MACHAKOS UNIVERSITY

University Examinations for 2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 402 POWER SYSTEMS II

INSTRUCTIONS

This paper consists of **FIVE** questions.

Answer **QUESTION ONE** and **ANY OTHER TWO** questions.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Give a very brief explanation of each of the essential features of switchgear below:

(i) Complete Reliability

(ii) Absolutely Certain Discrimination

(iii) Quick Operation

(iv) Provision for Manual Control

(v) Provision for Instruments. (5 marks)

b) A small generating station has two alternators of 3,000 kVA and 4,500kVA and percentage reactance of 7% and 8% respectively. The circuit breakers have a rupturing capacity of 150MVA. It is desired to extend the system by a supply from the grid via a transformer of 7,500 kVA and 7.5% reactance. Calculate the reactance of the reactor connected in the bus-bar section to prevent the circuit breakers from being overloaded, if a symmetrical short-circuit occurs on an outgoing feeder connected to it. Assume the bus voltage = 3,300V.

See Figure Question 1 (b). (8 marks)

c) A 20MVA, 11kV, 3-phase, 50 Hz generator has its neutral earthed through a 5% reactor. It is in parallel with another identical generator having isolated neutral. Each generator has a

positive sequence reactance of 20%, negative sequence reactance of 10% and zero sequence reactance of 15%. If a line to ground short circuit occurs in the common bus-bar, calculate the fault current**. See Figure Question 1 (c).** (7 marks)

d) A 500 kV, 2μs rectangular surge travels along a line, of surge impedance 400Ω, terminated by a capacitor of 2,500 pF. Calculate:

(i) the voltage across the capacitance,

(ii) the reflected voltage wave. (10 marks)

QUESTION TWO (20 MARKS)

a)

(i) Sketch diagrams to illustrate the direction of air-blast in relation to the arc for the following types of air-blast circuit breakers:

[a] Axial-blast type

[b] Cross-blast type

[c] Radial-blast type (3 marks)

(ii) **Figure Question 2(a)[ii]** illustrates a form of arc control in an oil circuit breaker. Give its name and describe how it facilitates arc control and extinction. (5 marks)

b) A 50Hz, 11kV, 3-phase alternator with earthed neutral has a reactance of 5 ohms per phase and is connected to a bus-bar through a circuit breaker. The distributed capacitance upto circuit breaker between phase and neutral is 0.01 μF. Calculate:

(i) Peak re-striking voltage across the contacts of the breaker

(ii) Frequency of oscillations

(iii) The average rate of rise of re-striking voltage up to the first peak

(6 marks)

c) **Figure Question 2(c)** illustrates a time-graded overcurrent protection scheme for an arrangement consisting of one generator and four sub-stations. Name the network configuration and describe how it fulfills its role. (6 marks)

S.No.	*Particular*	*Fuse*	*Circuit Breaker*
1	Function		
2	Operation		
3	Breaking Capacity		
4	Operating Time		
5	Replacement		

QUESTION THREE (20 MARKS)

a)

(i) Indicate the salient differences between a fuse and a circuit breaker as set out in the table below. (5 marks)

(ii) A fuse wire of circular cross-section has a radius of 0.8mm. The wire blows off at a current of 8 A. Calculate the radius of the wire that will blow off at a current of 1A.(3 marks)

b) **Figure Question 3(b)** illustrates the Translay Scheme. Briefly describe how it operates. (6 marks)

c) A star-connected, 3-phase, 10 MVA, 6.6 kV alternator has a per phase reactance of 10%. It is protected by Merz-Price circulating-current principle which is set to operate for fault currents not less than 175A. Calculate the value of earthing resistance to be provided in order to ensure that only 10% of the alternator winding remains unprotected. **Hint: Figure Question 3(c).**

(6 marks)

QUESTION FOUR (20 MARKS)

a)

(i) Sketch a well labeled diagram of a lightning surge.

