Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

COURSE NAME	:	HIGH VOLTAGE ENGINEERING
COURSE CODE	:	BEF 45203
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JUNE / JULY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) Briefly explain **two (2)** problems in high voltage engineering.

(4 marks)

(b) Compare **two (2)** conditions of normal and abnormal flow of high voltage.

(4 marks)

(c) Townsend mechanism is one of processes that is considered in gaseous dielectrics breakdown. It is based on the generation of successive secondary avalanches to produce breakdown.

(i) Classify the reason for electric stress being considered as the main contributor to the breakdown of insulation based on Townsend mechanism.

(3 marks)

(ii) Analyse which gases have the lowest static breakdown voltage, E_b in V/cm at 143 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)(ii)**. Assume $\gamma = 10^{-5}$ electron/incident positive ion. The gap distance, d = 0.025m. Neglect recombination and attachment.

(9 marks)

(d) Estimate the breakdown voltage, V_b in kV during the breakdown process using the Paschen's Law equation when the test was conducted at temperature of 120°C with electrodes gap of 0.035 m inside a pressurised chamber at p = 2.5bar filled with normal air. Use 1 bar = 750.06 mm.Hg.

(5 marks)

Q2 (a) Classify **two (2)** criteria that influence the type of high voltage testing.

(2 marks)

(b) (i) Liquid dielectric can be considered as less frequently used compared to gases or solids dielectrics. State **one (1)** active interest that currently being explored by many researchers.

(2 marks)

(ii) Conduction due to cavity formation is one of category for liquid dielectrics failure. Discuss **two (2)** points to explain the mechanism.

(4 marks)

(c) Classify the differences between electrical and water treeing growth aging mechanisms in polymeric solid materials.

(4 marks)

(d) Analyse the working concept of 2V's, 400 kV HVAC cascaded transformer together with its appropriate circuitry arrangement.

(10 marks)

(e) Justify implication to the quality assessment of the power equipment that not having the BIL verification.

(3 marks)

Q3 (a) Summarise the working concept of the whole scale HVAC testing together with its appropriate example of application.

(4 marks)

(b) A single phase HVAC resonant transformer is having RLC series circuit consists of inductance, L = 65 mH, capacitance, C = 300 μF and resistance, R = 0.15 Ω. The single phase supplied voltage, $V_i = 15\ kV_{a.c.\ rms}$. Calculate the maximum current, I_{max}, the voltage overshoot, V_L and Q factor of the circuit occurrence at the resonance frequency, f_r condition. Neglect any losses in the circuit.

(4 marks)

(c) The Schering Bridge circuit is typically being used to verify the aging condition (tan delta or dissipation factor angle) of insulation material. The related test is considered under the non-destructive test method. Propose circuitry connections and logical working conditions of the mentioned circuit.

(7 marks)

(d) The impulse tests usually being used to verify the durability of insulation product or sample in withstanding the transient impulse stress. The tests usually being conducted under dry and wet conditions. Propose **one (1)** comprehensive experiment setup and the working concept of the wet impulse test that use the two-stage Marx generator.

(10 marks)

Q4 (a) Summarise implication of the power transmission system condition when the insulators and the span conductors are swung closer towards the tower structure frame due to high wind.

(2 marks)

(b) Analyse the important of insulation coordination based on **two (2)** appropriate examples of high voltage applications.

(4 marks)

(c) According to Standard IEC 60071, types of overvoltages are classified based on their voltage magnitude and the duration. Sketch with appropriate labels and time scale (*voltage p.u vs. duration*) to illustrate these types of overvoltages classification.

(4 marks)

(d) An overhead line suspended on transmission tower needs to have 50 % ability to withstand 1425 kV_{peak} lightning, 1050 kV_{peak} switching and 480 kV_{peak} power frequency overvoltages.

(i) As an engineer, classify the required electrical clearance distances for the conductor to tower structure. Consider the gap factor, K_g = 1.55 and the altitude correction factor, K_A = 1.15.

(3 marks)

(ii) Calculate the value of gap factor, K_g if the electrical clearance distance for temporary overvoltages, *TOV* is to be at 0.55 m. Use K_A = 1.15.

(2 marks)

(e) **Figure Q4(e)(i)** shows the peak phase to earth U50 overvoltages of lightning, switching and power frequency for the conductor to the tower window clearance. Their distance relationship under electric field E50 overvoltages are shown in **Figure Q4(e)(ii)**. Based on the information observed in these graphs, analyse the behaviour of these overvoltages upon increases the gap clearances.

