UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2010/2011

COURSE	:	HIGH VOLTAGE ENGINEERING
COURSE CODE	:	BEK 4113
PROGRAMME	:	4 BEE
EXAMINATION DATE	:	APRIL / MAY 2011
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF ELEVEN (11) PAGES

Q1 (a) Define High Voltage term according to IEC Standard, 1983.

(1 mark)

(b) Describe two(2) main sources of High Voltage generation.

(2 marks)

(c) Calculate the static breakdown voltage E_b in V/cm of an H_2 gas at 65 mm.Hg pressure between two parallel plates that ensure a uniform field. α/p as a function of E/p can be determined from the coefficient for field-intensified ionisation by electrons graph shown in Figure Q1(c). Assume $\gamma = 10^{-3}$ electron/incident positive ion. The gap distance is 20 mm. Neglect recombination and attachment.

(4 marks)

(d) Figure Q1(d) shows the current-voltage growth characteristic of the air breakdown mechanism graph based on the Townsend's test measurement result.

Briefly explain:

(i) The Townsend's test method with the assist of appropriate illustration test setup model.
(ii) The phenomena of correspond group I, II, III and IV.

(8 marks)

(e) Propose three(3) suggestions of what people do with high voltages and explain each of them.

(8 marks)

(f) Recommend one(1) main international body that actively involved in High Voltage engineering field.

(2 marks)

Q2 (a) Define the dielectric term.

(1 mark)

(b) Summarise two(2) characteristics that must have in the dielectric together with appropriate examples.

(2 marks)

(c) A uniform static field was created in Methane at 110 mm.Hg pressure by a parallel plate electrode system with a gap distance of 3.5 cm. With an externally applied electric field E_0 of 3.5 kV/cm, it was found that the space charge created by an avalanche lay nearly in a

sphere of radius r_d = 1.5 cm. The constant absolute permittivity K_0 of the test area is 8.854 x 10^{-12} and the charge of electron ε is 1.6 x 10^{-19} Coulomb. Calculate the value of αd for favourable condition for the formation of streamers in the methane gap.

(4 marks)

(d) Briefly explain the whole process of Streamer's breakdown mechanisms method with the assist of appropriate illustration models.

(8 marks)

(e) Construct (by draw and label) a graph that shows the voltage-time and current-time relationship of a discharge condition during the 'post-breakdown process' of the gessoes dielectric, and briefly explain the process.

(7 marks)

(f) Justify the condition in the per-unit of decrease or increase value of the breakdown voltage V_b (kV) during the breakdown process at two different pressures at p_1 = 1.3 bar and p_2 = 2.6 bar. The tests were conducted inside a pressurised chamber filled with air that having a temperature measured at 125°C. The electrodes gap is 4.5cm. Use 1 bar = 750.06 mm.Hg.

(3 marks)

Q3 (a) Breakdown in the dielectrics can be categorised into three major groups. List two(2) of them.

(1 mark)

(b) Summarise two(2) characteristics of the liquid dielectric by comparing it with the gaseous and solid dielectrics.

(2 marks)

(c) Calculate the voltage applied V_s in MV, that caused deformation of 2.5cm thickness of fibre-glass composite-reinforced sample (Young Modulus = 155kN/m^2, εr composite = 6.3) to be at 1.65cm thickness. Use the relative permittivity of free air of 8.854x10^{-12}. Also calculate the highest electric stress E_{max} in MV/m of that specimen.

(4 marks)

(d) Below are the common types of conduction processes that lead to failure in liquid dielectric (oil).

The process seen in liquid
Movement of oil and particulates
Cavity formation
Chemical reaction

(i) Briefly explain the process seen in liquid.

(ii) The movement of oil and particulates in liquid can be categorised into the dielectrophoresis, thermal convection, electro convection and static electricfication processes. Choose only one(1) from these processes and briefly explain its process.

(iii) Briefly explain the cavity formation conduction process.

(iv) Briefly explain the chemical reaction conduction process.

