

**Government of Karnataka**  
**Department of Technical Education**  
**Board of Technical Examinations, Bengaluru**

Course Title: <b>SWITCHGEAR AND PROTECTION</b>	Course Code : <b>15EE53T</b>
Semester : <b>V</b>	Course Group : <b>Core</b>
Teaching Scheme (L:T:P) : <b>4:0:0 (in Hours)</b>	Credits : <b>4 Credits</b>
Type of course : <b>Lecture + Assignments</b>	Total Contact Hours : <b>52</b>
CIE : <b>25 Marks</b>	SEE : <b>100 Marks</b>

**Pre-requisites** :Electrical Machines, Transmission and Distribution, Fundamentals on Analog electronics and Digital electronics

**Course Objectives** : To study the principles, concepts of switchgear & protection. To emphasize on various type of relays and circuit breakers

**Course Topics:**

Unit No	Unit Name	Hours
1	Fundamentals of Protection	07
2	Fuse and Circuit Breakers	14
3	Protective Relays	12
4	Protection of Generators and Transformers	08
5	Protection of Feeders and Bus-Bars	05
6	Substation and Maintenance	06
	<b>Total</b>	<b>52</b>

## Course Outcomes

*On successful completion of the course, the students will be able to,*

1. Acquire knowledge in the field of sources and effect of short circuit current and calculations
2. Understand the construction and working of Fuse and circuit breakers
3. Understand protective relays
4. Analyze the faults and protection for the Alternators and Transformers
5. Analyze the faults and protection for the Feeders and Bus-Bars
6. Understand layout of Substations, neutral earthing, testing of CB, CT and PT.

## Composition of Educational Components

Questions for CIE and SEE will be designed to evaluate the various educational components (Bloom's Taxonomy) such as:

Sl. No.	Educational Component	Weightage (%)	Total Marks (Out of 145)
1	Remembering	15	30
2	Understanding	60	60
3	Application/ Analysis	25	55
<b>Total</b>		<b>100</b>	<b>145</b>

## Course Outcome linkage to Cognitive Level

Cognitive Level Legend: R- Remember, U- Understand, A- Application

Course Outcome		CL	Linked PO	Teaching Hrs
C01	Acquire knowledge in the field of sources and effect of short circuit current and calculations	<i>R/U/A</i>	2, 5, 10	7
C02	Understand the construction and working of Fuse and circuit breakers	<i>R/U/A</i>	2, 10	14
C03	Understand protective relays	<i>R/U</i>	2, 5, 10	12
C04	Analyze the faults and protection for the Alternators and Transformers	<i>U/A</i>	2, 5, 10	8
C05	Analyze the faults and protection for the Feeders and Bus-Bars	<i>U/A</i>	2, 5, 10	5
C06	Understand layout of Substations and neutral earthing and testing of CB, CT and PT.	<i>R/U</i>	2, 5, 10	6
			<b>Total</b>	<b>52</b>

## Course Content and Blue Print of Marks for SEE:

Unit	Unit Name	R/U/A	Hour	Max. Marks per Unit	5 Marks Qns.		Questions to be set for (5marks) PART - A			Questions to be set for (10marks) PART - B			Marks Weigh tage (%)
					Part A	Part B	R	U	A	R	U	A	
1	Fundamentals of Protection	R/U/A	7	20	2	1	1	1				1	14
2	Fuse and Circuit Breakers	R/U/A	14	40	2	3	1	1		1	2		28
3	Protective Relays	R/U	12	35	2	2.5	1	1		0.5	2		24
4	Protection of Generators and Transformers	U/A	8	20	1	1.5		1		0.5	1		14
5	Protection of Feeders and Bus-Bars	U/A	5	15	1	1			1		1		10
6	Substation and Maintenance	R/U	6	15	1	1		1			1		10
<b>TOTAL</b>			<b>52</b>	<b>145</b>	<b>9</b>	<b>10</b>	<b>9 (45 Marks)</b>			<b>10 (100 Marks)</b>			

## Course-PO Attainment Matrix

Course	Programme Outcomes										
	1	2	3	4	5	6	7	8	9	10	
<b>Switchgear and Protection</b>		3			3						3

