Ref No:

< Sri Krishna Institute of Technology, Bangalore>

COURSE PLAN

Academic Year 2019

Program:	B E – Electrical and Electronics Engineering
Semester :	7
Course Code:	15EE73
Course Title:	High voltage engineering
Credit / L-T-P:	4 / 4-0-0
Total Contact Hours:	50
Course Plan Author:	Shweta B

Academic Evaluation and Monitoring Cell

< Sri Krishna Institute of Technology
#29, Hesaraghatta Main Road
Chimney Hills, Chikkabanavara Post>
<Bangalore– 560090,Katakana, India.>
<Phone / Fax :+91-STD-080 >
<Web: skit.org.in, e-mail: >

Table of Contents

Note : Remove “Table of Content” before including in CP Book
Each Course Plan shall be printed and made into a book with cover page
Blooms

15EE73:High voltage engineering

A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	EE
Year / Semester:	2019/7	Academic Year:	2019-20
Course Title:	High voltage engineering.	Course Code:	15EE73
Credit / L-T-P:	4-0-0	SEE Duration:	180 Minutes
Total Contact Hours:	50	SEE Marks:	80Marks
CIA Marks:	20	Assignment	05Marks
Course Plan Author:	Shweta B	Sign	Dt:
Checked By:		Sign	Dt:

2. Course Content

Module	Module Content	Teaching Hours	Module Concepts	Blooms Level
1	**Conduction and Breakdown in Gases:** Gases as Insulating Media, Collision Process, Ionization Processes, Townsend's Current Growth Equation, Current Growth in the Presence of Secondary Processes, Townsend's Criterion for Breakdown, Experimental Determination of Coefficients α and γ, Breakdown in Electronegative Gases, Time Lags for Breakdown, Streamer Theory of Breakdown in Gases, Paschen's Law, Breakdown in Non-Uniform Fields and Corona Discharges. **ConductionBreakdown in Liquid Dielectrics:** Liquids as Insulators, Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure Liquids, Conduction and Breakdown in Commercial Liquids. **Breakdown in Solid Dielectrics**: Introduction, Intrinsic Breakdown, Electromechanical Breakdown, Thermal Breakdown	10	Dielectric Material Breakdown Mechanism	L3,
2	**Generation of High Voltages and Currents:** Generation of High Direct Current Voltages, Generation of High Alternating Voltages, Generation of Impulse Voltages, Generation of Impulse Currents, Tripping and Control of Impulse Generators	10	Generation	L4
3	**Measurement of High Voltages and Currents:** Measurement of High Direct Current, Voltages, Measurement of High AC and Impulse Voltages, Measurement of High Currents – Direct, Alternating and Impulse, Cathode Ray Oscillographs for Impulse Voltage and Current Measurements	10	Measurement	L4
4	**Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems**: National Causes for Over voltages - Lightning Phenomenon, Overvoltage due to Switching Surges, System Faults and Other Abnormal, Principles of Insulation Coordination on High Voltage and Extra High Voltage Power Systems	10	Over voltage Phenomenon	L4
5	**Non-Destructive Testing of Materials and Electrical Apparatus:** Introduction, Measurement of Dielectric Constant and Loss Factor, Partial Discharge Measurements. High Voltage Testing of Electrical Apparatus: Testing of Insulators and Bushings, Testing of Isolators and Circuit Breakers, Testing of Cables, Testing of Transformers, Testing of Surge Arrestors, Radio Interference Measurements,	10	High Voltage Testing	L4

3. Course Material

	Details	Available
1	Text books	
	M.S. Naidu, V. Kamaraju, "High Voltage Engineering ", Tata McGraw Hill Publishing India, 1999.	In Lib
	C.L. Wadhawa, "High Voltage Engineering", Wiley Eastern Ltd, New Age Ltd, India, 1995.	In Lib
2	Reference books	
1	E. Kuffel, "High Voltage Engineering Fundamentals", Butterworth-Heineman, 2000.	In dept
2	S.K.singh, "Fundamentals of High voltages Engineering", Dhanpat Rai ,&Co(Pvt) ltd, India 2012.	In dept
		In dept
3	Others (Web, Video, Simulation, Notes etc.)	
	Videos on breakdown mechanism in gaseous , liquids and solids	Not Available

4. Course Prerequisites

SNo	Course Code	Course Name	Module / Topic / Description	Sem	Remarks	Blooms Level
1	17EE33	Transformer and Generator	harmonics	7		L3
2	17EE553	dc machines	motors	3		L4

Note: If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

B. OBE PARAMETERS

1. Course Outcomes

#	COs	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
15EE73.1	Categorize the behavior of gas, liquid and solid under High voltage stress.	04	Dielectric Material	Lecture	Slip Test	L3 Apply
15EE73.2	Analysis the Breakdown Mechanism of gas, liquid and solid by Experimental method by comparing with IEEE standard rating	06	Breakdown Mechanism	Lecture	Assignment	L4 Analyze
15EE73.3	Analysis the constructional design of HV generation by Voltage doubler and Multiplier circuits	06	Generation	Lecture	Assignment and Slip Test	L4 Analyze
15EE73.4	Analysis the working of Impulse voltages by Marks circuits	04	Generation	Lecture / PPT	Assignment	L3 Apply
15EE73.5	Apply the systematic approach to measure High voltages by spark gap method by compare with standards	05	Measurement	Lecture	Slip test	L4 Analyze
15EE73.6	Analyze the measurement of Impulse current using CRO and magnetic Link method	05	Measurement	Lecture and Tutorial	Assignment	L3
15EE73.7	Determine the causes of over voltage by lightning.	05	Over voltage Phenomenon	Lecture	Assignment and Slip Test	L5 Evaluate
15EE73.8	Describe the Principles of Insulation coordination	05	Principles of Insulation coordination	Lecture	Assignment	L2

15EE73.9	Discuss the measurement principle of Partial discharge	05	principle of Partial discharge	Lecture	Assignment	L2
15EE73.10	Analysis the Testing of Electrical Insulation in Transformers and circuit breaker.	05	High voltages Testing	Lecture	Assignment	L4 Analyze
-	**Total**	**50**	-	-	-	-

Note: Identify a max of 2 Concepts per Module. Write 1 CO per concept.

2. Course Applications

SNo	Application Area	CO	Level
1	High voltage used in medical field , painting , Printing,	CO1	L2
2	Solid, liquid and gaseous dielectric materials used as a insulator for electrical operators.	CO2	L2

Note: Write 1 or 2 applications per CO.