(8 marks)

(e) The breakdown failure mechanisms processes in solid dielectric are dependable by the time and voltage application. Typically, lower level of electrical stress (V/cm) is required for the mechanism of failure that takes place in longer period (e.g. treeing and chemical), while higher stress is required to cause breakdown in transient time (e.g. avalanche).

(i) Construct (by draw and label) a graph that illustrates the breakdown electric field (V/cm) and duration of failure process (sec) of the different failure mechanisms process occurs in solid dielectrics.

(ii) Based on that constructed graph instructed in Q3(e)(i), briefly explain the electromechanical failure mechanism process seen in solid dielectrics.

(iii) Based on that constructed graph instructed in Q3(e)(i), briefly explain the thermal failure mechanism seen in solid dielectrics.

(8 marks)

(f) Justify one(1) thermal breakdown condition that may be occurred in the power cable application.

(2 marks)

Q4 (a) State two(2) common types of High Voltage generators.

(1 mark)

(b) Summarise two(2) characteristic of voltage levels that any insulation provided inside the High Voltage equipment must capable to withstand.

(2 marks)

(c) An observation from the single phase 45kVac_peak tracking test conducted in UTHM's High Voltage Laboratory has found that the composite-reinforced material sample having a relative permittivity ε_r of 6.5 generates the heat at 0.75 Watt/cm^3.

(i) Calculate the material dissipation factor angle (loss angle or δ) in degree value.

(ii) Calculate the total heat loss in surroundings during the test if the total heat absorb in the composite-reinforced material is measured at 0.33Watt/cm^3.

(4 marks)

(d) The HVAC tests are among the common types in High Voltage testing. Briefly explain the general concept of these tests.

(3 marks)

(e) Stated below are three common types of the testing methods on insulation that using HVAC potential.

Whole scale insulation tests
Small scale insulation tests
Long duration insulation test

Briefly explain each of them together with their example of applications.

(5 marks)

(f) The cascaded transformer is typically being used to generate the HVAC voltage level at higher than 200 kV r.m.s.

(i) Construct (by draw and label) an illustration model that shows the principle of the cascaded transformer that capable to generate up to 3V of HVAC voltage.
(ii) Based on that constructed model instructed in Q4(f)(i), briefly explain the condition of each stage of this 3V's cascaded transformer.

(8 marks)

(g) Justify one implication of generating that 3V HVAC as stated in Q(4)(f) to the insulation property if the voltage is generated by a normal straight transformer, not the cascaded one.

(2 marks)

Q5 (a) List two(2) types of HVDC transformer.

(1 mark)

(b) Summarise two(2) general characteristics can be found in the HVDC Half-Period type transformer.

(2 marks)

(c) The transient impulse voltages can be classified as the fast front overvoltages that typically created by lightning (FFO) and the slow front overvoltages by switching (SFO). Their impulse wave usually defined by the international standard.

Classify:

(i) The standard 1.2/50μs, 1425kV$_{peak}$ lightning and 250/2500μs, 1050kV$_{peak}$ switching overvoltages by draw and label their appropriate impulse waveforms.

(ii) The new rise time T1, and decay time T2 of both standard lightning and switching impulse waveforms at their maximum tolerances by draw and label their new-like waveforms.

(4 marks)

(d) The Marx generator is commonly used to generate higher lightning or switching impulse voltages. Briefly explain the general connection of the Four-stage Marx generator together with the assist of its appropriate circuitry diagram.

(8 marks)

(e) Salt fog tests usually being used to verify the durability of insulation product or sample. In other word, the tests could represent acceleration of ageing concept of the particular product over years in service in actual outdoor environment condition.

(i) Construct (by draw and label) a test setup of the salt fog tests.

(ii) Based on that constructed salt fog test setup as instructed in Q5(e)(i), briefly explain the working concept of the test.

(8 marks)

(f) Justify one(1) implication to the test object and human if no sufficient electrical clearances are applied on the test area and earthed structure.

(2 marks)

Q6 (a) Define an insulation coordination term according to IEC 60071-1 (1993).