(10 marks)

– END OF QUESTIONS –

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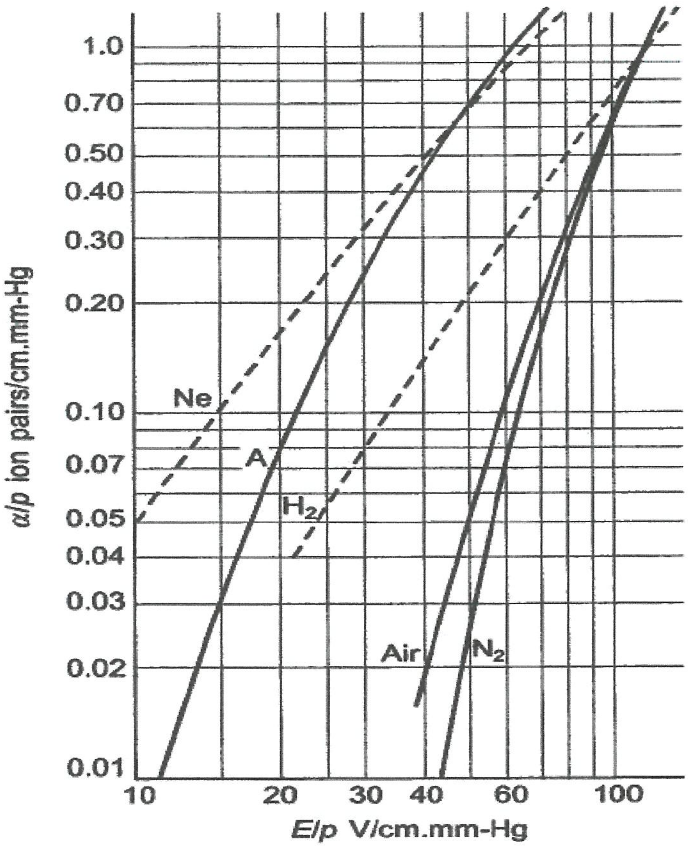

Figure Q1(c)(ii)

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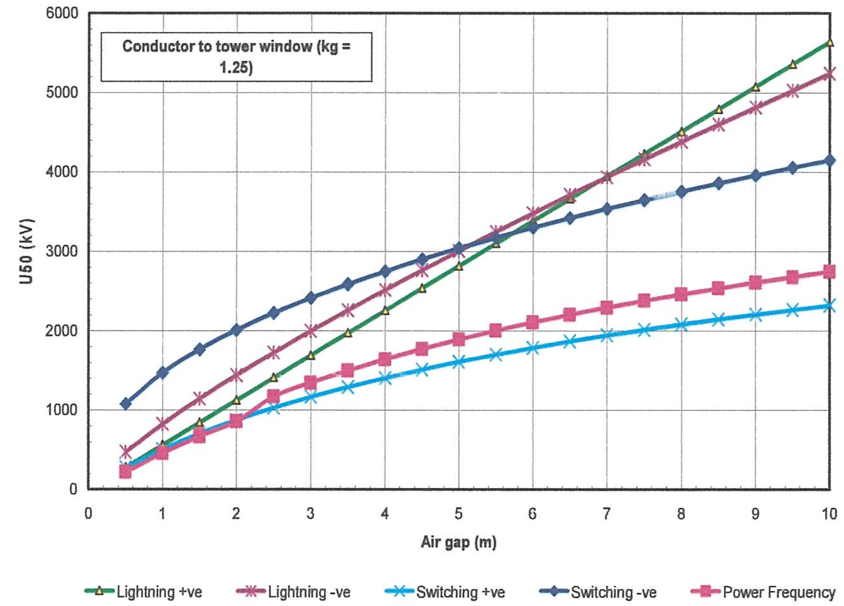

Figure Q4(e)(i)

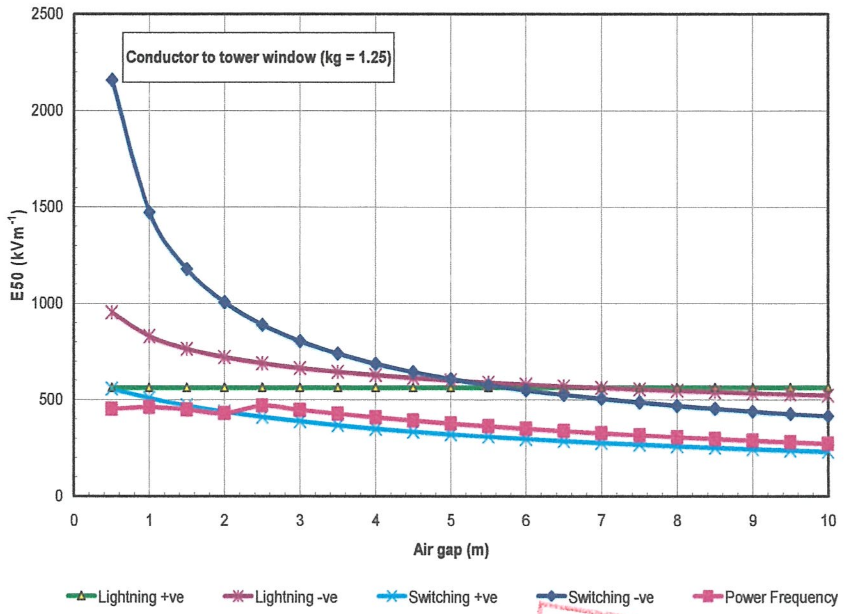

Figure Q4(e)(ii)

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Appendix A

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

$$E_{r\_V/m} = \frac{\varepsilon e^{\alpha d}}{4\pi\varepsilon_0 r_d^{\,2}}$$

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)

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

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

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