3. Articulation Matrix

(CO – PO MAPPING)

-	Course Outcomes	Program Outcomes												
#	COs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	Level
15EE73.1	Categorize the behavior of gas, liquid and solid under High voltage stress.	X	X	X	X									L3 Apply
15EE73.2	Analysis the Breakdown Mechanism of gas, liquid and solid by Experimental method by comparing with IEEE standard rating	X	X	X	X									L4 Analyze
15EE73.3	Analysis the constructional design of HV generation by Voltage doubler and Multiplier circuits	X	X	X	X									L4 Analyze
15EE73.4	Analysis the working of Impulse voltages by Marks circuits	X	X	X	X									L3 Apply
15EE73.5	Apply the systematic approach to measure High voltages by spark gap method by compare with standards	X	X	X	X									L4 Analyze
15EE73.6	Analyze the measurement of Impulse current using CRO and magnetic Link method	X	X	X										L3
15EE73.7	Determine the causes of over voltage by lightning.	X	X	X										L5 Evaluate
15EE73.8	Describe the Principles of Insulation coordination	X	X											L2
15EE73.9	Discuss the measurement principle of Partial discharge	X	X											L2
15EE73.10	Analysis the Testing of Electrical Insulation in Transformers and circuit breaker.	X	X	X										L4 Analyze
CS501PC.	Average													

Note: Mention the mapping strength as 1, 2, or 3

4. Mapping Justification

Mapping		Justification	Mapping Level
CO	**PO**	**-**	**-**
CO1	PO1	knowledge of behavioral characteristics of all dielectric material are required in application of High voltage	L3
CO1	PO2	Identification of behavioral accepts of dielectric materials are essential for analyze and design.	L3
CO1	PO3	By knowing the behavioral concepts of dielectric material, which will helps in design n of system components.	L3
CO1	PO4	Analysis of behavioral of dielectric material to pre step of investigate in research concepts	L3
CO2	PO1	Knowledge of Breakdown mechanism of dielectric material are required in order to known the dielectric strength.	L4
CO2	PO2	Identify and formulate breakdown mechanism in different dielectric media.	L4
CO2	PO3	various principles of breakdown mechanism , which help in estimate the design concepts of insulator.	L4
CO2	PO4	design the experimental setup to check the breakdown strength of dielectric materials.	L4
CO3	PO1	knowledge of generation of HVDC,HVAC components	L3
CO3	PO2	Analyse the proper design technique to generate HVAC,DC	L3
CO3	PO3	Analyse the complete design system process to achieve the proper generation method	L3
CO3	PO4	Experimental analysis be achieved in laboratories.	L3
CO4	PO1	Basic knowledge of Impulse voltage and their input are required	L3
CO4	PO2	Identify the impact of impulse voltage are required to before it generations.	L3
CO4	PO3	analyze the careful and safety design methods for generation of impulse voltage.	L3
CO4	PO4	Experimental analysis can be done in laboratories	L3
CO5	PO1	knowledge of basic measurement techniques are required.	L4
CO5	PO2	Identify the components requirements for measurements of HVAC,DC	L4
CO5	PO3	Design the systematic and safety methods of measurement of HVAC,HVDC.	L4
CO5	PO4	system approach can be done experimentally.	L4
CO6	PO1	knowledge of basic impulse measurement are required	L3
CO6	PO2	identify the required components used for measurement	L3

CO6	PO3	design the appropriate method to analyse and design to build the circuits	L3
CO7	PO1	basic knowledge of over voltage and cause of over voltage by lightening	L5
CO7	PO2	identify the problems due to lightening	L5
CO7	PO3	analyze the solution to over come from effect	L5
CO8	PO1	knowledge of insulation coordination concepts are required	L2
CO8	PO2	identify the different principle of insulation coordination	L2
CO9	PO1	knowledge on partial discharge is required	L2
CO9	PO2	analyze the different principle of partial discharge	L2
CO10	PO1	knowledge on electrical insulation are required	L4
CO10	PO2	identify the types of different electrical insulation process	L4
CO10	PO3	design the different testing process to find the insulation capability of equipments	L4

Note: Write justification for each CO-PO mapping.

5.Curricular Gap and Content

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					

Note: Write Gap topics from A.4 and add others also.

6. Content Beyond Syllabus

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					

Note: Anything not covered above is included here.

C. COURSE ASSESSMENT

1. Course Coverage

Module #	Title	Teaching Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Conduction and Breakdown in Gases:	10	2	-	-	1	1	2	CO1, CO2	L3, L4
2	Generation of High voltage , current,Impulse voltages and currents.	10	2	-	-	1	1	2	CO3, CO4	L4L4
3	Measurement of High voltage , current,Impulse voltages and currents.	10	-	2	-	1	1	2	CO5, CO6	L3, L4
4	Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems:	10	-	2	-	1	1	2	CO7, C08	L2, L3
5	Non-Destructive Testing of Materials and Electrical Apparatus:	10	-	-	4	1	1	2	CO9, CO10	L2, L4
-	**Total**	**50**	**4**	**4**	**4**	**5**	**5**	**10**	**-**	**-**

Note: Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

2.Continuous Internal Assessment (CIA)

Evaluation	Weightage in Marks	CO	Levels
CIA Exam – 1	30	CO1, CO2, CO3, CO4	l3, l4, l4, l4
CIA Exam – 2	30	CO5, CO6, CO7, C08	L3, L4L2, L3,
CIA Exam – 3	30	CO9, CO10	L2, L4
Assignment - 1	05	CO1, CO2, CO3, CO4	l3, l4, l4, l4
Assignment - 2	05	CO5, CO6, CO7, C08	L3, L4L2, L3,
Assignment - 3	05	CO9, CO10	L2, L4
Seminar - 1			
Seminar - 2			
Seminar - 3			
Other Activities – define – Slip test		CO1 to Co9	L2, L3, L4 . ..
Final CIA Marks	**40**	**-**	**-**

Note : Blooms Level in last column shall match with A.2 above.

D1. TEACHING PLAN - 1

Module - 1

Title:	**Conduction and Breakdown in Gases**	Appr Time:	16 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Categorize the behavior of gas, liquid and solid under High voltage stress.	CO1	L3
2	Analysis the Breakdown Mechanism of gas, liquid and solid by Experimental method by comparing with IEEE standard rating.	CO2	L4
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction to Subject, course objectives and outcomes, Introduction to high voltage and Insulating dielectric medias	C01	L3
2	Collision Process, Ionization Processes, Townsend's Current Growth Equation,	C01	L3
3	Current Growth in the Presence of Secondary Processes, Townsend's Criterion for Breakdown,	C01	L3
4	Experimental Determination of Coefficients α and γ, Breakdown in Electronegative Gases, Time Lags for Breakdown,	C01	L3
5	Streamer Theory of Breakdown in Gases, Paschen's Law, Breakdown in Non-Uniform Fields and Corona Discharges.	C01	L3
6	**ConductionBreakdown in Liquid Dielectrics:** Liquids as Insulators,	C02	L4
7	Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure Liquids	C02	L4
8	Conduction and Breakdown in Commercial Liquids.	C02	L4
9	**Breakdown in Solid Dielectrics**: Introduction, Intrinsic Breakdown,	C02	L4
10	Electromechanical Breakdown, Thermal Breakdownand problems	C02	L4
c	**Application Areas**	**CO**	**Level**
1	High voltage used in medical field , painting , Printing,	CO1	L3
2	Solid,liquid and gaseous dielectric materials used as a insulator for electrical operators.	CO2	L4
d	**Review Questions**	-	-
1	Discuss various the dielectric properties of Solid, liquid and gaseous dielectric materials.	CO1	L1

