Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	HIGH VOLTAGE ENGINEERING
COURSE CODE	:	BEF 45203
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	DECEMBER 2019/ JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) State **FIVE (5)** main international bodies that are actively involved in high voltage engineering field.

(5 marks)

(b) The main sources of high voltage generation can be categorised into two main group namely external and internal sources. Briefly describe their nature and related example.

(4 marks)

(c) Breakdown in gaseous dielectric can be described by Townsend and Streamer's mechanism.

(i) Interpret all three formation mechanisms of Streamer breakdown theories with the aid of suitable diagrams.

(7 marks)

(ii) A uniform static field was created between 0.045 m parallel plate electrodes system in an enclosed chamber that contain Argon gas at pressure of 800 mmHg. It was found that the space charge created by an avalanche lay nearly in a sphere of radius, r_d = 0.035 m with an external applied electric field, E_0 = 2.7 kV/cm is applied across the electrode plate. Estimate the value of first ionization coefficient, α under favourable condition for the formation of streamers in the Argon gap.

(9 marks)

Q2 (a) A test to investigate breakdown phenomena is conducted inside a pressurised chamber filled with normal air. The distance between electrodes is 0.025 m with the temperature value maintained at 110°C. The test was conducted under two different pressure conditions at p_1 = 1.5bar and p_2 = 2.2bar.

(i) Determine the breakdown voltage under both pressure conditions, V_{b1} and V_{b2} by using the Paschen's Law. Use 1 bar = 750.06 mm.Hg.

(8 marks)

(ii) Conclude your finding in **Q2(a)(i)** in terms of percentage.

(3 marks)

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

(4 marks)

(c) Tracking and treeing mechanism occur in the presence of conducting path over a long time of electrical stress. Briefly explain **TWO (2)** differences between tracking and treeing mechanism in connection with aging of dielectric material.

(4 marks)

(d) Oil-insulated test transformer can be categorised into tank type and insulated enclosure type. Compare both insulators in **THREE (3)** points.

(6 marks)

Q3 (a) Analyse the working concept of 2V's, 400 kV HVAC cascaded transformer together with its appropriate circuitry arrangement.

(10 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) Illustrate a standard waveform of single phase 1425 kV_{peak} fast front overvoltages (*FFO*) possesing a rise time, T_1 and decay time, T_2 at their recommended maximum tolerances in accordance with Standard IEC 60071.

(3 marks)

(d) Marx generator circuit is commonly used to generate higher lightning or switching impulse voltages. Propose the general circuit connections and logical working conditions of the two-stage Marx generator.

(8 marks)

Q4 (a) Summarise the working concept of the small scale HVAC insulation testing together with its appropriate example of application.

(4 marks)

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

(7 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 High Voltage 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.

(3 marks)

(e) The goal of insulation coordination is not only to select the minimum insulation strength but also is to select the minimum clearance to be equated to minimum cost. Compare the difference between internal clearance and external clearance in **TWO (2)** points.

(4 marks)

– END OF QUESTIONS –

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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)

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

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

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