UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: December 2015

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

[Three Hours]

[Answer **all questions**, each question carries **10 marks**]

Q1 a) If a conductor is carrying high alternating currents, the distribution of current is not evenly disposed throughout the cross-section of the conductor. Explain the reasons for this uneven distribution.

[3 Marks]

b) Why does SiO_2 surge arresters often manufacture with air gaps while ZnO arresters are manufactured gapless?

[2 Marks]

c) A surge arrester which has a protective level of 160 kV is mounted 30 m away from a transformer. This transformer is connected to the surge arrester with a cable having propagation velocity of 300 m/ms and negligible attenuation. What will be the highest voltage at the transformer terminals if a surge of linearly rising characteristics of 200 kV/ms approaches transformer passing the surge arrester? Draw the Bewley lattice diagram and voltage time graph to arrive at your answer. Assume transformer has relatively large impedance and surge arrestor characteristics are ideal.

[5 Marks]

Q2 a) Describe briefly the construction of Abraham voltmeter with the aid of diagrams.

[2.5 Marks]

b) What feature of the meter ensures that measuring mechanism does not experience too much distorted electric fields?

[2.5 Marks]

c) Derive an expression for the force between two plates and hence show that the voltmeter can be used for measuring both AC and DC voltages.

[5 Marks]

Q3 a) Draw the equivalent circuit of the belted cable showing various distributed capacitances provided that cable is laid on laboratory desk for testing purposes. What is the additional capacitance that comes in to play when this cable is buried underground? Show it in a diagram.

[2 Marks]

b) Derive an expression for the capacitance of neutral to any of the cores for a cable laid on a laboratory desk.

[2 Marks]

c) A pair of underground cable (live and neutral) has a length l and resistance r when measured from one end of the cable to the other end. The neutral of this cable develops an earth fault distance d away from the local end of the cable. Describe a methodology to locate the position of the fault.

[6 Marks]

Q4 a) A cable, having sheath radius R, has a conductor with radius r. This cable has two inter-sheaths positioned at r_1 and r_2. The dielectric medium used throughout the cable is the same. The potentials of the inter-sheaths have been so maintained that the maximum electric stresses at the boundary of the dielectric media are equal (to say E_{max}) and also the minimum electric stresses are also equal (to say E_{min}). Show that,

$$\frac{r}{r_1} = \frac{r_1}{r_2} = \frac{r_2}{R}$$

[6 Marks]

b) Above single-core cable of a 3 phase system is rated at 66 kV (phase to phase) has a conductor diameter of r = 2 cm and a sheath of diameter R = 5.3 cm. Find the following.

i) Positions of inter-sheaths
ii) Voltage of the inter-sheaths
iii) Maximum and minimum stress

[4 Marks]

Q5 a) Define the front time and fall time (tail time) of an impulse voltage with the aid of a diagram.

[1 Mark]

b) Refer the circuit shown in Figure Q5. The capacitor C_1 is charged at V voltage just before the break down of the spark gap. Show that the circuit generates,

$$e(t) = \frac{V}{R_1 C_2} \cdot \frac{1}{\beta - \alpha}(e^{-\alpha t} - e^{-\beta t})$$

Notations have their usual meanings.

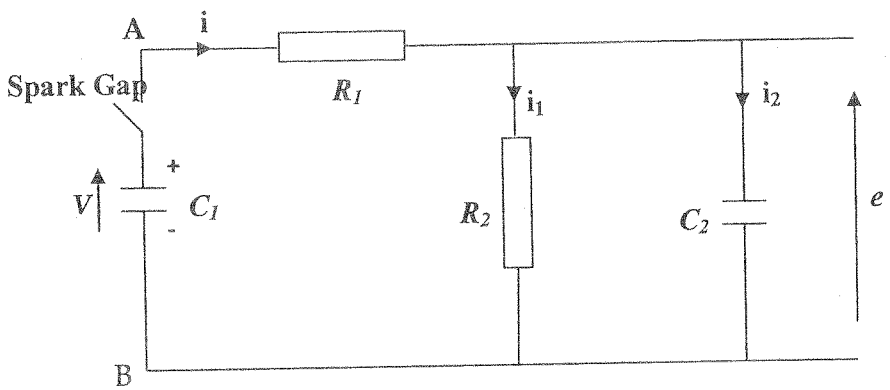

Figure Q5

[6 Marks]

c) Derive expressions for α and β stating assumptions in terms of C_1, C_2, R_1 and R_2.

[2 Marks]

d) State which parameter controls the wave front and which parameter controls wave tail.

[1 Mark]