Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	HIGH VOLTAGE ENGINEERING
COURSE CODE	:	BEF 45203
PROGRAMME	:	BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	JUNE 2015 / JULY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 (a) Give **two (2)** advantages for the provision of the electric field stress control in high voltage equipment.

(2 marks)

(b) Describe briefly the use of high voltage system in the following applications:

(i) Removing industrial flue gases or dust particles floating in air from steel mill chimneys

(3 marks)

(ii) Spraying pesticide to agricultural plantation

(2 marks)

(c) (i) Use the iteration method to find the finite difference approximation for the potentials at points 1, 2, 3, 9 and 15 of the system in **Figure Q1** (limit the iteration up to 1 only). The nodal voltage follows the sequence as shown in **Figure Q1** that the node number is 1, 2, 3, 4, 5, 6, 7 up to 16 respectively.

(9 marks)

(ii) Based on the **Figure Q1**, if all the points of disconnection are welded and connected together, determine the finite difference approximation to the point potential 2, 3, 4, 7, 8, 9, 10 and 11.

(3 marks)

(iii) The method of making an encloser or a cage at equipotential is known as Faraday Cage method (FCM). State **two (2)** cases where FCM are used in high voltage engineering field.

(1 mark)

Q2 (a) Describe briefly to differentiate the mechanism of gas discharge related to Townsend's first ionization coefficient and Townsend's secondary ionization coefficient.

(3 marks)

(b) Write in your own words the reason for Sulphur Hexafluoride (SF_6) better than air as a good gaseous dielectric material.

(2 marks)

(c) As a would-be graduate in electrical power engineering, you may be employed in a company that provides material and services which are applied to high voltage equipment. For business enhancement your company has come up with a solid dielectric material which requires some studies to determine the characteristics of the insulation.

(i) With the aid of a schematic diagram describe briefly the test set-up and test procedures to determine Dielectric Breakdown Strength of insulation.

(4 marks)

(ii) Using appropriate diagram, explain thermal breakdown in solid dielectrics.

(5 marks)

(d) In an experiment to determine breakdown properties of air, uniform field electrode is used. The breakdown occurs in accordance with Townsend first ionization and second ionization coefficients, α and γ. At a distance of 22.8mm and pressure 200mmHg, the breakdown voltage is found to be 19.5kV. Determine the breakdown voltage if the secondary ionization coefficient γ is doubled. Data for the ratio of electric field and pressure, E/p and ratio of first ionization coefficient, α/ p are given in **Table Q2**.

(6 marks)

Q3 Supposedly you have been engaged as a consultant by a corporation to come up with a design of lightning protection system of a building structure that will be built in a place where there is high lightning flashes activity. The building will house sensitive medical equipment and advanced and sophisticated telecommunication as well as up to date computer systems. Your consultancy works not only involve drawing board activities but also doing laboratory research works that involve generation of high voltage DC and high voltage lightning impulse as well as some related voltage measurements. The laboratory works require simultaneous generation of HVDC and HV impulse generation. A macro model of one of the designed building structures will be subjected to simultaneous direct lightning strike and balling lightning side-flash.

(a) (i) **Figure Q3** shows the schematic diagram of a half-wave rectifier which can be used for generation of HVDC in the ball lightning test. With the aid of suitable diagram, describe briefly the generation of HVDC.

(3 marks)

(ii) Describe briefly the principle of operation of a **two (2)**-stage Cockcroft-Walton-type voltage multiplier for a HVDC.

(3 marks)

(b) Lightning impulse voltage (LIV) is simulated in the laboratory using impulse generator to conduct lightning flashover test on test sample - a macro model building structure. An impulse generator has **ten (10)** stages with the following parameters;

- Charging capacitor of 2 μF rated at 120 kV
- Load capacitance of 1000 pF
- Impulse wave of 1.2/50 μs

(i) Determine the front and tail resistors.

(4 marks)

(ii) Calculate the maximum output voltage of the generator if the charging voltage is 120 kV.

(2 marks)

(iii) Sketch the schematic of a **three (3)**-stage impulse generator.

(4 marks)

(c) Sketch and draw the schematic diagram of an experimental set up to simulate building structure being tested with a simultaneous injection of high voltage impulse and ball lightning.

