



SWITCH GEAR & PROTECTION

Subject Code : EE603PC

Regulations : R16 - JNTUH

Class : III Year B.Tech EEE II Semester



Department of Electrical and Electronics and Engineering

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

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SWITCHGEAR GEAR 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-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Assignments
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	--
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 versus 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 Ungrounded Neutral 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):

Lectures	Week	Unit	Topics	Course Learning Outcomes	Teaching Methodologies	References
UNIT I–Circuit Breakers						
1	1	1	Necessity of switchgear protection in power system	Know about overall subject	Chalk and Talk	T1, T2 R3
2			Introduction to Circuit Breakers:	Gain the knowledge and understand about Circuit Breaker	Chalk and Talk	R3
3			Circuit Breakers: Elementary principles of arc interruption-Recovery, Restriking Voltage		Chalk and Talk	
4			Recovery voltages & Restriking Phenomenon,		Chalk and Talk	
5			Average and Maximum RRRV Numerical Problems		Chalk and Talk	
6			Current Chopping and Resistance Switching	Demonstrate and Acquire the knowledge about Restriking phenomenon.	Chalk and Talk	R3
7			CB ratings and Specifications: Types	Gain the knowledge about RRRV	Chalk and Talk	T1, T2
8			Numerical Problems Auto re-closures		Chalk and Talk	
9			3	1	Description and Operation of following types of circuit breakers: Minimum Oil Circuit breakers	Understanding the knowledge of Circuit Breaker rating



				and specification.			
10			Air Blast Circuit Breakers	Understanding the knowledge of Circuit Breaker rating and specification.	Chalk and Talk	T1,R3	
11			Vacuum circuit breakers.		Chalk and Talk		
12			SF6 circuit breakers.		Chalk and Talk		
13			Revision and Problems on Unit I	-	Chalk and Talk		
14	4		Mock Test – I	To Test the knowledge and preparing students for final examination			
UNIT – II Electromagnetic and Static Relays							
20			Principle of Operation and Construction of Attracted armature	Understanding the concept of Relays and its components	Ppt.	T1, T2, R3	
21			4	Principle of Operation and Construction of Balanced Beam	Understanding the concept of Relays and its components	Ppt.	T1, T2, R3
22				Principle of Operation and Construction of Induction Disc	Understanding the concept of Relays and its components	Ppt.	T1, T2, R3
23				Principle of Operation and Construction of Induction Cup relay	Understanding the concept of Relays and its components	Ppt.	T1, T2, R3
24	5		Types of Over Current Relays: Instantaneous	Understanding the concept of Relays and its components	Ppt.	T1, T2, R3	
25	DMT and IDMT types Over Current Relays						
26			Types of Over Current Relays: Instantaneous	Understanding the concept of Relays and its components	Ppt.		
			DMT and IDMT types Over Current Relays				
27			Application of relays	Understanding the Knowledge of Relays and its components	Chalk and Talk	T1, T2, R3	
28			Universal torque equation	To Gain the knowledge about Torque equation.	Chalk and Talk	T1, T2, R3	
			Distance relays: Impedance, Reactance				
29			6	2	Mho and Off-Set Mho relays	Understanding the concept of	Chalk and Talk



				Relays and its types		
30	7	2	Universal torque equation	To Gain the knowledge about Torque equation.	Chalk and Talk	T1, T2, R1, R3
31			Distance relays: Impedance, Reactance		Chalk and Talk	
32			Mho and Off-Set Mho relays	Understanding the concept of Relays and its types	Chalk and Talk	T1, T2, R3
33			Characteristics of Distance Relays and Comparison	To Gain the knowledge about characteristics and comparison.	Chalk and Talk	T1, T2, R2
34			Static Relays: Static Relays verses Electromagnetic Relays.	Understanding the knowledge about characteristics of static relays.	Chalk and Talk	T1, T2, R2
35			Revision and Problems on Unit II		-	Chalk and Talk
36	8	2	Slip Test – I	To Test the knowledge and preparing students for final examination		
UNIT-III Protection of Power System Equipment						
37	8	3	Protection of generators against Stator faults, Rotor faults, and Abnormal Conditions	To Understand the concept of fault in Generator.	Chalk and Talk	T1, T2, R3
38			Restricted Earth fault Protection	To Gain the knowledge about earth fault protection.	Chalk and Talk	T1, T2, R3
39			Inter-turn fault Protection	To Understand and Gain the knowledge about inter-turn fault and protection.	Chalk and Talk	T1, T2, R3
40			Numerical Problems on % Winding Unprotected	To Understand and Gain the knowledge about Fast decoupled load flow method	Chalk and Talk	T1, T2, R3
41			Numerical Problems	Applying the concepts to solve the problems	Chalk and Talk	T1, T2



MID EXAM -1 (WEEK-10)						
42	9		Protection of transformers: Percentage Differential Protection	To Know the concept of Protection of transformers	Chalk and Talk	T1, T2, R3
43						
44	10	3	Numerical Problem on Design of CT s Ratio	To Apply and Gain the Knowledge by solving different problems	Chalk and Talk	T1, T2, R2, R3
45			Buchholtz relay Protection	Understanding the knowledge of relay protection	Chalk and Talk	T1, T2, R3
46			Protection of Lines: Over Current			
47			Carrier Current relays			
48			Three-zone distance relay protection using Impedance relays	Understanding the knowledge of relay protection.	Chalk and Talk	T1, T2, R3
49	Protection of Bus bars – Differential protection.					
50	11	3	Revision and Problems on Unit II	Overview	Chalk and Talk	
UNIT IV –Neutral Grounding						
51	11		Ungrounded Neutral Systems	Understanding the knowledge of Undergrounded Neutral system	Chalk and Talk	T1, T2
52						R2
53	12	4	Effects of Ungrounded Neutral on system performance	To Understand and Gain the Knowledge about Undergrounded Neutral system	Chalk and Talk	T1, T2
54			Methods of Neutral Grounding	To Understand the concept of methods etc.	Chalk and Talk	R2
55			Tutorial / Bridge Class # 2	-		
56			Solid Grounding	Understanding the knowledge of Solid grounded	Chalk and Talk	T1, T2
57	12	4	Resistance Grounding	To Gain the Knowledge about Resistance grounding.	Chalk and Talk	T1, T2
58	13	4	Reactance - Arcing Grounds	Understand the	Chalk and	T1, T2