**LEVEL 3- HIGHLY ADDRESSED, LEVEL 2-MODERATELY ADDRESSED, LEVEL 1-LOW ADDRESSED.**  
 METHOD IS TO RELATE THE LEVEL OF PO WITH THE NUMBER OF HOURS DEVOTED TO THE COS WHICH ADDRESS THE GIVEN PO.  
 IF ≥40% OF CLASSROOM SESSIONS ADDRESSING A PARTICULAR PO, IT IS CONSIDERED THAT PO IS ADDRESSED AT LEVEL 3  
 IF 25 TO 40% OF CLASSROOM SESSIONS ADDRESSING A PARTICULAR PO, IT IS CONSIDERED THAT PO IS ADDRESSED AT LEVEL 2  
 IF 5 TO 25% OF CLASSROOM SESSIONS ADDRESSING A PARTICULAR PO, IT IS CONSIDERED THAT PO IS ADDRESSED AT LEVEL 1  
 IF < 5% of classroom sessions addressing a particular PO, it is considered that PO is considered not-addressed.

## Course Contents:

### Unit I

#### Fundamentals of Protection

07hrs

Sources of Fault Power, Illustrate the Phenomena of Short Circuit with the help of a general circuit diagram, Types of faults & Harmful Effects of short circuit current, Symmetrical Faults on Three Phase Systems, Importance of calculation of Short Circuit Current, Define Percentage reactance and Base KVA, Meaning of Reactor, Use of current limiting reactors & their arrangements, List the steps for Symmetrical Fault Calculations, Simple Problems on Symmetrical Fault Calculations.

Causes of over voltages, Lightning phenomena & over voltage due to lightning

Types of lightning arresters and surge absorbers- their Construction and principle of operation.

(Reference Book: Principles of Power System” by V. K. Mehta, Rohit Mehta S. Chand, 4th revised edition 2008)

### Unit II

#### Fuse and Circuit Breakers

14hrs

Meaning of Switchgear, Essential features of Switchgear, List different Switchgear equipment used for switching and interruption of current. Differences between Indoor and Outdoor type Switchgear.

Desirable Characteristics of Fuse elements, Types of Fuses, Fuse Element Materials

Important Terms: Current Rating of Fuse element, Fusing current, Fusing factor, Prospective current, cut off current , Pre Arcing Time, Arcing Time, Breaking Capacity, Total Operating Time.

HRC fuses –construction, types, working, Merits, Demerits and applications

Arc formation process, methods of arc extinction, working of Circuit Breaker by Trip Circuit Mechanism, Circuit Breaker rating.

Explain the terminologies – Arc-Voltage, arcing Time, Pre –Arching Time, Prospective Current, TRV, Recovery Voltage, RRRV, Total Break Time

Circuit breakers-Concept, Classification, Working principle, Construction, Merits, Demerits & Applications of OCB (Plain oil), ACB(Axial blast, cross blast), SF<sub>6</sub> (Sulphur Hexa-fluoride) CB, Non Puffer Type, Vacuum CB.

Maintenance Schedule of OCB, ACB, SF<sub>6</sub> and VCB Circuit Breakers

(Reference Book: Principles of Power System” by V. K. Mehta, Rohit Mehta S. Chand, 4th revised edition 2008)

### Unit III

#### Protective Relays

12hrs

Relay definition, required qualities of Protective Relaying, Necessity for Protection, Primary and Back up protection, Classification of protective Relaying, Important Terms: Pickup current, current setting, PSM, TSM, Time -PSM Curve

Construction and working of Induction type Non-directional over current relay

Introduction of Static relay, merits and Limitations, Static Type Over Current Relay, Comparison of Static Relays with Electro-Magnetic Relays

Block diagram and working of Microprocessor based Over Current Relay  
Differential relay- Principle of operation, Current differential and Voltage balanced Differential relay  
Distance relays: Definite distance and Time-distance Impedance Relay  
Introduction to Numerical relays, Block diagram, working, Advantages of Numerical relays and different types  
List different Testing Methods for Relays

(Reference Book: Madhava Rao T.S., 'Power System Protection - Static Relays', McGraw Hill, New Delhi, 2nd Edition, 21st reprinted, 2008.

