11.		Description & operation of SF6 Circuit Breakers, Numerical problems	solving various problems related to cbs	
		<i>Mock Test – I</i>		
UNIT – 2				
12.	4	Principle of Operation and Construction of Attracted armature	Understand the principle of operation of attracted armature.	Book No. 4,7
13.		Balanced Beam, induction Disc and Induction Cup relays.	discuss balanced beam, induction disc and induction cup relays.	
14.		Relays Classification: Instantaneous, DMT and IDMT types	distinguish various types of relays.	
15.		Application of relays: Over current/ Under voltage relays	analyse types of relays.	
		<i>Tutorial / Bridge Class # 1</i>		
16.	5	Direction relays, Differential Relays, Percentage Differential relays	understand the principles of various relays	
17.		Universal Torque Equation	analyse ute	
18.		Distance Relays: Impedance Relay	understand distance relay	
19.		Reactance Mho Relay	understand reactance mho relay	
			<i>Tutorial / Bridge Class # 2</i>	
20.	6	Off-set Mho Relays	understand off-set mho relays	
21.		Characteristics Of Distance Relays and Comparison	understand characteristics of distance relays	
22.		Static Relays verses Electromagnetic Relays.	understand static relay vs emr	
23.		Revision		
			<i>Tutorial / Bridge Class # 3</i>	
UNIT – 3				
24.	7	Protection of generators against Stator faults	analyse faults	Text Book No. 5,7
25.		Rotor faults	analyse rotor faults	
26.		Abnormal Conditions	analyse	
27.		Restricted Earth fault protection	analyse earth fault protection	
28.		<i>HVDC Circuit Breaker(CBS-1)</i>	understand hvdc cb	
29.	8	Inter-turn fault Protection	analyse inter turn faults	



30.		Numerical Problems on % Winding Unprotected	analyse	
31.		Revision		
32.		Revision		
		Tutorial / Bridge Class # 4		
I Mid Examinations (Week 9)				
UNIT – 3 Contd.				
33.	10	Percentage Differential Protection	analyse % differential protection	Text Book No. 1, 3,7
34.		Numerical Problem on Design of CT s Ratio,	analyse	
35.		Buchholtz relay Protection	analyse	
36.		Numerical Problems	analyse	
		Tutorial / Bridge Class # 5		
UNIT – 4				
37.	11	Introduction, Over Current, Carrier Current	understand over current ,carrier current	Text Book No. 2,7
38.		Three-zone distance relay protection using Impedance relays	understand three zone relay	
39.		Three-zone distance relay protection using Impedance relays	understand three zone relay	
40.		Translay Relay	understand translay relay	
41.		Microprocessor based Relays(CBS-2)	understand	
42.	12	Protection of Bus bars	understand protection of busbars	
43.		Differential Protection, Numerical Problems	understand differential protection	
44.		Grounded and Ungrounded Neutral Systems	understand	
45.		Effects of Ungrounded Neutral on system performance	understand ungrounded neutral system	
		Tutorial / Bridge Class # 6		
46.	13	Methods of Neutral Grounding	understand methods of grounding	
47.		Solid, Resistance, Reactance, Arcing grounds	understand	
48.		Grounding Practices, Numerical Problems	understand grounding practices	
49.		Revision		
		Mock Test – II		
UNIT – 5				
50.	14	Generation of Over Voltages in Power	understand generator	Book No.



		Systems	protection	1, 2, 7
51.		Protection against Lightning Over Voltages	understand protection against lightning	
52.		Valve type	understand valve type	
53.		Zinc-Oxide Lighting Arresters	understand zinc-oxide lighting arresters	
		Tutorial / Bridge Class # 7		
54.	15	Insulation Coordination –BIL	understand insulation coordination	
55.		Impulse Ratio	understand impulse ratio	
56.		Standard Impulse Test Wave	understand standard impulse test wave	
57.		Volt-Time Characteristics	understand volt-time characteristics	
58.		Protection of induction motor(CBS-3)	understand	
59.	16	Numerical problems	analyse	
60.		Numerical problems	analyse	
61.		Revision		
62.		Revision		
63.		Advanced Modern relays for Power system Protection(CBS-4)	Learn advanced knowledge of modern relays.	
64.	17	Revision	-	
65.		Revision	-	
66.		Revision	-	
67.		Revision	-	
		Tutorial / Bridge Class # 8		
II Mid Examinations (Week 18)				

