THE INSTITUTION OF ENGINEERS, SRI LANKA

PART III EXAMINATION – NOVEMBER 2008

319 HIGH VOLTAGE ENGINEERING

Time Allowed: 3 hours

Answer Any **Five** Questions Only. All Questions carry equal marks

1. Describe briefly with the aid of suitable diagrams the following:

   (a) streamer mechanism in the spark breakdown in gasses, [4 marks]

   (b) thermal breakdown of a solid dielectric, [4 marks]

   (c) breakdown of a solid dielectric due to internal discharges, [4 marks]

   (d) mechanism of lightning. [4 marks]

   In a high voltage equipment, two electrodes 6 mm apart are separated by oil ($\varepsilon_{r1} = 2.2$, $\xi_{max1} = 25$ kV/mm). Determine the maximum permissible voltage across the electrodes. A solid dielectric material ($\varepsilon_{r2} = 4.4$, $\xi_{max2} = 80$ kV/mm) of thickness 1 mm is introduced into the oil between the electrodes in an attempt to increase the maximum voltage. Calculate the new maximum voltage and comment on the decision. [4 marks]

2.

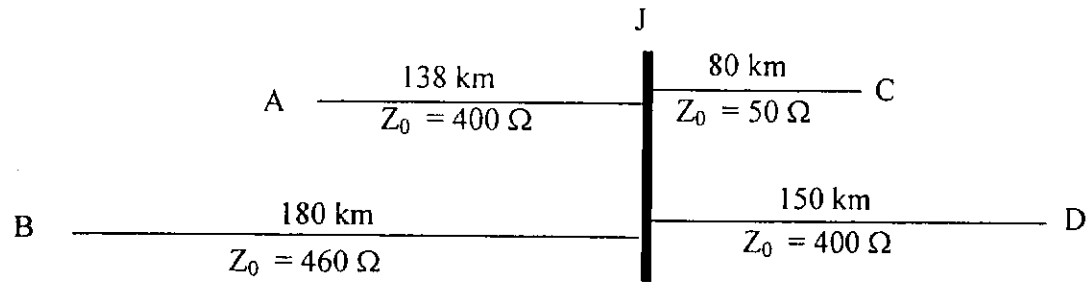

Figure Q2

A part of a power system, with overhead lines AJ, BJ, DJ and a cable CJ, is shown in Figure Q2,. A rectangular surge of vertical front of magnitude 100 kV and duration 1000 μs originates at B and travels towards the junction J. If the line DJ is on open circuit at end D, line AJ is terminated at end A with a resistive load of 400 Ω, and the cable CJ is terminated at end C with a resistive load of 950 Ω, determine the voltages appearing at J for the first 1.5 ms after the surge originates at B. Attenuation in the lines and cable can be neglected. [16 marks]

Sketch the voltage waveform at J and mark the significant values on the waveform. [4 marks]

[velocity of propagation: overhead line – 3×10^5 km/s, cable – 2×10^5 km/s]

3. (a) Describe very briefly the problems associated in using a capacitive potential divider for the observation of an impulse voltage across a test device on the oscilloscope. Explain how these problems may be minimised [4 marks]

(b) An overhead line AB (length 100 km, surge impedance = 450 Ω) is terminated in a resistive load of 1500 Ω at D, through another overhead line BC (length 5 km, surge impedance = 300 Ω, attenuation in single transit = 0.95) and a cable CD (length= 0.5 km, surge impedance = 60 Ω, attenuation factor for a single transit = 0.90). Determine using the Bewley lattice diagram the voltage waveforms appearing at B and D for the first 25 μs after a step voltage surge of magnitude 100 kV originates at B along AB. [16 marks]

[velocity of propagation: overhead line – 3×10^5 km/s, cable – 2×10^5 km/s].

4. (a) Describe briefly with the aid of suitable diagrams one form of electrostatic generator used to obtain high direct voltages. [4 marks]

(b) Using an example, outline the significance of type tests, sample tests and routine tests performed on high voltage equipment. [4 marks]

(c) Give the basic circuit and explain briefly a resonance method used to control the output of a high voltage test transformer.. [4 marks]

(d) With the aid of suitable diagrams briefly describe the operation of the Kydonograph for the measurement of lightning. [4 marks]

(e) With the aid of suitable diagrams briefly describe the measurement of dielectric constant and loss tangent of an insulating liquid. [4 marks]

5. An impulse generator is to be designed to generate the standard impulse waveform (1.2/50 μs) with rated voltage of 270 kV and a voltage efficiency of 90%. 6 capacitors each of 0.16 μF and rated at 50 kV are available.

(a) Sketch the simple equivalent circuit of this impulse generator [1 mark]

Determine in terms of the values of its elements

(b) an expression for the wavefront time (based on 30% to 90%) [6 marks]

(c) an expression for the the wavetail time of the waveform [4 marks]

(d) the nominal capacity of the impulse generator. [1 mark]

(e) the values of the remaining components of the impulse generator [4 marks]

(f) Sketch the complete impulse generator indicating the values of all the components that may be deemed necessary. [4 marks]

6. (a) Draw the circuit diagram for a high voltage Schering Bridge where the standard capacitor has a known but very small loss tangent. [4 marks]

(b) Derive expressions for the values of the capacitance C and the loss tangent tan δ of the unknown, stating any assumptions made in your calculations. [4 marks]

(c) Explain briefly, making use of suitable examples, what is meant by Type Tests, Sample Tests and Routine Tests. [3 marks]

(d) Explain briefly, with the aid of suitable diagrams, the operation of the Cockroft Walton Circuit to obtain high direct voltages for testing purposes. [3 marks]

(e) Describe the use of sphere gaps in the calibration of high voltage meters. [3 marks]

(f) Derive an expression for the effective thermal resistance of the ground of a single core cable buried at a known depth below the surface. [3 marks]