Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	HIGH VOLTAGE ENGINEERING
COURSE CODE	:	BEF 45203
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **ALL** QUESTIONS.

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Dielectric is a material in which electrostatic fields can remain almost indefinitely.

(i) Briefly describe the ionization process in a material.

(4 marks)

(ii) Briefly explain the difference between Townsend and Streamer's theory.

(2 marks)

(iii) Suggest **two (2)** advantages of liquid dielectric as compared to the gas or solid dielectric.

(4 marks)

(b) A test to study breakdown phenomena is conducted inside a pressurized chamber occupied with air. The distance between electrodes is 1.5 cm and the temperature is maintained at 80 °C. The test is performed under two different pressure conditions at p1 = 1.5 bar and p2 = 2.5 bar.

(i) Estimate the breakdown voltage under both pressure conditions, Vb_1 and Vb_2 by using the Paschen's Law. Use 1 bar = 750.06 mmHg.

(6 marks)

(ii) Plot a graph of Breakdown Voltage, V_b against Pressure, p.

(2 marks)

(ii) Analyse and describe the result obtained in **Q2(b)(ii).**

(2 marks)

(c) A small sample of cured silicone rubber with 50 mm of thickness is placed between electrodes. After applying a certain voltage magnitude, the original thickness of the sample is reduced by 2 mm. Given that relative permittivity, ε_r of silicone rubber is 4.7 and constant Young Modulus = 170 kN/m^2.

(i) Determine the applied voltage, V_s that caused the deformation.

(3 marks)

(ii) Estimate the highest electric stress, E_{max} of the sample.

(2 marks)

Q2 (a) Describe **two (2)** advantages of insulated enclosure type transformer as compared to the tank type transformer.

(4 marks)

(b) A single phase HVAC RLC circuit, with 1.5 kV ac peak applied voltage, consists of a capacitor, inductance L = 75 mH and resistor R_1 = 0.1 ohm in series with R_2 = 0.2 ohm. If the resonance phenomenon is found to occur at 18.2 Hz.

(i) Calculate the value of capacitance, C used in the ccircuit.

(3 marks)

(ii) Determine the overshoot voltage, V_L and Q factor during the resonance.
(5 marks)

(iii) Identify **two (2)** scenarios in which resonance may be utilised for a benefit.
(4 marks)

(c) Impulse waveform is characterised by the rise time, T_1 and decay time, T_2.

(i) Sketch waveform of 300 kVpeak standard lightning impulse waveform with *T1* and *T2* with appropriate labels.
(2 marks)

(ii) Propose an equivalent circuit to produce output waveform in **Q2(c)(i)** with *Vc* = 100 kV.
(3 marks)

(iii) Explain **two (2)** purposes for the need of impulse generator in the high voltage engineering.
(4 marks)

Q3 (a) The salt fog test usually being used to verify the durability of the insulation material in withstanding severe electrical stresses. The test can represent the acceleration aging processes that typically occur at outdoor environment over the years in service. Propose **one (1)** comprehensive experiment setup and the working concept of the test.
(7 marks)

(b) Explain the concept of dissipation factor or tan delta for measuring the dielectric loss in insulation material. Provide suitable diagram for your explanation.
(6 marks)

(c) A Schering bridge as in **Figure Q3(c)** is used to measure the capacitance and dissipation factor of insulation system in power transformer. The bridge achieved balance at the following condition:

Arm I	Standard condenser of 1000 pF.
Arm II	Resistance of 200 Ω.
Arm IV	A capacitance of 70 nF in a parallel with a resistance of 1000 Ω.

Determine the capacitance and dissipation factor of the transformer's insulation.
(4 marks)

(d) List out **three (3)** comparisons between destructive test and non-destructive test.
(6 marks)

(e) Briefly explains the importance of performing partial discharge test on the insulation of high voltage equipment.
(2 marks)

Q4 (a) Briefly explain the importance of insulation coordination in high voltage system.

(3 marks)

(b) A 3-phase 132 kV overhead transmission line having basic insulation level (BIL) of 400 kV is supported on steel towers and protected by a circuit breaker. The ground resistance at each tower is 20 Ω whereas the neutral of the lines is solidly grounded at the transformer just ahead of the circuit breaker. During a lightning storm, one of the towers is hit by lightning stroke of 30 kA. By referring to **Figure Q4(b)**.

(i) Calculate the peak voltage across each insulator string under normal condition.

(3 marks)

(ii) Describe the sequence of events during and after the lightning stroke.

