

Techno India NJR Institute of Technology



Course File

Power System Protection (6EE4-03)

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(Professor)

Department of Electrical Engineering

Syllabus:



RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Syllabus

III Year - VI Semester: B.Tech. (Electrical Engineering)

6EE4-03: POWER SYSTEM PROTECTION

Credit: 3
3L+0T+0P

Max. Marks: 150(IA:30, ETE:120)
End Term Exam: 3 Hours

SN	CONTENTS	HOURS
1	Introduction: Objective, scope and outcome of the course.	01
2	Introduction and Components of a Protection System Principles of Power System Protection, Relays, Instrument transformers, Circuit Breakers.	04
3	Faults and Over-Current Protection Review of Fault Analysis, Sequence Networks. Introduction to Overcurrent Protection and overcurrent relay co-ordination.	08
4	Equipment Protection Schemes Directional, Distance, Differential protection. Transformer and Generator protection. Bus bar Protection, Bus Bar arrangement schemes.	08
5	Digital Protection Computer-aided protection, Fourier analysis and estimation of Phasors from DFT. Sampling, aliasing issues.	07
6	Modeling and Simulation of Protection Schemes CT/PT modeling and standards, Simulation of transients using Electro-Magnetic Transients (EMT) programs. Relay Testing.	08
7	System Protection Effect of Power Swings on Distance Relaying. System Protection Schemes. Under-frequency, under-voltage and df/dt relays, Out-of-step protection, Synchro-phasors, Phasor Measurement Units and Wide-Area Measurement Systems (WAMS). Application of WAMS for improving protection systems.	06
	TOTAL	42

Course Overview:

In an electric power system, switchgear is the combination of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment. Switchgear is used both to de-energize equipment to allow work to be done and to clear faults downstream. This type of equipment is directly linked to the reliability of the electricity supply. The very earliest central power stations used simple open knife switches, mounted on insulating panels of marble or asbestos. Power levels and voltages rapidly escalated, making opening manually operated switches too dangerous for anything other than isolation of a de-energized circuit. Oil-filled equipment allowed arc energy to be contained and safely controlled. By the early 20th century, a switchgear line-up would be a metal-enclosed structure with electrically operated switching elements, using oil circuit breakers. Today, oil-filled equipment has largely been replaced by air-blast, vacuum, or SF6 equipment, allowing large currents and power levels to be safely controlled by automatic equipment.

Course Outcome:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	Student will be able to introduction to protection, Trip circuit of a circuit breaker, CTs &PTs Current transformer, Steady state ratio and phase angle errors in CTs and PTs, CVT
2	Synthesis	Students will be able to design HRC fuse and thermal relay, different types of Overcurrent relays, Earth fault relay, Parallel feeders and ring mains.
3	Synthesis	Students will be able to explain generator Protection, Differential and percentage differential protection, Rotor protection-protection against excitation and prime mover failure, Field earth fault and unbalanced stator currents (negative sequence current protection).
4	Analysis	Students will be able to outline and analyze power Transformer protection, Percentage differential protection, Magnetizing inrush current, percentage differential relay with harmonic restrain, Buchholz relay, Busbar Protection, High impedance relay scheme, frame leakage protection.
5	Application	Students will be able to solve transformer Line Protection: Construction problems, show operating principle and characteristics of an electromagnetic impedance relay, and can choose Induction Motor Protection: can illustrate various faults and abnormal operating conditions, Earth fault and negative sequence voltage relays.

Prerequisites:

1. The prerequisites for this course are fundamentals of Protection system.
2. Students should be efficient in protective relay basics.

