UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 8 Examination in Engineering: October 2015

Module Number: EE8230 **Module Name: High Voltage Engineering**

[Two Hours]

[Answer **all questions**, each question carries **5 marks**]

Q1 a) State two main environmental issues of gaseous insulation SF_6.

[1 Mark]

b) Explain why elastic collisions between gas molecules and electron will not result in gas ionizations.

[1 Mark]

c) Describe how point of wave switching control method reduces switching transients.

[1 Mark]

d) A solid dielectric specimen of dielectric constant of $\varepsilon_2 = 4.0$ shown in Figure Q1.d has an internal void of thickness $d_1 = 1$ mm. The specimen is $d_2+d_1=1$ cm thick and is subjected to a voltage of $V_0=80$ kV (rms). If the void is filled with air and if the breakdown strength of air can be taken as $V_{1b} = 30$ kV (peak)/cm, find whether the void will break down under above applied voltage.

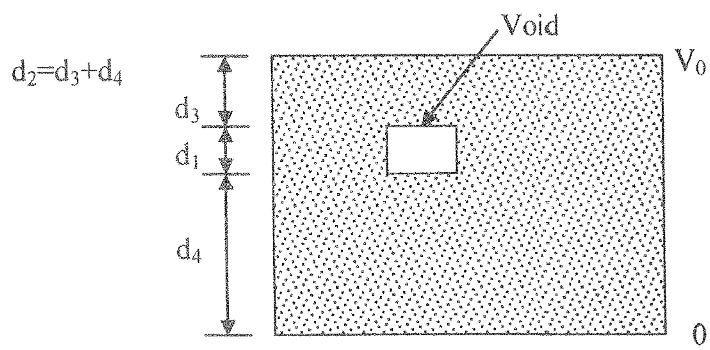

Figure Q1.d

[2 Marks]

Q2 a) Explain the reasons why corona has to be taken in to account when designing power system components.

[1 Mark]

b) Explain the mechanism of losing power by corona with suitable diagrams.

[1 Mark]

c) Briefly explain how stable corona is formed around a charged conductor.

[0.5 Marks]

d) Two conductors carrying currents in opposite directions are distance d apart and each conductor has radius r. Assuming $d >> r$, show that following condition should be satisfied for corona to develop in to a breakdown of gaseous insulation where e is the base of the natural logarithm.

$$\frac{d}{r} < e$$

[2.5 Marks]

Q3 a) State three reasons which have led to the increased usage of composite insulators and less attention to porcelain / glass insulators?

[1 Mark]

b) Describe the rolling sphere method of determining most protected areas from lightning.

[1 Mark]

c) Briefly explain the practical application of Faraday Cage principle for lightning protection.

[1 Mark]

d) A mast of height h erected as lightning protection. Show that shielding angle θ can be expressed as below where r_s is the striking distance. State your assumptions in arriving at the result.

$$\theta = \tan^{-1}\left(\sqrt{\frac{2r_s}{h} - 1}\right)$$

[2 Marks]

Q4 a) A transient travel along an overhead conductor with characteristic impedance Z_{C1} towards a junction at which another overhead line of characteristic impedance Z_{C2} is connected. Let E, I be forward voltage, current, E', I' be reflected voltage, current, and E'', I'' be transmitted voltage, current. Derive following equations.

$$E' = \beta E \quad \text{where} \quad \beta = \frac{Z_{C2} - Z_{C1}}{Z_{C1} + Z_{C2}}$$

$$E'' = \alpha E \quad \text{where} \quad \beta = \frac{2Z_{C2}}{Z_{C1} + Z_{C2}}$$

$$I' = \frac{Z_{C1} - Z_{C2}}{Z_{C1} + Z_{C2}} I$$

$$I'' = \frac{2Z_{C1}}{Z_{C1} + Z_{C2}} I$$

[2 Marks]

b) A long transmission line AB (Z_o = 450 Ω) is connected to a terminal device at C (Z_o = 1950 Ω) through a short length of cable BC (Z_o = 50 Ω, 400 m, attenuation factor in single transit = 0.9). A triangular surge (100 kV vertical front, 6 μs duration to zero) originates in the overhead line AB and travels towards the cable. Sketch the voltage waveform at junction C for the first 11 μs from the arrival of the surge at junction B. Junction A may be assumed to be too far from junction B to consider reflections at junction A coming back to junction B. Velocities of propagation in overhead line and cable are 3×10^5 kms^{-1} and 2×10^5 kms^{-1} respectively.

[3 Marks]