(4 marks)

Q4 Malaysia lies in a region where there are a lot of lightning flashes activity where almost every second there are about 100 lightning flashes strike to ground. Lightning ground flashes caused millions of ringgit lost in building and structural damages and interruption of power supply, communication breakdown and unhappiness to the. So, efficient lightning protection systems should be installed to industrial, commercial, residential and others structures to alleviate the effects of direct or indirect lightning strikes to facilities, human being and animals.

(a) (i) Describe briefly the difference between lightning ground flashes (LGF) and lightning cloud flashes (LCF).

(2 marks)

(ii) Which of the flashes in **Q4(a)(i)** is more damaging to man-made system.

(1 mark)

(iii) Explain briefly on the relationship between lightning flashes and the parameter *Ng*-lightning flashes per m^2 per year.

(2 marks)

(b) (i) State the various precautions taken when lightning flashes are in someone's vicinity during his outdoor activities. Limit the precautions to 2 only.

(1 mark)

(ii) If a lightning thunder bolt is about to strike very close to you and you have a choice to make whether taking a refuge in a nearby house or a car which one is the most preferred choice and give reason for the choice.

(2 marks)

(c) Lightning strike at mid-span of a transmission line ground wire at point M as shown in **Figure Q4**. This wave travels in both direction of the transmission line from the point of struck M. The surge impedance of the ground wire is $Z_g = 100\ \Omega$ on the ground wire whereas the surge impedance of tower 1 and tower 2 is $Z_T =$

200 Ω and the tower ground resistance is R_g = 10 Ω. The tower span is 150 meter long and tower height is 60 meter tall. The lightning strike current is linearly rising to 30 kA at 1.0 μs and starts to decay to zero at 100 μs. Assume the lightning channel impedance is infinity Ω and there is no returning or reflected waves coming from the right and left side of the ground wire. The α_n and β_n are the coefficient of reflection and refraction or transmission respectively.

(i) Calculate the following parameters: α_1, α_2, α_g, β_{dl}, β_{ll}, β_{gl}

(6 marks)

(ii) Determine the maximum potential rise at point M at the time when the lightning strikes the ground wire (consider worst case scenario).

(2 marks)

(iii) If the surge propagation velocity in the tower is 3.0 x 10^8 meter per second, calculate the time of transit of a surge travelling from the tower top 'aa' to the base of tower.

(2 marks)

(iv) If the surge propagation velocity in the ground wire is 2.90 x 10^8 meter per second, calculate the time of transit of surge travelling from the point M to the adjacent tower.

(2 marks)

Q5 (a) A Schering Bridge as shown in **Figure Q5** is used to measure the dielectric loss and capacitance of the insulation of an electrical power equipment. Prove that the capacitance, C and tangent loss are given by $C = \frac{C_2 R_4}{R_3}$ and $\tan\delta = \omega C_4 R_4$.

(4 marks)

(b) Partial discharge (PD) measurements and the discharge locations are important for cables, since the life of the insulation at a given voltage stress depends on the internal discharges. Also, the weakness of the insulation or faults can be detected with the help of these tests. There are two different methods of detecting partial discharges, which are;

-Tests which depend on the energy losses in the discharges.

-Tests which detect the voltage pulses produced by the discharges.

Describe the test methods which depend on the energy losses in the discharges.

(5 marks)

(c) Derive and prove that the breakdown criterion in gas according to Townsend's equation is given by:

$$I_0 = \frac{I_0 \exp(\alpha d)}{1-\gamma(\exp(\alpha d)-1)}$$

where

α – Townsend's Primary coefficient
γ – Townsend's Secondary coefficient
d – gap distance at sparkover voltage

(11 marks)