Power System Protection And Switchgear by Buvanesh A Oza, Nirmalkumar C Nair, Rases P Mehta and Vijay H Makwana, McGraw HILL Education (India Pvt. Ltd) Newdelhi)

#### **Unit IV**

##### **Protection of Alternators and Transformers**

**08hrs**

Protection of Alternators- Abnormalities & Faults  
Differential protection, Balanced Earth Fault Protection, Stator Inter Turn Protection  
Protection of Transformers- Abnormalities & Faults  
Protective Systems for Transformers, Buchholz Relay, Earth Fault or Leakage Protection, Combined Leakage and Overload Protection, Circulating Current Scheme for Transformers Protection

(Reference Book: Principles of Power System” by V. K. Mehta, Rohit Mehta S. Chand, 4th revised edition 2008)

#### **Unit V**

##### **Protection of Feeders and Bus-Bars**

**05hrs**

Feeder Protection- Abnormalities & Faults, Time Graded Over Current Protection, Differential Pilot – Wire Protection, Basic principle of Distance Protection  
Bus – Bar Protection- Abnormalities & Faults, Differential Protection of Bus –Bars.

(Reference Book: Principles of Power System” by V. K. Mehta, Rohit Mehta S. Chand, 4th revised edition 2008)

#### **Unit VI**

##### **Substation and Maintenance**

**06hrs**

Explain the indoor and outdoor type substation, Identify the various units of substation, Testing methods of Circuit Breakers, Testing methods of CT's & PT's, Maintenance Schedule of Relays, Neutral Earthing - Introduction, Types & its importance. Substation Earthing, Principle and applications of Peterson coil.

(Reference Book: Testing, commissioning, operation and maintenance of electrical equipment by Sunil S Rao, Khanna Publications

Power System Protection and Switchgear by Buvanesh A Oza, Nirmalkumar C Nair, Rases P Mehta and Vijay H Makwana, McGraw Hill Education (India Pvt. Ltd) New Delhi)

### Reference Books:

- 1) Principles of Power System” by V. K. Mehta, Rohit Mehta S. Chand, 4th revised edition 2008
- 2) Power System Protection And Switchgear by Buvanesh A Oza, Nirmalkumar C Nair ,Rases P Mehta and Vijay H Makwana, McGraw HILL Education(India Pvt. Ltd) Newdelhi
- 3) J.B.Gupta “Switchgear & Protection”, (edition), Katson Publisher,2008
- 4) MadhavaRao T.S., 'Power System Protection - Static Relays', McGraw Hill, New Delhi,2nd Edition, 21st reprinted, 2008.
- 5) Handbook of Switchgears by BHEL
- 6) Testing , commissioning , operation and maintenance of electrical equipment by Sunil S Rao ,Khanna Publications

### E-Resources:

1. <http://www.pdfdocuments.com/testing-commissioning-operation-maintenance-electrical-equipments.pdf>
2. YOUTUBE VEDIOS ON CIRCUIT BREAKERS
3. YOUTUBE VEDIOS ON PROTECTIVE RELAYS
4. NPTEL VEDIOS ON SWITCHGEAR PROTECTION

## Course Delivery:

The Course will be delivered through Lectures, Classroom Interaction, Animations, Group Discussion, Exercises and Assignments.

## Course Assessment and Evaluation Scheme:

	What		To Whom	Frequency	Max Marks	Evidence Collected	Course Outcomes
Direct Assessment	CIE (Continuous Internal Evaluation)	I A Tests	Students	Three tests (average of three)	20	Blue Books	1 to 6
				Student Activity	05	Hand written report	1 to 6
				TOTAL	25		
	SEE (Semester End Examination)	End Exam	Students	End Of the Course	100	Answer Scripts at BTE	1 to 6
Indirect Assessment	Student Feedback on course		Students	Middle Of The Course	Questionnaire		1 to 6
	End Of Course Survey			End Of The Course			

\*CIE – Continuous Internal Evaluation      \*SEE – Semester End Examination

**Note:** I.A. test shall be conducted for 20 marks. Average marks of three tests shall be rounded off to the next higher digit.

**Note to IA verifier:** The following documents to be verified by CIE verifier at the end of semester

1. Blue books ( 20 marks)
2. Student suggested activities report for 5 marks evaluated through appropriate rubrics.
3. Student feedback on course regarding Effectiveness of Delivery of instructions & Assessment Methods.



## Suggested Student activity:

A student has to prepare a handwritten report on any one of the activity suggested in a blue book or spiral binding form.