Note: CBS means Content beyond Syllabus

SUGGESTED BOOKS:

TEXT BOOK:

1. Switchgear and Protection – by Sunil S Rao, Khanna Publishers.
2. Power System Protection and Switchgear by Badari Ram , D.N Viswakarma, TMH Publications

REFERENCES:

3. Transmission network Protection by Y.G. Paithankar, Taylor and Francis, 2009.
4. Power system protection and switch gear by Bhuvanesh Oza, TMH, 2010.
5. Electrical Power Systems – by C.L.Wadhwa, New Age international (P) Limited, Publishers, 3rd edition
6. Electrical power System Protection by C. Christopoulos and A. Wright, 2nd Edition, Springer International Edition



7. Electrical Power Systems by V.K.Mehta, Volume-II.

Special books to gain in depth Concept:

1. Power System protection by P.M.Anderson
2. Power System protection & switchgear by Bhuvaneshwar oza, Nirmal kumar Nair

IX.MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CO's	Program Outcomes (PO's)												Program Specific Outcomes (PSO's)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
	3	2	2	2	1			3			2		3	2
	2		3	1	2	2		2				2	2	2
	2	3	2			3					2			1
		2		3	2			2			1		3	
	2		3		1	2		3			2	2		2
	2	2	2	3	2	2		2					2	2

1: Slight (Low)

2: Moderate (dium)

3: Substantial (High)

-:None

QUESTION BANK: (JNTUH)

DESCRIPTIVE QUESTIONS:

UNIT-I

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Discuss the average and max RRRV	CREATE L6	C01
2	Explain the elementary principles of arc interruption?	UNDERSTAND L2	C01
3	Explain about classification of circuit breakers?	UNDERSTAND L2	C01
4	Explain the differences between minimum and bulk oil circuit breakers?	UNDERSTAND L2	C01
5	Discuss about auto reclosures?	CREATE L6	C01

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Write short notes on the rate of restripping voltage and explain its importance in arc extinction?	UNDERSTAND L2	C01
2	Discuss the merits and demerits of vacuum circuit	CREATE L6	C01



	breakers?		
3	What are the key features of SF6 Circuit Breaker over other circuit breakers?	REMEMBER L1	C01
4	Write short notes on the maintenance of Oil circuit breaker?	UNDERSTAND L2	C01
5	Discuss the merits and demerits of vacuum circuit breakers?	CREATE L6	C01
6	Explain in detail about Air blast circuit breakers?	UNDERSTAND L2	C01
7	Explain the ratings of circuit breakers with necessary derivations?	UNDERSTAND L2	C01
8	Briefly discuss the arc extinction methods in circuit breaker?	CREATE L6	C01
9	Discuss in detail about auto reclosures and their types?	CREATE L6	C01
10	Derive and explain about RRRV?	EVALUATE L5	C01

UNIT-2

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	What are the characteristics of distance relays and also compare them?	REMEMBER L1	C01
2	Explain the terms a) Pickup level b) operating time c) under reach d) over reach	UNDERSTAND L2	C01
3	Classify the relays based on application?	UNDERSTAND L2	C01
4	Explain about IDMT relay?	UNDERSTAND L2	C01
5	What are offset mho relays?	REMEMBER L1	C01

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain the Principle of Operation and Construction of Attracted armature type of relay?	UNDERSTAND L2	C01
2	Briefly explain the classification of Electromagnetic relays with neat sketch?	UNDERSTAND L2	C01
3	In detail explain about Instantaneous, DMT and IDMT types with neat diagrams?	UNDERSTAND L2	C01
4	Explain the advantages of reactance relay from universal torque equation?	UNDERSTAND L2	C01



5	What is the differential protection of relays?	REMEMBER L1	C01
	Explain about static and microprocessor relays in detail?	UNDERSTAND L2	C01
7	Derive and explain universal torque equation?	EVALUATE L5	C01
8	Explain about the mho relay and its application with diagram?	UNDERSTAND L2	C01
9	In detail explain about percentage differential protection of relays?	UNDERSTAND L2	C01
10	Explain about types of distance relays and briefly explain impedance relay in detail?	UNDERSTAND L2	C01

