SGP HANDOUT

Course Name: SWITCHGEAR AND PROTECTION

Year/SEM: III year /IInd sem

Subject code: : RT32022

Academic Year:2017-18

Name of the Faculty: Mr. P.Subhani Khan

Preamble: In order to supply power from generating end to receiving end several equipments are connected in to the system. In order to protect the equipments and components against various operating conditions and over voltages protective devices are required to be installed in the system. Topics specified in this subject deal with various types of protective equipments and their working principle including limitations etc.

Learning objectives:

• To provide the basic principles of arc interruption, circuit breaking principles, operation of various types of circuit breakers.

• To study the classification, operation, construction and application of different types of electromagnetic protective relays.

• To explain various types of faults in generators and transformers and different types of protective schemes.

• To impart knowledge of various protective schemes used for feeders and bus bars.

• To explain the principles and operations of different types of static relays.

• To study different types of over voltages in a power system and principles of different protective schemes for insulation co– ordination.

Course Objectives:

1. To understand the principles of arc interruption for application to high voltage circuit breakers of air, oil, vacuum, SF6 gas type.
2. To understand the working principle and constructional features of different types of electromagnetic protective relays..

3. To analyze different types of faults that is observed to occur in high power generator and transformers and protective schemes used for all protections.
4. To understand various types of protective schemes used for feeders and bus bar protection.
5. To understand different types of static relays with a view to application in the system.
6. To explain the different types of over voltages appearing in the system, including existing protective schemes required for insulation co–ordination.

Syllabus:

UNIT–I: Circuit Breakers Miniature Circuit Breaker(MCB)– Elementary principles of arc interruption– Restrike Voltage and Recovery voltages– Restrike phenomenon– Average and Max. RRRV– Current chopping and Resistance switching– Introduction to oil circuit breakers– Description and operation of Air Blast– Vacuum and SF6 circuit breakers– CB ratings and specifications– Auto reclosing.

UNIT–II: Electromagnetic Protection Principle of operation and construction of attracted armature– Balanced beam– induction disc and induction cup relays– Relays classification– Instantaneous– DMT and IDMT types– Applications of relays: Over current/under voltage relays– Directional relays– Differential relays and percentage differential relays– Universal torque equation– Distance relays: Impedance– Reactance– Mho and offset mho relays– Characteristics of distance relays and comparison.

UNIT–III: Generator Protection Protection of generators against stator faults– Rotor faults and abnormal conditions– restricted earth fault and inter turn fault protection– Numerical examples. Transformer Protection Protection of transformers: Percentage differential protection– Design of CT's ratio– Buchholz relay protection–Numerical examples.

UNIT–IV: Feeder and Bus bar Protection Protection of lines: Over current– Carrier current and three zone distance relay using impedance relays–Translay relay–Protection of bus bars– Differential protection.

UNIT–V: Static and Digital Relays Static relays: Static relay components– Static over current relay– Static distance relay– Micro processor based digital relays.

UNIT–VI: Protection against over voltage and grounding 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– Grounded and ungrounded neutral systems–Effects of ungrounded neutral on system performance– Methods of neutral grounding: Solid–resistance–Reactance–Arcing grounds and grounding Practices.

COURSE OUTCOMES:

Course Code	Course Outcome	Taxonomy Level
CO32.1	understand the principles of arc interruption for application to high voltage circuit breakers of air, oil, vacuum, SF6 gas type	COMPREHENSION (TL2)
CO32.2	understand the working principle and constructional features of different types of electromagnetic protective relays	COMPREHENSION (TL2)
CO32.3	analyze different types of faults that is observed to occur in high power generator and transformers and protective schemes used for all protections.	ANALYZE (TL4)
CO32.4	understand various types of protective schemes used for feeders and bus bar protection	COMPREHENSION (TL2)
CO32.5	understand different types of static relays with a view to application in the system	COMPREHENSION (TL2)
CO32.6	To explain the different types of over voltages appearing in the system, including existing protective schemes required for insulation co–ordination.	COMPREHENSION (TL2)

CO-PO MAPPING:

Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO32.1	3	2	3			-	-	-	-		-	-
CO32.2	3	2	3			-	-	-	-	-	-	-
CO32.3	3	2	2			-	-	-	-	-	-	-
CO32.4	3		2	2		-	-	-	-	-	-	-
CO32.5	3		2		3	-	-	-	-	-	-	-
CO32.6	3	2	2			-	-	-	-	-	-	-
Average												

CO-PO mapping Reasons

Course Code	Mapping with PO	Reason
CO32.1	PO1	Obtain the fundamental knowledge of various circuit breakers
	PO2	Solutions for different types of problems of CBs
	PO3	used in the T &D systems
CO32.2	PO1	Concepts of different types of electromagnetic protective relays
	PO2	Analyzing of problems of T &D systems
	PO3	Solution for the TRANSIENT PROBLEMS
CO32.3	PO1	Fundamental knowledge of different types of faults AND protective schemes
	PO2	Analyze the problems due to faults
	PO3	Solutions to the faults in power systems
CO32.4	PO1	various types of protective schemes used for feeders and bus bar protection
	PO3	Solutions to the problems of feeders and bus bars
	PO4	Analysis of real time problems of feeders and bus bars
CO32.5	PO1	Fundamental knowledge of static relays
	PO3	Design of digital relaying schemes
	PO5	Solution to the problems by microprocessor based relaying
CO32.6	PO1	Concepts of different types of over voltages and protective schemes
	PO2	Analyze the problems of over voltages
	PO3	Solution to the problems by insulation coordination and effective grounding methods

LESSON PLAN

Faculty Name: **Mr. P.Subhani Khan** Semester: **II**

Academic Year: **2017 – 18** Class: **III B.Tech (EEE)**

Subject: **SWITCHGEAR AND PROTECTION** Regulation**: R13**

L/ T No	Topic Name	Teaching Aid	Text / REF Book	Page numbers
UNIT-I: CIRCUIT BREAKERS				
L -1	Introduction to Circuit Breakers(MCB), Elementary principles of arc interruption	GB & CP	R1,W1	346-352
L -2	Restrike Voltage and Recovery voltages	GB & CP	R1	346-348
T -1	Problems on above topics	GB & CP	R1	351-352
L-3	Restrike phenomenon	GB & CP	R1	346-352
L -4	Average and Max.RRRV	GB & CP	R1	346-352
L -5	Current chopping and Resistance switching	GB & CP	R1	352-356
L -6	Introduction to oil circuit breakers	GB&CP	R1	358
T -2	Problems on above topics	GB & CP	R1	354-355
L -7	Different oil circuit breakers	GB&CP	R1	358-364
L -8	Description and operation of Air Blast Circuit Breakers	GB & CP	R1	364-368
L -9	Vacuum and SF6 circuit breakers	GB&CP	R1	368-374
L -10	CB ratings, specifications and Auto reclosing.	GB & CP	R1	376-379 150-153
T -3	Problems on above topics	GB & CP	R1	354-355
UNIT-II: ELECTROMAGNETIC PROTECTION				
L -11	Principle of operation relays and construction of attracted armature	GB & CP	T1	5-11
L -12	Balanced beam, induction disc and induction cup relays	GB & CP	T1	5-11

L -13	Instantaneous– DMT and IDMT types	GB & CP	T1	34-37
L -14	Over current/under voltage relays	GB & CP	R1	60
T -4	Problems on above topics	GB & CP		
L -15	Directional relays	GB &CP	T1	44-49
L -16	Differential relays and percentage differential relays	GB & CP	T1	139-143
T -5	Problems on above topics			
L -17	Universal torque equation and Impedance relay	GB & CP	T1 R1,W2	10-11 95-99
L -18	Reactance relays	GB & CP	R1,W2	104-106
T- 6	Problems on above topics	GB & CP		
L -19	Mho and offset mho relays	GB & CP	R1	111-115
L -20	Characteristics of distance relays and comparison.	GB & CP	R1	117-125
T -7	Problems on above topics			
UNIT-III: GENERATOR PROTECTION & TRANSFORMER PROTECTION				
L -21	Protection of generators against stator faults	GB &CP	R1	179-186
L -22	Rotor faults and abnormal conditions	GB & CP	R1	186-193
L -23	restricted earth fault and inter turn fault protection and Numerical examples	GB & CP	T1	145-151
T- 8	Problems on above topics	GB & CP	T1	186-193
L -24	Percentage differential protection	GB & CP	R1	193-195
L -25	Design of CT's ratio	GB & CP	R1	193-195
L -26	Buchholz relay protection	GB & CP	R1	197-199
T- 9	Problems on above topics	GB & CP	T1	194-199
L -27	Numerical examples	GB & CP	T1	194-199
UNIT-IV: FEEDER AND BUS BAR PROTECTION				
L -28	Carrier current Protection	GB & CP	R1,W3	165-169
L -29	three zone distance relay using impedance relays	GB & CP	R1	169-177
L -30	Translay relay	GB & CP	R1	162-163

