MACHAKOS UNIVERSITY

University Examinations for 2020/2021

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 402 POWER SYSTEMS II

DATE: 18/8/2021 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

This paper consists of F**OUR** questions.

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

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Figure Question 1(a) shows the single line diagram of a 3-phase system. The percentage reactance of each alternator is based on its own capacity. Calculate the short-circuit current that will flow into a complete 3-phase short-circuit at F. (6 marks)

b) A 3-phase, 20 MVA, 10 kV alternator has internal reactance of 5% and negligible resistance. Calculate the external reactance per phase to be connected in series with the alternator so that steady current on short-circuit does not exceed 8 times the full load current. (6 marks)

c) A 3-phase transmission line operating at 10 kV and having a resistance of 1Ω and reactance of 4 Ω is connected to the generating station bus-bars through 5 MVA step-up transformer having a reactance of 5%. The bus-bars are supplied by a 10 MVA alternator having 10% reactance. Figure Question 1(c). Calculate the short-circuit kVA fed to symmetrical fault between phases if it occurs:

i) at the load end of transmission line. (3 marks)

ii) at the high voltage terminals of the transformer. (3 marks)

d) In a 3-phase, 4-wire system, the currents in R, Y and B lines under abnormal conditions of loading are as under: $I_R = 100 \angle 30^o$ A; $I_Y = 50 \angle 300^o$ A ; $I_B = 30 \angle 180^o$ A. Calculate the positive, negative and zero sequence currents in the R-line and return current in the neutral wire. (6 marks)

e) A 3-phase, 10 MVA, 11 kV generator with a solidly earthed neutral point supplies a feeder, Figure Question 1(e) The relevant impedances of the generator and feeder in ohms are as under:

	Generator	Feeder
Positive Sequence Impedance	j 1.2	j 1.0
Negative Sequence Impedance	j 0.9	j 1.0
Zero Sequence Impedance	j 0.4	j 3.0

If a fault from one phase to earth occurs on the far end of the feeder, calculate:

i) the magnitude of fault current

ii) line to neutral voltage at the generator terminal. (6 marks)

QUESTION TWO (20 MARKS)

a) List THREE disadvantages in using Generator Reactors in limitation of Short-Circuit Fault Currents. (3 marks)

b) Draw a diagram illustrating the use of Generator Reactance in limitation of Short-Circuit Fault Currents. (6 marks)

c) The plant capacity of a 3-phase generating station consists of two 10,000 kVA generators of reactance 12% each and one 5000 kVA generator of reactance 18%. The generators are connected to the station bus-bars from which load is taken through three 5000 kVA step-up transformers each having a reactance of 5%; Figure Question 2(b). Determine the maximum fault MVA which the circuit breakers on

i) low voltage side and

ii) high voltage side may have to deal with. (11 marks)

QUESTION THREE (20 MARKS)

a) Give an indication of the values/relationship of/between the Sequence Impedances of a Synchronous Generator. (3 marks)

b) Given Figure 3(b) which illustrates a Single Line-to-Ground Fault on the Red Phase:

i) state the value of V_R, (1 mark)

ii) state the value of I_B, (1 mark)

iii) state the value of I_Y, (1 mark)

iv) derive the expression for the Zero sequence current, I_0 (1 mark)

v) derive the expression for the Positive sequence current, I_1 (1 mark)

vi) derive the expression for the Negative sequence current, I_2 (1 mark)

vii) derive the expression for the Fault current, I_{FAULT} (2 marks)

viii) draw the equivalent circuit diagram from which the fault current may be calculated.

(2 marks)

c) A 3-φ, 4-wire-system supplies loads which are unequally distributed in the three phases. An analysis of the current flowing in R, Y and B lines shows that in R line, positive phase sequence component is 200 ∠0º A and the negative phase sequence component is 100 ∠60ºA. The total observed current flowing back to the supply in the neutral conductor is 300 ∠300º A. Calculate the currents in the three lines.

(7 marks)

QUESTION FOUR (20 MARKS)

a) One conductor of a 3-phase line is open. The current flowing to the Δ-connected load through the line R is 10 A. With the current in line R [Figure Question 4(a)] as reference and assuming that line B is open, find the symmetrical components of the line currents.

(9 marks)

b) Three impedances of 5—j10, 6 + j 5 and 3 + j15 ohms are connected in star to red, yellow and blue lines of a 3300 V, 3-phase, 3-wire supply. The phase sequence is RYB.

Calculate the line current I_R.