(2 marks)

(iii) State and explain one measure which can help to avoid any possible flashover under the circumstance.

(2 marks)

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

(4 marks)

(d) Explain the causes or sources of the following over-voltages:

(i) Temporary overvoltage (TOV).

(2 marks)

(ii) Lightning overvoltage (FFO).

(2 marks)

(iii) Switching overvoltage (SFO).

(2 marks)

(iv) Very fast overvoltage (VFFO).

(2 marks)

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

(3 marks)

-END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER / SESSION : SEM II 2020/2021 PROGRAMME CODE : BEV
COURSE NAME : HIGH VOLTAGE ENGINEERING COURSE CODE : BEF 45203

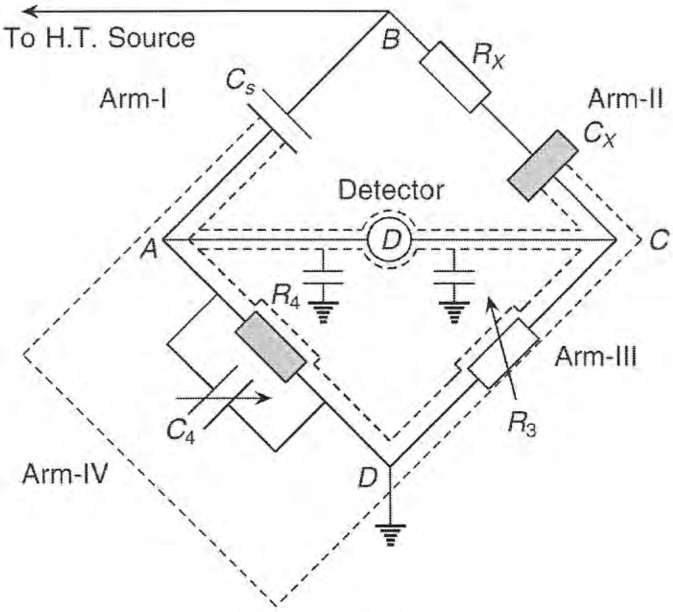

Figure Q3(c)

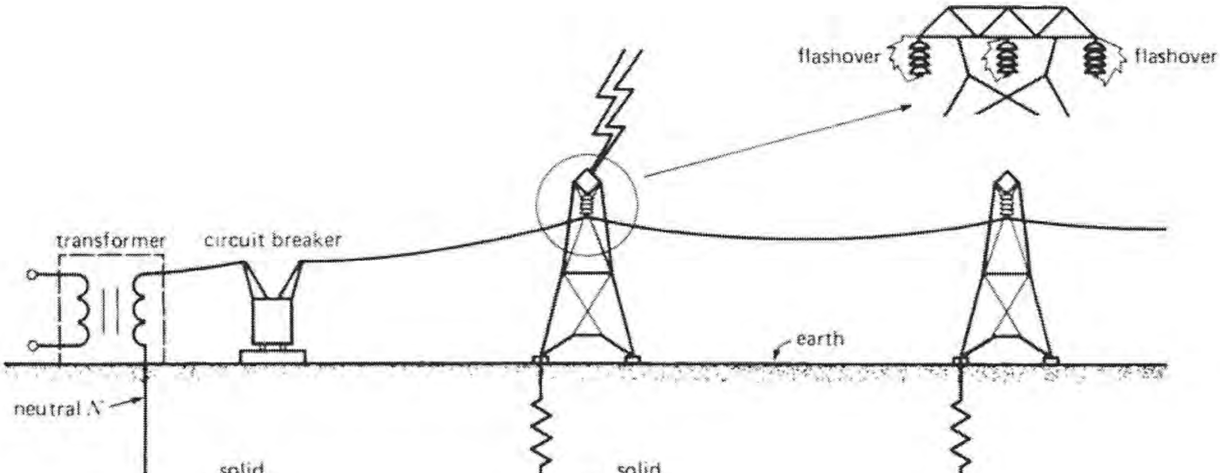

Figure Q4(b)

FINAL EXAMINATION

SEMESTER / SESSION : SEM II 2020/2021 PROGRAMME CODE : BEV
COURSE NAME : HIGH VOLTAGE ENGINEERING COURSE CODE : BEF 45203

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

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

Frequency at Resonant

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

FINAL EXAMINATION

SEMESTER / SESSION : SEM II 2020/2021 PROGRAMME CODE : BEV
COURSE NAME : HIGH VOLTAGE ENGINEERING COURSE CODE : BEF 45203

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

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

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

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

TERBUKA