UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2011/2012

COURSE NAME	:	HIGH VOLTAGE ENGINEERING
COURSE CODE	:	BEK 4113
PROGRAMME	:	BEE
EXAMINATION DATE	:	JUNE 2012
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY.

THIS PAPER CONSISTS OF **ELEVEN** (11) PAGES

Q1 (a) State the maximum voltage carrying of the transmission line in Malaysia.

(1 mark)

(b) Summarise one (1) formation mechanism that typically being considered under the Streamer breakdown theories.

(2 marks)

(c) Calculate the static breakdown voltage E_b in kV/cm of an H_2 at 80 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 15 mm. Neglect recombination and attachment.

(4 marks)

(d) Briefly explain the whole process of the Streamers's breakdown mechanisms with the assist of appropriate illustrations models.

(10 marks)

(e) In some early cases, the power system equipments at the higher voltages were introduced before the principles are fully understood, in which cause problem during the application in the field. Propose three (3) examples of the problems.

(6 marks)

(f) Justify implication to the human safety and the equipment if the power capacitor in the high voltage circuit is not properly earthed when not in use.

(2 marks)

Q2 (a) State the general purpose of dielectric material in the high voltage application.

(1 mark)

(b) Summarise two (2) characteristics of the dielectric material together with its appropriate application example.

(2 marks)

(c) A uniform static field was created in Helium gas at 45 mm.Hg pressure by a parallel plate electrode system with a gap distance of 12 mm. With an externally applied electric field E_0 of 1.5 kV/cm, it was found that the space charge created by an avalanche lay nearly in a sphere of radius r_d = 20 mm. 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 α in ion_pairs/m for favourable condition for the formation of streamers in the Helium gap.

(4 marks)

(d) The gaseous we met are generally excellent insulators. Air is also the combination gasses and is used to separating the potential electrodes. However, at high fields the discharge and breakdown may also take place in the gaseous.

Briefly explain
(i) The reason of this breakdown to happen.
(ii) The step ionisation processes.

(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 $p_1 = 0.75$ bar and $p_2 = 3.3$ bar. The tests were conducted inside a pressurised chamber filled with air that having a temperature measured at 125°C. The electrodes gap is 0.07 m. Use 1 bar = 750.06 mm.Hg.

(3 marks)

Q3 (a) Define the term of ionisation process.

(1 mark)

(b) Summarise two (2) applications of gaseous dielectric materials in the power system field.

(2 marks)

(c) Calculate the voltage applied V_s in MV, that caused deformation of 3.5 cm thickness of the glass sample (Young Modulus = 155kN/m^2, εr glass = 5.7) to be at 3.3 cm thickness. Use the relative permittivity of free air of 8.854×10^{-12}. Also calculate the highest electric stress E_{max} in MV/m of that specimen.

(4 marks)

(d) Liquid dielectrics, particularly hydrocarbon oils, are used in insulating media in high voltage equipment such as oil immersed transformer, oil circuit breaker, power capacitors and etc.

(i) Summarise two (2) advantageous of the liquid dielectric.
(iii) The conduction processes due to the force of natural convection and thermal convection are among the mechanisms that would cause failure in liquid dielectric. Briefly explain these mechanisms.

(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) Briefly explain the tracking condition that could cause a failure in solid dielectrics.

(8 marks)

(f) Justify implication to the condition of the cable dielectric if it is being exposed with prolong ageing at elevated temperature.

(2 marks)

Q4 (a) State two (2) types of overvoltages that occur in power system.

(1 mark)

(b) Summarise two (2) types of high voltage testing will depend on, together with their appropriate example of applications.

(2 marks)

(c) An observation from the three phase 100 kVac_peak tracking test conducted in Manchester University High Voltage Laboratory, UK had found that the silicone rubber sample having a relative permittivity ε_r of 6.7, absorbed the heat at 1.02 Watt/cm^3.

(i) Calculate the total heat generated during the test if the total heat loss in surrounding in the silicone rubber sample is measured at 0.23 Watt/cm^3.