1. Identify various faults on the power system other than faults studied in the curriculum
2. Identify various Unsymmetrical faults on the power system other than faults studied in the curriculum
3. Identify the components of different types of circuit breakers used in LV & HV side with their specifications (through visits, video or model).
4. Study of specification of lightning arresters of different manufacturers through Brochures / Literature
5. Study latest types of over/under voltage relays, differential and distance relays using static relays ,microprocessor based and numerical relays
6. Identify various faults in motors, Relays and Circuit Breakers and relevant protection schemes

### MODEL OF RUBRICS / CRITERIA FOR ASSESSING STUDENT ACTIVITY ( Course Coordinator)

Dimension	Scale					Students score (Group of five students)				
	1 Unsatisfactory	2 Developing	3 Satisfactory	4 Good	5 Exemplary	1	2	3	4	5
1	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	3				
2	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	2				
3	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	5				
4	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	4				
<b>Note: Concerned faculty (Course coordinator) must devise appropriate rubrics/criteria for assessing Student activity for 5 marks</b> <b>One activity on any one CO (course outcome) may be given to a group of FIVE students</b> <b>Grand Average/Total</b>						14/4				
						=3.5				
						≈4				

**Example only: MODEL OF RUBRICS / CRITERIA FOR ASSESSING STUDENT ACTIVITY-  
Task given- Industrial visit and report writing**

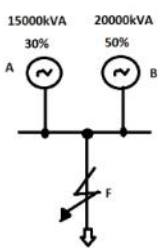
Dimension	Scale					Students score (Five students)				
	1 Unsatisfactory	2 Developing	3 Satisfactory	4 Good	5 Exemplary	1	2	3	4	5
1. Organisation	Has not included relevant info	Has included few relevant info	Has included some relevant info	Has included many relevant info	Has included all relevant info needed	3				
2. Fulfill team's roles & duties	Does not perform any duties assigned	Performs very little duties	Performs partial duties	Performs nearly all duties	Performs all duties of assigned team roles	2				
3. Conclusion	Poor	Less Effective	Partially effective	Summarises but not exact.	Most Effective	5				
4. Conventions	Frequent Error	More Error	Some Error	Occasional Error	No Error	4				
Total marks						14/4=3.5 ≈4				

### FORMAT OF I A TEST QUESTION PAPER (CIE)

Test/Date and Time	Semester/year	Course/Course Code	Max Marks			
Ex: I test/6 <sup>th</sup> week of sem 10-11 Am	V SEM	<b>SWITCHGEAR AND PROTECTION</b>	20			
	Year:					
Name of Course coordinator :			Units: __ CO's: __			
Question no	Question		MARKS	CL	CO	PO
1						
2						
3						
4						

**Note: Internal Choice may be given in each CO at the same cognitive level (CL).**

## MODEL QUESTION PAPER (CIE)

Test/Date and Time	Semester/year	Course/Course Code	Max Marks	
1 <sup>st</sup> Test/ 6 <sup>th</sup> week, 10-11 AM	V SEM, E & E Engg.	<b>SWITCHGEAR AND PROTECTION</b>	20	
	Year: 2016-17	Course code:15EE53T		
Name of Course coordinator : Units Covered : 1 and 2 Course Outcomes : 1 and 2 <b>Instruction :</b> (1). Answer all questions (2). Each question carries five marks				
Question No.	Question	CL	CO	PO
1	List the Harmful Effects of short circuit current	R	1	2,5,10
2	The below figure shows single line diagram of a 3-phase systems. The percentage reactance of each alternator is based on its own capacity. Find the short circuit current that will flow into a complete 3-phase short circuit at F <div style="text-align: center;">  </div> [OR] A 3-phase, 20MVA, 10KV alternator as internal reactance of 5% and negligible reactance. Find the external reactance per phase to be connected in series with the alternator so that steady current on short circuit does not exceed 8 times the full load current	A	1	2,5,10
3	State Merits and Demerits of : 1. OCB 2. ACB 3. SF6 CB	R	2	2,10
4	Explain construction and working of Puffer Type SF6 CB  [OR] Explain construction and working of VACUUM CB	U	2	2,10
		U	2	2,10

CL: Cognitive Level, R-Remember, U-Understand, A-Application, PO: Program Outcomes

