MUZAFFARPUR INSTITUTE OF TECHNOLOGY, Muzaffarpur

COURSE FILE

OF

PROTECTIONS OF POWER APPARATUS AND SYSTEMS

(031713)

Faculty Name:

MR. HARI CHARAN VERMA

ASSISTANT PROFESSOR, DEPARTMENT OF ELECTRICAL ENGINEERING

Content

Govt. of Bihar

MUZAFFARPUR INSTITUTE OF TECHNOLOGY,
MUZAFFARPUR-842003

(Under the Department of Science & Technology Govt. of Bihar, Patna)

VISION STATEMENT OF ELECTRICAL ENGINEERING DEPARTMENT

To produce cutting edge Electrical Engineers, innovators, researchers, and entrepreneurs with high human values to serve society, industry, nation and the world.

MISSION STATEMENT OF ELECTRICAL ENGINEERING DEPARTMENT

M1. To create state-of-the-art facilities for under-graduate, post- graduate and R&D work.

M2. To cater the needs of society with recent technologies, innovative ideas and inculcate ethical responsibilities.

M3. To develop strong collaborative links with premier industries, institutions and the government agencies.

Program Educational Objectives (PEOs) of Electrical Engineering Department:

PEO 1. Students will be able to engage in life-long learning and research including supportive and responsible roles on multi-disciplinary tasks.

PEO 2. Students will acquire, use and develop skills as required for effective professional and societal practices and leadership quality.

PEO 3. Students will be able to create a new dimension of innovation and entrepreneurship.

Program Outcomes (POs) based on Program Educational Objectives (PEOs) of Electrical Engineering Department:

PO 1. Students will be able to apply knowledge of applied mathematics & science in electrical engineering problems.

PO 2. Students will be able to identify, formulate and solve society and industries related problems.

PO 3. Students will be able to apply knowledge to design a system, component or process to meet desired needs within realistic constraints.

PO 4. Students will be able to conduct laboratory experiments and to critically analyze and interpret experimental data.

PO 5. Students will be able to use the recent techniques, skills, and modern tools necessary for engineering practices.

PO 6. Students will be able to understand the impact of engineering problems, solutions in a global and societal context.

PO 7. Students will be able to demonstrate professional and ethical responsibilities.

PO 8. Students will be able to apply leadership quality to work with team in the area of electrical engineering towards the solution of multi-disciplinary tasks.

PO 9. Students will be able to communicate effectively through verbally, technical writing, reports and presentation.

PO 10. Students will be able to develop confidence for self-education and ability to engage in life-long learning.

COURSE OBJECTIVE AND COURSE OUTCOMES:

Institute/college Name	Muzaffarpur Institute of Technology, Muzaffarpur
Program Name	B.E. Electrical (VII semester)
Course Code/course credits	031713(5)
Course Name	**Protections of Power Apparatus and Systems**
Lecture/ Sessional (per week)	3/2
SEE duration	9 hours
Course Coordinator Name	Mr. Hari Charan Verma

Course objective:

This course is designed to know about the fundamentals of Switchgear & Protection System of Power Systems within the Electrical Engineering curriculum. Students will know about the need of protection of electric equipment and their protection schemes. They can understand the operations & characteristics of various types of electromagnetic relay, static relay & Circuit Breaker. This will help the student to understand the basic facts of electrical power system protection and to develop their career in future in Power System Engineering.

Course outcomes (CO):

CO1: Identify various types of faults in Power system. Select suitable switchgears for different applications

CO2: Explain the working of different types of switchgear equipment's like circuit breakers and relays. Design the ratings for fuses according to the requirement.

CO3: Explain various protection schemes of various power system components like alternators, motors, feeders, transformers and bus-bars.