UNIT-3

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	What is a Buchholtz relay?	REMEMBER L1	CO2
2	Explain about restricted earth fault in alternators?	UNDERSTAND L2	CO2
3	What is the differential protection of transformers?	REMEMBER L1	CO2
4	Explain about inter turn protection of alternators?	UNDERSTAND L2	CO2
5	What is the differential protection of alternators?	REMEMBER L1	CO2

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Draw the connection diagram of a differential relay for the protection a star-delta transformer. How does bias the winding of a differential relay restricts malfunctioning of the relay against (a) CT mismatch (b) On load changing and (c) Magnetizing current?	REMEMBER L1	CO2
2	Describe how protection is provided in large turbo-alternators against earth-Fault in the rotor?	UNDERSTAND L2	CO2
3	Explain how the inclusion of a resistance in the neutral earthling circuit of an alternator affects the performance of the differential protection of the three- phase stator.	UNDERSTAND L2	CO2
4	What is magnetizing Inrush current? What is the principle used to make a differential relay insensitive to magnetizing inrush current?	REMEMBER L1	CO2
5	Explain the protection scheme for internal faults of a transformer?	UNDERSTAND L2	CO2



6	Discuss the unbalanced loading and overload protection in alternators. Overload protection is not necessary for alternators? Justify yourself?	UNDERSTAND L2	CO2
7	Prove that the restricted earth fault relay does not operate for faults beyond the star connected winding of a 3-phase delta-star transformer?	EVALUATE L5	CO2
8	What factors cause spill current on external fault in case of transformer differential protection?	REMEMBER L1	CO2
9	Explain the protection of alternators against stator faults?	UNDERSTAND L2	CO2
10	Explain the percentage differential protection of alternators?	UNDERSTAND L2	CO2

UNIT-4

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	What is back up protection of bus bars?	REMEMBER L1	CO3
2	What is over and carrier current?	REMEMBER L1	CO3
3	Explain about arcing grounds?	UNDERSTAND L2	CO4
4	Explain the types of neutral groundings?	UNDERSTAND L2	CO4
5	Write a short note on differential protection of bus bars?	UNDERSTAND L2	CO3

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain with the aid of circuit and phasor diagrams the function of a Peter-son coil in a 3-phase system. What are permissible practical deviations from resonance in the tuning of the Peterson coil?	UNDERSTAND L2	CO4
2	What are the various methods of neutral grounding?	REMEMBER L1	CO4
3	Derive the expression for torque developed by a double activating quantity distance relay. Show that the relay operates when fault is within the protected distance of line.	EVALUATE L5	CO3
4	Discuss about effectively grounded system and ungrounded system.	UNDERSTAND L2	CO4
5	A 132 kV, 3-Phase, 50Hz, 100km long transmission line has a capacitance of $0.012\mu\text{F}$ per km per phase. Determine the inductive reactance and kVA rating of the arc suppression coil suitable	EVALUATE L5	CO3



	for this line.		
6	Derive the expression for torque developed by a double activating quantity distance relay. Show that the relay operates when fault is within the protected distance of line?	EVALUATE L5	CO3
7	Explain the three zone protection using impedance relay?	UNDERSTAND L2	CO3
8	Explain in detail about Translay scheme?	UNDERSTAND L2	CO3
9	Explain bus bar protection need special attention. Why?	UNDERSTAND L2	CO3
10	Discuss with a neat sketch the general principle of operation of a distance protection scheme?	UNDERSTAND L2	CO3

UNIT-5

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain types of over voltages in power systems?	CREATE L6	CO5
2	What is impulse ratio?	REMEMBER L1	CO5
3	What are transients?	REMEMBER L1	CO5
4	Explain about valve type arresters?	UNDERSTAND L2	CO5
5	What is insulation coordination?	REMEMBER L1	CO5

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain clearly with neat diagram different types of lightning arresters?	UNDERSTAND L2	CO5
2	State the various causes of over voltages in a power system?	REMEMBER L1	CO5
3	Explain the working of types of lightning arresters: (a) Rod gap (b) Horn gap (c) Multi gap (d) Expulsion type	UNDERSTAND L2	CO5
4	Explain how over voltages are generated in power system?	UNDERSTAND L2	CO5
5	Explain briefly about zinc oxide lightning arresters?	UNDERSTAND L2	CO5
6	Draw and explain about volt time characteristics?	REMEMBER L1	CO5