(ii) List THREE harmful effects of lightning. (7 marks)

b) With the aid of suitable diagrams, describe the development, initiation, progression and termination of a lightning stroke. (9 marks)

c) An overhead transmission line having a surge impedance 500Ω branches into two lines having a surge impedance of 40Ω and 60Ω respectively. If a traveling wave of vertical front and magnitude 100kV travels along the overhead line, calculate, immediately after the travelling wave has reached the fork, the magnitude of:

(i) voltage in the overhead line
(ii) current in the overhead line
(iii) voltage in the two branches
(iv) current in the two branches

(4 marks)

QUESTION FIVE (20 MARKS)

a) An 100 kV, $2\mu s$ rectangular surge travels along the line terminated by an inductance of 1 mH. Calculate the voltage across the inductance and reflected voltage wave if the surge impedanace of the line is 500Ω. (6 marks)

b) A star-connected, 3-phase, 10 MVA, 6·6 kV alternator is protected by circulating current protection, the star point being earthed via a resistance r. Estimate the value of earthing resistor if 85% of the stator winding is protected against earth faults. Assume an earth fault setting of 20%. Neglect the impedance of the alternator winding.
(7 marks)

c) An air-blast circuit breaker is designed to interrupt a transformer magnetizing current of 11 A (r.m.s.) chops the current at an instantaneous value of 7 A. If the values of L and C in the circuit are 35·2 H and 0·0023 μF, find the value of voltage that appears across the contacts of

the breaker. Assume that all the inductive energy is transferred to the capacitance. (7 marks)

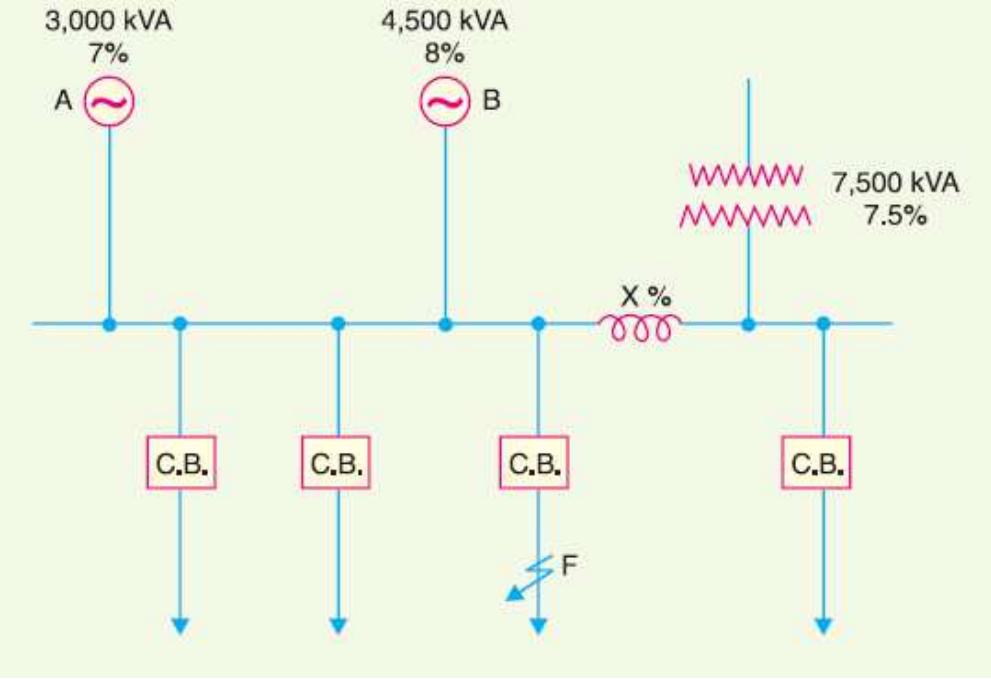

Figure Question 1(b)