CO4: Explain various methods to protect power system against over voltages

MAPPING OF COs AND POs

Sr. No.	Course Outcome	PO
1.	CO1: Identify various types of faults in Power system. Select suitable switchgears for different applications	PO1, PO2, PO3, PO5, PO6, PO9, PO10
2.	CO2: Explain the working of different types of switchgear equipment's like circuit breakers and relays. Design the ratings for fuses according to the requirement.	PO3, PO6, PO9, PO10
3.	CO3: Explain various protection schemes of various power system components like alternators, motors, feeders, transformers and bus-bars.	PO1, PO3, PO6, PO7, PO8, PO10
4.	CO4: Explain various methods to protect power system against over voltages	PO1, PO2, PO4, PO10

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	√	-	√	√	-	-	√	√
CO2	-	-	√	-	-	√	-	-	√	√
CO3	√	-	√	-	-	√	√	√	-	√
CO4	√	√	-	√	1	-	-	-	-	√

Course Syllabus:

UNIT-I

Name and cause of faults. Schemes of protection: Methods of fault discrimination.

Protective Relaying: Introduction to protective relaying, thermal relay, over current relay, Directional relay, Differential really.

UNIT-II

Protection of feeders: Over current protection and distance protection.

Protection of transformer and generator.

UNIT-III

Mechanism of arc interruption: Restriction voltage, Recovery voltage, RRRV, factors affecting the performance of circuit breaker, current chopping.

Circuit breaker: construction and operating principle of air blast, oil, SF6 and vacuum circuit breaker.

UNIT-IV

Protection against over voltage: cause of over voltage, lightning phenomenon, lightning arrestors, surge absorber, insulation co-ordination.

Grounding: Advantage, solid, resistance and reactance grounding, Peterson coil.

Books:

- **Power System Protection & Switch Gear by Badriram and Vishwakarma, TMH Publication.**

- **Switch Gear and Protection by Sunil S. Rao, Khanna Publications**
- **Power System Protection & Switch Gear by Ravindranath & Chander, New Age Publications**
- **The Art and Science of Protective Relaying by C. Russel Mason, Wiley Western Ltd.**

GATE Syllabus of Protections of Power Apparatus and Systems:

Section: Power Systems

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.

ELECTRICAL 7TH SEM TIME TABLE.

ROOM NO.: 50

DAY/TIME	9:00-10:00	10:0-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	16:00-17:00
MONDAY		DCS (RKM)	LCT (HCV)	DCS (T1) (RKM)		WEEKLY TESTS (40 MIN. EACH PAPER)		
						DCS	LCT	PPAS	INT
TUESDAY	INT (SK)	DCS (RKM)	PPAS (HCV)			INT LAB (SK+MK)/LCT (HCV+AKS)		
WEDNESDAY	DCS (RKM)	LCT (HCV)	INT (SK)	DCS (T2) (RKM)		PROJECT-I (FA+MS+HCV)		
THURSDAY		LCT (HCV)	INT (SK)	PPAS (HCV)		INT LAB (SK+MK)/LCT (HCV+RKM)		
FRIDAY	DCS(T3)(RKM)	PROJECT-I (SA+FA+MS+AKS+RKM+HCV)				PPAS (HCV+MS)		
SATURDAY	PPAS (HCV)	PPAS LAB (HCV+MS)				DCS(T4) (RKM)		

LUNCH

ROLL NO. [15E01 -- 15E19 (T1) 15E20 -- 15E37 (T2) 5E38 -- 15E56 (T3) 15E57 – 16E(LE)10 (T4)]

SUBJECT NAME		FACULTY NAME	
LCT	LINEAR CONTROL THEORY	HCV	HARI CHARAN VERMA
DCS	DIGITAL CONTROL SYSTEM	RKM	ROUSHAN KUMAR MISHRA
PPAS	PROTECTION OF POWER APPARTATUS AND SYSTEM	SK	SAKET KUMAR GUPTA
INT	INTELLIGNT INSTRUMENT		

STUDENT LIST:

S.NO.	*Roll No*	*AKU REG. NO.*	*Name*
1	15E56	15103107055	KRISHNA KUMAR
2	15E25	15103107126	SUJEET KUMAR
3	15E35	15103107127	HAPPY KUMAR
4	15E45	15103107128	MAYANK KASHYAP
5	15E01	15103107129	PRASOON BALA
6	15E02	15103107130	SUMI SINGH
7	15E03	15103107131	SURYA NARAYAN SINGH
8	15E07	15103107132	VIVEK KUMAR
9	15E09	15103107133	ANKITA KUMARI SINDURIYA
10	15E10	15103107134	NIRAJ KUMAR
11	15E11	15103107135	SANDEEP KUMAR SITESH
12	15E12	15103107136	NISHANT GUPTA
13	15E13	15103107137	PRAKASH KUMAR
14	15E14	15103107138	PRADEEP KUMAR
15	15E15	15103107139	RAVI RANJAN
16	15E16	15103107140	RAVI SHANKAR SAH
17	15E17	15103107141	ALOK KUMAR
18	15E18	15103107142	RAVI KANT SINGH
19	15E23	15103107143	NAYAN PRIYA
20	15E26	15103107144	ATUL SHAKTI
21	15E27	15103107145	RAHUL KUMAR
22	15E28	15103107146	ABHISHEK KISHORE
23	15E29	15103107147	RUHI KUMARI
24	15E30	15103107148	RAJEEV KUMAR CHOUDHARY

