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

Course Title:	**TESTING, MAINTENANCE AND CONTROL OF SUBSTATION**	Course Code	: **15EE63B**
Semester	: **VI**	Course Group	: **Elective**
Teaching Scheme (L:T:P)	:**4:0:0** (in Hours)	Credits	: **4 Credits**
Type of course	:**Lecture +Assignments**	Total Contact Hours	: **52**
CIE	: **25 Marks**	SEE	: **100 Marks**
Programme: Diploma in Electrical and Electronics Engg.			

Pre-requisites	**:** Knowledge on basics of electrical engineering, Transmission and Distribution and Switch gear components
Course Objectives	**:** To understand the various Substation components, testing, maintenance and control of the substation.

COURSE TOPICS:

Unit No	Unit Name	Hours
1	Introduction to Substation	05
2	Testing and maintenance of Bus Bars, Isolators	08
3	Testing and maintenance of Circuit Breaker and Reactors	12
4	Testing and maintenance of Protective Relays	10
5	Testing and maintenance of Current and Voltage Transformers and Insulators	13
6	Substation monitoring and control	04
	Total	**52**

Course Outcomes:

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

1. Remember the basics of substation system
2. Understand the testing and maintenance of bus bars and isolators
3. Understand the testing and maintenance of circuit breakers and reactors
4. Understand the testing and maintenance of protective relays
5. Understand the testing and maintenance of CT, PT and Insulators
6. Analyse the substation monitoring and control

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	20	30
2	Understanding	60	90
3	Application/ Analysis	20	25
Total		**100**	**145**

Course Outcome linkage to Cognitive Level

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

		CL	Linked PO	Teaching Hrs
CO1	Remember the basics of Substation system	***R***	1,2,10	05
CO2	Understand the testing and maintenance of bus bars, isolators	***U/A***	2,3,4,5,8,910	08
CO3	Understand the testing and maintenance of circuit breakers and reactors	***U/A***	2,3,4,5,8,910	12
CO4	Understand the testing and maintenance of protective relays	***U/A***	2,3,4,5,8,910	10
C05	Understand the testing and maintenance of CT, PT and Insulators	***U/A***	2,3,4,5,8,910	13
C06	Analyse the substation monitoring and control	***R/U/A***	3,4,5,7,8,9,10	04
		Total		**52**

Course Content and Blue Print of Marks for SEE:

Unit	Unit Name	R/U/A	Hour	Max. Marks per Unit	5 Marks Qns.	10 Marks Qns.	Questions to be set for (5marks) PART - A			Questions to be set for (10marks) PART - B			Marks Weightage (%)
					Part A	Part B	R	U	A	R	U	A	
1	Introduction to Substation	*R*	5	10	1	0.5	1			0.5			7
2	Testing and maintenance of Bus Bars, Isolators	*U/A*	8	25	1	2		1			1	1	17
3	Testing and maintenance of Circuit Breaker and Reactors	*U/A*	12	30	2	2		1	1		1	1	21
4	Testing and maintenance of Protective Relays	*U/A*	10	30	2	2		1	1		1	1	21
5	Testing and maintenance of Current and Voltage Transformers and Insulators	*U/A*	13	40	2	3		1	1		1	2	28
6	Substation monitoring and control	*R/U/A*	4	10	1	0.5	1			0.5			7

Course-PO Attainment Matrix

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
TESTING, MAINTENANCE AND CONTROL OF SUBSTATION	**1**	**3**	**3**	**3**	**3**		**1**	**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 Content:

Unit –I

Introduction to Substation System: Definition of substation, necessity of substation, essential features, types of substation - advantages and disadvantages, single line diagram of substation, List and functions of each component of substation. Auxiliary systems, Over head earthing screen, Sub-station earthing system. **05 Hrs**

Unit –II

Testing and maintenance of Bus Bars, and Isolators: Types and ratings - Bus bar configuration, Tests on Bus bars. Types of isolators and ratings, Load Break switches, Maintenance of isolators. **08 Hrs**

