B.E. ELECTRICAL ENGINEERING THIRD YEAR SECOND SEMESTER - 2024

SUBJECT: HIGH VOLTAGE ENGINEERING

Time: Three Hours   Full Marks 100

(50 Marks for each part)

Use a separate Answer-Script for each part

Two marks are reserved for neat and well-organized answers

Question No.	Part I	Marks

Answer any three questions

1. (a) Discuss how cost of the material in transmission line can be reduced with increment of the voltage level. Also, explain why voltage level in high voltage transmission cannot be increased beyond a certain value to reduce the conductor cost.   3+3

    (b) For a string of three-suspension insulators, the equivalent arrangement of capacitance is shown in Fig. 1. The capacitance of each of A, B and C is α, D and E is 0.2α, F and G is 0.1α 10
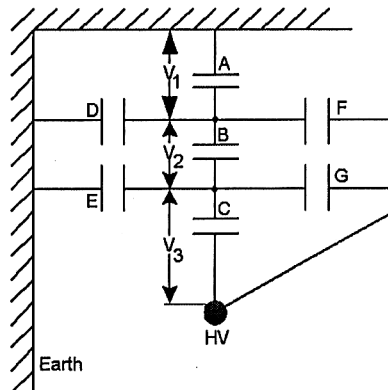

Fig. 1

    (i) Express the voltage across each insulator as a percentage of the line voltage to earth with proper derivation.

    (ii) If the capacitance G becomes 1.2G, find the redistributed voltage.

2. (a) Show that for a single phase two conductor system V_d is proportional to $\left[r \times \ln \dfrac{d}{r} \right]$ (kV_{rms} to neutral), where the symbols have usual meaning.   7

    (b) Mention some of the effects associated with corona in high voltage transmission line.   3

(c)   A three phase 220 kV, 50Hz transmission line has conductors spaced in 5m at the corners of a delta. Each conductor has a radius of 1cm with surface irregularity factor of 0.92. Weather conditions are: temperature 40°C and pressure 75.2cm of Hg. Find the corona loss/km of the transmission line if there is an overvoltage of 1.8 p.u. Also, calculate visual corona voltage of the transmission line for surface correction factor of 0.82.   6

3.   (a)   Find out the general expression of surge impedance and hence find the surge impedance in the case of transmission line.   6

(b)   With the help of a neat diagram, explain the waveshapes of lightning and switching impulse voltages and specify their tolerance levels.   4

(c)   A rectangular surge of 100kV travels along an overhead line of surge impedance 400Ω towards a junction comprising of another overhead line of 350Ω. Find out the reflected and transmitted voltage and the current waves as applicable in the junction.   6

4.   (a)   A 33kV, 50Hz network has the capacitance to neutral of 1.0μF per phase. Calculate the value of inductance that is to be added to prevent the arcing ground condition. Draw the phasor diagram.   5

(b)   Show how the switching of breakers in a charged high voltage line can give rise to overvoltage.   7

(c)   With the help of volt-time characteristics, explain the insulation co-ordination of substation equipment.   4

5.   (a)   Discuss about comparative gain in the case of an optimum size normal single core cable to that of an inter sheath cable.   8

(b)   Find most economical value of the diameter of a single-core cable to be used on 66 kV three phase systems. Also calculate the overall diameter of the insulation if the maximum permissible stress is not to exceed 5 kV/mm.   8

Ex/EE/PC/B/T/322/2024

B.E. ELECTRICAL ENGINEERING EXAMINATION, 2024

(3rd Year, 2nd Semester)

HIGH VOLTAGE ENGINEERING

Time: Three Hours   Full Marks: 100

(50 marks for each part)

Use a separate Answer-script for each Part

PART-II

Answer question No.1 any _TWO_ from the rest

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

1. Answer the following questions: 6x3=18

    a) Why is the short-circuit impedance of a testing transformer higher compared to a power transformer? (CO4)

    b) Explain why the insulation of the winding near the live terminal of a high voltage transformer is stressed most. (CO4)

    c) Explain why series resonance circuit cannot be used for testing objects having very low capacitance, such as insulators. (CO4)

    d) Mention the advantage of using a series resonance circuit as the high voltage source for the measurement of Dielectric Dissipation Factor (*tanδ*) of a capacitor using a Schering Bridge. (CO4)

    e) What is the rationale of taking the band 40% to 60% disruptive discharge voltage as equivalent to 50% disruptive discharge voltage for sphere gap method? (CO5)

    f) Why a reactor is connected in series with the LV arm of the capacitive potential divider and the transformer in the case of a Capacitive Voltage Transformer? (CO5)

2. a) Draw a properly labelled Cockcroft-Walton voltage doubler circuit. Explain with the help of the relevant wave diagram why voltage regulation improves if the frequency increases. (CO4)   3+5

   b) A Cockcroft-Walton voltage doubler circuit is used to test a cable at 170kV. The insulation resistance of the cable is $3.0 \times 10^7 \Omega$/m and the length of the cable is 15m. Stage capacitances are 0.15μF and 0.25μF, respectively. The doubler circuit is supplied from a 500V/250kV testing transformer. Calculate the voltage to be applied to the input of the testing transformer at 50Hz. (CO4)   7

3. a) Design an eight-stage impulse generator to generate 1000kVp with voltage efficiency of 96%. The energy stored in the impulse generator is 14 kJ and the input dc voltage is 125kV. (CO4)9

   b) Show that the standard lightning impulse waveform can be represented as superposition of two exponential waveforms. What are the two main functions of the damping resistor in the impulse voltage generator circuit? Explain with the relevant diagrams. (CO4)   4+3

4. a) Draw the properly labelled circuit diagram of a Chubb-Fortescue peak voltmeter circuit. Explain why two diodes are used in back-to-back in this circuit. With the help of wave diagram explain the problems encountered in this Peak Voltmeter if the voltage waveform contains local maxima. (CO5)   3+3+3

   b) What should be the length of a signal cable having an insulating material of relative permittivity 4 to introduce a delay of 0.6 micro-s for the impulse voltage to reach the recorder from the generator? (CO4)   6

5. a) Draw a diagram of horizontal sphere gap arrangement used in the measurement of high voltage. What is irradiation of sphere gap and under what conditions irradiation is to be done? How is it related to time delay in discharge formation in the sphere gap?   (CO5)   2+3+2

   b) With a neat sketch, explain the principle of a three-stage cascade connection of testing transformers for generating high ac power frequency voltage. Why is the lowest unit loaded more? (CO4)   8