25	15E32	15103107149	KISHAN KUMAR
26	15E33	15103107150	MANISH KUMAR
27	15E34	15103107151	AMIT KUMAR
28	15E36	15103107152	RAVI RANJAN
29	15E37	15103107153	SHASHANK SUDHANSHU
30	15E38	15103107154	NEHA GUPTA
31	15E39	15103107155	SWETA JAMUAR
32	15E40	15103107156	SURUCHI KUMARI
33	15E42	15103107157	TAHA ALAM
34	15E44	15103107159	NIKET NIRAJ
35	15E47	15103107160	ASHUTOSH SHIVAM JHA
36	15E49	15103107161	MEDHA CHAUDHARY
37	15E41	15103107162	SOURAV SRIKANT
38	15E51	15103107163	PRIYANKA SUMAN
39	15E52	15103107164	PALLAVI KUMARI
40	15E54	15103107165	SHASHI RANJAN
41	15E57	15103107166	RAJLAXMI KUMARI
42	15E59	15103107168	AJIT KUMAR
43	15E61	15103107170	NAYAN KUMAR NAYAN
44	15E63	15103107171	RAJU KUMAR
45	15E64	15103107172	PREM NARAYAN CHAUDHARY
46	15E31	15103107173	SAURAV KUMAR
47	15E04	15103107174	BINDIA RANI
48	15E06	15103107176	MADHU KUMARI
49	15E08	15103107177	KAJAL RAJ

50	15E19	15103107178	OM PRAKASH CHAUDHARY
51	15E20	15103107179	AMAN KUMAR
52	15E24	15103107180	JYOTI KUMARI
53	15E21	15103107181	MD SARFARAJ AHMAD
54	15E46	15103107182	SATISH KUMAR
55	15E48	15103107183	PAVAN KUMAR
56	15E55	15103107184	DEO
57	15E62	15103107185	SUDEEP KUMAR
58	15E50	15103107186	NAGESHWAR SHARMA
59	15E22	15103107278	AZIM ANSARI
60	15E65	15104107203	PRIYANKA KUMARI
62	15E66	15106107258	DEEPAK KUMAR SINGH
63	16(LE)E10	16103107901	GAUTAM BHARTI
64	16(LE)E06	16103107902	SHEKHAR KUMAR
65	16(LE)E01	16103107903	SHAFAQUE NAZREEN
66	16(LE)E07	16103107904	MD MOIN
67	16(LE)E03	16103107905	PRIYANKA KUMARI
68	16(LE)E02	16103107906	PAVAN KUMAR
69	16(LE)E04	16103107908	ROHAN RAJ
70	16(LE)E09	16103107909	PINTU KUMAR

Course Plan:

Text Books:

TB1: Sunil S Rao, "Switchgear and Protection" 12th ed., Khanna Publlishers, 2007.

TB2: Badari Ram, "Power System Protection and Switchgear" 1st ed., D.N Viswakarma, TMH Publications, 2005.

TB3: J. B. Gupta, "Switchgear and Protection" S. K. Kataria & Sons, 2009

Reference Books:

RB1: T S Madhav Rao, "Power System Protection: Static Relays", 2nd ed. Tata MC Graw-Hill, 2007.

RB2: CL Wadhwa, "Electrical Power Systems", 4th ed., New Age international (P) Limited, 2008.

RB3. Paithankar and S. R. Bhide, "Fundamentals of Power System Protection" 1st ed., Prentice Hall of India, 2007.

RB4. Power System Protection & Switch Gear by Ravindranath & Chander, New Age Publications.

