



**University of Moratuwa, Sri Lanka**  
Faculty of Engineering  
Department of Electrical Engineering  
B. Sc. Engineering Honours Degree Course  
Level 4 – Semester 2 Examination

**EE427 – HIGH VOLTAGE BREAKDOWN & TESTING**

Time Allowed: 2 Hours

June 2006

**Additional Material**

Graph Paper will be provided if required.

**Instructions to Candidates**

This paper contains 5 questions in 4 pages.

This examination accounts for 70% of the module assessment.

Total marks for the paper is 70 marks.

The maximum marks attainable is indicated in square brackets.

Answer **All** Questions.

This is a closed book examination and only authorised Calculators will be permitted.

**Technical Information for candidates**

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

Permittivity of free space  $\epsilon_0 = 8.854 \times 10^{-12}$  F/m

Velocity of light in free space =  $2.998 \times 10^8$  m/s

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### Question 1

(a) Describe briefly, with the aid of suitable diagrams and equations, the avalanche process in the breakdown process of gaseous dielectrics [2 marks]

(b) In a certain Townsend type discharge, the following measurements were made.

d (mm)	4	6	8	10	12	14	16	18	20	22
I (pA)	25	35	45	60	80	120	180	300	550	2000

(c) Deriving any equations used, determine the Townsend's first and second ionization coefficients. [8 marks]

(d) Explain briefly the components of time lag in the impulse breakdown of a gas. [2 marks]

(e) Show with the aid of suitable diagrams how the time lag characteristic of spark breakdown may be determined for the standard impulse voltage waveform. [2 marks]

### Question 2

(a) Derive an expression for the corona inception in a two conductor system with the radius of each conductor  $r$  and the spacing between the conductors  $d$ . Modify it suitably to account for normal deviations in a practical line. [3 marks]

Explain with the aid of suitable diagrams, how the expression may be extended to a three phase transmission line with equilateral spacing. [1 marks]

A certain transmission line has been designed to have corona inception occurring at a voltage of 80 kV under normal temperature and pressure conditions. If the actual ambient temperature is 35 °C and the atmospheric pressure is 765 torr, what would be the actual corona inception voltage. [1 marks]

(b) Describe briefly the breakdown of commercial liquids below their intrinsic strength due to the 3 types of impurities which may be present. [3 marks]

(c) Describe briefly 4 processes by which solid insulation may breakdown below their intrinsic strength. [6 marks]

### Question 3

(a) Describe briefly, with the aid of suitable diagrams the cascade arrangement of transformers to obtain high alternating voltage for testing purposes. [3 marks]

(b) A 200 kVA, 230V/50 kV, 50 Hz, testing transformer has an 8% leakage reactance and a 2% winding resistance. An insulator of capacitance 20 nF is to be tested at 300 kV using this transformer as part of the resonance circuit. Determine the value of the inductance (Q-factor = 15) required to obtain resonance. [5 marks]

Determine also the value of the input voltage required. [2 marks]

(c) Describe with the aid of suitable diagrams the Cockroft-Walton method of generating high direct voltages for testing purposes. [4 marks]

#### Question 4

- (a) Show that the deflecting torque of an electrostatic voltmeter is proportional to the product of the square of the applied voltage and the rate of change of capacitance. [3 marks]  
Describe the principle of operation of the attracted disc electrostatic voltmeter. [2 marks]
- (b) Describe briefly, with the aid of suitable diagrams why a resistive potential divider needs to be matched to the cable connecting it to an oscilloscope, and how the matching may be achieved [4 marks]
- (c) Describe with the aid of suitable diagrams how the dielectric loss in a lossy capacitor is measured in comparison with a standard lossless capacitor using the x-y mode in the oscilloscope. Show that the area of the ellipse displayed is proportional to the loss. [5 marks]

#### Question 5

- (a) Sketch the circuit diagram of a high voltage Schering Bridge for the measurement of capacitance  $C$  and loss tangent  $\tan \delta$ . Derive expressions for the values of  $C$  and  $\tan \delta$  of the unknown, when the standard capacitor has a known but very small loss tangent  $k$  stating any assumptions made in your derivations. [4 marks]
- (b) With the aid of suitable diagrams briefly describe the test cell used in the measurement of dielectric constant and loss tangent of an insulating liquid. [2 marks]  
Explain how the properties of the resonance curve is made use of in determining the Q-factor and the loss tangent. [2 marks]
- (c) With the aid of suitable diagrams briefly describe the use of sphere gaps in the measurement of high voltages. [3 marks]
- (d) Describe briefly why high voltage tests are generally classified into routine tests, sample tests and type tests (or acceptance tests). [3 marks]

[END OF QUESTION PAPER]