(ii) By using the answer value in Q4(c)(i), calculate the material dissipation factor angle (loss angle or δ) in degree value.

(4 marks)

(d) Figure Q4(d) shows the Schering Bridge circuit that typically being used in measuring the dissipation factor or tan δ state of dielectric material under the non-destructive test method.

Briefly explain

(i) The general concepts of the non-destructive test method together with the appropriate test types.

(ii) The connection of the Schering Bridge circuit.

(8 marks)

(e) Briefly explain the HVAC small scale tests and long duration tests together with their appropriate example of applications.

(8 marks)

(f) Justify implication to the equipment commercial quality if the non-standard impulse waveforms are used in the switching and lightning withstand tests.

(2 marks)

Q5 (a) State two (2) general characteristics of an insulated enclosure type HVAC transformer.

(1 mark)

(b) Summarise two (2) problems that typically encounter during partial discharge measurements.

(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 rise and decay times are usually defined by the international standard, such as 1.2/50 μs for FFO and 250/2500 μs for SFO.

By using above information for FFO and SFO, classify

(i) The new rise time T1, and decay time T2 of single phase 500 kV_{peak} standard lightning impulse waveform at their recommended maximum tolerances by draw and label its new-like waveform.

(ii) The new rise time T1, and decay time T2 of single phase 750 kV_{peak} standard switching impulse waveform at their recommended maximum tolerances by draw and label its new-like waveform.

(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 diagrams.

(8 marks)

(e) The tracking test usually being used to verify the durability of the insulation samples in withstanding the electrical stress under influence of contaminant conductive channels. The test also known as an inclined plane test.

(i) Propose one (1) tracking test experiment by construct (by draw and label) its test setup.

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

(8 marks)

(f) Justify one (1) implication to the power system equipments (e.g. transformer, insulator, circuit breaker etc.) that have not been tested at higher voltages (normal and overvoltages level) before they can actually put into use.

(2 marks)

Q6 (a) Define the insulation coordination term in accordance with the standard IEC 60071.

(1 mark)

(b) Summarise the meaning of an external and internal source of overvoltages together with their appropriate examples.

(2 marks)

(c) Calculate the required electrical clearances for the conductor to obstacle to have 50% ability in withstanding a $750kV_{\_peak}$ lightning, $650kV_{\_peak}$ switching and $230kV_{\_peak}$ power frequency overvoltages. Use the gap factor $K_g = 1.6$ and the altitude correction factor $K_A = 1.20$.

(4 marks)

(d) The lightning flash may be created based on the interaction of charge separation take place in the thunderhead cloud. The creation of the flash can be divided into two groups, the first stroke and the second stroke. Figure Q6(d) shows the cloud drawings associated with the creation of first stroke phenomenon.

(i) Construct (by draw and label) the cloud drawings associated with the creation of second stroke phenomenon.

(ii) Based on that constructed clouds drawings as instructed in Q6(d)(i) and in Figure Q6(d), briefly explain both the first stroke and second stroke phenomenon.

(8 marks)

(e) Figure Q6(e)(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(e)(ii). Based on the information observed in these graphs, briefly explain the behaviour of these overvoltages.

(8 marks)

(f) Justify one (1) implication to the power transmission system condition if the insulators and the span conductors are swung closer towards the tower structure frame due to high wind.

(2 marks)