Other readings and relevant websites

S.No.	**Link of Journals, Magazines, websites and Research Papers**
1.	http://nptel.ac.in/downloads/108101039/
2.	http://nptel.ac.in/courses/108101039/39
3.	http://nptel.ac.in/courses/Webcourse-contents/IIT%20Bombay/Power%20System%20Protection/TOC_M1.html
4.	https://www.eiseverywhere.com/.../aaf42a76a5588f69c7a1348d6f77fe0f_Introduction
5.	http://www.faadooengineers.com/threads/25566-Power-system-protection-complete-notes-ebook-free-download-pdf
6.	http://doctord.dyndns.org/Courses/BEI/ECE477/LectureNotes.pdf

COURSE PLAN

Lecture Number	Topics	Web Links for video lectures	Text Book / Reference Book	Page numbers o Text Book(s)
1-5	**Introduction**		TB2, RB4	533-575
	Name and cause of faults. Methods of fault discrimination.	https://www.youtube.com/watch?v=6zhOFTBf1wU		
6-10	**Protective Relaying**		TB2, RB3	1-64
	Introduction to protective relaying, thermal relay, over current relay, Directional relay, Differential really.	https://www.youtube.com/watch?v=4J51nID431E&list=PL8B4h5UPC4CXKTE7-CQ8e2nbFYwQgRRAx		
11-15	**Protection of Feeders**		TB1, TB2, RB4	221-304
	Over current protection and distance protection	https://www.youtube.com/watch?v=4sc2Dq-is_M&list=PL8B4h5UPC4CXKTE7-CQ8e2nbFYwQgRRAx&index=10		
16-20	**Transformer Protection**		TB2, TB3, RB3	364-377
	Types of faults, over current protection, differential protection, Differential relay with harmonic restraint, Protection against high resistance ground faults, interturn faults, Buchholz relay.	https://www.youtube.com/watch?v=pYbznK0nqW0&index=3&list=PL8B4h5UPC4CXKTE7-CQ8e2nbFYwQgRRAx		
20-25	**Mechanism of arc interruption**		TB2, RB2	349-361
	Restriction voltage, Recovery voltage, RRRV, factors affecting the performance of circuit breaker, current chopping.	https://www.youtube.com/watch?v=kX0gQ9MOSKI		
26-32	**Circuit Breaker**		TB2, RB4	533-575
	Construction and operating principle of air blast, oil, SF6 and vacuum circuit breaker.	https://www.youtube.com/watch?v=6zhOFTBf1wU		
33-38	**Protection against over voltage:**		TB2, RB4	379-450

	cause of over voltage, lightning phenomenon, lightning arrestors, surge absorber, insulation co-ordination.	https://www.youtube.com/watch?v=j3o5n80gyjU		

LECTURE PLAN

Topics	Lecture Number	Date on which the Lecture was taken
Introduction		
Name and cause of faults	**1**	
. Methods of fault discrimination.	**2**	
Protective Relaying		
Introduction to protective relaying	**3**	
thermal relay	**4**	
over current relay	**5**	
Directional relay	**6**	
Differential relay	**7**	
Feeder Protection		
Over Current and directional relay applications	**8**	
distance Protection using impedance relay	**9**	
Reactance relay	**10**	

MHO relay	**11**	
Transformer Protection		
Types of faults, over current protection	**12**	
differential protection,	**13**	
Differential relay with harmonic restraint	**14**	
Protection against high resistance ground faults, interturn faults, Bucholz relay.	**15**	
Circuit breakers		
Arc voltage mechanism of arc interruption	**16**	
Restriking voltage and recovery voltage	**17**	
classification of CBs oil	**18**	
Oil circuit breaker	**19**	
Sf6 CB and Vacuum CB	**20**	
Rating and Resting of CBs	**21**	

DETAILS OF ASSIGNMENTS:

S.No.	Assignment	Topic No.
1	Assignment 1	1
2	Assignment 2	2
3	Assignment 3	3
4	Assignment 4	3
5	Assignment 5	4
6	Assignment 6	4
7	Assignment 7	5
8	Assignment 8	6

Protections of Power Apparatus and Systems (EE-031713)
Assignment 1 (Protective Relaying)

1. What is an impedance relay? Explain its operating principle. Discuss how it is realized using the
(i)Electromagnetic principle

(ii)Amplitude comparator

(iii)phase comparator

2. Explain impedance, reactance and mho relay characteristic on the R-X diagram. Discuss the range setting of three impedance relays placed at a particular location. Discuss why the I zone unit is not set for the protection of 100% of the line.