**COURSE CONTENT DELIVERY:**

Lesson no/Topic no	Unit	Session/Duration
<b>I</b>	<b>Fundamentals of Protection</b>	<b>07hrs</b>
1	Sources of Fault Power, Illustrate the Phenomena of Short Circuit with the help of a general circuit diagram	01
2	Types of faults & Harmful Effects of short circuit current, Symmetrical Faults on Three Phase Systems	01
3	Importance of calculation of Short Circuit Current, Define Percentage reactance and Base KVA, Meaning of Reactor	01
4	Use of current limiting reactors & their arrangements, List the steps for Symmetrical Fault Calculations	01
5	Simple Problems on Symmetrical Fault Calculations.	01
6	Causes of over voltages, Lightning phenomena & over voltage due to lightning, Types of lightning arresters	01
7	Lightning arresters & surge absorbers & their Construction & principle of operation.	01
<b>II</b>	<b>Fuse and Circuit Breakers</b>	<b>14hrs</b>
8	Meaning of Switchgear, Essential features of Switchgear, List different Switchgear equipment used for switching and interruption of current	01
9	Explain Differences between Indoor type and Outdoor type Switchgear	01
10	Desirable Characteristics of Fuse elements, Types of Fuses, Fuse Element Materials	01
11	Important Terms: Current Rating of Fuse element, Fusing current, Fusing factor, Prospective current, cut off current, Pre Arcing Time, Arcing Time, Breaking Capacity, Total Operating Time.	01
12	HRC fuses –construction, types, working, Merits, demerits and applications	01
13	Arc formation process, methods of arc extinction (HT & LT Method)	01

14	Circuit Breaker rating, Explain the terminologies – Arc-Voltage, arching Time, Pre –Arching Time, Prospective Current, TRV, Recovery Voltage, RRRV, Total Break Time	01
15	Working of Circuit Breaker by Trip Circuit Mechanism, Classification of Circuit Breakers	01
16	Working principle, Construction, Merits, Demerits & Applications of Plain Break Oil CB	01
17	Working principle, Construction, Merits, Demerits & Applications of ACB (Axial blast, cross blast)	01
18	Working principle, Construction, Merits, Demerits & Applications of Puffer Type SF6 CB	01
19	Working principle, Construction, Merits, Demerits & Applications of Non Puffer Type SF6CB	01
20	Working principle, Construction, Merits, Demerits & Applications of VACUUM CB	01
21	Maintenance Schedule of OCB,ACB, SF6 and VCB Circuit Breakers	01
<b>III</b>	<b>Protective Relays</b>	<b>12hrs</b>
22	Relay definition, required qualities of Protective Relaying, Necessity for Protection	01
23	Primary and Back up protection, Classification of protective Relaying, Important Terms: Pickup current, current setting, P S M, T S M, Time P S M Curve	01
24	Construction and working of Induction type Non-directional over current relay	01
25	Introduction of Static relay, Static Type Over Current Relay, merits and Limitations	01
26	Block diagram and working of Microprocessor based Over Current Relay	01
27	Comparison of Static Relays with Electro-Magnetic Relays and microprocessor based relays	01
28	Differential relay- Principle of operation, sketch and working of Current differential and Voltage balanced Differential relay	01
29	Differential relay- Principle of operation, sketch and working of Voltage balanced Differential relay	01

30	Distance relays: Construction and working of Definite distance Impedance Relay	01
31	Construction and working of Time-distance Impedance Relay	01
32	Introduction to Numerical relays ,Advantages of Numerical relays and different types	01
33	List and explain different Testing Methods for Relays	01
<b>IV</b>	<b>Protection of Alternators and Transformers</b>	<b>08hrs</b>
34	Types of Protection of Alternators, Explain Abnormalities & List different types of Faults	01
35	Construction and working Differential protection, Construction and working Balanced Earth Fault Protection	01
36	Construction and working Stator Inter Turn Protection	01
37	Types of Protection of Transformers, Explain Abnormalities & List different types of Faults	01
38	Construction and working of Buchholz Relay	01
39	Construction and working of Earth Fault or Leakage Protection Systems for Transformers	01
40	Construction and working of Combined Leakage and Overload Protection	01
41	Construction and working of Circulating Current Scheme for Transformers Protection	01
<b>V</b>	<b>Protection of Feeders and Bus-Bars</b>	<b>05 hrs</b>
42	Feeder Protection, Explain Abnormalities & List different types of Faults Time Graded Over Current Protection on transmission line	01
43	Construction and working of Differential Pilot – Wire Protection	01
44	Discuss Basic principle of Distance Protection	01