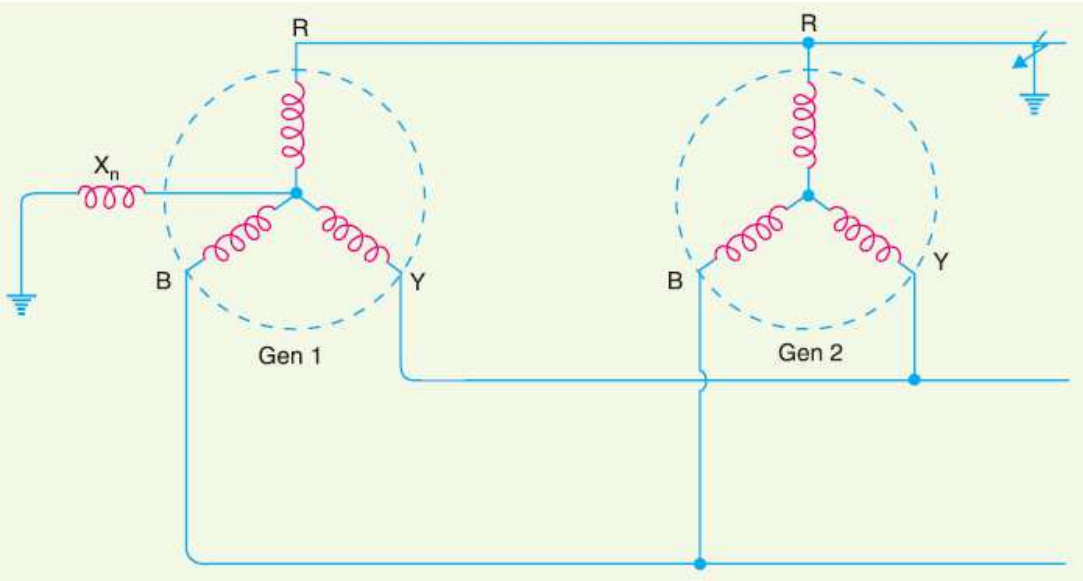

Figure Question 1(c)

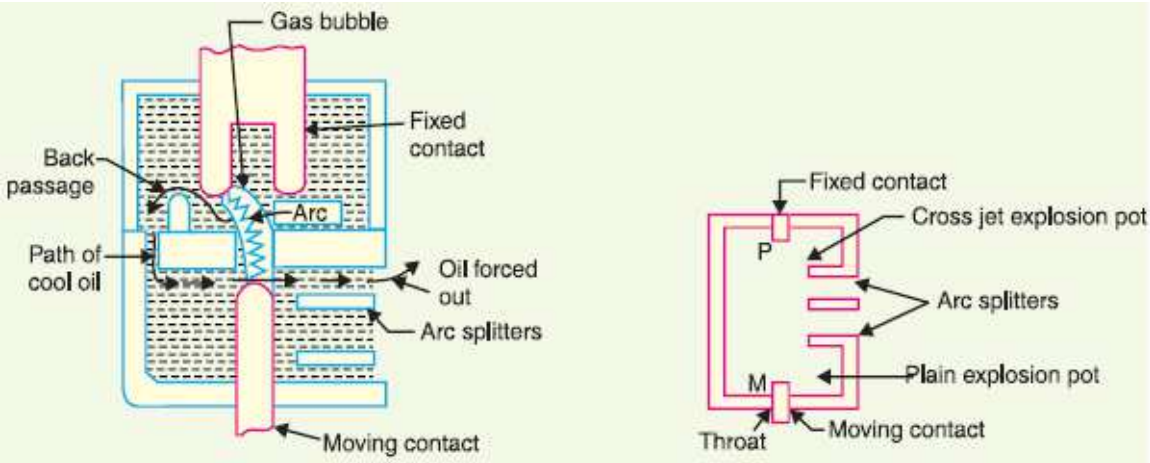

Figure Question 2(a)[ii]