7	In detail explain about insulation coordination-BIL?	UNDERSTAND L2	CO6
8	Explain about impulse ratio and impulse test wave with its characteristics?	UNDERSTAND L2	CO5
9	What are switching surges in power systems?	REMEMBER L1	CO5
10	What are transient over voltages in power systems?	REMEMBER L1	CO5

OBJECTIVE QUESTIONS:

JNTUH:

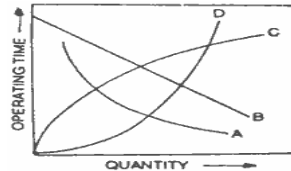
UNIT-1

- Sparking between the contacts can be reduced by inserting:
 - A capacitor in parallel with the contacts
 - A capacitor in series with the contacts
 - A resistor in the line
 - A reactor in the line
 Ans: **A**
- The contact resistance is least affected by:
 - Shape of the contact faces
 - Ambient temperature
 - Mechanical forces applied
 - Amount of surface commutation
 Ans: **B**
- The arc voltage produced in an ac circuit breaker is always:
 - In phase with the arc current
 - Lagging the arc current by 90 deg
 - Leading the arc current by 90 deg
 - In phase opposition with the arc current
 Ans: **A**
- Breaking capacity of the circuit breaker is usually expressed in:
 - MVA
 - MW
 - Kilo-Amperes
 - kV
 Ans: **A**
- Which of the following circuit breakers produce least arc energy:
 - Plain oil
 - Minimum oil
 - Air blast
 - Air break
 Ans: **C**
- Arc chutes are used in:
 - Oil circuit breaker
 - Vacuum circuit breakers
 - SF₆ circuit breakers
 - Air blast circuit breakers
 Ans: **D**
- A thermal protection switch is used to provide protection against:
 - Over load
 - Temperature
 - Short circuit
 - Over voltage
 Ans: **A**
- A circuit breaker is
 - Power factor correcting device
 - A device to neutralize the effect of transients
 - A waveform correcting device
 - A current interrupting device.
 Ans: **D**
- The fault clearing time of a circuit breaker is usually
 - Few minutes
 - Few seconds
 - one second
 - Few cycles of supply voltage.
 Ans: **D**
- The medium employed for extinction of arc in air circuit breaker is
 - SF₆
 - Oil
 - Air
 - Water.
 Ans: **C**

UNIT-2

- Relay contacts are normally made up of:
 - Silver contacts
 - Copper contacts
 - Aluminum contacts
 - Lead contacts
 Ans: **A**

2. The most efficient torque-producing actuating structure for induction type relays is:
 a) Shaded pole structure b) Watt-hour meter structure
 c) Induction cup structure d) Single induction cup structure Ans: C
3. Impedance relays can be used for:
 a) Phase faults only b) Earth faults only
 c) Both earth and phase faults d) None of the above Ans: C
4. Thermal relays are used for the protection of motors against over-current owing to:
 a) Short circuit b) Heavy loads
 c) Earth fault d) All the above Ans: B
5. The relay used for the feeder protection is:
 a) Under-voltage relay b) Translay relay
 c) Thermal relay d) Buchholz relay Ans: B
6. The values of fault current depend on
 (A) voltage at the faulty point (B) total impedance up to the fault
 (C) both (A) and (B) above (D) none of the above Ans: C
7. The function of protective relay in a circuit breaker is
 (A) to each any stray voltages
 (B) to close the contacts when the actuating quantity reaches a certain predetermined value
 (C) to limit arcing current during the operation of circuit breaker
 (D) to provide additional safety in the operation of circuit breaker. Ans: B
8. A relay used for protection of motors against overload is
 (A) Impedance relay (B) Electromagnetic attraction type
 (C) Thermal relay (D) Buchholz's relay Ans: C
9. Which curve in the figure represents inverse time characteristics?