2	Discuss Ionization process, Explain primary ionization process.	CO1	L3
3	Derive the current growth equation using Townsend methods	CO1	L3
4	Explain the Townsend's Criterion for Breakdown	CO1	L3
5	Explain the Breakdown in Electronegative Gases,	CO1	L3
6	Explain the Time Lags for Breakdown,,.	CO1	L3
7	Explain the Streamer Theory of Breakdown in Gases	CO1	L3
8	Derive Paschen's Law	CO2	L3
9	Write a brief note on Breakdown in Non-Uniform Fields and Corona Discharges	CO2	L4
10	Mention the gases used as the insulating medium in electrical apparatus? What is breakdown voltage?	CO1	L1
11	What is breakdown voltage?	CO1	L4
12	What are the two types of electrical discharges in gases?		
13			
14	State the two types of theories which explain the mechanism for breakdown	CO2	L3
15	Mention the gases used as the insulating medium in electrical apparatus? What is breakdown voltage?	CO2	L4
16	What are pure liquids ?Give examples.	CO1	L1
17	.Mention some of the applications of liquid dielectrics.	CO1	L4
18	Name some examples of liquid dielectrics.	CO2	L3
19	What are the different types of solid insulating materials?	CO2	L4
20	Explain the two types of intrinsic breakdown mechanisms.	CO1	L1
21	Explain suspended particle theory and cavitation &bubble theory in commercial liquid dielectrics.	CO2	L3
22	Explain electronic breakdown and electro-convection breakdown in commercial liquid dielectrics	CO1	L1
23	In an experiment with certain gas, it was found that the steady state current is 5.5 X 10-8 A at 8KV at a distance of 0.4cm between the electrode plates. Keeping the field constant and reducing the distance to 0.01cm results in a current of 5.5 X 10-9A. Calculate Townsend's primary ionization co-efficient.	CO2	L3
24	In an experiment with certain gas, it was found that the steady state current is 6 X 10-8 A at 10KV at a distance of 0.4cm between the electrode plates. Keeping the field constant and reducing the distance to 0.2cm results in a current of 10 X 10-9A. Calculate Townsend's primary ionization co-efficient.	CO2	L4
25	A steady current of 600 μA flows through the plane electrode separated by a distance of 0.5 cm when a voltage of 10 kV is applied. Determine the Townsend's first ionization coefficient if a current of 60 μA flows when the distance of separation is reduced to 0.1 cm and the field is kept constant at the previous value.	CO2	L3
26	A solid dielectric specimen has a dielectric constant of 4.2, ad tanδ = 0.001 at a frequency of 50 Hz. If it is subjected to an alternating field of 50 kV/cm, calculate the heat generated in the specimen due to the dielectric loss.	CO2	L4
27	A solid dielectric specimen with a dielectric constant of 4.0 has an internal void of thickness 1 mm. The specimen is 1 cm thick and is subjected to a voltage of 80 kV (rms). If the void is filled with air and if the breakdown strength of air can be taken as 30 kV (peak)/cm, find the voltage at which an internal discharge can occur.	CO1	L1
28	The following observations were made in an experiment for determination of dielectric strength of transformer oil. Determine the power law equation. Gap Spacing: 4 6 8 10 Vb (kV): 88 135 165 212 Q9. The following observations were made in an experiment for determination of dielectric strength of transformer oil. Determine the power law equation. Gap Spacing: 4 6 10 12 Vb (kV): 90 140 210 255	CO1	L4

	Explain the Electromechanical Breakdown, Thermal Breakdown **of** solid dielectrics.	CO2	L3
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO3	L3
5			

Module – 2

Title:	**Generation of High Voltages and Currents:**	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Analyze the constructional design of HV generation by voltage Doubler circuits and multiplier circuits	CO3	L4
2	Analyze the working of Impulse voltage by Marks circuits.	CO4	L3
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction to Subject, course objectives and outcomes	CO3	L4
2	In the fields of electrical engineering and applied physics, high voltages (d.c., a.c., and impulse) are required for several applications	CO4	L3
3	Generation of High Direct Current Voltages using Half wave and full wave rectifier .	CO3	L4
4	problems	CO4	L3
5	Generation of High Alternating Voltages,	CO3	L4
6	problems	CO4	L3
7	Generation of Impulse Voltages,	CO3	L4
8	problems	CO4	L3
9	Generation of Impulse Currents,	CO3	L4
10	Tripping and Control of Impulse Generators	CO4	L3
c	**Application Areas**	**CO**	**Level**
1	Electron microscopes and xray units require high d.c. voltages of the order of 100 kV or more. Electrostatic precipitators, particle accelerators in nuclear physics, etc. require high voltage (d.c) of several kilovolts and even megavolts.	CO3	L3
2	High a.c. voltages of one million volts or even more are required for testing power apparatus rated for extra high transmission voltages (400 kV system and above).	CO4	L4
d	**Review Questions**	-	-
1	Explain with diagrams, different types of rectifier circuits for producing high d.c. voltages.,?	CO3	L1
2	Why is a Cockcroft-Walton circuit preferred for voltage multiplier circuits? Explain its working with a schematic diagram.	CO4	L3
3	Give the expression for ripple and regulation in voltage multiplier circuits. How are the ripple and regulation minimized?	CO3	L2
4	Explain the different schemes of cascade connection of transformers for producing very high a.c. voltages	CO4	L4
5	Why is it preferable to use isolating transformers for excitation with cascade transformer units, if the power requirement is large	CO4	L2
6	What is the principle of operation of a resonant transformer? How is it advantageous over the cascade connected transformers?	CO3	L5
7	What is the principle of operation of a resonant transformer? How is it advantageous over the cascade connected transformers?	CO3	L2
8	What is a Tesla coil? How are damped high frequency oscillations	CO3	L3

	obtained from a Tesla coil?		
9	Define the front and tail times of an impulse wave. What are the tolerances allowed as per the specifications?	CO3	L5
10	Give different circuits that produce impulse wave explaining clearly their relative merits and demerits	CO3	L2
11	Describe the circuit arrangement for producing lightning current wave-forms in laboratories.	CO3	L3
12	How is the circuit inductance controlled and minimized in impulse current generators?	CO3	L5
13	Explain with neat diagram the principle of operation of (i) series (ii) parallel resonant circuits for generating high a.c. voltages. Compare their performance.	CO3	L5
14	Explain with neat sketches Cockroft-Walton voltage multiplier circuit. Derive the expression for a) high voltage regulation, b) ripple, c) optimum no of stageswhen the circuit is (i) unloaded (ii) loaded.	CO3	L2
15	Explain with neat diagram the principle of operation of (i) series (ii) parallel resonant circuits for generating high a.c. voltages. Compare their performance.	CO3	L3
16	How will you specify an impulse generator? Describe the working of a multi-stage Marks impulse generator with a neat sketch	CO3	L5
17	Write short note on (a) impulse current generator, (b) generation of switching surges, (c) multistage Marx circuit, (d) generation of high frequency high voltage, (e) Trigation gap	CO3	L5
18	An impulse generator has eight stages with each condenser ra impulse wave. What is the maximum output voltage of the generator, if the charging voltage is 120kV? 5. Define the terms (i) Impulse voltages; (ii) Chopped wave; (iii) Impulse flash overvoltage; (iv) Impulse puncture voltage; (v) Impulse ratio for flash over; (vi) Impulse ratio for puncture	CO3	L2
19	Define Impulse waveform. Draw the graph with different components associated with it. Write about different components of impulse generator.	CO3	L3
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO3	L3
5			

