UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	HIGH VOLTAGE ENGINEERING
COURSE CODE	:	BEF 45203
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY 2020
DURATION	:	4 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATIONS**

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

Q1 (a) *Discuss* ***THREE (3)*** *points of activity over the past 5 years performed by any one of* the international electrical bodies listed below.

- Institute of Electrical and Electronics Engineers (IEEE)
- International Electrotechnical Commission (IEC)
- International Council on Large High Voltage Electric Systems (CIGRE)
- International Symposium for High Voltage Engineering (ISH)
- The Institution of Engineering and Technologies (IET)

(6 marks)

(b) Summarise **TWO (2)** conditions of abnormal flow of high voltage.

(5 marks)

(c) 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, $r_d = 0.015$ m in radius when an external applied electric field, $E_0 = 4.7$ 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) Electrical breakdown in air has been extensively studied to understand the breakdown mechanism. Differences electrode gap configurations gives differences breakdown mechanisms. List out **FOUR (4)** types of electrode gaps configuration.

(4 marks)

(b) Tracking and treeing mechanism occurs in the presence of conducting path over a long time of electrical stress. Summarise **ONE (1)** difference between tracking and treeing mechanism in connection with aging of dielectric material.

(2 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. The ionization coefficient α/p as function of field strength E and gas pressure p is given by the following threshold equation:

$$\left(\frac{\alpha}{p}\right) = f\left(\frac{E}{p}\right)$$

(i) By using the Townsend's breakdown criterion, show that the breakdown voltage for uniform field gaps is a function of gap length (d) and gas pressure (p).

(6 marks)

(ii) Prove that the discharge current in a multi avalanche Townsend process in a non-attaching gas is given by:

$$I = \frac{I_o e^{\alpha d}}{1 - \gamma[e^{(\alpha d - 1)}]}$$

Where
I_0 – initial voltage
α – first Townsend ionization coefficient
γ – Second Townsend ionization coefficient
d – Gap distance in cm

Use the information shown in **Figure Q2(c)(ii)** in your analysis.

(8 marks)

Q3 (a) Impulse testing is used to assess the ability of power system plant to withstand such lightning and switching overvoltages. Both lightning and switching impulse tests generator produce the rise and decay waveforms based on the double exponential expression below.

$$V = V_c\left(e^{-\alpha t} - e^{-\beta t}\right)$$

(i) Analyse the concept α and β coefficient in double exponential expression above by highlighting their important function and recommended values to produce 1.2/50μs and 250/2500μs double exponential waveforms.

(6 marks)

(ii) Illustrate a standard waveform of single phase 1425 kV_{peak} lightning impulse that having a rise time, T_1 and decay time, T_2 at their recommended maximum tolerances in accordance with Standard IEC 60071.

(4 marks)

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

(10 marks)

Q4 (a) Differentiate **ONE (1)** behaviour of ripple factor and ripple frequency in half-period and full-period rectifier to generate HVDC.

(2 marks)

(b) Suggest the illustration waveform patterns of temporary overvoltages (TOV) category **A**, **B** and **C**. Consider the TOV voltage raise to be at 1.4p.u from the normal 1.0 p.u, 50 Hz steady state waveform such as shown in **Figure Q4(b)**.

(6 marks)

(c) **Figure Q4(c)** shows a testing container used to test the Breakdown Level Voltage (BLV) or dielectric strength of transformer oil. A low value of BLV indicates presence of moisture content and conducting substances in the oil. Propose a test setup illustration and working concept of BLV testing that highlight the following criteria:

- HV generator
- Test sample
- Measurement system
- Protection system
- Test procedure
- Result analysis

The parameter of the test is shown in **Table Q4(c).**

(12 marks)

– END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER/SESSION : II/ 2019/ 2020 PROGRAMME CODE: BEV
COURSE NAME : HIGH VOLTAGE ENGINEEERING COURSE CODE : BEF 45203