T- 10	Problems on above topics	GB & CP	R1	
L -31	Introduction to different faults in bus bars	GB & CP	R1	203
L -32	Protection of bus bars	GB &CP	T1	204
L -33	Differential protection.	GB & CP	R1	205
T -11	Problems on above topics	GB & CP		
UNIT–V: STATIC AND DIGITAL RELAYS				
L -34	Static relay components	GB & CP	R1,W4	54-66
L -35	Static over current relay	GB & CP	R1	87-91
T -12	Problems on above topics	GB & CP		
L -36	Static distance relay- Impedance relay	GB & CP	R1	102-103
L -37	Static Reactance relay	GB & CP	R1	106-107
L -38	Static Mho relay	GB & CP	R4	109-111
T -13	Problems on above topics	GB & CP		
L- 39	Micro processor based digital relays- over current relay and Impedance relay	GB & CP	R1	261-277
L -40	Micro processor based digital relays- Reactance relay and Mho relay	GB & CP	R1	277-292
UNIT-VI: PROTECTION AGAINST OVER VOLTAGE AND GROUNDING				
L -41	Generation of over voltages in power systems	GB & CP	R1	402-408
L -42	Protection against lightning over voltages	GB & CP	R1	402-408
L -43	Valve type lighting arresters and zinc–Oxide lighting arresters	GB&CP	T1	276-284
L -44	Insulation coordination and BIL– impulse ratio	GB & CP	R1	430
L -45	Standard impulse test wave– volt-time Characteristics	GB & CP	R1	430-432
L -46	Grounded and ungrounded neutral systems,Effects of ungrounded neutral on system performance	GB & CP	T1	266-271
L -47	Solid,Resistance and Reactance grounding	GB & CP	T1	267-272
L -48	Arcing grounds and grounding Practices	GB & CP	T1	248-249
T -14	Problems on above topics	GB & CP		

Total number classes required =64/ Total number Tutorial required =12

Note: Teaching aid: GB-Glass Board, PC-Piece of Chalk, PPT-Power Point Presentation, L-Lecture, T-Tutorial….etc

Text Books:

T1. Protection and SwitchGear by BhaveshBhalja, R.P. Maheshwari, NileshG. Chothani, Oxford University Press, 2013
T2. Power system protection- Static Relays with microprocessor applications. by T.S. Madhava Rao, TMH
T3. Electrical Power System Protection by C. CHRISTOPOULOS and A. Wright, Springer publications

Reference Books:

R1. Power System Protection and Switchgear by Badari Ram, D.N Viswakarma, TMH Publications.
R2. Fundamentals of Power System Protection by Paithankar and S.R. Bhide, PHI, 2003.
R3. Art & Science of Protective Relaying – by C R Mason, Wiley Eastern Ltd.

WEB REFERENCES:

S.No	TOPIC NAME	WEB REFERENCES
W1	Circuit breakers	https://en.wikipedia.org/wiki/Circuit_breaker
W2	Distance relays	http://www.fecime.org/referencias/npag/chap12-192-201.pdf
W3	Carrier current Protection	http://www.gegridsolutions.com/multilin/notes/artsci/art06.pdf
W4	Static relay	http://electrical-engineering-portal.com/the-solid-state-relay-static-relay-overview
W5	Micro processor based digital relays	https://en.wikipedia.org/wiki/Digital_protective_relay

UNIT-WISE QUESTIONS:

UNIT-1 -

1)a)Discuss the rate of rise of restricking voltage and explain its importance in arc extinction.
b) Explain the working of a SF6 circuit breaker.
2)a)Explain the reason for initiation of electric arc during contact separation.
b) Describe with the aid of neat sketch the working of air blast circuit breaker.
3)a)Define recovery voltage

b) Describe with the aid of neat sketch the working of an oil circuit breaker.
4)a)Define restricking voltage?
b)Describe with the aid of neat sketch the working of vaccum circuit breaker
5)a) explain about Auto reclosing.

b)Define RRRV and write a short note on Average and Max.RRRV

6)a)Explain Current chopping and Resistance switching

b) Explain Restrike phenomenon

UNIT-2

7) a) Explain the requirement of primary and back up protection in any equipment.