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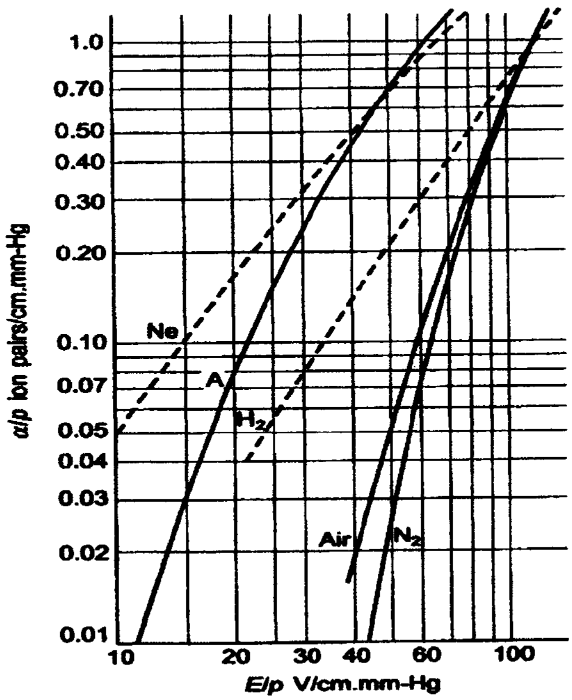

FIGURE Q1(c)

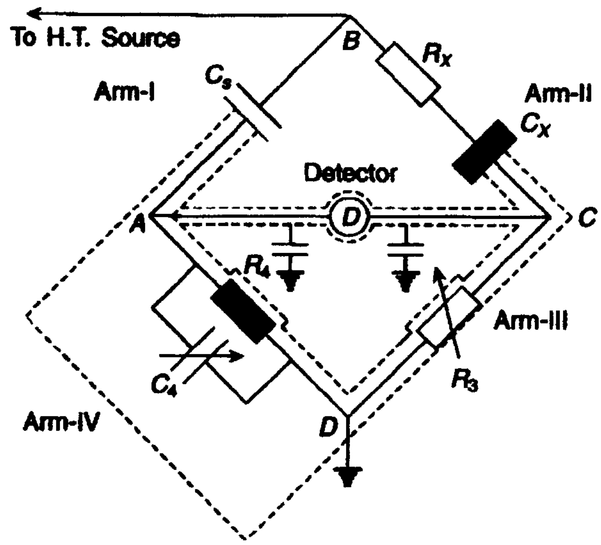

FIGURE Q4(d)

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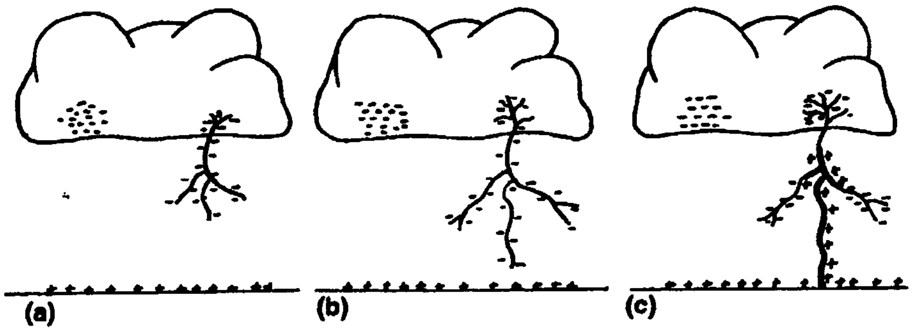

Figure 1 The first stroke. (a) Stepped leader starts. (b) Stepped leader reaches ground. (c) Upward channel moves toward cloud.

FIGURE Q6(d)

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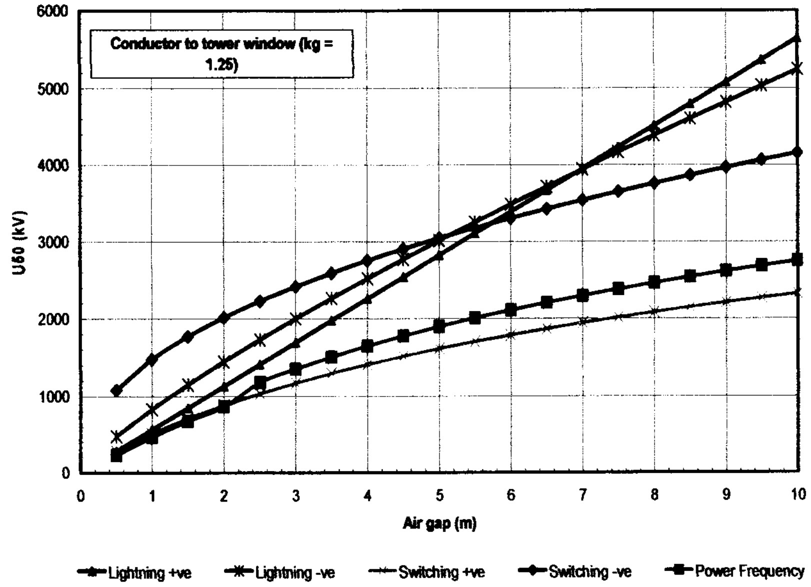

