University of Moratuwa, Sri Lanka
Faculty of Engineering
: Department of Electrical Engineering
BSc Engineering

Level 4 - Semester 1 Examination **EE402 -**

INSULATION CO-ORDINATION

17th September 2007 Time

Allowed: 2 **Hours**

Instructions to candidate

This paper contains 4 questions. Answer AH questions.

Total marks for the paper is 70 marks.

This examination accounts for 70% of the module assessment.

Clearly state any assumptions made, data assumed or interpretations made in the script. *Additional*

Materials

Graph paper is available if required.

Only authorised calculators will be permitted.

Technical information

Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ H/m

Permittivity of free space $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m Velocity of light in free space = 2.998×10^8 m/s

Question 1

(a) Describe with the aid of suitable diagrams the phenomena of lightning. [4 marks]

(b) Describe briefly with the aid of suitable diagrams the theory of shielding overhead transmission line against a direct lightning stoke. [4 marks]

(c) From first principles show that surges in transmission lines can be represented by a combination of forward travelling waves and reverse travelling waves. [5 marks]

(d) Describe with the aid of suitable diagrams, the controlled operation of impulse generator using trigartron gap [4 marks]

Question 2

(a) A long transmission line AB (Z_0= 450 Ω.) is connected to a terminal device at C (Z_0= 1950 Ω) through a 400m, cable BC wi.th characteristic impedance of 50 Ω and attenuation factor in single transit of 0.95. A triangular surge with 150 kV vertical front and 10 us duration to zero originated in the overhead line AB travels towards the cable. Sketch the voltage waveform at C for the first 12 us from the arrival of the surge at B. A may be assumed to be too far from junction B to consider reflections at A coming back to B. [12 marks]

(b) Sketch also the waveform that would have appeared, if the overhead line was directly terminated in the device instead of through the cable. [2 marks]
[Velocities of propagation in overhead line and cable are 3×10^5 km/s and 2×10^5 km/s]

(c) Briefly explain the transform method of solving transients in power systems. [4 marks]

Question 3

(a) Draw the simplified equivalent circuit of a single stage impulse generator to generate a double exponential waveform. Mark on it the output voltage, wavefront control resistor and the wavetaiI control resistor. [1 mark]

Using suitable approximations derive expressions in terms of the components of the equivalent circuit.

(b) for the wavefront time, and [6 marks]

(c) the wavetail time [3 marks]

(d) It is required to generate an output voltage of 1500 kV at the standard 1.2/50 PS impulse waveform with an energy capacity of 15 kJ. Determine the value of the components of the single stage impulse generator. [4 marks]

(e) Draw the 6 stage impulse generator, indicating the values of the components that would be used to generate the above waveform in practice. [3 marks]

Question 4

(a) Briefly explain, with the aid of suitable diagrams, the statistical method of insulation co ordination. [4 marks]

(b) With the aid of suitable diagrams, show that wavetail distortion due to corona in an overhead line can be expressed in the form [6 marks]

$$\frac{\Delta v}{v} = k\left[1 - \frac{e_0}{e}\right]$$

(c) A surge arrester is required to protect a 20 MVA, 132/33 kV, 3 phase transformer (effectively earthed, BIL = 550 kV, Zo = 1600 Ω). With appropriate calculations, select the required discharge current rating for the arrester to protect it from 900 kV surges arriving on a transmission line with a surge impedance of 400 Ω. [8 marks]

Discharge current (kA)	5	10	20
Discharge Voltage (kV)	316	350	418

[END OF QUESTION PAPER]