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:		CS501PC	Sem:	I	Marks:	30	Time:	75 minutes		
Course:		High voltage engineering								
-	**-**	**Note: Answer any 3 questions, each carry equal marks.**						**Marks**	**CO**	**Level**
1	a	Derive the current growth equation in electronegative gases.						20	CO1	L1
	b	Define statistical time lag and formative time lag to breakdown. Show with V-t diagram								L2
	c	In an experiment to measure α for a certain gas, it was found that the steady current is 3.8×10-8 A at a voltage of 8 kV and at a distance of 4 mm between the plane electrodes. Keeping the field constant and reducing the distance to 1 mm resulted in a current of 3.8×10-9 A. (a) Calculate α; (b)Calculate the number of electrons emitted from the cathode to anode; (c) Determine the electrode spacing that would lead to an electron multiplication factor of 10-8.							CO2	L3
2	a	What are the commercial liquids dielectrics, and how are they different from pure liquids dielectrics?						20		L2

	b	What is "stressed oil volume theory", and how does it explain breakdown in large volumes of commercial liquid dielectrics?			L4
	c	What is 'thermal breakdown' in solid dielectrics, and how is practically more significant than other mechanism?			L3
	d				L2
3	a	Explain with diagrams, different types of rectifier circuits for producing high d.c. voltages.	20	CO3	L1
	b	Why is a Cockcroft-Walton circuit preferred for voltage multiplier circuits? Explain its working with a schematic diagram		CO4	L2
	c	Define the front and tail times of an impulse wave. What are the tolerances allowed as per the specifications?			L1
	d				L2
4	a	Explain the different schemes of cascade connection of transformers for producing very high a.c. voltages,	20		L2
	b	What is the principle of operation of a resonant transformer? How is it advantageous over the cascade connected transformers?			L2
	c	Give the expression for ripple and regulation in voltage multiplier circuits. How are the ripple and regulation minimized?			L1
	d				L3

b. Assignment -1

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions

Crs Code:	15EE73	Sem:	VII	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	High voltage engineering						

Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.

SNo	USN	Assignment Description	Marks	CO	Level
1		Describe the circuit arrangement for producing lightning current wave-forms in laboratories.	5	CO1	L2
2		How is the circuit inductance controlled and minimized in impulse current generators?	5	CO2	L3
3		Give different circuits that produce impulse wave explaining clearly their relative merits and demerits.	6	CO2	L4
4		Define the front and tail times of an impulse wave. What are the tolerances allowed as per the specifications?	5	CO1	L3
5		What is a Tesla coil? How are damped high frequency oscillations obtained from a Tesla coil?	6	CO2	L4
6		An impulse generator has eight stages with each condenser rated for 0.16μFD and 125 kV. The load capacitor available is 1000 pFD. Find the series resistance and damping resistance needed to produce standard lighting impulse. If the charging voltage is 120 kV, what is the maximum output voltage and discharge energy?	5	CO1	L3
7		When over voltages are generated in EHV system?	6	CO2	L4
8		What are the causes for power frequency and its harmonic over voltages?	5	CO1	L3
9		Define: Elastic and inelastic collision.			
10		Classification of liquid dielectrics.?.			
11		Which are the electrical properties of liquid dielectrics			
12		Define intrinsic breakdown			
13		Give different types of liquid dielectrics.			
14		Give different types of solid dielectrics			
15		What is a cascaded transformer? Explain why cascading is done?			
16		Explain and compare the performance of half wave rectifier and voltage doublercircuits for generation of high dc voltages.			
17		Describe with neat diagram a three stage cascaded transformer. Label the power ratings of various stages of the transformer.			
18		Write in details the principle of operation and advantages of series			

		resonant circuit.			
19		Discuss the working principle of high frequency ac high voltage generation.			
20		Explain with neat sketches Cockroft-Walton voltage multiplier circuit. Derive the expression for a) high voltage regulation, b) ripple, c) optimum no of stageswhen the circuit is (i) unloaded (ii) loaded.			
21		A ten stage Cockraft-Walton circuit has all capacitors of 0.06 μF. The secondaryvoltage of the supply transformer is 100 kV at a frequency of 150 Hz. If the loadcurrent is 1 mA, determine (i) voltage regulation (ii) the ripple (iii) the optimumnumber of stages for maximum output voltage (iv) the maximum output voltage.			
22		A 100 kVA 250 V/200 kV feed transformer has resistance and reactance of 1% and5% respectively. This transformer is used to test a cable at 400 kV at 50 Hz. The cable takes a charging current of 0.5 A at 400 kV. Determine the series inductance required. Assume 1% resistance of the inductor. Also determine input voltage to the transformer. Neglect dielectric loss of the cable			
23		Explain with neat diagram the principle of operation of (i) series (ii) parallel resonant circuits for generating high a.c. voltages. Compare their performance.			

D2. TEACHING PLAN - 2

Module – 3

Title:	Measurement of High Voltages and Currents:	Appr Time:	16 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Apply the systematic approach to measurements of High AC , DC voltage by Spark gap method by compare with standard values.	CO5	L2
2	Analyze the measurement of Impulse voltage, current using CRO and magnetic link method.	CO6	L3
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction to Subject, course objectives and outcomes	CO5	L2
2	Measurement of High Direct Current, Voltages,	CO6	L3
3	Voltage Doubler Circuits, Voltage Multiplier Circuits, Van de Graaff Generator	CO5	L2
4	Measurement of High AC by Cascade Transformers,	CO6	L3
5	Measurement of High AC by Resonant Transformers	CO5	L2
6	damped high frequency oscillations obtained from a Tesla coil	CO6	L3
7	Standard sphere gap measurements of HV AC, HV DC, and impulse voltages	CO5	L2
8	Measurement of Impulse Voltages , Standard Impulse Wave-shapes	CO6	L3
9	Analysis of Impulse Generator Circuit Series	CO5	L2
10	Cathode Ray Oscillographs for Impulse Voltage and Current Measurements	CO6	L3
c	**Application Areas**	**CO**	**Level**
1	Direct measurement of high voltages is possible up to about 200 kV, and several forms of voltmeters have been devised which can be connected directly across the test circuit.	CO1	L3
2	A generating voltmeter is a variable capacitor voltage generator which generates current proportional to the voltage to be measured	CO2	L4
3	High currents are used in power system for testing circuit breakers, cables lightning arresters etc. and high currents are encountered during lightning discharges, switching transients and shunt faults. These		