3. Draw and explain the circuit connection of three impedance relays together with the directional relay, circuit breaker trip coil, CB auxiliary switch, flags, seal-in relay.

4. Explain stepped time-distance characteristics of three distance relaying units used for I, II, III zone of protection.

Protections of Power Apparatus and Systems (EE-031713)
Assignment 2 (Protective Relaying)

1. What is an impedance relay? Explain its operating principle. Discuss how it is realized using the
(i)Electromagnetic principle

(ii)Amplitude comparator

(iii)phase comparator

2. Explain impedance, reactance and mho relay characteristic on the R-X diagram. Discuss the range setting of three impedance relays placed at a particular location. Discuss why the I zone unit is not set for the protection of 100% of the line.

3. Draw and explain the circuit connection of three impedance relays together with the directional relay, circuit breaker trip coil, CB auxiliary switch, flags, seal-in relay.

4. Explain stepped time-distance characteristics of three distance relaying units used for I, II, III zone of protection.

5. What are different types of distance relays. Compare their merits and demerits. Discuss their field of applications.

Protections of Power Apparatus and Systems (EE-031713)
Assignment 3 (Distance Protection)

1. What are different types of distance relays. Compare their merits and demerits. Discuss their field of applications.

2. What is an angle impedance relay. Discuss how its characteristics is realized using the phase comparison technique.

3. Discuss the protection employed against loss of excitation of an alternator.

4. What type of a protective scheme is employed for the protection of the field winding of the alternator against ground faults.

5. What type of protective device is used for the protection of an alternator against overheating of its (a) stator (b) rotor
Discuss them in brief.

6. Describe with a neat sketch, the percentage differential protection of a modern alternator.

Protections of Power Apparatus and Systems (EE-031713)
Assignment 4 (Circuit Breaker)

1. What are the different types of circuit breaker when the arc quenching medium is the criterion ? Mention the voltage range for which a particular types of circuit breaker is recommended.

2. Discuss the recovery rate theory and energy balance theory of arc interruption in a circuit breaker.

3. What are the advantages of an air blast circuit breaker over the oil circuit breaker?

4. Explain the phenomenon of current chopping in a circuit breaker. What measures are taken to reduce it?

5. Briefly describe the various types of SF_6 circuit breakers and discuss the arc extinction phenomenon in SF_6 circuit breakers.

6. Describe the construction, operating principle and application of vaccum circuit breaker. What are its advantages over conventional type circuit breakers? For what voltage ranges it is recommended?

Protections of Power Apparatus and Systems (EE-031713)
Assignment 5 (Circuit Breaker)

1. What are the advantages of an air blast circuit breaker over the oil circuit breaker.

2. Explain the phenomenon of current chopping in a circuit breaker.

3. Explain the different types of circuit breaker.

4. Explain the phenomenon of restriking voltage.

5. Briefly describe SF_6 circuit breaker. And for what voltage ranges it is recommended

6 Operating principle and application of vaccum circuit breaker,

Protections of Power Apparatus and Systems (EE-031713)
Assignment 6 (Arc interruption)

