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 | March 2008

Additional Material

Graph Paper will be provided if required.

Instructions to Candidates

This paper contains 5 questions in 3 pages, including the cover page.

This examination accounts for 70% of the module assessment.

Answer All Questions.

Total allocation for the paper is 70 marks.

Each question carries a total 14 marks. Maximum marks allocated to each part of a question is indicated in square brackets at the end of the part.

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 $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m

Velocity of light in free space = 2.998×10^{8} m/s

Question 1

(a) Describe briefly, with the aid of suitable diagrams where applicable, the basic ionization processes and the avalanche mechanism in spark breakdown of gaseous dielectrics. *[2 marks]*

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

d (mm)	3	5	7	9	11	13	15	17	19	21	22
I (pA)	25	33	45	65	90	130	195	300	540	1220	2470

Deriving any equations used, determine the Townsend's first ionization coefficients. *[7 marks]*

(c) Describe briefly with the aid of suitable diagrams the time lag characteristic of spark breakdown for the standard impulse waveform. *[2 marks]*

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

Question 2

(a) Explain briefly the breakdown of solid insulation due to internal discharges, and how such discharges may be detected. *[3 marks]*

(b) A certain transmission line has been designed to have corona inception occurring at a voltage of 90 kV under normal temperature and pressure conditions, assuming perfectly cylindrical conductors. If the actual ambient temperature is 40 ^{o}C, the atmospheric pressure is 765 torr and the conductors have been roughened by weather, estimate what would be the actual corona inception voltage under fair weather and stormy weather conditions. State any assumptions made. *[3 marks]*

(c) Describe briefly the use of sphere gaps in high voltage measurements. *[2 marks]*

(d) Derive an expression for the deflecting torque of an electrostatic voltmeter used to measure high voltages. *[3 marks]*

(e) Derive an expression for the current rating of a buried cable considering its thermal behavior. *[3 marks]*

Question 3

(a) By deriving from first principles, show that the electric stress in a single core cable is not uniform. *[2 marks]*

(b) Describe briefly two methods that may be used to distribute the stress more equally in the dielectric. *[4 marks]*

(c) In a 132 kV, 3-phase system, the insulation of a single phase cable has a relative permittivity of 4.0 and a critical breakdown stress of 240 kV/cm (peak). In addition to the nominal supply voltage, transformer can supply an additional voltage of 40 kV. If the conductor radius is 9.5 mm, determine the radii of the sheath and of the intersheath for optimum utilisation of the cable. Take a safety factor as 2.5 in the design. *[8 marks]*

Question 4

(a) With the aid of suitable diagrams briefly describe the construction and operation of the Klydonograph for the measurement of lightning. *[2 marks]*

(b) In a certain standard Schering Bridge measurement, the standard capacitor has a value of 100 nF and a loss tangent of 0.001. At balance the remaining arms are (i) a resistance of 210 Ω, and (ii) a resistance of 100 Ω with a capacitance of 140 nF in parallel. Sketch the circuit diagram of the high voltage Schering Bridge showing the locations of the arms, and determine the values of C and tan δ of the unknown stating any assumptions made in your derivations. *[6 marks]*

(c) Explain briefly, with the aid of suitable diagrams, why a potential divider connected at the output of an impulse generator needs to be matched to the cable connecting it to an oscilloscope and how matching may generally be achieved. You may select any specific type of potential divider as an example. *[4 marks]*

(d) With the aid of sketches describe a typical cascade arrangement of transformers used to obtain high alternating voltages for testing purposes. Why is such an arrangement not suitable for power generation. *[2 marks]*

Question 5

(a) Explain briefly, with the aid of suitable diagrams, one form of electrostatic generator that may be used to obtain high voltages for testing. *[2 marks]*

(b) In the measurement of a capacitance and loss tangent of a dielectric using a parallel resonance circuit, with fixed inductance and variable capacitance, the following readings were obtained.

i. Reading of variable capacitor at resonance without the dielectric in the circuit was 100 nF

ii. Reading of variable capacitor at half power points without the dielectric in the circuit were 98 nF and 102 nF

iii. Reading of variable capacitor at resonance with the dielectric included in parallel in the circuit was 40 nF

iv. Reading of variable capacitor at half power points with the dielectric in the circuit were 33.3 nF and 47.7 nF

Determine the values of the unknown capacitance and its loss tangent. State any assumptions made in your derivations. *[7 marks]*

(c) 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]*

(d) By considering a suitable example, explain briefly type tests, sample tests and routine tests in high voltage equipment. *[3 marks]*

[END OF QUESTION PAPER]