	currents require special techniques for their measurements.		
d	**Review Questions**	-	-
1	Explain the principle and construction of an electrostatic voltmeter for very high voltages. What are its merits and demerits for high voltage AC. measurements ?	CO1	L1
2	Explain the different methods of high current measurements with their relative merits and demerits.	CO1	L3
3	What are the requirements of an oscillograph for impulse and high frequency measurements in high voltage test circuits ?	CO2	L2
4	The H. V. arm of an R-C, divider has 15 numbers of 120 ohm resistors with a 20 pF capacitor to ground from each of the junction points. The L.V. arm resistance is 5 ohms. Determine the capacitance needed in the L.V. arm for correct compensation.	CO2	L4
5	Explain the Factors affecting the measurements.	CO2	L2
6	Explain the Measurement of high impulse currents-Rogogowsky coil and Magnetic Links	CO2	L5
7		CO2	L2
8	Potential dividers-resistance dividers capacitance dividers mixed RC potential dividers.	CO2	L3
9	Explain the Series resistance micro ammeter for HV DC measurements.	CO5	L2
10	Chubb and Fortescue method for HV AC measurement.	CO6	L3
11	Explain the Electrostatic voltmeter-principle, construction and limitation.	CO5	L2
12	Explain the Chubb-Fortesque method for peak voltage measurement bringing out the sources of errors.	CO6	L3
13	Write principle and construction of generating voltmeter	CO5	L2
14	Discuss the main sources of errors common to all type of dividers	CO6	L3
15	Explain the principle of operation and construction of an electrostatic voltameter used for the measurement of high voltage. What are the limitations?	CO5	L2
16	Explain sphere gap method? Explain specifications on spheres and associated accessories	CO6	L3
17	Write short notes on Rogogowsky coil and Magnetic Links.	CO5	L2
18	Determine the breakdown voltage for air gaps of 2 mm and 15 mm lengths under uniform field and standard atmospheric conditions. Also, determine the voltage ifthe atmospheric pressure is 750 mm Hg and temperature 35°C	CO6	L3
19	A Rogogowsky coil is required to measure impulse current of 8 kA having rate of changeof current of 1010 A/sec. The voltmeter is connected across the integrating circuitwhich reads 8 volts for full scale deflection. The input to the integrating circuit isfrom the RogogowskyCoil. Determine the mutual inductance of coil R and C of theintegrating circuit.	CO5	L2
e	**Experiences**	-	-
1			
2			
3			
4			
5			

Module – 4

Title:	Over-voltage Phenomenon and Insulation Coordination in Electric Power Systems	Appr Time:	16 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**

1	Determine the causes of over voltage by Lightning Transient.	CO7	L3
2	Describe the Principles of Insulation co-ordination.	CO8	L2
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction to Subject, course objectives and outcomes	CO7	L3
2	National Causes for Over voltages	CO7	L4
3	problems	CO7	L3
4	Lightning Phenomenon	CO7	L2
5	problems	CO8	L3
6	Overvoltage due to Switching Surges,	CO8	L4
7	System Faults and Other Abnormal,	CO8	L3
8	Principles of Insulation Coordination on High Voltage	CO8	L3
9	Extra High Voltage Power Systems	CO8	L4
10	Lightning Phenomenon	CO8	L3
c	**Application Areas**	**CO**	**Level**
1	Insulation Coordination on High Voltage	CO8	L3
2	Estimation of System Faults and Other Abnormal	CO7	L4
d	**Review Questions**	-	-
1	Explain the losses in a dielectric.	CO7	L1
2	Explain the measurement of dielectric constant and loss factor	CO7	L3
3	With a neat sketch explain high voltage Schering bridgefor the measurement of capacitance of bushings	CO8	L2
4	A Schering bridge was used to measure the capacitance and loss angle of ah.v. bushing. At balance, the 636 Ohm. What are the values of capacitance	CO7	L4
5	The observations obtained were as follows. (Method employed: Substitution method) (i) With standard condenser and leads, the capacitance, C1 = 504 pF the dissipation factor, D1 = 0.0003. (ii) With standard condenser in parallel with the empty test cell, capacitance C2 = 525 pF, and dissipation factor D2 = 0.00031. (iii) With the standard condenser in parallel with the test cell and oil, capacitance C3 = 550 pF and dissipation factor D3 = 0.00075.	CO8	L2
6	A 33KV, 50Hz high voltage Schering Bridge is used to test a sample of insulation. The various arms have the following parameters at balance, the standard capacitors 500pF, the resistive branch 800Ohm, and branch with the capacitance of the sample, its parallel equivalent loss resistant, the power factor and the power loss under the test conditions	CO8	L5
7	Explain measurement of large capacitance.	CO8	L2
8	Write short note on transformer ratio Arm Bridge.	CO8	L5
9	What are partial discharges? How are they detected using (a) straight detection, (b) balance detection methods?	CO8	L2
10	Explain the measurement of dielectric constant and loss factor	CO8	L5
11	With a neat sketch explain high voltage Schering bridgefor the measurement of capacitance of bushings	CO8	L2
e	**Experiences**	-	-
1			
2			
3			
4			
5			

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:		15EE73	Sem:	VII	Marks:	30	Time:	75 minutes		
Course:		High voltage engineering								
-	**-**	**Note: Answer any 2 questions, each carry equal marks.**						**Marks**	**CO**	**Level**
1	a	With a neat sketch explain high voltage Schering bridgefor the measurement of capacitance of bushings						15	CO5	L1
	b	A 33KV, 50Hz high voltage Schering Bridge is used to test a sample of insulation. The various arms have the following parameters at balance, the standard capacitors 500pF, the resistive branch 800Ohm, and branch with the capacitance of the sample, its parallel equivalent loss resistant, the power factor and the power loss under the test conditions							CO6	L2
2	a	Write short note on transformer ratio Arm Bridge.						15	CO7	L2
	b	Explain the measurement of dielectric constant and loss factor							CO6	L2
	c	Explain the Series resistance micro ammeter for HV DC measurements.							CO8	L2
3	a	What are partial discharges? How are they detected using (a) straight detection, (b) balance detection methods?						15	CO8	L1
	b	The observations obtained were as follows. (Method employed: Substitution method) (i) With standard condenser and leads, the capacitance, C1 = 504 pF the dissipation factor, D1 = 0.0003. (ii) With standard condenser in parallel with the empty test cell, capacitance C2 = 525 pF, and dissipation factor D2 = 0.00031. (iii) With the standard condenser in parallel with the test cell and oil, capacitance C3 = 550 pF and dissipation factor D3 = 0.00075.							CO8	L2
4	a	Explain sphere gap method? Explain specifications on spheres and associated accessories						15	CO8	L2
	b	A Rogogowsky coil is required to measure impulse current of 8 kA having rate of changeof current of 1010 A/sec. The voltmeter is connected across the integrating circuitwhich reads 8 volts for full scale deflection. The input to the integrating circuit isfrom the RogogowskyCoil. Determine the mutual inductance of coil R and C of theintegrating circuit.							CO6	L2

b. Assignment – 2

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions										
Crs Code:	15EE73	Sem:	VII	Marks:	5 / 10	Time:	90 – 120 minutes			
Course:	High voltage engineering									
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.										
SNo	**USN**	**Assignment Description**						**Marks**	**CO**	**Level**
1		Explain experimental set up of any one method of testing of a circuit breaker						5	CO8	L2
2		What is insulation coordination? Explain statistical method of insulation coordination						5	CO9	L3
3		Write a short note on capacitance potential dividers.							CO10	L4
4		What are the methods for measurement of High AC voltage measurement? Explain any one in detail.						5	CO9	L3