Unit –III

Testing and maintenance of Circuit Breaker and Reactors: Circuit breakers -Type Tests, Routine tests, Short circuit Testing of CB -Direct Testing, Indirect testing, Maintenance of CBs. Reactors -Routine Tests**,** Type Tests, Special tests, Loss Measurement and maintenance of reactors. **12 Hrs**

Unit –IV

Testing and maintenance of Protective Relays: Tests on relays, Test equipment, Static relays, Digital Relays, Maintenance of relays. **10 Hrs**

Unit –V

Testing and maintenance of Power Transformers, Current and Voltage Transformers and Insulators: Preliminary tests, Final tests, Impulse test, Partial discharge test, Transformer maintenance. Current Transformer tests, Potential Transformer tests. CT and PT maintenance. Tests and maintenance of insulator. **13Hrs**

Unit –VI

Substation monitoring and control: Fault Monitoring, Two Hierarchical levels, Inter level communication **04Hrs**

Text Books:

1 Switch gear & protection By : Sunil S Rao, Khanna Publishers Ltd, New Delhi

2 Transformers - BHEL Tata McGrawHill, New Delhi

Reference Books:

1. Testing, Commissioning, operation and maintenance of electrical equipment by S.Rao, Khanna Publishers Ltd, New Delhi.
2. Sub-Station Engineering Design, Concepts & Computer Applications ByEr. R.S. Dahiya,Er. VinayAttri, S.K. Kataria and Son's, New Delhi
3. Power Transformers and Special Transformers, By : Sunil S Rao

Course Delivery:

The Course will be delivered through lectures, classroom interaction, animations, group discussion, exercises and student activities, assignments.

Course Assessment and Evaluation:

<table>
<tr><th></th><th colspan="2">What</th><th>To Whom</th><th>Frequency</th><th>Max Marks</th><th>Evidence Collected</th><th>Course Outcomes</th></tr>
<tr><td rowspan="4">Direct Assessment</td><td rowspan="3">CIE (Continuous Internal Evaluation)</td><td>I A Tests</td><td rowspan="3">Students</td><td>Three IA tests for Theory: (Average marks of Three Tests to be computed).</td><td>20</td><td>Blue Books</td><td>1 to 6</td></tr>
<tr><td rowspan="2">Student Activity</td><td>Student Activity</td><td>05</td><td>Report of 2 pages</td><td>1 to 6</td></tr>
<tr><td>TOTAL</td><td>25</td><td></td><td></td></tr>
<tr><td>SEE (Semester End Examination)</td><td>End Exam</td><td>Students</td><td>End Of the Course</td><td>100</td><td>Answer Scripts at BTE</td><td>1 to 6</td></tr>
<tr><td rowspan="2">Indirect Assessment</td><td colspan="2">Student Feedback on course</td><td rowspan="2">Students</td><td>Middle Of The Course</td><td colspan="2">Feed Back Forms</td><td>1 to 6</td></tr>
<tr><td colspan="2">End Of Course Survey</td><td>End Of The Course</td><td colspan="2">Questionnaires</td><td>1 to 6</td></tr>
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***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.

Course Contents with Lecture Schedule:

Lesson No./ Session No.	Contents	Duration
Unit I	**Introduction to Substation System**	**05 Hours**
1.	Introduction to the substation. Define substation. List the types of substation. List the specifications of sub-station. Explain the necessity of substation.	01 Hour
2.	List the essential features of sub-station. Draw the single line diagram of 220KV /11KVSubstation using standard Symbol. State the function of each component	01 Hour
3.	List the auxiliary systems used in sub stations. Explain auxiliary ac system. Explain fire fighting system	01 Hour
4.	Explain Transformer water spray system	01 Hour
5.	Explain the function of earthing screen in a substation	01 Hour
Unit II	**Testing and maintenance of Bus Bars and Isolators**	**08 Hr**
6.	Define bus bars. List the types of bus bars. Define the following terms (a) Rated voltage of bus bars (b) Rated current of bus bars (c) Rated frequency of bus bars (d) Rated short time current of bus bars	01 Hour
7.	List the materials commonly used for Bus bars. List the types of configuration of Bus bars in out door substation List the differences between Rigid and Flexible Bus bar systems.	01 Hour
8.	Explain (a) Single Bus Bar arrangement (b) Duplicate Bus Bar arrangement (c) Sectionalisation of Bus	01Hour
9.	Explain (d) Ring Bus (e) One and Half Breaker arrangement (f) Mesh arrangement	01Hour
10.	Explain temperature rise and Short time current test on Bus Bars	01 Hour
11.	Explain momentary current, Vibration test and High Voltage test on Bus Bars	01 Hour
12.	Define Isolator. List the types of Isolators. List the interlock arrangement to prevent mal-operation of isolator.	01 Hour
13.	Explain the different type of tests on isolators. Explain the use of load break switch in sub-station	01Hour
Unit III	**Testing and maintenance of Circuit Breaker and Reactors**	**12 Hr**
14.	Explain mechanical test, temperature rise, milivolt drop test	01 Hour
15.	Explain Dc resistance test and dielectric test	01 Hour
16.	Explain routine tests on CB	01 Hour

17.	List the short circuit tests on CBs. Explain stresses on CBs during short circuits	01 Hour
18.	Explain the layout of simple SC Testing station. Explain the rules for Type Tests ,short time current test	01 Hour
19.	Explain critical current tests and short line fault tests	01 Hour
20.	Explain Line Charging Breaking current Tests and out of phase switching tests	01 Hour
21.	Explain capacitive current switching Tests and small inductive current Breaking Tests	01 Hour
22.	List the methods of indirect Testing. Explain unit testing and Parallel current injection method	01 Hour
23.	Explain series current injection method and Brown Boveri 's synthetic testing Circuit	01 Hour
24.	List the steps in general Maintenance of Circuit Breaker. Explain maintenance of MOCB	01 Hour
25.	Explain maintenance of Air Blast CB, Vacuum CB and SF6 CB	01 Hour
Unit IV	**Testing and maintenance of Protective Relays**	**10 Hours**
26.	List the four classes of tests on Relays. Explain acceptance tests and installation test	01 Hour
27.	Explain maintenance Tests and repair tests	01 Hour
28.	Explain Primary current injection test set and secondary current injection test set	01 Hour
29.	Explain testing circuit for differential relays and testing circuit for BuchHolz relays	01 Hour
30.	Lists the steps involved in maintenance of relays	01 Hour
31.	Explain basic principle of static over current relay and directional over current relay	01 Hour
32.	Explain Static time lag Over current relay and Static Distance relay based on comparison principle	01 Hour
33.	Explain Static differential Protection of Transformers and Testing of static relays with respect to over voltage transients	01 Hour
34.	Draw the block diagram of a digital relay. Explain the two families of digital relays. List the advantages of microprocessor based Relays	01 Hour
35.	Explain microprocessor based distance relay for protection of Transmission lines	01 Hour
Unit V	**Testing and maintenance of Power Transformers, Current and Voltage Transformers and Insulators**	**13 Hr**
36.	List the 4 Preliminary tests on transformer. Explain core insulation Test, Core loss test and ratio polarity test	01 Hour
37.	List the 3 final tests. Explain routine Tests	01 Hour
38.	Explain type tests and Special tests	01 Hour