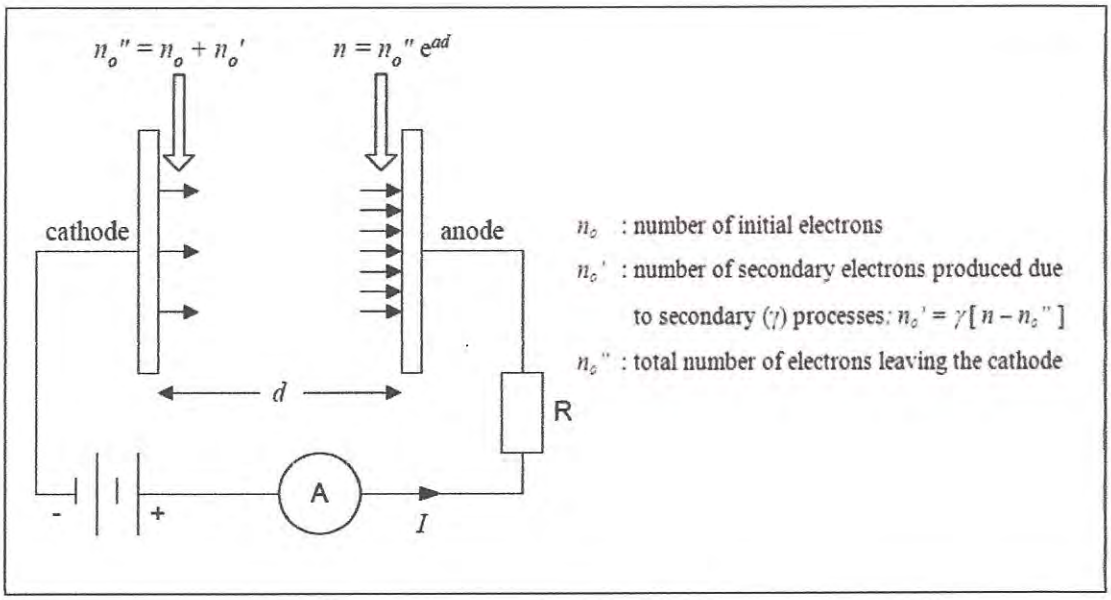

Figure Q2(c)(ii)

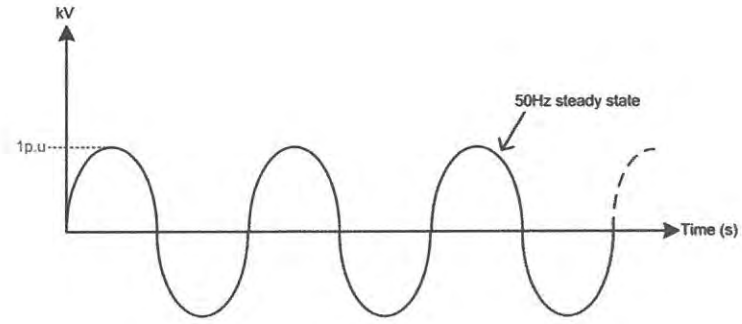

Figure Q4(b)

FINAL EXAMINATION

SEMESTER/SESSION : II/ 2019/ 2020 PROGRAMME CODE: BEV
COURSE NAME : HIGH VOLTAGE ENGINEEERING COURSE CODE : BEF 45203

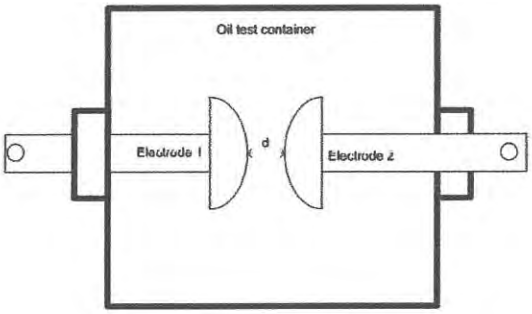

Figure Q4(c)

Electrodes	:	Copper
Pre-set gap d	:	2.5 mm
Cup dimension	:	140 mm L x 100 mm W x 1100mm T
Liquid dielectric	:	Transformer oil
HV source	:	HVAC single phase set
Voltage	:	Interval 2 kV/s
Protection	:	Overcurrent relay set off at 3A within 2s
Measurement	:	Voltage DAQ Leakage Current DAQ Visual recorded Chemical Labview GUI
Testing repetition	:	6 times
Rating	:	≥ 30kV = Good dielectric strength < 30kV – Poor dielectric strength

Table Q4(c)