5		Explain the different methods of high current measurements with their relative merits and demerits.		CO8	L2
6		Explain working principle, construction and applications of van-de-graff generator		CO9	L3
7		Explain the classification of solid dielectrics used in practice		CO10	L4
8		What is the principle of operation of a resonant transformer? How is it advantageous over the cascade transformer units, if the power requirement is large?		CO9	L3
9		What are the methods for measurement of High AC voltage measurement? Explain any one in detail.		CO8	L2
10		Explain the different methods of high current measurements with their relative merits and demerits.		CO9	L3
11		Explain working principle, construction and applications of van -de-graff generator		CO10	L4
12		Explain the classification of solid dielectrics used in practice.		CO9	L3
13		What is the principle of operation of a resonant transformer? How is it advantageous over the cascade transformer units, if the power requirement is large?		CO8	L2
14		A 12 stage impulse generator has 0.126 μF capacitors. The wave front and the wave tail resistances connected are 800 ohms and 5000 ohms respectively. If the load capacitor is 1000 pF. Find the front and tail times of the impulse wave produced?		CO9	L3
15		With suitable illustrations explain how insulation level is chosen for various equipments in a 230/132 KV substation.		CO10	L4
16				CO9	L3

D3. TEACHING PLAN - 3

Module – 5

Title:	Non-destructive insulation testing techniques , High voltage tests on electrical apparatus	Appr Time:	16 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Discuss the Measurement principle of Partial Discharge	CO9	L2
2	Analyze the Testing of Electrical insulation in Transformer and circuit breakers.	CO10	L4
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction to Subject, course objectives and outcomes	CO9	L2
2	Dielectric loss and loss angle measurements using Schering Bridge,	CO10	L4
3	Transformer ratio Arms Bridge.	CO9	L2
4	Need for discharge detection and PD measurements aspects	CO10	L4
5	Factor affecting the discharge detection. Discharge detection methods-straight and balanced methods.	CO9	L2
6	Definitions of terminologies, tests on isolators,	CO10	L4
7	Insulation testing of circuit breakers,	CO9	L2
8	Insulation testing of cables insulators	CO10	L4
9	Insulation testing of transformers	CO9	L2
10	Insulation testing of power capacitance.	CO10	L4
11			
c	**Application Areas**	**CO**	**Level**
1		CO10	L3
2		CO9	L4

d	**Review Questions**	-	-
1	What is insulation coordination? Explain statistical method of insulation coordination		
2	What is a partial discharge? Explain method to measure it with neat diagram.	CO10	L1
3	Explain High voltage Schering bridge	CO10	L3
4	Explain High voltage test on insulator	CO9	L2
5	Explain experimental set up of any one method of testing of a circuit breaker	CO9	L4
6	Explain, with a schematic diagram, one method of measuring RIV of transmission line	CO9	L2
7	Explain the importance of RIV measurements for EHV power apparatus.	CO10	L4
8	Write a short note on design and layout of HV laboratory	CO9	L2
9	Define Electrical discharge.	CO10	L4
10	Define Discharge Inception voltage.	CO9	L2
11	Define Discharge extinction voltage	CO10	L4
12	Define Discharge magnitude.	CO9	L2
13	Define Discharge magnitude.	CO10	L4
14	Define Discharge energy	CO9	L2
15	Define Discharge rate	CO10	L4
16	Define Discharge detector.	CO9	L2
17	Define Electrical discharge.	CO10	L4
18	Define Discharge Inception voltage.	CO9	L2
19	Define Discharge extinction voltage	CO10	L4
20	A Schering bridge was used to measure the capacitance and loss angle of hv bushing. At balance, the observations were: the value of the standard condenser = 100 pF, R3 = 3180 values of capacitance and tan δ of the bushing?	CO9	L2
21	Explain the losses in a dielectric.	CO9	L2
22	Explain the testing of overhead line insulators.	CO10	L4
23	Explain the testing of bushings.	CO9	L2
24	Explain the methods for testing of cables.	CO10	L4
25	Explain the method of impulse testing of high voltage transformer? What is the procedure adapted for locating the fault?	CO9	L2
26	Explain the testing of power transformers	CO10	L4
27	Define the following terms – (a) withstand voltage (b) flash over voltage (c) 50% flash over voltage, (d) wet and dry power frequency tests as referred to high voltage testing, (e) creepage distance of an insulator	CO9	L2
28	Explain the testing of circuit breakers	CO10	L4
29	What are the different power frequency tests done on insulator, mention the procedure of testing.	CO9	L2
30	What are the different power frequency tests done on insulator, mention the procedure of testing	CO10	L4
31	An audio frequency Schering bridge was used to determine the dielectric constant and tan δ of transformer oil at 1 kHz. The observations obtained were as follows. (Method employed: Substitution method) (i) With standard condenser and leads, the capacitance, C1 = 504 pF the dissipation factor, D1 = 0.0003. (ii) With standard condenser in parallel with the empty test cell, capacitance C2 = 525 pF, and dissipation factor D2 = 0.00031. (iii) With the standard condenser in parallel with the test cell and oil, capacitance C3 = 550 pF and dissipation factor D3 = 0.00075. Find the dielectric constant and tan δ of the transformer oil?	CO9	L2
32	A 33KV, 50Hz high voltage Schering Bridge is used to test a sample of insulation. The various arms have the following parameters at balance, the standard capacitors 500pF, the resistive branch 800Ohm, and branch with parallel combination of resistance and the sample, its parallel equivalent loss resistant, the power factor and the power loss under the test conditions.	CO9	L2
33	Write short note on transformer ratio Arms Bridge.	CO10	L4

34	What are partial discharges? How are they detected using (a) straight detection, (b) balance detection method.	CO9	L2
35	With a neat sketch explain high voltage Schering Bridge for the measurement of capacitance of bushings.	CO10	L4
36	Explain the measurement of dielectric constant and loss factor.	CO9	L2
37	Define Discharge magnitude.	CO10	L4
e	**Experiences**	-	-
1			
2			
3			
4			
5			

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	15EE73	Sem:	VII	Marks:	30	Time:	75 minutes
Course:	High voltage engineering						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	What is insulation coordination? Explain statistical method of insulation coordination	20	CO9	L1
	b	Explain High voltage test on insulator of any one power apparatus.		CO9	L2
	c	Explain the measurement of dielectric constant and loss factor.		CO10	L4
2	a	What is a partial discharge? Explain method to measure it with neat diagram	20	CO9	L2
	b	A 33KV, 50Hz high voltage Schering Bridge is used to test a sample of insulation. The various arms have the following parameters at balance, the standard capacitors 500pF, the resistive branch 800Ohm, and branch with parallel combination of resistance and the sample, its parallel equivalent loss resistant, the power factor and the power loss under the test conditions.		CO10	L4
3	a	Explain experimental set up of any one method of testing of a circuit breaker	20	CO9	L2
	b	Explain High voltage Schering bridge		CO10	L4
	c	What are partial discharges? How are they detected using (a) straight detection, (b) balance detection method.			L1
4	a	Explain the method of impulse testing of high voltage transformer? What is the procedure adapted for locating the fault?	20	CO9	L2
	b	Explain the testing of bushings.		CO9	L2
	c	Explain the methods for testing of cables.		CO10	L4

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15EE73	Sem:	VII	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	High voltage engineering						

Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.