39.	Explain Lighting impulse test Circuit and switching impulse test Circuit	01 Hour
40.	Explain recording and Measurement of Impulses. Explain fault detection	01 Hour
41.	Define partial discharge. Explain the typical test circuit arrangement for partial discharge. Explain different methods of locating partial discharge	01 Hour
42.	List daily checks, monthly and annual checks to be carried out for the maintenance of transformer	01 Hour
43.	Explain unscheduled maintenance of transformer. Explain the procedure for maintenance of transformer oil	01 Hour
44.	List the various type tests and routine tests on CTs. Explain error Measurement Tests. Explain turns ratio test	01 Hour
45.	Explain exciting current test, polarity test and Insulation Test	01 Hour
46.	Explain over voltage inter turn test and Explain precautions to be taken while using CTs	01 Hour
47.	List the various types tests on PTs. Explain error Measurement Tests and Insulation Tests on PT	01 Hour
48.	Explain polarity test and High voltage tests	01 Hour
Unit VI	**Substation monitoring and control**	**04 Hr**
49.	List the basic variables related with substation monitoring. List two categories of primary control in sub station. Explain the equipment used in automatic control of sub station	01 Hour
50.	List the two sub systems in a sub station. Explain the desirable features of the sub systems	01 Hour
51.	Explain on line microprocessor based fault monitoring and fault locators. Explain the two Hierarchical levels in a sub station.	01 Hour
52.	Explain the function of Substation level and unit level. Explain inter level communication. Explain the function performed by protection and control equipment	01 Hour
	TOTAL:	**52 HOURS**

Student Activity (any one to be submitted with 3 pages self HAND WRITTEN report):

1. Study and identify the components of a outdoor and indoor substation
2. List different kinds of bus bars, isolators, lightning arrestors. Explain any two in detail.
3. Develop one simple hardware model of circuit breaker for demonstration.
4. List different kinds of electromechanical, static and numerical relays. Explain any two in detail.
5. Perform the market survey and write brief comparative report on power transformers, distribution transformer, current transformer and voltage transformer.
6. Explain the role of information technology in the field of substation monitoring and control. Illustrate any two examples.

RUBRICS FOR ACTIVITY(5 Marks)						
Dimension	**Unsatisfactory**	**Developing**	**Satisfactory**	**Good**	**Exemplary**	**Student Score**
	1	**2**	**3**	**4**	**5**	
Collection of data	Does not collect any information relating to the topic	Collects very limited information; some relate to the topic	Collect much information; but very limited relate to the topic	Collects some basic information; most refer to the topic	Collects a great deal of information; all refer to the topic	Ex: 4
Fulfill team's roles & duties	Does not perform any duties assigned to the team role	Performs very little duties but unreliable.	Performs very little duties	Performs nearly all duties	Performs all duties of assigned team roles	5
Shares work equally	Always relies on others to do the work	Rarely does the assigned work; often needs reminding	Usually does the assigned work; rarely needs reminding	Normally does the assigned work	Always does the assigned work without having to be reminded.	3
Listen to other Team mates	Is always talking; never allows anyone else to speak	Usually does most of the talking; rarely allows others to speak	Talks good; but never show interest in listening others	Listens, but sometimes talk too much	Listens and speaks a fair amount	2
Average / Total marks=(4+5+3+2)/4=14/4=3.5=4						

MODEL QUESTION PAPER (CIE)

Test/Date and Time	Semester/year	Course/Course Code	Max Marks
1st Test/ 6 th week,	VI SEM, E & E Engg	**Testing, Maintenance and Control of Substation**	20
	Year: 2016-17	Course code: 15EE63B	

Name of Course coordinator :
Units Covered :1 and 2
Course Outcomes : 1 and 2
Instruction :*(1). Answer all questions (2). Each question carries five marks*

Question No.	Question	CL	CO	PO
1	Define substation. List the different types of substation	R	1	2, 10
2	List the auxiliary systems used in sub stations OR Explain Transformer water spray system	R U	1	2, 10
3	Define the following terms (a) Rated voltage of Bus Bars (b) Rated current of Bus Bars (c) Rated frequency of Bus Bars (d) Rated short time current of Bus Bars OR Explain (a) Single Bus Bar arrangement (b) Duplicate Bus Bar arrangement .	U U	2	2, 10
4	Explain temperature rise test on Bus Bars	A	2	2, 10

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

MODEL QUESTION PAPER BANK:

Course Title: **Testing, Maintenance and Control of Substation**	Course Code: 15EE63B

CO1- Remember the basics of substation system

Unit 1 -Introduction to Substation

Cognitive Level: UNDERSTAND

1) Define substation with examples.
2) List the different types of substation
3) List the advantage and disadvantages of substation
4) State the necessity of substation
5) List the components of general substation
6) Label the components of substation on a single line diagram
7) List the auxiliary systems used in sub stations
8) Explain auxiliary ac System
9) Explain fire fighting system
10) Explain Transformer water spray system
11) Explain the function of earthing screen in a substation

