



MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

**BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION
TECHNOLOGY)**

EEE 506: HIGH VOLTAGE TECHNOLOGY AND HVDC TRANSMISSION

DATE:

TIME:

INSTRUCTIONS

Answer question one and any other two questions

QUESTION ONE (COMPULSORY) (30 MARKS)

- a) With aid of a diagram, briefly describe the following three regions in the breakdown phenomenon of a gas:
- Ohmic region
 - Saturation region
 - Townshend region (6 marks)
- b) Overhead ground wires are used to protect lines against lightning strokes. With aid of a diagram, show the shielding angle of overhead ground wires. Explain two disadvantages of using them. (4 marks)
- c) One of the equipment in a HVDC converter station is a DC reactor. Explain any four roles played by the Dc reactor. (4 marks)
- d) A steady current of $100\mu\text{A}$ flows through the plane electrode separated by a distance of 0.5cm when a voltage of 11000V is applied. Determine the Townsend's first ionization coefficient if a current of 10 micro amperes flows when the distance of separation is reduced to 0.18 cm and the field is kept constant at the previous value. (6 marks)

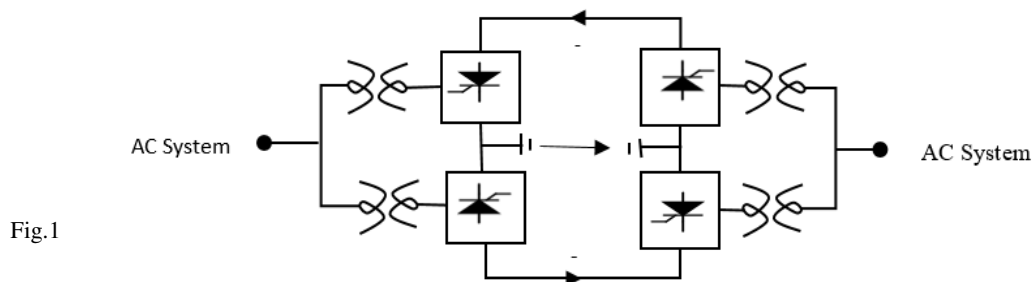
- e) A nonlinear resistance medium is used in series with rod gap to make a surge diverter. The expression of the nonlinear medium is given by $i = kv^\alpha$, where k is a constant. If $\alpha=8$, determine by what factor the voltage will increase if the current increases by a factor of 200. (6 marks)
- f) An impulse current generator has a total capacitance of $15\mu F$, the charging voltage 125KV, the circuit inductance 2mH and the dynamic resistance 1 Ohm. Determine the peak current. (4 marks)

QUESTION TWO (20 MARKS)

- a) Briefly explain the three processes that results in secondary ionization in gases. (6 marks)
- b) Explain TWO harmful effects of lightening. (4 marks)
- c) Corona phenomena leads to power loss in a transmission line. Tests done on a 132 kilovolt, 60 Hz, three phase line with 1.956 cm diameter observed that corona starts to takes place if the line voltage exceeds 210 kilovolts. Assuming that the value of the potential gradient at which ionization occurs is 21.2 KV/cm, $m_o=1$ and $\delta=1$, determine:
- The spacing between the conductors
 - Visual critical voltage (6 marks)
- d) A 100KVA 250/200KV feed transformer has resistance and reactance of 1% and 5% respectively. This transformer is used to test a cable at 400KV at 50 Hz. The cable takes a charging current of 0.5A at 400KV. Determine the series inductance required. Assume 1% resistance of the inductor. (4 marks)

QUESTION THREE (20 MARKS)

- a) State any three things that are involved in corona phenomena. (3 marks)
- b) Derive the expression of the average number of new electrons created by each electron in terms of initial number of electrons, electrons reaching the anode and Townshend's first ionization coefficient. (5 marks)
- c) A dc link is shown in fig. 1.
- What is the name of the link
 - Explain its advantage. (6 marks)



- d) Electromechanical breakdown of a solid dielectric, when subjected to high potential gradient, occurs as a result of electrostatic forces which reduces the thickness of the dielectric. For any value of voltage V , prove that the reduction in thickness of the specimen cannot be more than 40% (6 marks)

QUESTION FOUR (20 MARKS)

- a) Liquid dielectrics are easily contaminated and hence require degeneration before use. Mention the three contaminants and explain how they lead to breakdown in liquid dielectrics. (6 marks)
- b) Differentiate between critical disruptive voltage and visual critical voltage. (5 marks)
- c) State any three tests carried out on an overhead line insulator. (3 marks)
- d) Discuss why three phase overhead lines are transposed. A three phase overhead line consists of three conductors transposed and arranged as shown in fig. 2. The conductor diameter is 15 millimeter and surface factor of 0.8. the air temperature and pressure are 298.1°K and 75 cmHg respectively. Find disruptive critical voltage. Assume the potential gradient at which ionization occurs is 21.2 KV/cm (6 marks)

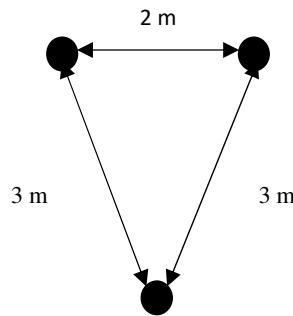


Fig.2

Question 5 (20 marks)

- a. Breakdown mechanisms in solids are time dependent and vary from nanoseconds to years. Sketch a well labelled diagram showing different breakdown mechanisms in relation to time and breakdown voltage level. (4 marks)
- b. Discuss three ways of incorporating HVDC in ac systems. (6 marks)
- c. A 200 KV travelling on a line of surge impedance 400 ohms and reaches a junction of the line with two branch lines of surge impedance 500 ohms and 300 ohms respectively. Determine:
- Transmitted voltage and current.
 - Reflected voltage and current. (6 marks)
- d. A glow discharge tube is to be designed such that the breakdown occurs at the Paschen minimum voltage. For a certain gas, the Paschen minimum voltage is 220v corresponding to a potential difference of 4.5 torr-cm. if the gap distance in the tube is in mm:
- What is the gas pressure in the discharge tube.

- ii. If the gas in the tube is air, what would be the breakdown strength for a small gap of 1.5 mm under uniform field conditions and standard atmospheric pressure conditions. (4 marks)