– END OF QUESTIONS –

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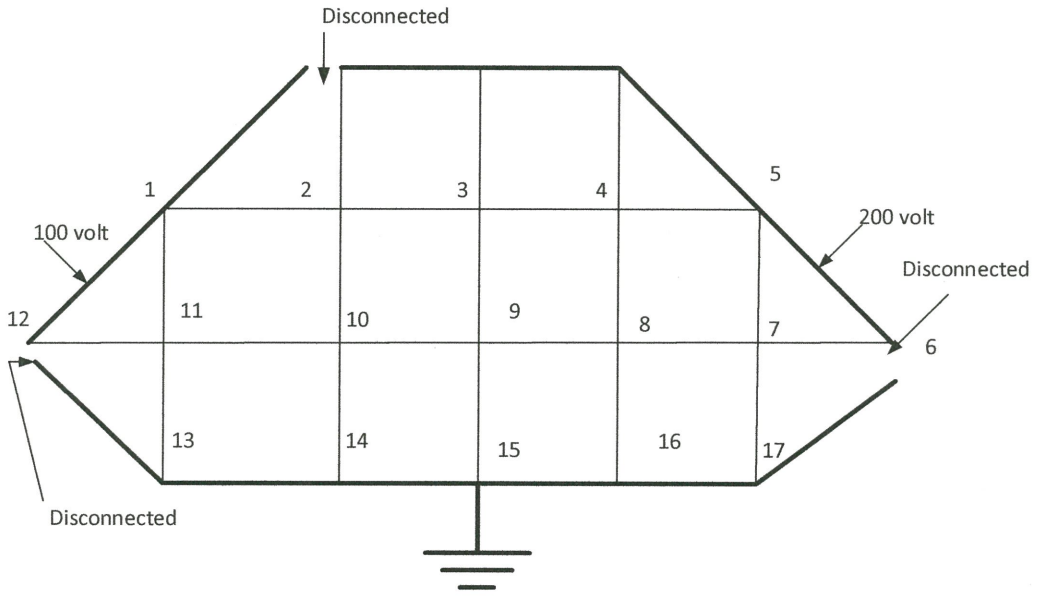

FIGURE Q1

TABLE Q2

E/p (V/cm mmHg)	α/p (ion pairs/cm mmHg)
41	0.0196
42	0.0222

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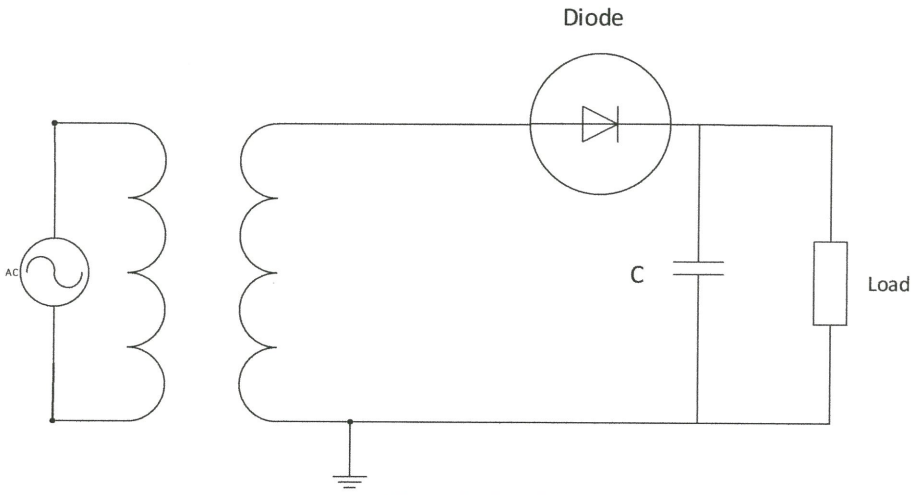