45	Bus – Bar Protection, Explain Abnormalities & List different types of Faults	01
46	Construction and working of Differential Protection of Bus -Bars	01
<b>VI</b>	<b>Substation and Maintenance</b>	<b>06 hrs</b>
47	Explain the indoor and outdoor type substation Identify the various units of substation	01
48	List Testing methods of Circuit Breaker, Explain type test and routine test & maintenance	01
49	List & Explain Testing methods of CT's & PT's and Maintenance of Relays	01
50	Introduction, Types & Importance of Neutral Earthing	01
51	Explain Substation Earthing (Solid, Resistance and Reactance Earthing)	01
52	Explain Principle and applications Peterson coil.	01

**V Semester Diploma Examination****SWITCHGEAR AND PROTECTION**

**CO1 Acquire knowledge in the field of sources and effect of short circuit current and calculations**

**UNIT-I Fundamentals of protection**

**Cognitive Level: Remember**

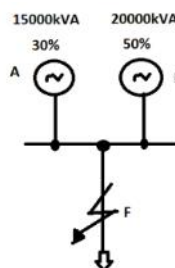
1. List the types of faults with diagram
2. List the Harmful Effects of short circuit current
3. Define Percentage reactance and Base KVA
4. List Use of current limiting reactors and their arrangements
5. List steps for Symmetrical Fault Calculations
6. List Methods of Voltage and Reactive Power Control
7. List Causes of over voltages
8. List Types of lightning arresters

**Cognitive Level: Understanding**

1. Explain Sources of Fault Power
2. Explain Phenomena of Short Circuit with the help of a general circuit diagram
3. Explain Importance of calculation of Short Circuit Current
4. Explain Power and Frequency Characteristics of Interconnected systems
5. Explain methods of Reactive power control
6. Explain Lighting phenomena
7. Explain over voltage due to lightning
8. Explain Rod gap arrester and Horn gap arrester.
9. Explain Oxide Film Type and Thyrite Arrester.
10. Explain surge absorbers

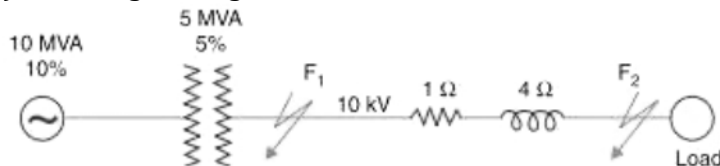
**Cognitive Level: Application/Analyze**

11. The below figure shows single line diagram of a 3-phase systems. The percentage reactance of each alternator is based on its own capacity. Find the short circuit current that will flow into a complete 3-phase short circuit at F





12. A 3-phase, 20MVA, 10KV alternator as internal reactance of 5% and negligible reactance. Find the external reactance per phase to be connected in series with the alternator so that steady current on short circuit does not exceed 8 times the full load current
13. A 3phase transmission line operating at 10 kV and having a resistance of 1ohm and reactance of 40ohm is connected to the generating station bus-bars through 5MVA step up transformer having a reactance of 5%. The bus-bars are supplied by 10 MVA alternators having 10% reactance. Calculate the short-circuit kVA fed at symmetrical fault between phases if it occurs A) At the load end of transmission line B) At the high voltage terminal of the transformer



14. The plant capacity of a 3-phase generating station consists of two 10,000kVA generators of reactance 12% each and one 5000kVA generator of reactance 18%. The generators are connected to the station bus-bars from which load is taken through three 5000kVA step-up transformers having a reactance 5%. Determine the reactance 12% maximum fault MVA which the circuit breakers on (i) low voltage side (ii) high voltage side

## CO2 Understand the construction and working of Fuse and circuit breakers

### UNIT-II- Fuse and Circuit Breakers

#### Cognitive Level: Remember

1. List different Switchgear equipment
2. List Differences between Indoor type and Outdoor type Switchgear
3. List Desirable Characteristics of Fuse elements
4. List Fuse Element Materials
5. State Merits and Demerits of HRC fuse
6. List any 3 Application of HRC fuse
7. List the different methods of arc extinction
8. List different circuit breakers
9. List the Features of Intelligent Circuit Breaker
10. State Merits and Demerits of Plain oil OCB
11. State Merits and Demerits of Air circuit breaker
12. State Merits and Demerits of SF6 CB
13. State Merits and Demerits of Vacuum Circuit breaker
14. List the Applications of OCB
15. List the Applications of ACB
16. List the Applications of SF6 CB
17. List the Applications of VCB
18. Lists the steps in maintenance of OCB
19. Lists the steps in maintenance of SF6 CB
20. Lists the steps in maintenance of ACB
21. Define breaking capacity, making capacity and Sort time rating
22. Lists the steps in maintenance of VCB