3. Students should be familiar with CT and PT.
4. Basic protection scheme for generator, transformers.

Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
	Domain Specific (PSO)					Domain Independent (PO)						
CO. NO.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	-	-	-	-	-	-	-	-
CO2	1	2	1	2	1	-	-	-	-	-	-	-
CO3	3	2	2	1	1	-	-	-	-	-	-	-
CO4	2	1	2	2	-	-	-	-	-	-	-	-
CO5	2	3	2	2	1	-	-	-	-	-	-	-

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)

Course Coverage Module Wise:

Lect. No.	Unit	Topic
1	1	INTRODUCTION: Objective, Scope And Outcome Of The Course.
2	2	INTRODUCTION AND COMPONENTS: A Protection System
3	2	Principles of Power System Protection
4	2	Relays
5	2	Instrument transformers,
6	2	Circuit Breakers
7	2	Numerical Practice
8	3	FAULTS AND OVER-CURRENT PROTECTION: Review of Fault Analysis
9	3	Review of Fault Analysis
10	3	Sequence Networks
11	3	Introduction to Over current Protection
12	3	Over current relay co-ordination
13	3	Numerical Practice
14	4	EQUIPMENT PROTECTION SCHEMES: Directional Protection
15	4	Directional Protection
16	4	Distance Protection
17	4	Differential protection

18	4	Transformer Protection
19	4	Generator protection
20	4	Bus bar Protection
21	4	Bus Bar arrangement schemes
22	4	Numerical Practice
23	5	DIGITAL PROTECTION: Computer-aided protection
24	5	Computer-aided protection
25	5	Fourier analysis of DFT
26	5	Estimation of Phasors from DFT
27	5	Sampling
28	5	Aliasing issues
29	6	MODELING AND SIMULATION OF PROTECTION SCHEMES: CT/PT modeling
30	6	CT/PT modeling and standards
31	6	Simulation of transients using EMT
32	6	Electro-Magnetic Transients (EMT) programs
33	6	Relay Testing
34	7	SYSTEM PROTECTION: Effect of Power Swings
35	7	Effect of Power Swings on Distance Relaying
36	7	System Protection Schemes
37	7	Under-frequency relays
38	7	Under-voltage relays
39	7	Df/dt relays
40	7	Out-of- step protection
41	7	Synchro phasors
42	7	Phasor Measurement Units
43	7	Wide-Area Measurement Systems (WAMS
44	7	Application of WAMS for improving protection systems.
45		Revision to course work.
46		Revision to course work.

Text/Reference Books:

1. Badri Ram: Power System Protection and Switchgear, MGH.
2. RavindraNath M. Chander: Power System Protection and Switchgear, John Wiley Eastern.

3. Sunil S. Rao.: Power System Protection and Switchgear, Khanna Publishers.
4. Oza: Power System Protection and Switchgear, MGH.
5. T. S. Madhava Rao: Power System Protections (Static Relays), MGH.

Teaching and Learning resources:

NPTEL Course Link	https://nptel.ac.in/courses/108/105/108105167/
Quiz	https://quizizz.com/admin/quiz/5e5f7c9f780279001db07529/power-system-1-topic-1-part-1
Notes	https://sites.google.com/site/eenotes2u/courses/switchgear-and-protection

Assessment Methodology:

1. Assignments one from each unit.
2. Midterm subjective paper where they have to solve the given problem. (Twice during the semester)
3. Final paper at the end of the semester subjective

Previous year Question papers

6E1573	Roll No. _____	[Total No. of Pages : 2]
	6E1573 B.Tech. VI Sem. (Main/Back) Examination, June - 2022 Electrical Engg. 6EE4-03 Power System Protection	

Time : 3 Hours

Maximum Marks : 120
Min. Passing Marks : 42

Instructions to Candidates:

Attempt all ten questions from Part A, five questions out of Seven from Part B and Four questions out of Five from Part C.

Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination (As mentioned in form No. 205)

PART - A

(Answer should be given up to 25 words only)

All questions are compulsory

(10×2=20)

1. Define the term pick up value in a protective relay.
2. Write universal torque equation.
3. What are the different types of faults occurring in power system?
4. Discuss the merits of MHO relay.
5. What do you mean by digital protection?
6. What is relay testing?
7. What is reach, under reach and over reach of relay?
8. Compare CT and PT.
9. What are df/dt relays?
10. Name different system protection schemes.

PART - B

(Analytical/Problem solving questions)

Attempt any Five questions

(5×8=40)

1. Explain the essential qualities of relay in detail.

2. Explain the working principle of distance relays.
3. Write a detailed note on overcurrent protection.
4. Describe use of fourier analysis in digital protection.
5. Discuss CT/PT modeling and standards.
6. What are application of WAMS for improving protection systems.
7. Explain the phenomenon on arc interruption.