SNo	**USN**	**Assignment Description**	**Marks**	**CO**	**Level**
1		What are partial discharges? Define: hundred percent flashover voltages.	5	CO9	L2
2		What are broad band and narrow band detectors?	5	CO9	L3
3		Define Electrical discharge.		CO10	L4

4		Define Discharge Inception voltage.	5	CO10	L3
5		Define Discharge extinction voltage		CO9	L2
6		Explain the testing of overhead line insulators		CO9	L3
7		Explain the methods for testing of cables		CO10	L4
8		Explain the testing of power transformers		CO10	L3
9		Explain the method of impulse testing of high voltage transformer? what is the procedure adapted for locating the fault?		CO9	L2
10		What are the different power frequency tests done on insulator, mention the procedure of testing		CO9	L3
11		Define the following terms – (a) withstand voltage (b) flash over voltage (c) 50% flas over voltage, (d) wet and dry power frequency tests as referred to high voltage testing, (e) creepage distance of an insulator. 8. Explain the testing of circuit breakers.		CO10	L4
12		Define Disruptive discharge voltage.		CO10	L3
13		Define: Fifty percent flashover voltage.		CO9	L2
14		Define: Withstand Voltage.		CO9	L3
15		Define: Creep age distance.		CO10	L4
16		State the advantages and disadvantages of field tests		CO10	L3
17		State the different tests on cables.		CO9	L2
18		Which are the tests normally conducted on surge arresters?		CO9	L3
19					
20					

F. EXAM PREPARATION

1. University Model Question Paper

Course:		High voltage engineering					Month / Year	May /2018	
Crs Code:		15EE73	Sem:	VII	Marks:	100	Time:	180 minutes	
-	**Note**	Answer all FIVE full questions. All questions carry equal marks.					**Marks**	**CO**	**Level**
1	a	What are the advantages of transmitting electrical power at high voltages? 2. What is the Need for Generating High Voltages in laboratory?					16 / 20	CO1	L3
	b	Discuss the following breakdown methods in solid dielectric; (i) intrinsic breakdown; (ii) avalanche breakdown;						CO2	L4
	c	Discuss the limitations of Townsend's theory.						CO2	L4
		OR							
-	a	Define Townsend's first and second ionization coefficients. Explain the Townsends criterion for a spark.					16 / 20	CO1	L3
	b	What are applications of High Voltages?						CO2	L4
	c	What is time-lag? Discuss its components and the factors which affect these components						CO1	L3
2	a	(b) A ten stage Cockraft-Walton circuit has all capacitors of 0.04 μF. The secondary voltage of the supply transformer is 120 kV at a frequency of 150 Hz. If the load current is 1.2 mA, determine (i) Voltage regulation (ii) Ripple content in output voltag					16 / 20	CO4	L3
	b	(a) Describe Cockroft- Walton voltage multiplier circuit in detail. Derive the expression for voltage regulation for an n-stage voltage multiplier. (15 marks)						CO3	L4
		OR							
-	a	Define a standard impulse voltage wave. Define its basic parameters along with a near sample waveform. (5 marks)					16 / 20	CO3	L3
	b	Describe a modified multi-stage Marx circuit for generation of impulse voltages. (15 marks)						CO4	L4
	c	What are the advantages and disadvantages of High Voltage generation						CO6	

		using cascaded transformers?			
3	a	How will you specify an impulse generator? Describe the working of a multi-stage Marks impulse generator with a neat sketch	16 / 20	CO5	L3
	b	Explain the Chubb-Fortesque method for peak voltage measurement bringing out the sources of errors.		CO5	L4
	c	Explain sphere gap method? Explain specifications on spheres and associated accessories		CO6	L3
		OR			
-	a	Define the terms (i) Impulse voltages; (ii) Chopped wave; (iii) Impulse flash overvoltage; (iv) Impulse puncture voltage; (v) Impulse ratio for flash over; (vi) Impulse ratio for puncture	16 / 20	CO5	L3
	b	Explain the multistage impulse generator circuit		CO7	L4
	c	Write principle and construction of generating voltmeter		CO6	L3
4	a	What do you mean by non-destructive testing? List out various techniques used.	16 / 20	CO7	L3
	b	What is insulation coordination?		CO7	L4
	c	Explain measurement of large capacitance.		C08	L3
		OR			
-	a	What are partial discharges? How are they detected using (a) straight detection, (b) balance detection methods?	16 / 20	CO7	L3
	b	Explain the measurement of dielectric constant and loss factor		CO8	L4
5	a	Explain in detail about the various tests conducted on overhead line insulators. (10marks)	16 / 20	CO9	L4
	b	Define the following: (i) Disruptive discharge voltage. (ii) Impulse flashover voltage and impulse ratio. (iii) 50% flashover voltage. (5 marks		CO10	L3
	c	(c) Explain the method of impulse testing of high voltage transformers. What is the procedure adopted for locating the failure? (5 marks)		CO9	L4
		OR			
	a	Explain with neat diagram, the method to measure the specific resistivity of an insulation specimen, along with dielectric constant and loss factor (15 marks)	16 / 20	CO9	L4
	b	Following measurements are made to determine the dielectric constant and complex permittivity of a test specimen: The air capacitance of the electrode system = 60 pF The capacitance and loss angle of the electrodes with specimen = 180 pF and 0.0085 respectively. (5 marks		CO9	L3
	c	Explain the testing of circuit breakers.		C010	L4
	d				

2. SEE Important Questions

Course:		High voltage engineering					Month / Year	May /2018
Crs Code:		15EE73	Sem:	VII	Marks:	100	Time:	180 minutes
	Note	Answer all FIVE full questions. All questions carry equal marks.					-	-
Module	Qno.	Important Question					**Marks**	**CO**	**Year**
1	1	Explain with diagrams, different types of rectifier circuits for producing high d.c. voltages.,?					16 / 20		2014
	2	Why is a Cockcroft-Walton circuit preferred for voltage multiplier circuits? Explain its working with a schematic diagram.							2015
	3	Give the expression for ripple and regulation in voltage multiplier circuits. How are the ripple and regulation minimized?							2013
	4	Explain the different schemes of cascade connection of transformers for producing very high a.c. voltages							2016
	5	Why is it preferable to use isolating transformers for excitation with cascade transformer units, if the power requirement is large							2017
2	1	What is the principle of operation of a resonant transformer? How is it					16 /		2007