### **Cognitive Level: Understanding**

23. Explain Essential features of Switchgear
24. Explain Switchgear equipment
25. Explain terms: Terms: Current Rating of Fuse element, Fusing current, Fusing factor, Prospective current, cut off current , Pre Arcing Time, Arcing Time, Breaking Capacity, Total Operating Time.
26. Explain construction and working of HRC fuse
27. Explain the different methods of arc extinction
28. Explain Arc Extinction phenomena in CB by high resistance method
29. Illustrate the working of Circuit Breaker by Trip Circuit Mechanism
30. Explain circuit breaker rating
31. Explain the terminologies – Arc-Voltage, arcing Time, Pre –Arcing Time, Prospective Current, T R V, Recovery Voltage, R RR V, Total Break Time
32. Explain Working principle of Circuit Breakers
33. Explain construction and working of Plain oil OCB ACB
34. Explain construction and working of Axial blast ACB
35. Explain construction and working of cross blast ACB
36. Explain construction and working of Puffer Type SF6 CB
37. Explain construction and working of Non Puffer Type SF6 CB
38. Explain construction and working of VACUUM CB
39. Differentiate between fuse and circuit breaker.

### **Cognitive Level: Application/Analyze**

1. Compare fuse and circuit breaker.
2. Explain Working principle of Circuit Breakers
3. Explain Essential features of Switchgear
4. Explain Switchgear equipment
5. Explain terms: Terms: Current Rating of Fuse element, Fusing current, Fusing factor, Prospective current, cut off current , Pre Arcing Time, Arcing Time, Breaking Capacity, Total Operating Time.
6. Explain construction and working of HRC fuse
7. Explain the different methods of arc extinction
8. Explain breaking capacity of CB
9. Explain making capacity of CB
10. Explain Sort time rating of CB

## **CO3 Analyze the faults and protection for the Alternators and Transformers**

### **UNIT-III Protective Relays**

### **Cognitive Level: Remember**

1. Define Relay
2. List different requirements of Protective Relays
3. List different types of protective Relaying
4. List the applications of Static Relays
5. List the applications of Microprocessor based Relays
6. Explain the Necessity for Protection
7. List the different types of Numerical relays
8. List the Advantages of Numerical relays

9. List the testing methods on Relays

**Cognitive Level: Understanding**

10. Explain Primary and Back up protection
11. Explain terms: Pickup current, current setting, P S M, T S M, Time P S M Curve
12. Explain construction and working of Induction type Non-directional over current relay
13. Explain construction and working of Static Type Over Current Relay
14. Compare Static Relays with Electro-Magnetic Relays
15. Explain with block diagram Microprocessor based Over Current Relay
16. Explain with a neat sketch the working of Voltage balance differential Relay
17. Explain with a neat sketch the working of Current differential Relay
18. Explain with a neat sketch the working of Definite Distance Type Impedance Relays
19. Explain with a neat sketch the working of Time-distance Impedance Relay
20. Draw block diagram of Numerical relays
21. Compare Static relays and Microprocessor based relays

**CO4 Understand the construction and working of Fuse and circuit breakers**

**UNIT-IV Protection of Generators and Transformers**

**Cognitive Level: Understanding**

1. Explain with a neat sketch construction and working of Differential protection of alternators
2. Explain with a neat sketch construction and working of , Balanced Earth Fault Protection of alternators
3. Explain with a neat sketch construction and working of Stator Inter Turn Protection of alternators
4. Explain with a neat sketch construction and working of Buchholz Relay
5. Explain with a neat sketch construction and working of Earth Fault or Leakage Protection of Transformers
6. Explain with a neat sketch construction and working of Combined Leakage and Overload Protection of Transformers
7. Explain with a neat sketch construction and working of Circulating Current Scheme for Transformers Protection

**Cognitive Level: Application/ Analyze**

1. Explain various Abnormalities occurs in Alternators
2. Explain various Abnormalities occurs in Transformers
3. List different types of faults in alternator
4. List different types of faults in Transformers