				Knowledge of Arc grounding.	Talk	R2
59			Grounding Practices.	To Understand and Gain the knowledge of grounding Practices.	Chalk and Talk	T1, T2
60			Revision and Problems on Unit IV	Overview	Chalk and Talk	
61			Mock Test – II	-	-	-
UNIT V –Protection against Over Voltage						
62			Generation of Over Voltages in Power Systems	To Know about generation of Over Voltages.	Chalk and Talk	T1,T2, R3
63			Protection against Lightning Over Voltages	To Understand the concept	Chalk and Talk	T1,T2, R3
64				of Protection against Lightning		
65			Valve type Lighting Arresters	Understand the knowledge of Lighting Arresters.	Chalk and Talk	T1,T2, R3
66			Zinc-Oxide Lighting Arresters	Understand the knowledge of Lighting Arresters.	Chalk and Talk	T1,T2, R3
67	14					
68			Tutorial / Bridge Class # 3	-	-	-
69			Insulation Co-ordination	Understand the concept of Insulation Co-ordination .	Chalk and Talk	T1,T2, R3
70			BIL, Impulse Ratio	To Understand the concept of Impulse Ratio.	Chalk and Talk	T1,T2, R3
71			Standard Impulse Test Wave	To Understand and Gain the knowledge of Standard Impulse Test Wave	Chalk and Talk	T1, T2, R2
72	15	5	Volt-Time Characteristics	To Understand and Gain the knowledge of Volt-Time Characteristics.	Chalk and Talk	T1, T2, R3
II Mid Examinations						
* Contents beyond syllabus						



VIII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM 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 SF ₆ 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 50 μ 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 SF ₆ 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 out of balance current of 0.5 A. Find the percentage of generator winding protected by percentage differential protection?	Solving	3
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	Applying,	4

	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?	Solving	
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 ungrounded neutral systems?	Solving	4
2	Explain effects 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.



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

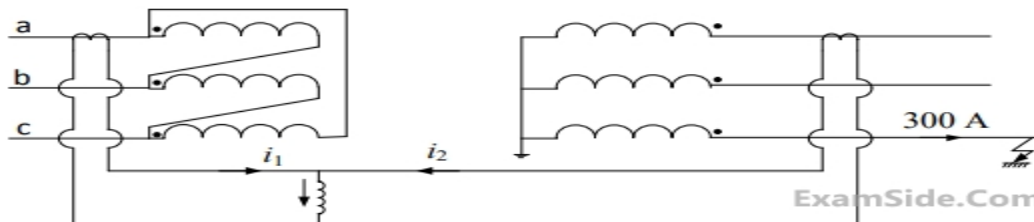
Answer. d.

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

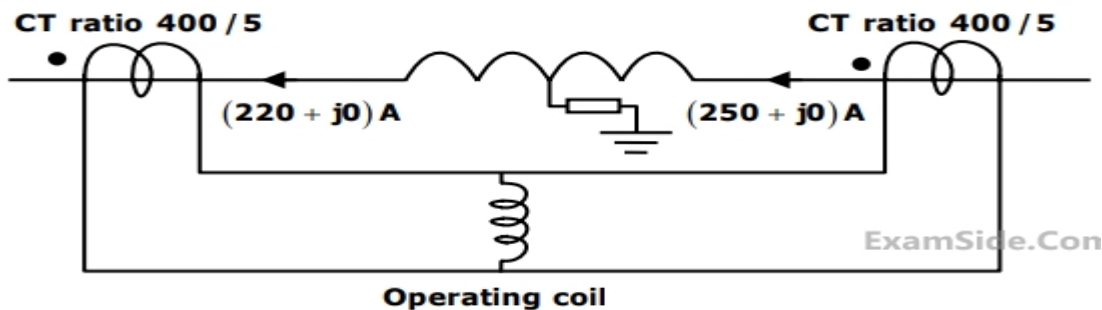
Answer.b.

GATE:

- A negative sequence relay is commonly used to protect (2011)
 - An alternator
 - A transformer
 - A transmission line
 - A busbar
- In a biased differential relay the bias is defined as a ratio of (2005)
 - Number of turns of restraining and operating coil
 - Operating coil current and restraining coil current
 - Fault current and operating coil current
 - Fault current and restraining coil current
- The transmission line distance protection relay having the property of being inherently directional is (2006)
 - impedance relay
 - MHO relay
 - OHM relay
 - reactance relay
- A 3-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 i_1 and i_2 if the fault current is 300 A as shown in figure (2015)



- $i_1 = 1/\sqrt{3}$ A, $i_2 = 0$ A
 - $i_1 = 0$ A, $i_2 = 0$ A
 - $i_1 = 0$ A, $i_2 = 1/\sqrt{3}$ A
 - $i_1 = 1/\sqrt{3}$ A, $i_2 = 1/\sqrt{3}$ 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 400/5 AA as shown. The current through the operating coil is (2011)



- 0.1875 A
- 0.2 A
- 0.375 A
- 60 kA

X.WEBITES:

- <https://nptel.ac.in/courses/108/101/108101039/>.
- <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.