		advantageous over the cascade connected transformers?	20		
	2	What is a Tesla coil? How are damped high frequency oscillations obtained from a Tesla coil?			2009
	3	Define the front and tail times of an impulse wave. What are the tolerances allowed as per the specifications?			2012
	4	Give different circuits that produce impulse wave explaining clearly their relative merits and demerits			2013
	5	Describe the circuit arrangement for producing lightning current wave-forms in laboratories.			2014
		How is the circuit inductance controlled and minimized in impulse current generators?			
3	1	Explain with neat diagram the principle of operation of (i) series (ii) parallel resonant circuits for generating high a.c. voltages. Compare their performance.	16 / 20		2016
	2	Explain with diagrams, different types of rectifier circuits for producing high d.c. voltages.,?			2010
	3	Why is a Cockcroft-Walton circuit preferred for voltage multiplier circuits? Explain its working with a schematic diagram.			2017
	4	Give the expression for ripple and regulation in voltage multiplier circuits. How are the ripple and regulation minimized?			2014
	5	Explain the different schemes of cascade connection of transformers for producing very high a.c. voltages			2012
		Why is it preferable to use isolating transformers for excitation with cascade transformer units, if the power requirement is large			
4	1	Explain the method of impulse testing of high voltage transformer? what is the procedure adapted for locating the fault?	16 / 20		2017
	2	Explain the method of impulse testing of high voltage transformer? what is the procedure adapted for locating the fault?			2014
	3	What are the different power frequency tests done on insulator, mention the procedure of testing			2012
	4	Define the following terms – (a) withstand voltage (b) flash over voltage (c) 50% flas over voltage, (d) wet and dry power frequency tests as referred to high voltage testing, (e) creepage distance of an insulator. 8. Explain the testing of circuit breakers.			2017
	5	Define Disruptive discharge voltage.			2007
5	1	What are the different power frequency tests done on insulator, mention the procedure of testing	16 / 20		2017
	2	Define the following terms – (a) withstand voltage (b) flash over voltage (c) 50% flas over voltage, (d) wet and dry power frequency tests as referred to high voltage testing, (e) creepage distance of an insulator. 8. Explain the testing of circuit breakers.			2014
	3	Define Disruptive discharge voltage.			2012
	4	Explain the method of impulse testing of high voltage transformer? what is the procedure adapted for locating the fault?			2004
	5	What are the different power frequency tests done on insulator, mention the procedure of testing			2005

G. Content to Course Outcomes

1. TLPA Parameters

Table : TLPA – Example Course

Module-#	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	InstructionMethods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	**Conduction and Breakdown in Gases:** Gases as Insulating Media, Collision Process, Ionization Processes, Townsend's Current	10	- L1 - L2	L2	- Remembering	- Lecture	-Unit Test - Assignment

	Growth Equation, Current Growth in the Presence of Secondary Processes, Townsend's Criterion for Breakdown, Experimental Determination of Coefficients α and γ, Breakdown in Electronegative Gases, Time Lags for Breakdown, Streamer Theory of Breakdown in Gases, Paschen's Law				- Explaining		
1	Breakdown in Non-Uniform Fields and Corona Discharges. **ConductionBreakdown in Liquid Dielectrics:** Liquids as Insulators, Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure Liquids, Conduction and Breakdown in Commercial Liquids. **Breakdown in Solid Dielectrics**: Introduction, Intrinsic Breakdown, Electromechanical Breakdown, Thermal Breakdown	10	- L1 - L2	L2	- Remembering - Explaining	- Lecture	-Unit Test - Assignment
2	**Generation of High Voltages and Currents:** Generation of High Direct Current Voltages, Generation of High Alternating Voltages	6	- L2 - L3	L3	- Understanding - Calculate	- Lecture	-Unit Test - Assignment
2	Generation of Impulse Voltages, Generation of Impulse Currents, Tripping and Control of Impulse Generators	5	- L2 - L3	L3	- Understanding - Calculate	- Lecture -	-Unit Test - Assignment
3	**Measurement of High Voltages and Currents:** Measurement of High Direct Current, Voltages, Measurement of High AC and Impulse Voltages,	8	- L2 - L4	L4	- Understanding - Explaining &analyzing	- Lecture -	-Unit Test - Assignment
3	Measurement of High Currents – Direct, Alternating and Impulse, Cathode Ray Oscillographs for Impulse Voltage and Current Measurements,	4	- L2 - L4	L4	- Understanding - Explaining &analyzing	- Lecture -	-Unit Test - Assignment
4	**Overvoltage Phenomenon and Insulation Coordination in Electric Power Systems**: National Causes for Over voltages - Lightning Phenomenon, Overvoltage due to Switching Surges	4	- L1 - L2	L2	- Remembering - Explaining	- Lecture	-Unit Test - Assignment
4	. System Faults and Other Abnormal, Principles of Insulation Coordination on High Voltage and Extra High Voltage Power Systems	8	- L2 - L4	L4	- Understanding - Explaining	- Lecture	-Unit Test - Assignment
5	. **Non-Destructive Testing of Materials and Electrical Apparatus:** Introduction, Measurement of Dielectric Constant and Loss Factor, Partial Discharge Measurements.	6	- L2 - L4	L4	- Understanding - Explaining	- Lecture - -	-Unit Test - Assignment

	High Voltage Testing of Electrical Apparatus:				g		
5	Testing of Insulators and Bushings, Testing of Isolators and Circuit Breakers, Testing of Cables, Testing of Transformers, Testing of Surge Arrestors, Radio Interference Measurements,	04	- L1 - L2	L2	- Remembering - Explaining	- Lecture - -	-Unit Test - Assignment

2. Concepts and Outcomes:

Table : Concept to Outcome – Example Course

Module-#	Learning orOutcome fromstudy of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What allLearning Happened from the study of Content / Syllabus. Ashort word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	Townsend's Criterion for Breakdown, Experimental Determination of Coefficients α and γ,	Breakdown in Electronegative Gases, Time Lags for Breakdown, Streamer Theory of Breakdown in Gases,	Paschen's Laweakdown in Non-Uniform Fields and Corona Discharges.	ConductionBreakdown in Liquid Dielectrics: Liquids as Insulators, Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure Liquids,	Conduction and Breakdown in Commercial Liquids.	Breakdown in Solid Dielectrics: Introduction, Intrinsic Breakdown, Electromechanical Breakdown, Thermal Breakdown
2	Generation of High Voltages and Currents: Generation of	High Direct Current Voltages,	Generation of High Alternating Voltages,	Generation of Impulse Currents,	Auto transformers andTap changing transformers: Introduction to autotransformer-copper economy,	Tripping and Control of Impulse Generators
3	Measurement of High Voltages and Currents: Measurement of High Direct Current,	Voltages, Measurement of High AC and Impulse Voltages,	Measurement of High Currents – Direct,	Alternating and Impulse,	Cathode Ray Oscillographs for Impulse	Voltage and Current Measurements
4	Overvoltage Phenomenon and Insulation Coordinatio	National Causes for Overvoltages - Lightnin	Overvoltage due to Switching Surges,	System Faults and Other Abnormal,	Principles of Insulation Coordination	on High Voltage and Extra High Voltage Power Systems

	n in Electric Power Systems:	g Phenomenon,				
5	Non-Destructive Testing of Materials and Electrical Apparatus: Introduction,	Measurement of Dielectric Constant and Loss Factor,	Partial Discharge Measurements	. High Voltage Testing of Electrical Apparatus: Testing of Insulators and Bushings,	Testing of Isolators and Circuit Breakers,	Testing of Cables, Testing of Transformers, Testing of Surge Arrestors, Radio Interference Measurements,