CO2- Understand the testing and maintenance of bus bars and isolators

Unit 2 -Testing and maintenance of Bus Bars and Isolators

Cognitive Level: UNDERSTAND/APPLY

1) Define bus bars. List the types of bus bars.
2) Define the following terms (a) Rated voltage of bus bars (b) Rated current of bus bars (c) Rated frequency of bus bars(d) Rated short time current of bus bars
3) List the materials commonly used for Bus bars.
4) List the types of configuration of Bus bars used in out door substation
5) State the differences between Rigid and Flexible Bus bar systems.
6) Explain Single Bus Bar arrangement
7) Explain Duplicate Bus Bar arrangement
8) Explain Sectionalisation of Bus
9) State the advantage and disadvantages of single and duplicate bus bar sytem
10) State the advantages of sectionalisation of bus
11) Explain Ring Bus
12) Explain One and Half Breaker arrangement
13) Explain Mesh arrangement
14) State the advantages of ring bus system
15) List the differences between ring bus and mesh arrangement

16) Explain temperature rise test on bus bar
17) Explain short time current test on bus bar
18) Explain momentary current test on bus bar
19) Explain vibration test on bus bar
20) Explain high voltage test on bus bar
21) Define Isolator.
22) List the types of Isolators
23) List the interlock arrangement to prevent mal-operation of isolator
24) Explain the different type of tests on isolators.
25) Explain the use of load break switch in sub-station

CO3- Understand the testing and maintenance of circuit breakers and reactors

Unit 3 -Testing and maintenance of Circuit Breaker and Reactors

Cognitive Level: UNDERSTAND / APPLY

1) List the various types of tests to test the circuit breaker
2) List the various types of tests to test the CB
3) Explain mechanical test on CB
4) Explain temperature rise test on CB
5) Explain milivolt drop test on CB
6) Explain DC resistance test on CB
7) Explain dielectric test on CB
8) List the various types of routine tests on CB
9) List the various short circuit tests on CB
10) Explain the stresses on CBs during short circuits
11) Explain the layout of simple SC Testing station.
12) Explain the rules for Type Tests and short time current test
13) Explain critical current test on CB
14) Explain short line fault test on CB
15) Explain Line Charging Breaking current Tests on CB
16) Explain out of phase switching tests on CB
17) Explain capacitive current switching test on CB
18) Explain small inductive current breaking test on CB
19) List the methods of indirect Testing.
20) Explain unit testing and Parallel current injection method
21) Explain series current injection method
22) Explain Brown Boveri 's synthetic testing Circuit
23) List the steps in general Maintenance of Circuit Breaker
24) Explain maintenance of MOCB
25) Explain maintenance of Air Blast CB
26) Explain the maintenance of Vacuum CB
27) Explain the maintenance of SF6 CB

CO4-Understand the testing and maintenance of protective relays

Unit 4 -Testing and maintenance of Protective Relays

Cognitive Level: UNDERSTAND / APPLY

1) List the four classes of tests on relays.
2) Explain acceptance tests on relays.
3) Explain installation teston relays.
4) Explain maintenance tests on relays.
5) Explain repair tests on relays.
6) Explain Primary current injection test set for relays
7) Explain secondary current injection test set for relays
8) Explain testing circuit for differential relays
9) Explain testing circuit for BuchHolz relays
10) List the steps involved in maintenance of relays
11) Explain basic principle of static directional over current relay
12) Explain Static time lag Over current relay
13) Explain Static Distance relay based on comparison principle
14) Explain basic principle of static directional over current relay
15) Explain Static differential Protection of Transformers
16) Explain the testing of static relays with respect to over voltage transients
17) Explain microprocessor based distance relay for protectionof Transmission lines

CO5- Understand the testing and maintenance of CT, PT and Insulators

Unit 5 -Testing and maintenance of Power Transformers, Current and Voltage Transformers and Insulators