1. In a 132 kV system, the reactance per phase up to the location of the circuit -breaker is 5 Ω and capacitance to earth is 0.03 μF. Calculate (a) The maximum value of restriking voltage. (b) The value of RRRV, and (c) the frequency of transient oscillations.
2. Apply The short-circuit current of a 132 kV system is 8000 A. The current chopping occurs at 2.5% of peak value of the current. Calculate the prospective value of the voltage which will appear across the contacts of the circuit breakers. The value of stray capacitance to the earth is 100 μF.
3. In a 132 kV system, the inductance and capacitance per phase up to the location of the circuit breaker is 10 H and 0.02 μF, respectively. If the circuit breaker interrupts a magnetizing current of 20 A (instantaneous), current chopping occurs. Determine the voltage which will appear across the contacts of the circuit breaker. Also calculate the value of the resistance which should be connected across the contacts to eliminate the transient restriking voltage.
4. In a 132 kV system, reactance and capacitance up to the location of the circuit breaker is 5 Ω and 0.02 μF, respectively. A resistance 500Ω is connected across the breaker of the circuit breaker. Determine the (a) natural frequency of oscillation, (b) damped frequency of oscillation, and (c) critical value of resistance.
5. In a 132 kV system, the inductance and capacitance up to the location of the circuit breaker are 0.4H and 0.015μF respectively. Determine (a) the maximum value of the restriking voltage across the contacts of the circuit breaker, (b) frequency of transient oscillation and the maximum value of RRRV.
6. Dual In a 220 kV system, the reactance and capacitance up to the location of circuit breaker is 8 Ω and 0.025 μF, respectively. A resistance of 600 Ω is connected across the contacts of the circuit breaker. Determine the following:
   (a) Natural frequency of oscillation.
   (b) Damped frequency of oscillation.
   (c) Critical value of resistance which will give no transient oscillation.
   (d) The value of resistance which will give damped frequency of oscillations, one-forth of the natural frequency of oscillation.

Protections of Power Apparatus and Systems (EE-031713)
Assignment 7 (Circuit Breaker)

1. What are the different methods of testing of circuit breakers? Discuss their merits and demerits. Which method is more suitable for testing the circuit breakers of large capacity?

2. In a multi-break circuit breaker, what measures are taken to equalize the voltage distribution across the breaks?

3. In a 132 kV system, reactance and capacitance up to the location of the circuit breaker is 5 Ω and 0.02 μF, respectively. A resistance 500Ω is connected across the breaker of the circuit breaker. Determine the (a) natural frequency of oscillation, (b) damped frequency of oscillation, and (c) critical value of resistance.

4. In a 132 kV system, the inductance and capacitance up to the location of the circuit breaker are 0.4H and 0.015μF respectively. Determine (a) the maximum value of the restriking voltage across the contacts of the circuit breaker, (b) frequency of transient oscillation and the maximum value of RRRV.

5. What is the difficulty in the development of HVDC circuit breaker? Describe its construction and operating principle.

6. What are the main parts of equipment which are used for the testing of a laboratory type testing station.

Question Bank:

Code : 031713

B.Tech 7th Semester Exam., 2015

PROTECTION OF POWER APPARATUS AND SYSTEM

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Write short notes on (any *seven*) : 2×7=14

(a) Arc voltage

(b) Reach of a relay

(c) Zone of protection

(d) Pickup current

(e) Recovery voltage

(f) Restriking voltage

(g) Unit system of protection

(h) Time grading

(i) Thermal relay

(j) Making capacity

2. *(a)* What are different types of circuit breaker when the arc quenching medium is the criterion? What is resistance switching? 3+3

(b) For a 32-kV system, the reactance and capacitance up to the location of the circuit breaker are 3 ohm and 0·015 μF respectively. Calculate—

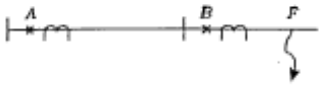
(i) the frequency of transient oscillation;

(ii) the maximum value of restriking voltage across the contacts of the circuit breaker;

(iii) the maximum value of RRRV. 8

3. *(a)* What is a directional relay? Where is directional relay used? 4

(b) An earth fault develops at point *F* on the feeder as shown in the figure below and the fault current is 16000 A :



The IDMT relay at point *A* and *B* are fed via 800/5 A CTs. The relay at *B* has a plug setting of 125% and time multiplier

setting of 0·2. The circuit breaker takes 0·20 s to clear the fault and the relay error in each case is 0·15 s. For plug setting of 200% on the relay A, determine the minimum TMS on that relay for it not to operate before the circuit breaker at B has cleared the fault. At TMS = 1, operating time at various PSM are as follows : 10

PSM	:	2	4	5	8	10	16	20
Operating time (in sec)	:	10	6	4·8	4·5	3	2·5	2·4

4. *(a)* In what way is distance protection superior to over-current protection of transmission lines? 4

(b) A 3-phase 11-kV, 15000-kVA star-connected alternator has differential protection. The neutral is earthed through a resistance of 8 ohm. The relay operates for out of balance of 18% full load. Calculate the percentage of winding unprotected against ground fault. 10