(1 mark)

(b) Summarise two(2) consequences that could happen if under-rated insulation coordination is applied in the HV equipment or application.

(2 marks)

(c) Calculate the required electrical clearances for the conductor to tower structure to have 50% ability in withstanding a 1425kV$_{_peak}$ lightning, 1050kV$_{_peak}$ switching and 480kV$_{_peak}$ power frequency overvoltages. Use the gap factor $K_g = 1.25$ and the altitude correction factor $K_A = 1.0$.

(4 marks)

(d) Figure Q6(d)(i) shows the peak phase to earth U50 values (kV$_{_peak}$) of lightning, switching and power frequency overvoltages for the conductor to the tower window clearance (m). Their distance relationship under electric field U50 (kV$_{_peak}$) values are shown in Figure Q6(d)(ii). Based on the information observed in these graphs, briefly explain the behaviour of these overvoltages.

(8 marks)

(e) The lightning flash may be created based on the interaction of charge separation take place in the thunderhead cloud such as shown in Figure (Q6)(e). The creation of the flash can be divided into two groups, the first stroke and the second stroke.

(i) Construct (by draw and label) the cloud drawings associated with these phenomena.
(ii) Based on that constructed clouds drawings as instructed in Q6(e)(i), briefly explain their conditions.

(8 marks)

(f) Justify the implication to the power system equipment if the lightning strikes to the line conductors (shielding failure) instead to the shield wire.

(2 marks)

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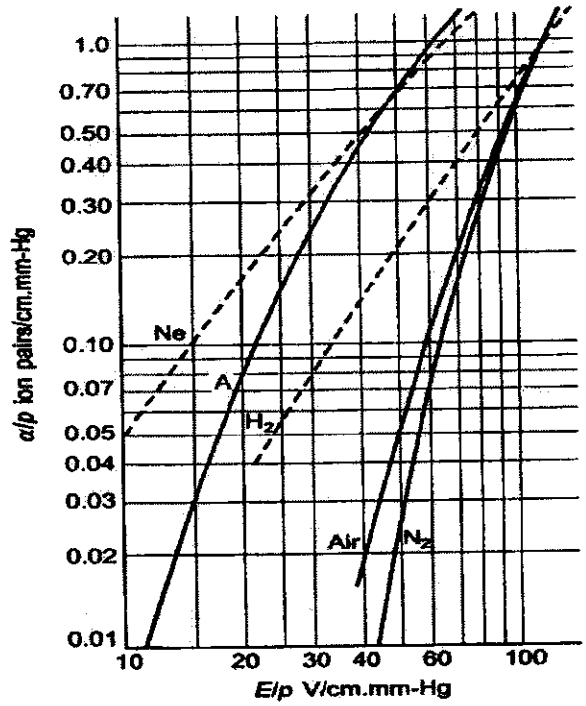

FIGURE Q1(c)

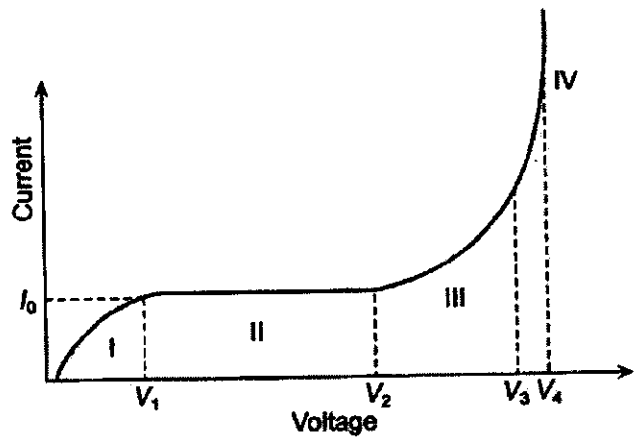

FIGURE Q1(d)