FIGURE Q3

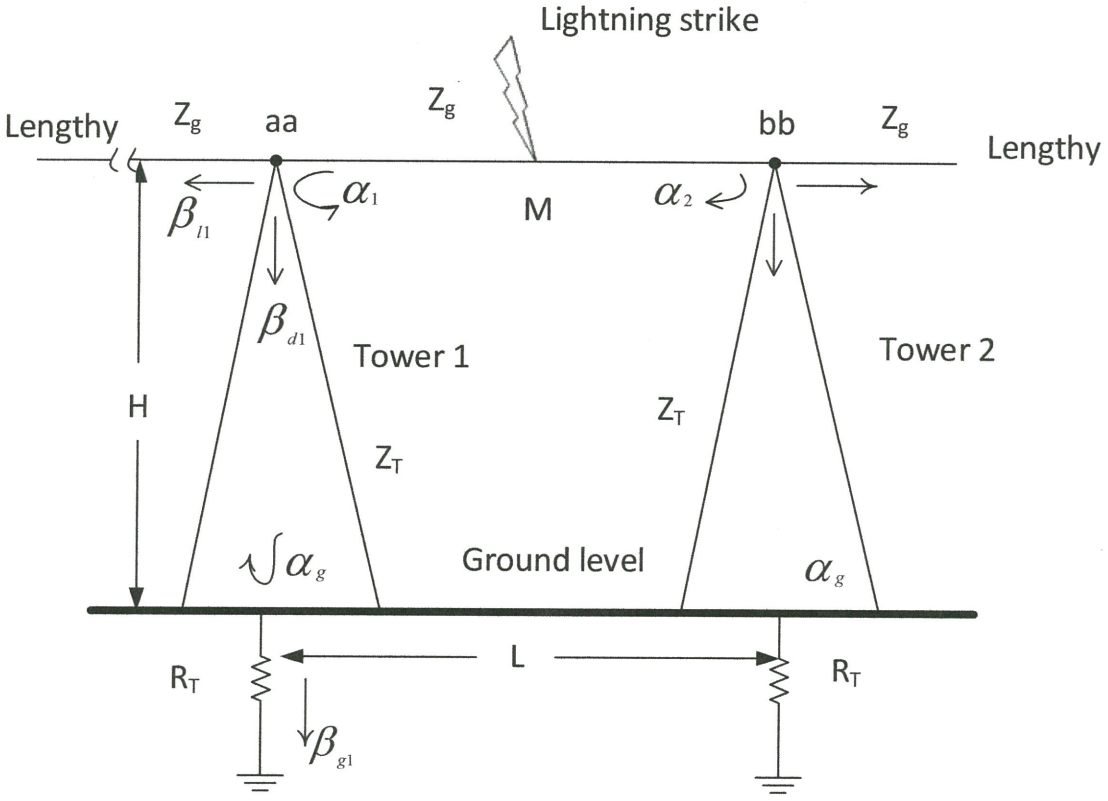

FIGURE Q4

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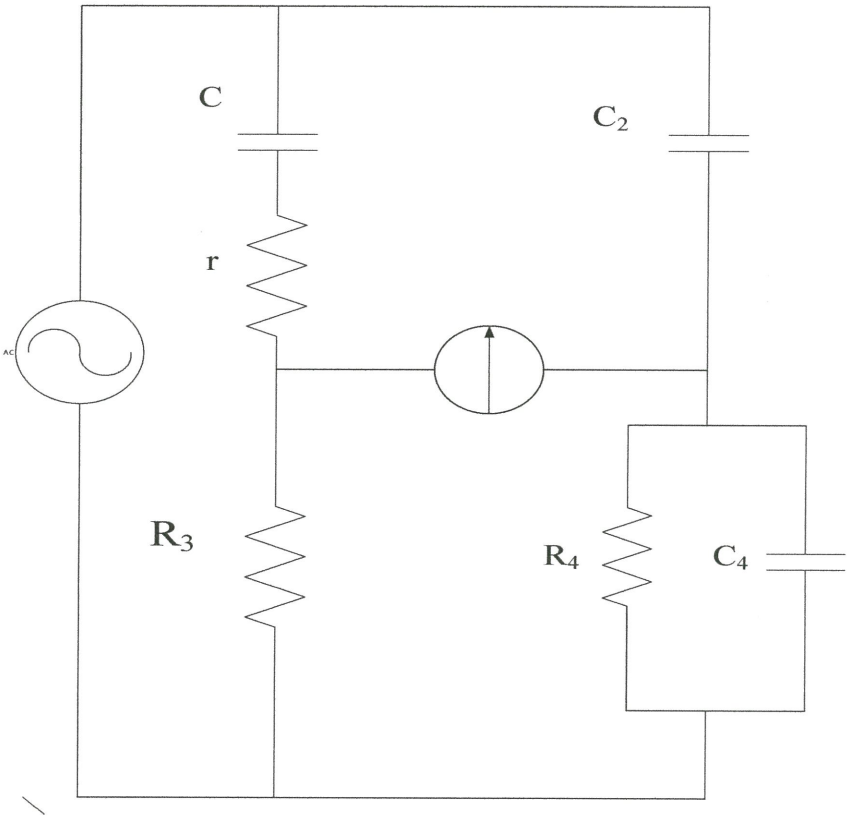

FIGURE Q5