## **CO5 Analyze the faults and protection for the Feeders and Bus-Bars**

### **UNIT-V Protection of Feeders and Bus-Bars**

#### **Cognitive Level: Understanding**

1. Explain Time Graded Protection for Radial Feeders
2. Explain with a neat sketch construction and working of Differential Pilot – Wire Protection
3. Explain basic distance protection scheme for protection of lines.
4. List different types of faults in Bus – Bars
5. Explain Differential Protection of Bus –Bars
6. Explain the Importance of Protection of Lines and Bus –Bars

#### **Cognitive Level: Application/ Analyze**

1. Explain various Abnormalities occurs in Transmission lines
2. Explain various Abnormalities occurs in Bus – Bars
3. List different types of faults in Transmission lines
4. List different types of faults in Bus – Bars

## **CO6 Understand layout of Substations, neutral earthing, testing of CB, CT and PT.**

### **UNIT-VI Substation and Maintenance**

#### **Cognitive Level: Remember**

1. List the tests conducted on Circuit Breakers
2. List the steps to Maintenance of Circuit Breakers
3. List the Testing methods of CT's & PT's
4. List the steps to Maintenance of Relays
5. List importance of Neutral Earthing
6. List the application of Peterson coil
7. List the methods of sub-station Earthing

#### **Cognitive Level: Understanding**

1. Explain the indoor and outdoor type substation
  2. Explain Type Test and Routine Test
  3. Explain Maintenance schedule of relays
  4. Explain Neutral Earthing
  5. Explain Solid, Resistance and Reactance Earthing
  6. Explain Peterson coil
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## Model Question Paper:

Code: 15EE53T

### V Semester Diploma Examination SWITCHGEAR AND PROTECTION

[Time: 3 Hours]

[Max.Marks: 100]

- Note:** (i) Answer any **SIX** questions from Part – A. (Each question carries 5 marks)  
(ii) Answer any **SEVEN** questions from Part – B. (Each question carries 10 marks)

PART - A		
1	List the Harmful Effects of short circuit current	5
2	Explain methods of Reactive power control	5
3	Explain the different methods of arc extinction	5
4	Explain terms: Terms: Current Rating of Fuse element, Fusing current, Fusing factor, Prospective current, cut off current , Pre Arcing Time, Arcing Time, Breaking Capacity, Total Operating Time.	5
5	List different requirements of Protective Relays	5
6	Explain terms: Pickup current, current setting, P S M, T S M, Time P S M Curve	5
7	i. Explain various Abnormalities occurs in Alternators ii. Explain various Abnormalities occurs in Transformers	5
8	i. List different types of faults in Transmission lines ii. List different types of faults in Bus – Bars	5
9	Lists the steps in maintenance of Circuit Breakers	5
PART - B		
1	<p>A 3phase transmission line operating at 10 kV and having a resistance of 1ohm and reactance of 40hm is connected to the generating station bus-bars through 5MVA step up transformer having a reactance of 5%. The bus-bars are supplied by 10 MVA alternators having 10% reactance. Calculate the short-circuit kVA fed at symmetrical fault between phases if it occurs A) At the load end of transmission line B) At the high voltage terminal of the transformer</p>	10
2	i. List Desirable Characteristics of Fuse elements ii. State Merits and Demerits of HRC fuse	5 5
3	i. Explain construction and working of Plain oil OCB ACB ii. State Merits and Demerits of Plain oil OCB	5 5
4	i. Explain construction and working of non Puffer Type SF6 CB ii. List the maintenance of SF6 CB	5 5
5	i. Explain the Necessity for Protection ii. List different types of faults in Transformers	5 5
6	i. Explain with block diagram Microprocessor based Over Current Relay ii. List any 4 applications of Microprocessor based Relay	5 5
7	i. Explain construction and working of Static Type Over Current Relay ii. Compare Static Relays with Electro-Magnetic Relays	5 5
8	i. Explain with a neat sketch construction and working of Differential protection of	5

	alternators ii. Explain with a neat sketch construction and working of Earth Fault or Leakage Protection of Transformers	5
9	i. Explain Time Graded Protection for Radial Feeders	5
	ii. Explain Differential Protection of Bus –Bars	5
10	i. Explain Solid Earthing	5
	ii. Explain Peterson coil	5