- (A) Curve A (B) Curve B (C) Curve C (D) Curve D. Ans: A
10. Match the following:
- | Relay | Operation |
|------------------------|---|
| (a) Static relay | (i) Responds to vector difference between two electrical quantities |
| (b) Over current relay | (ii) Quick operation |
| (c) Differential relay | (iii) Responds to increase in current |
| (d) Instantaneous | (iv) No moving parts relay |
- (A) a - (i), b- (ii), c - (iii), d - (iv) (B) a - (iv), b - (iii), c - (i), d- (iv)
 (C) a - (ii), b - (i) c- (iii), d - (iv) (D) a - (iii), b - (ii), c - (i), d - (iv). Ans: B

UNIT-3

1. Buchholz relay is:
 a) Located in the conservator tank



- b) Located in the transformer tank itself
 c) Connected in the pipe connecting main tank of transformer and conservator
 d) Installed in the circuit breaker **Ans: C**
2. Thermal relays are used for the protection of motors against over-current owing to:
 a) Short circuit b) Heavy loads
 c) Earth fault d) All the above **Ans: B**
3. Which of the following relays is used on transformers?
 (A) Buchholz relay (B) MHO relay
 (C) Merz price relay (D) None of the above **Ans: A**
4. Merz-price protection is used on
 (A) Substations (B) Capacitor bank
 (C) Induction motor (D) Generators. **Ans: D**
5. Match the following:

	Symbol		Equipment
(a)		(i)	Current transformer
(b)		(ii)	Lighting arrester
(c)		(iii)	Earthing switch
(d)		(iv)	Isolator.

- (A) a - (i), b - (ii), c - (iii), d - (iv) (B) a - (ii), b - (iii), c - (i), d - (iv)
 (C) a - (iii), b - (i), c - (iv), d - (ii) (D) a - (iv), b - (iii), c - (ii), d - (i).
Ans: D
6. Any winding of a power transformer develops short circuit owing to:
 a) Loose connections b) Insulation failure
 c) Impulse voltage d) Mechanical vibration **Ans: C**
7. For ground fault, which of the relay is preferred:
 a) Plain impedance relay b) Directional relay
 c) Reactance relay d) Over-current relay **Ans: C**
8. The short circuit current of an alternator, inc case of line to line fault depends on its:
 a) Short circuit resistance b) Transient reactance
 c) Synchronous reactance d) None of the above **Ans: C**
9. Over-current protection for motor is provided by
 (A) Cartridge fuses (B) High resistance fuses
 (C) Over-current relay (D) all of the above. **Ans: C**
10. In which method of starting a motor, the starting current is the maximum?
 (A) Auto-transformer (B) Star-delta starter
 (C) Stator rotor starter (D) Direct-on-line. **Ans: D**

UNIT -4

1. The relay best suited for phase fault relaying for medium transmission lines is:
 a) Mho relay b) Reactance relay
 c) Impedance relay d) None of the above **Ans: C**



2. The relay used for the feeder protection is:
a) Under-voltage relay b) Translay relay
c) Thermal relay d) Buchholz relay **Ans: B**
3. Mho relay have an R-X characteristics depicted by:
a) A straight line passing through origin b) A straight line parallel to X-axis
c) A straight line parallel to R-axis d) A circle passing through the origin **Ans: D**
4. Solid ear thing is provided for the voltage below:
a) 100 kV b) 600 V c) 11 kV d) 66 kV **Ans: B**
5. The advantage of neutral ear thing is
a) Simplified design of earth fault protection
b) Over-voltages due to lightning can be discharged to the earth
c) Freedom from persistent arcing grounds d) all of the above. **Ans: D**
6. The disadvantage offered by ungrounded systems is
(A) Frequent arcing grounds (B) Difficult earth fault relaying
(C) Voltage oscillations (D) all of the above **Ans: D**
7. Resistance grounding is used for voltages
(A) Below 220 V (B) Up to 660 V
(C) Between 3.3 kV to 11 kV (D) Above 66 kV **Ans: C**
8. Series reactors are installed at strategic locations of power systems to
(A) Bring down the fault level within the capacity of switchgear
(B) Directly pass the fault surges to ground
(C) Pass neutralizing surges of opposite nature
(D) Discharge the capacitors. **Ans: A**
9. In which portion of the transmission system faults occur most frequently?
(A) Transformers (B) Overhead lines
(C) Alternators (D) Underground cables. **Ans: B**
10. Differential protection principle is used in the protection of
(A) Generators (B) Transformers
(C) Feeders (D) all of the above. **Ans: D**