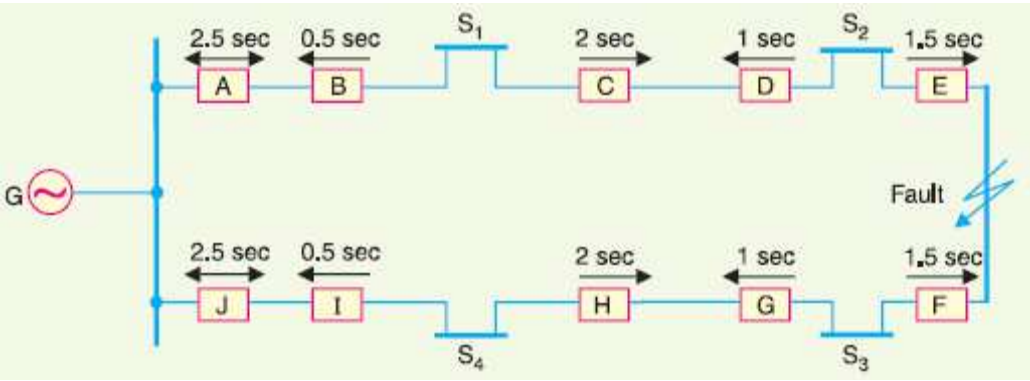

Figure Question 2(c)

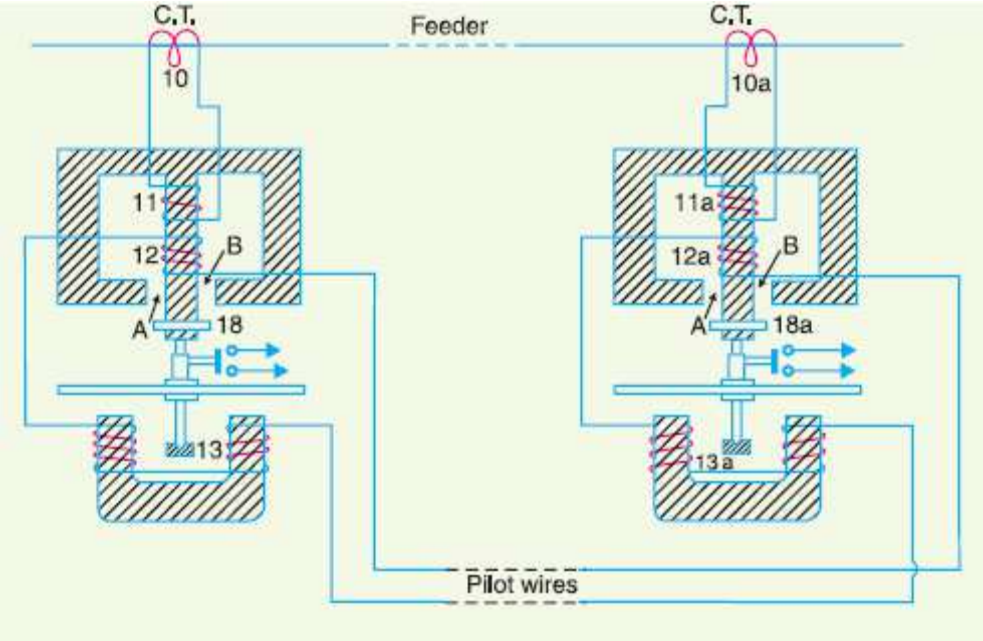

Figure Question 3(b)

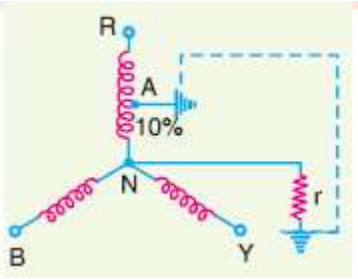

Figure Question 3(c)