PART - C

(Descriptive/Analytical/Problem Solving/Design questions)

Attempt any **Four** questions

(4×15=60)

1. Describe the principle of
 - i. Under - frequency relay.
 - ii. Under - voltage relay.
 2. Describe estimation of phasors from DFT.
 3. Explain construction and operation of differential relays and explain how these relays are helpful in protection.
 4. How transients are simulated using electro - magnetic transients (EMT) programs.
 5. Explain the initiation of arc, maintenance of arc and methods for interrupting arc in a circuit breaker.
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Mid Term papers



TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY
B. TECH III – YEAR (VI SEM.)
Electrical Engineering
Power System Protection (6EE4-03)

Max Marks: 70

Time: 3 Hrs

Note:

- 1) The paper is divided into 2 parts: Part-A and, Part-B
- 2) Part-A contains 10 questions and carries 2 mark each.
- 3) Part-B contains 5 questions. Each question is having two options and carries 10 marks each.

PART - A

1.	What is reach, under reach and over reach of a relay?	[CO]
2.	What are the different types of faults in power system?	[CO]
3.	Write difference in primary and back up protection.	[CO]
4.	What is transient error in CT and CVT?	[CO]
5.	How many sequence network are there in power system? List them.	[CO]
6.	What is the main function of protecting relay?	[CO]
7.	List types of relays.	[CO]
8.	List the desirable qualities of protective relays.	[CO]
9.	Write two important characteristics of over current relay.	[CO]
10.	Define use of CT and PT in protection system.	[CO]

PART - B

1.	Explain functional characteristics of relay with suitable diagram.	[CO]
OR		
1.	Explain the nature and causes of faults. Discuss the consequences of fault on power system.	[CO]
OR		
2.	With help of suitable diagram discuss working principle of directional static over current relay.	[CO]
OR		
2.	Discuss following parameters of overcurrent relay 1. instantaneous time 2. definite time	[CO]
OR		
3.	Explain steady state ration in error in PT.	[CO]
OR		
3.	Discuss CT/PT modelling and standards.	[CO]
OR		
4.	Explain the essential qualities of relay in detail.	[CO]
OR		
4.	Explain term Pick up value in protective relay.	[CO]
OR		
5.	Discuss different types of fault and its effect on power system in details.	[CO]
OR		
5.	Differentiate between electromagnetic relay and static relay.	[CO]

TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY, UDAIPUR

B. TECH 3rd – YEAR (VI SEM.) – II MT

Power System Protection (6EE4-03)

Time: 3 Hr

Max. Marks: 70

Note:

- 1) The paper is divided into 2 parts: Part-A and, Part-B.
- 2) Part-A contains 10 questions and carries 2 mark each.
- 3) Part-B contains 5 questions. Each question is having two options and carries 10 marks each.

Part- A (20 Marks)

A.	Write the fundamental torque equation.	CO1
B.	Write advantages of static relay.	CO1
C.	Write characteristics of overcurrent relay.	CO2
D.	Compare CT and PT.	CO2
E.	Draw operating characteristics of differential relay.	CO3
F.	Discuss merits of directional impedance relay.	CO3
G.	Write conditions for instantaneous and IDMT protection.	CO4
H.	Elaborate the differential protection scheme.	CO4
I.	What are df/dt relays?	CO5
J.	List the simulation techniques in relays.	CO5

Part- B (50 Marks)

1. Discuss the essential qualities of relay.	CO1
OR	
1. Discuss with the help of suitable diagram the principle of measurement of directional relays.	CO1
2. Write a detailed note on overcurrent protection.	CO2
OR	
2. Write in detail about directional earth-fault protection scheme.	CO2
3. Explain construction and operation of differential relays and explain how these are helpful in protection?	CO3
OR	
3. Discuss in detail the R-X diagram of directional relay.	CO3
4. Describe estimation of phasors in DFT.	CO4
OR	
4. What are the applications of WAMS for improving protection system?	CO4
5. How transients are simulated using electro-magnetic transients (EMF) programs	CO5
OR	
5. Explain the initiation of arc, maintenance of arc and methos of interrupting arc in a circuit breaker.	CO5