UNIT -5

1. A lightning arrester connected between the line and earth in a power system
a) Protects the terminal equipment against travelling surges
b) Protects the terminal equipment against lightning strokes
c) Suppresses the high frequency oscillations in the line
d) Reflects back the travelling waves approaching it **Ans: A**
2. The over-voltage surges in power systems may be caused by
(A) Lightning (B) Switching
(C) Resonance (D) Any of the above. **Ans: D**
3. The protection against over-voltage due to lightening is provided by
(A) Use of surge diverters (B) Low tower footing resistance
(C) Use of overhead ground wires (D) Any of the above **Ans: D**
4. Over-voltage transients may occur due to



- (A) Lightning (B) Switching
(C) Arcing grounds (D) Any of the above. Ans: **D**
5. Which of the following protective devices can be used against lightning surges?
(A) Horn gap (B) Surge diverters
(C) Lightning arresters (D) Any of the above. Ans: **D**
6. Switching surges may be caused by
(A) Closing of unchanged line (B) Load shedding at receiving end of line
(C) Switching of magnetizing current (D) Any of the above Ans: **D**
7. The surge impedance of under-ground cables is of the order of
(A) 20 to 60 ohms (B) 200 to 600 ohms
(C) 2 k ohm to 5 k ohm (D) 20 k ohm to 60 k ohm. Ans: **A**
8. Surge impedance of over-head transmission lines is of the order of
(A) 20 to 30 ohms (B) 300 to 500 ohms
(C) 3000 to 5000 ohms (D) 30 k ohm to 60 k ohm. Ans: **B**
9. Surge modifiers are used to
(A) Reduce the current of wave-front (B) Reduce the voltage of wave-front
(C) Reduce the steepness of wave-front (D) Modify the shape of wave-front. Ans: **C**
10. Switching over-voltages are more hazardous than lightning surges in case of
(A) Low voltage systems (B) 11 kV systems
(C) Unbalanced systems (D) EHV and UHV systems. Ans: **D**

GATE:

1. Which of the following circuit breaker can be installed on 400 kV line
(A) Tank type oil circuit breaker (B) Miniature circuit breaker
(C) Vacuum circuit breaker (D) Air blast circuit breaker. Ans: **D**
2. In a vacuum circuit breaker, the vacuum is of the order of
(A) 10mm Hg (B) 10^{-2} mmHg (C) 10^{-6} mmHg (D) 10^{-9} mmHg.
Ans: **D**
3. Using factor for a HRC fuse is
(A) Minimum fusing current / Current rating
(B) Minimum fusing current / Minimum rupturing time
(C) Maximum fusing current / Minimum fusing current
(D) Minimum fusing current / Prospective current of circuit. Ans: **A**
4. Which of the following circuit breakers does not use pneumatic operating mechanism
(A) Air blast circuit breaker (B) SF₆ blast circuit breaker
(C) Air break circuit breaker (D) Bulk-oil circuit breaker. Ans: **D**
5. The insulation resistance of high voltage circuit breaker is
(A) 1k Ohm (B) 10 k Ohm
(C) 20 Mega ohms (D) 2000 Mega ohm. Ans: **D**



6. The normal frequency rms voltage that appears across the breaker poles after final arc extinction has occurred, is
(A) Recovery voltage (B) Re striking voltage
(C) Supply voltage (D) Peak voltage. **Ans: A**
7. The transient voltage that appears across the contacts at the instant of arc extinction is called
(A) Recovery voltage (B) Re striking voltage
(C) Supply voltage (D) Peak voltage. **Ans: B**
8. The power factor of the arc in circuit breaker is
(A) Always zero (B) Always unity
(C) Always lagging (D) Always leading. **Ans: B**
9. In a circuit breaker the lime duration from the instant of the fault to the extinction of arc is known as
(A) Operation time (B) Total clearing time
(C) Lag time (D) Lead time. **Ans: B**
10. For high speed circuit breakers the total lime is nearly
(A) 1/2 cycle (B) 1 cycle
(C) Few cycles (D) 10 cycles. **Ans: A**
11. Insulation resistance of HV circuit breaker is more than
(A) 100 Ohms (B) 1 M Ohms
(C) 500 ohms (D) 100M Ohms **Ans: D**

ESE:

1. The isolator is interlocked with circuit breaker and ear thing switch. While opening the circuit opens first, then the and only after this the..... can close
(A) Isolator circuit breaker..... earthing switch
(B) Earthing switch isolator..... circuit breaker
(C) Circuit breaker..... ear thing switch isolator
(D) Circuit breaker..... Isolator..... Earthing switch **Ans: D**
2. Over-current protection for motor is provided by
(A) Cartridge fuses (B) High resistance fuses
(C) Over-current relay (D) all of the above **Ans: C**
3. Which statement is correct?
(A) SF₆ gas is nontoxic (B) SF₆ gas is lighter than air
(C) SF₆ gas has pungent smell (D) SF₆ gas is yellow in colour. **Ans: A**
4. The surge impedance, of a transmission line is given by
(A) $(LC)^{1/2}$ (B) $(C/L)^{1/2}$ (C) $(L/C)^{1/2}$ (D) $(L+C)^{1/2}$ **Ans: C**
5. In the circuit breaker, the arcing contacts are made of
(A) Electrolytic copper (B) Copper tungsten alloy
(C) Aluminium alloy (D) Porcelain. **Ans: B**



6. Switching over-voltages are more hazardous than lightning surges in case of
(A) Low voltage systems (B) 11 kV systems
(C) Unbalanced systems (D) EHV and UHV systems. Ans: **D**
7. In which portion of the transmission system faults occur most frequently?
(A) Transformers (B) Overhead lines
(C) Alternators (D) Underground cables. Ans: **B**
7. Bulk-oil circuit breaker is suitable for voltages up to
(A) 10kV (B) 16 kV (C) 26 kV (D) 36 kV. Ans: **D**
8. A bimetal strip consists of two metal strips have different
(A) Thermal diffusivity (B) Thermal conductivity
(C) Specific heat (D) Coefficient of expansion. Ans: **D**
9. For the same current, which of the following fuse wires will have the least fusing time?
(A) 18 SWG TIN - 12.5 A (B) 20 SWG TIN - 10 A
(C) 22 SWG TIN-7.5 A (D) 24 SWG TIN-5 A. Ans: **D**
10. An automatic device that operates at present values is known as
(A) Mercury switch (B) Relay (C) Fuse (D) Contactor. Ans: **B**

WEBSITES:

1. www.electrical4u.com/electrical-switchgear-protection
2. www.systemcontrols.co.in
3. <https://en.wikipedia.org/wiki/Switchgear>

EXPERT DETAILS:

1. Dr.Siva Sarma DVSS, Prof at NIT Warangal
2. Dr.Ravi Kumar Bhima Singhu, IIT Hyderabad
3. Dr.Surya kalavathi, Professor-JNTUH (EEE).
4. Y.Naresh, teaching faculty-Made easy GATE & IES academy (Jaipur).

JOURNALS:

1. Springer Journal of Protection and control of modern power systems
2. Protection & Control Journal-GE Grid solutions.
3. CPRI Journal
4. International Journal of Electrical and Electronics Engineering.
5. Institute of Electrical and Electronics Engineer (IEEE Explorer)

LIST OF TOPICS FOR STUDENT SEMINARS:

1. Types of circuit breakers
2. Merz prize circulating scheme
3. Concept of neutral grounding
4. Types of relays based on operation
5. Types of relays based on construction
6. Recent technologies in circuit breakers
7. Protection against over voltages
8. Types of lightening arresters

CASE STUDIES / SMALL PROJECTS



1. Check the Polarity of Current Transformer and Potential Transformer and connect it with the relay
2. Draw schematic diagram of protective schemes for 66 KV/ 132 KV/220 KV Substation nearby area
3. Test static relay for the protection of motor
4. Set up a Horn gap lightning arrester
5. Test overload relay and plot Time-Current characteristic
6. Over current and under voltage protection schemes
7. Over or under frequency protection schemes
8. Directional over current protection relay characteristics
9. Power Reverse relay protection schemes
10. earth fault relay protection schemes
11. Differential relay protection schemes
12. Digital relay and design of distance protection schemes
13. Study of MCB, Characteristics of HRC fuse, Visit report on protection schemes in substation
14. Simulation exposure of switchgears and protection schemes
15. Study of industrial circuit breaker and testing