Cognitive Level: UNDERSTAND / APPLY

1) List the 4 Preliminary tests on transformer.
2) Explain core insulation Test on transformer.
3) Explain Core loss test on transformer.
4) Explain ratio polarity teston transformer.
5) List the 3 final tests on transformer.
6) Explain routine Tests on transformer.
7) Explain type tests on transformer.
8) Explain Special tests on transformer.
8) Explain Lighting impulse test Circuit a power transformer
9) Explain switching impulse test Circuit for a power transformer
9) Explain recording and Measurement of Impulses on transformer.
10) Define partial discharge.
11) Explain the typical test circuit arrangement for partial discharge.
12) Explain different methods of locating partial discharge
13) List daily checks, monthly and annual checks to be carried out for the maintenance of power transformer
14) Explain unscheduled maintenance of transformer.
15) Explain the procedure for maintenance of transformer oil
16) List the various type tests and routine tests on CTs.
17) Explain error Measurement Tests for CT
18) Explain turns ratio test for CT
19) Explain exciting current test on CT

20) Explain polarity test on CT
21) Explain Insulation Test on CT
22) Explain over voltage inter turn test
23) Explain precautions to be taken while using CTs
24) List the various types tests on PTs.
25) Explain error Measurement Tests and Insulation Tests on PT
26) Explain polarity test and High voltage tests

CO6- Analyse the substation monitoring and control

Unit 6 - Substation Monitoring and Control

Cognitive Level: UNDERSTAND / APPLY

1) List the basic variables related with substation monitoring.
2) List two categories of primary control in substation.
3) Explain the equipment used in automatic control of substation
4) List the two sub systems in a sub station.
5) Explain the desirable features of the sub systems
6) Explain on line microprocessor based fault monitoring and fault locators.
7) Explain the two Hierarchical levels in a sub station.
8) Explain the function of Substation level and unit level.
9) Explain inter level communication.
10) Explain the function performed by protection and control equipment

Model Question Paper

Code: 15EE63B

TESTING, MAINTENANCE AND CONTROL OF SUBSTATION

VI Semester Examination

Diploma in Electrical and Electronics Engg

Time: 3 Hours **Max Marks: 100**

***Note*:** i) Answer any SIX questions from PART - A. Each question caries 5 marks.
ii) Answer any SEVEN Questions from PART - B. Each question caries 10 marks.

PART – A

1	Define substation with examples.	5
2	Define the following terms (a) Rated voltage of bus bars (b) Rated current of bus bars	5
3	Explain Single Bus Bar arrangement	5
4	List the interlock arrangement to prevent mal-operation of isolator	5
5	Explain milivolt drop test on CB	5
6	List the four classes of tests on relays	5
7	List the steps involved in maintenance of relays	5
8	Explain ratio polarity teston power transformer.	5
9	List the basic variables related with substation monitoring	5

PART – B

10) (a)	State the advantage and disadvantages of single and duplicate bus bar system	6
(b)	State the necessity of substation	4
11) (a)	Explain vibration test and high voltage test on bus bar	7
(b)	Define Isolator.	3
12) (a)	Explain critical current test and short line fault test on CB	7
(b)	List the various types of tests to test the CB	3
13) (a)	Explain maintenance of MOCB and Air Blast CB	7
(b)	List the types of Isolators	3
14) (a)	Explain basic principle of static directional over current relay	5
(b)	Explain testing circuit for BuchHolz relays	5
15) (a)	Explain turns ratio test and exciting current test for CT	8
(b)	Define partial discharge.	2
16) (a)	List the various types tests on PTs.	3
(b)	Explain error Measurement Tests and Insulation Tests on PTs	7
17) (a)	List two categories of primary control in substation.	3
(b)	Explain the equipment used in automatic control of substation	7
18) (a)	Explain recording and Measurement of Impulses on transformer	7
(b)	List the various short circuit tests on CB	3
19) (a)	Explain maintenance tests and repair tests on relays	7
(b)	List the four classes of tests on relays	3

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