[b) Explain in detail about the Induction disc type relay with a neat sketch.

c)Explain the working of differential relays.

8)a) Explain the characteristics of distance relays.

b) Explain the importance of under voltage/ over voltage relays with an example for each.

9)What is universal torque equation and derive it? Using this equation derive the characteristics of (i) impedance relay (ii) reactance relay (iii) mho relay.

10)a)What are the advantages of induction cup relays over induction disc relays?

b) Explain the working of impedance relays

11)a)Why directional feature provided for impedance relay cannot be used for reactance relay?

b) Explain the working of reactance relays

12)a)What is protective relay? Give its fundamental requirements.

b) Describe the functionality of a mho relay.

c) Compare various types of distance relays.

UNIT-3

13) a) What are various faults that occur in the rotor of an alternator and how the rotor is to be protected from these faults?

b) Explain in detail about Bucholtz relay with a neat sketch.

14)a) Describe with a neat sketch the percentage differential protection of a modern alternator.

b) Explain a scheme of protection for failure of alternator excitation.

15) Discuss the different types of transformer faults. What are various protective schemes available for transformers?explain any one method?

16) Explain relaying protection of a 3 phase alternator against stator faults and rotor faults with relevant diagrams?

17)a) Explain the protective scheme for the transformer that takes care of magnetizing inrush current without affecting the sensitivity.

b)What are the difficulties experienced in differential protection of a Generator? How are they over – come?

18)With suitable diagram, describe the application of the Mertz-Price circulating current system to protect the alternator. What precautions must be taken in installing this system

UNIT 4

19a) Explain about the over current protection of bus bars with relevant connection diagram

b) Describe the protection scheme of a single feeder using Translay relay.

20 a) Elaborate on various methods for protection of feeders.

b) What is the importance of bus-bar protection?

21 a) Explain in detail about the Merz price voltage balanced system with a neat single line diagram.

b) Describe in detail the protection of parallel feeder and ring mains.

22)a) What are the advantages and disadvantages of static relays over electro mechanical relays?
b) What are the requirements of protection of lines?

23)a) Explain the zero crossing detector and sequence detectors with neat diagrams?
b) explain three zone distance relaying using impedance relays

24) explain Differential protection schemes in feeders and bus bars.

UNIT 5

25)a) Draw and explain the characteristics of static over current relays?
b) Explain the Working principle and importance of zero crossing detectors used in the static relays.

26)a) Explain the operation of static impedance relay along with its characteristics
b) Discuss the properties of static relays, its advantages?

27)a) Explain the construction and working of static distance relay.

b) Explain the different components of static relay with a neat block diagram.

28)a) Write the pseudo code for programming the distance relays on the microprocessor.

b) Explain in detail about the static over current relay.

29) Describe the basic functional blocks of a digital relay and explain Micro processor based digital relays

30)a)List the advantages and disadvantages of microprocessor based relays.

b) With the help of neat diagram explain the principle of static differential relay?

UNIT 6

31)a) Explain about the valve type and zinc oxide type lightning arresters?
b) Why is insulation coordination needed in a large power system?

32) Explain the concept of arcing grounds in the power system and derive the necessary expression

33)a) What are the causes of over voltages arising in a power system? Why is it necessary to protect the lines and other equipment of the power system against over voltages?

b) Explain the differences between grounded and un grounded neutral systems

34.a)Describe the construction, principle of operation and application of valve type lightning arrester?

b) What are the different types of grounding? Explain the reactance grounding?

35)What is the function of surge absorber? In what way it is different from lightening arrestor?

b) State the advantages of neutral grounding of an electrical system.

36)a)Give a connection diagram of typical arc suppression coil.

b)What are the methods that are used to give protection against over voltages in the power system?