

B.E. ELECTRICAL ENGINEERING EXAMINATION, 2025

(4th Year, 2nd Semester)

HIGH VOLTAGE TECHNIQUE - II

Time: Three Hours

Full Marks: 100

(50 marks for each part)

Use a separate Answer-script for each Part

PART-I

Answer questions from all the modules

(Two marks are reserved for neatness and well organized answers)

Answer any one question from Module 1 (CO2)

1. a) Explain the operation of (i) Spark gaps for surge protection and (ii) Surge Diverters. 8
- b) Explain the following terms related to surge diverters. 8
Residual voltage; Discharge Current; Power frequency spark over voltage; Impulse spark over voltage.
2. a) Explain the following terms related to insulation co-ordination. 8
Factor of Earthing; Conventional Impulse Withstand Voltage; Statistical Impulse Withstand Voltage; Protective Level of Protective Device.
- b) A transformer has an impulse insulation level of 1100 kV and is to be operated with an insulation margin of 15% under lightning impulse conditions. The transformer has a surge impedance of 1500Ω and is connected to a transmission line having a surge impedance of 500Ω . A short length of overhead earth wire is to be used for shielding the line near the transformer from direct strikes. Beyond the shielded length, direct strokes on the phase conductor can give rise to voltage waves of the form $1000 e^{-0.06t}$ kV (where t is expressed in μs). If the corona distortion in the line is represented by the expression $\frac{\Delta t}{x} = \frac{1}{B} \left[1 - \frac{e_0}{e} \right] \mu s / m$, where $B = 115 m/\mu s$ and $e_0 = 210$ kV, determine the minimum length of shielding wire necessary in order that the transformer insulation will not fail due to lightning surges. 8

or

- b) A lightning arrester is required to protect a 5 MVA, 66/11 kV transformer which is effectively earthed in the system. The transformer is connected to a 66 kV, 3 phase system which has a BIL of 350 kV. Select a suitable lightning arrester. 8

[Turn over

Answer any one question from Module 2 (CO3)

3. Describe the experimental procedure to perform the lightning impulse voltage withstand test of a line insulator according to IS 731. Explain the condition of the insulators, the method of supporting the insulator and the correction factor associated with this experimental setup. 16
4. Describe the chopped lightning impulse voltage withstand test performed on transformers and answer the questions (i) to (iv) associated with this test. 16
 - i) Connection of this test setup with neat diagram
 - ii) Sequence of application of impulse voltages
 - iii) Necessity of application of chopped impulses
 - iv) Detection of failure after chopped lightning impulse test

Answer any one question from Module 3 (CO3)

5. a) What are Polarization and Depolarization Current (PDC) measurements? Explain how these measurements help in assessing the condition of transformer insulation. 8
 - b) What is the central time constant (CTC) in the context of RVM spectra, and how does it relate to the condition of transformer insulation? 8
6. a) Illustrate with the help of a diagram the experimental setup used for polarization and depolarization current measurement. Describe the working of the two-electrode technique. 8
 - b) Explain the procedure and significance of Recovery Voltage Measurement (RVM). How does RVM help in evaluating the insulating properties of a dielectric material? 8
7. a) Explain the principle behind FDS measurements. How are complex capacitance and dielectric dissipation factor ($\tan \delta$) determined from the measured voltage and current? 8
 - b) Compare and contrast the dielectric response measurements in time domain (PDC, RVM) and frequency domain (FDS). Discuss their advantages and disadvantages. 8

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PART-IIAnswer *any three* questions*Two marks* are reserved for neatness and well-organized answer script.

Assume suitable values wherever necessary.

1. a) Draw a neat plan and elevation of a typical high voltage laboratory, clearly showing the placement of major testing equipment. 10
 b) A high voltage laboratory needs to test a 400 kV transmission line insulator. Determine the constructional requirements and layout considerations of the laboratory suitable for this testing application.
 Given Data: (i) Dry temperature: 30 °C, (ii) Absolute humidity: 11 g/m³ and (iii) Atmospheric pressure: 765 mm of Hg 6

2. a) A high voltage pulse is required for a Trigatron supply, and the trigger transformer is to be designed accordingly.
 (i) Design the transformer using the given specifications, evaluating the design in terms of secondary turns and layer arrangement. Clearly show the calculations for each step of your evaluation.
 (ii) Calculate the total number of trigger pulses a fully charged battery can deliver, based on the given switch press time.
 (iii) Explain the role of the capacitor in enhancing switching performance. What would be the effect on circuit operation if the capacitor is not included?
 (iv) Draw a neat and labeled circuit diagram of the Trigatron arrangement. 3+2+2+3

 Given Data: (a) Required output pulse: 25 kV, (b) Battery supply: 12 V, 30 Ah, (c) Primary coil resistance: 0.48 Ω , (d) Primary turns: 10, (e) Capacitor: 1 μ F, (f) Core material: Silicon steel ($\mu_r = 4000$), (g) Core shape: Cylindrical, 10 cm diameter, 120 cm length, (h) Maximum secondary coil density: 50 turns/layer (i) Switch press time: 2 seconds per pulse.

- b) Compare and contrast the conventional and modern triggering arrangements used in high-voltage lightning impulse generators. 6

[Turn over

3. a) How would you approach the design of a non-contact type high-voltage DC measuring instrument? Explain with the help of suitable illustrations. 10
- b) A generating voltmeter driven by a four-pole synchronous motor is to be designed to measure a voltage range of 20 kV to 200 kV DC. If the indicating instrument has a minimum sensitivity of $2 \mu\text{A}$, determine the required capacitance of the generating voltmeter. Also, calculate the maximum current range of the indicating instrument. 6
4. a) What is a Klydonograph? 2
- b) With the help of suitable diagrams, explain its principle of operation and the significance of Lichtenberg figures in lightning impulse voltage measurement. 7
- c) How can the magnitude and polarity of the impulse be interpreted using these figures? 3
- d) Mention one modern application of this phenomenon in today's technology. 4
5. a) What is the difference between a low-voltage Schering bridge and a high-voltage Schering bridge? Explain how the measurement of high-voltage capacitors can be simplified in practical field applications. 6
- b) With proper derivation, show how the capacitance and dielectric dissipation factor ($\tan \delta$) can be evaluated in a high-voltage Schering bridge when the test capacitor is grounded. 10