FIGURE Q6(e)(i)

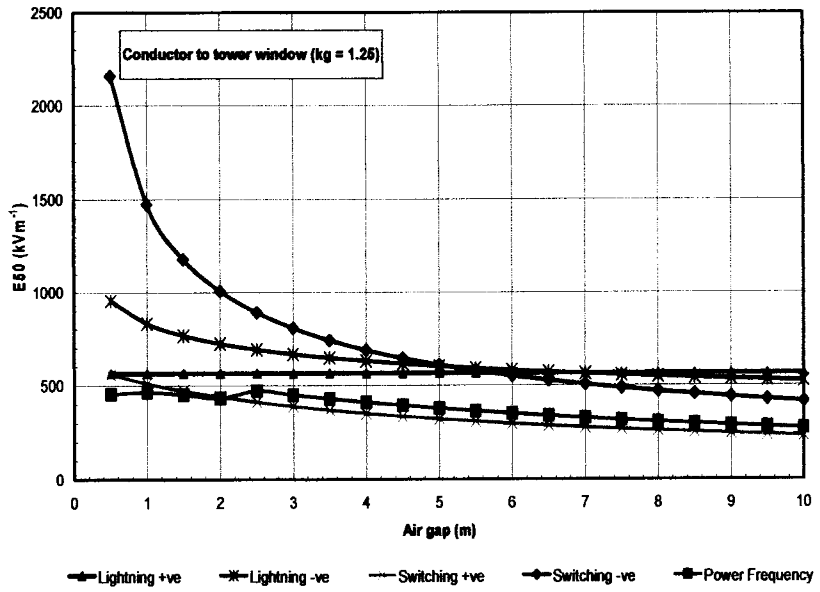

FIGURE Q6(e)(ii)

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The Townsend's Ion Pairs Criterion Equation

$$\alpha d = \ln\left(1+\frac{1}{\gamma}\right) = ion\_pairs$$

The Electric Field of Charged Sphere Surface Equation

$$E_{r\_V/m} = \varepsilon \frac{e^{\alpha d}}{4\pi K_0 r_d^{\ 2}}$$

The Paschen's Law Equation

$$V_{b\_kV} = 24.22\frac{293p}{760T}d + 6.08\sqrt{\frac{293p}{760T}d}$$

The Stark and Garton's Equation

$$V_s = d\sqrt{\frac{2Y}{\varepsilon_0 \varepsilon_r}\ln\left(\frac{d_o}{d}\right)}$$

The Dielectric Dissipation Factor's (tan δ) Equation

$$\tan\delta = \frac{W_{ac} \times 1.8 \times 10^{12}}{E^2 f \varepsilon_r}$$

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U50 Electrical Clearances (metre) in Accordance with IEC 60071-1 (1993)

$$d_{\_ffo} = \frac{U50_{ffo}}{530 \times (0.74 + 0.26K_g) \times K_A}$$

$$d_{\_sfo} = \frac{e^{\left(\frac{U50_{sfo}}{1080 \times K_g \times K_A}\right)} - 1}{0.46}$$

$$d_{\_pf} = \left(\frac{e^{\left(\frac{U50_{pf}}{750\sqrt{2} \times K_g \times K_A}\right)} - 1}{0.55}\right)^{0.833}$$