5. *(a)* What are TSM and PSM? Compare the time-current characteristics of inverse, very inverse and extremely inverse over-current relays. 2+6

(b) Explain, with proper diagram, the working of SF6 circuit breakers. 6

6. *(a)* What is back-up protection? What are the operating time for IDMT relay, very inverse relay and extremely inverse relay, when TSM = 0·4 and PSM = 2? 2+6

(b) Explain the operation of electro-mechanical reactance relay with proper diagram and supporting equations. 6

7. *(a)* Explain protection of generator transformer unit with neat diagram. 4

(b) What is balanced voltage differential protection? Explain. 4

(c) Explain the theory of arc quenching mechanism by Slepian's theory. 6

8. Write short notes on any *two* of the following : 7×2=14

(a) Rating of circuit breaker

(b) Current chopping

(c) Electromechanical mho relay

(d) Shaded pole-type induction relay

9. Discuss the direct test performed on the circuit breaker. 14

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8. (a) The neutral point of a three phase 20MVA, 11KV alternator is earthed through a resistance of 5Ω . The relay is set to operate when there is an out of balance current of 1·5 A. The C Ts have a ratio of 1000/5. What percentage of winding is unprotected against an earth fault and what is the minimum value of earthing resistance to protect 90% of the winding? 7

(b) Derive the expression with suitable circuit for percentage of protected winding of phase-to-earth fault protection of generator. 7

9. Write the short notes on any of two: 7×2=14

(a) Resistance grounding

(b) Horn gap diverter

(c) MHO relay

(d) Carrier aided protection

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Code : 031713

B.Tech.7th Semester Special Examination,2016

Protection of Power Apparatus and system

Time : 3 hours *Full Marks : 70*

Instructions :

*(i) There are **Nine** questions in this paper.*

*(ii) Attempt **Five** questions in all.*

*(iii) **Questions No.1 is Compulsory.***

(iv) The marks are indicated in the right hand margin.

1. Write down the short answer on any of Seven. 2×7=14

(a) What is Restricted Earth fault relay ?

(b) Why bus bar protection is needed?

(c) What is current grading of relay ?

(d) What is RRRV?

(e) What is standing arc?

(f) What is lightning phenomenon ?

(g) What is breaking capacity of a circuit breaker ?

(h) What do you mean by electro negativity of SF_6 gas?

(i) What are the disadvantage of an air-blast circuit breaker?

(j) What is recovery voltage of a circuit breaker?

2. (a) Describe the types of lightning strokes and its different harmful effects on a transmission line. 7

(b) Define surge absorber and discuss the causes of surge absorption. 7

3. (a) Describe the principle and need for protective system. 7

(b) Define and explain the following termology in context with protecting relay: 7

(i) Pick-up current

(ii) Current setting

(iii) Plug setting multiplier (PSM)

(iv) Time Setting multiplier (TSM)

4. (a) Explain the working principle of distance relays. 7

(b) Explain with diagram for primary protection and Back up protection in detail. 7

5. (a) A relay is connected to 400/5 C.T. and set at 120% and if the fault current on the primary side is 1440 A. Calculate PSM. 3

(b) What are the various time current characteristic of an over current relay. 2

(c) Define relay operating time. 2

(d) Explain with diagram for time-graded over current protection of parallel feeders. 7

6. (a) Describe with the help of a neat diagram connection of differential protection of a transformer. A 3-phase 33/6.6 kV star-delta connected transformer is protected by differential system. The CTs on LT side have a ratio of 300/5. Show that the CTs on HT side will have a ratio of $60 : 5\sqrt{3}$. 7

(b) Discuss the phenomenon of the following: 7

(i) Current chopping

(ii) Capacitive current breaking

7. (a) A circuit breaker interrupts the magnetizing current of a 100 MVA transformer at 220 KV. The magnetizing current of the transformer is 5% of the full load current. Determine the maximum voltage which may appear across the gap of the breaker when the magnetizing current is interrupted at 53% of its peak value. The stray capacitance is 2500 micro-farad. The inductance is 30 H. 7

(b) What is the principle of arc extinction and describe the current zero method of arc extinction ? 7