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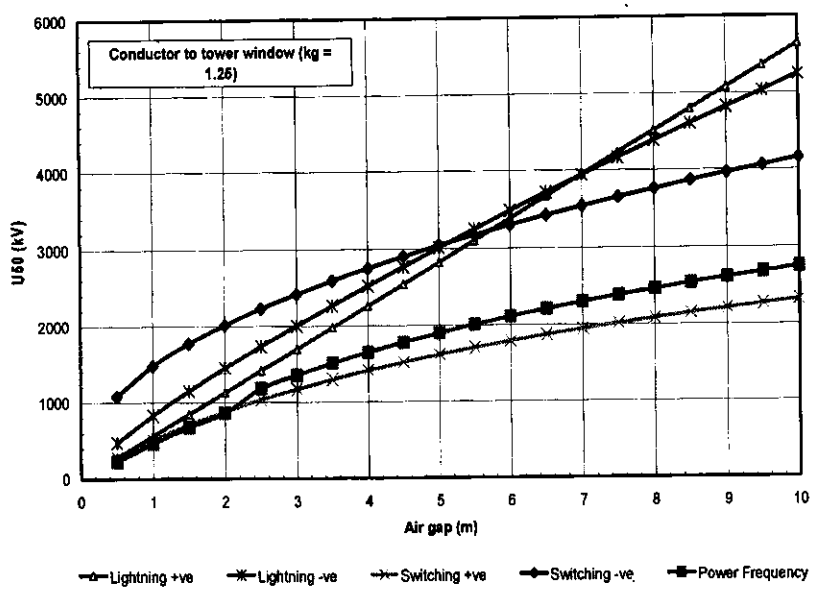

FIGURE Q6(d)(i)

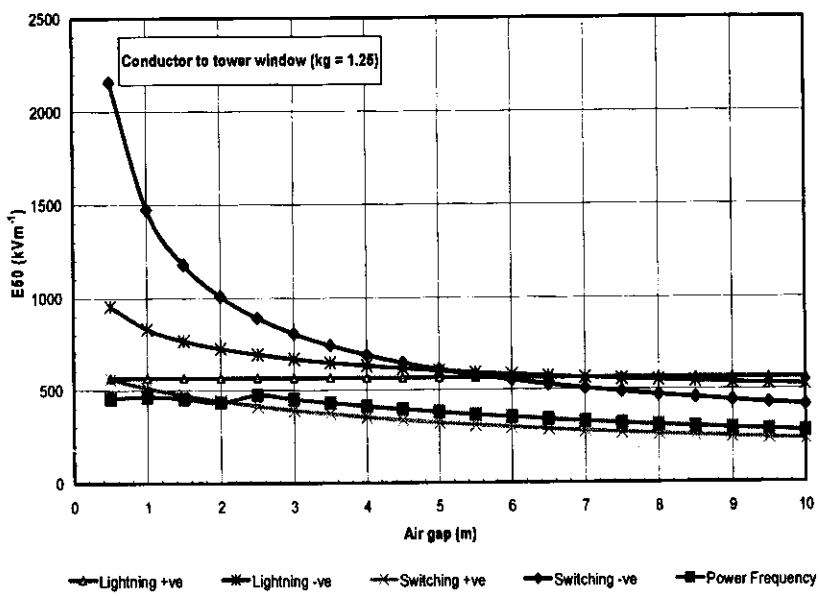

FIGURE Q6(d)(ii)

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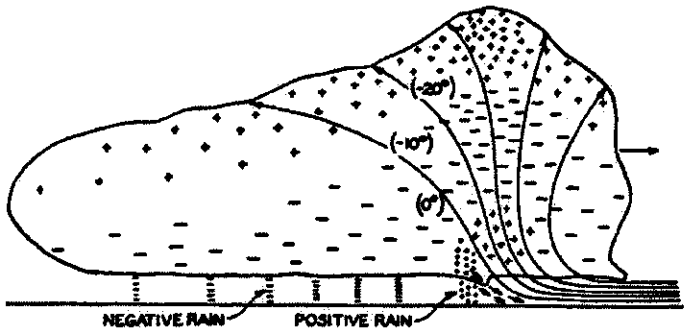

FIGURE Q6(e)