(11 marks)

QUESTION FIVE (20 MARKS)

a) A 3-phase, 11 kV, 10 MVA alternator has sequence reactances of X0 = 0·05 p.u., X1 = 0·15 p.u. and X2 = 0·15 p.u. If the generator is on no load, find the ratio of fault currents for L-G fault to that when all the 3-phases are dead short-circuited. (6 marks)

b) A 3-phase, 11 kV, 25 MVA generator with X_0 = 0·05 p.u., X_1 = 0·2 p.u. and X_2 = 0·2 p.u. is grounded through a reactance of 0·3 Ω. Calculate the fault current for a single line to ground fault. (7 marks)

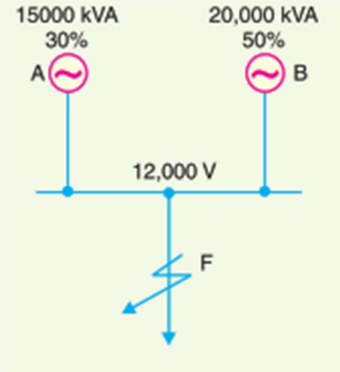

Figure Question 1(a)

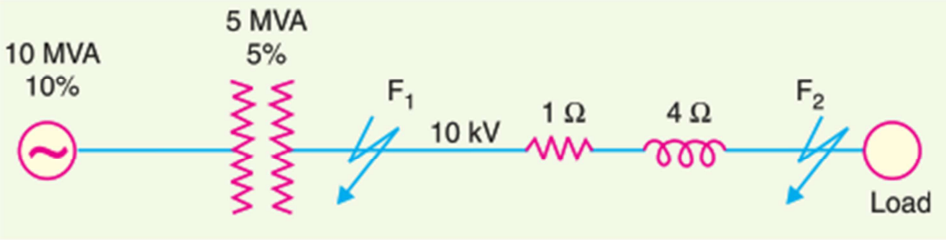

Figure Question 1(c)

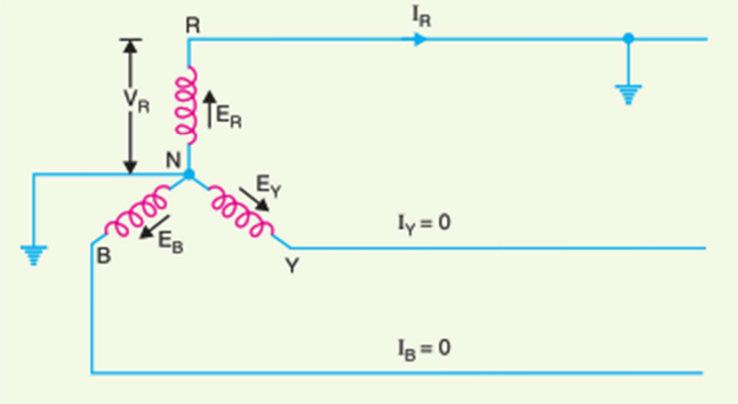

Figure Question 1(e)

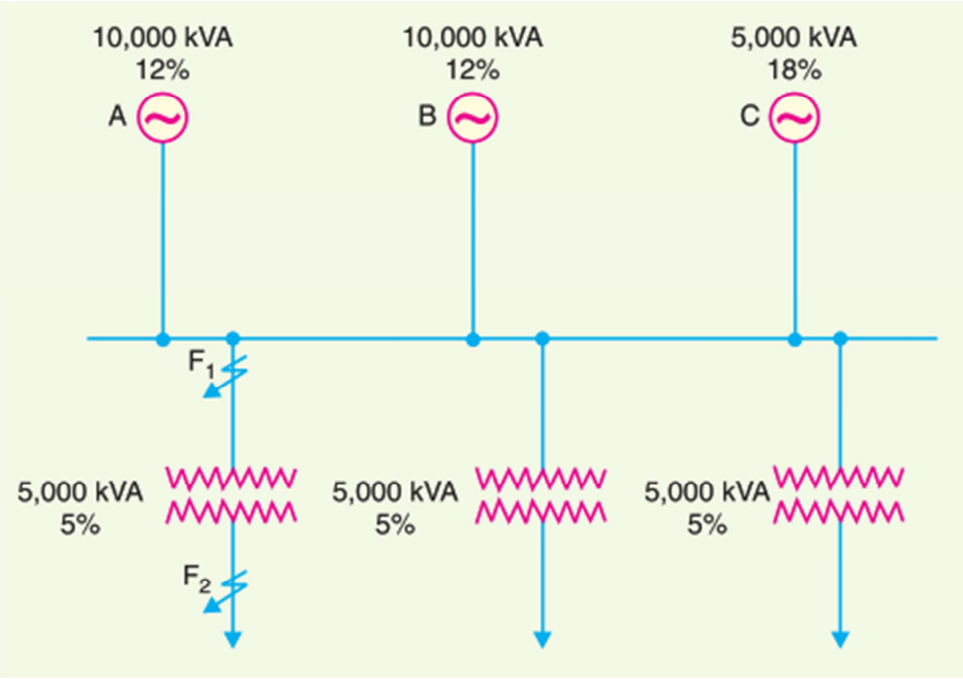

Figure Question 2(b)

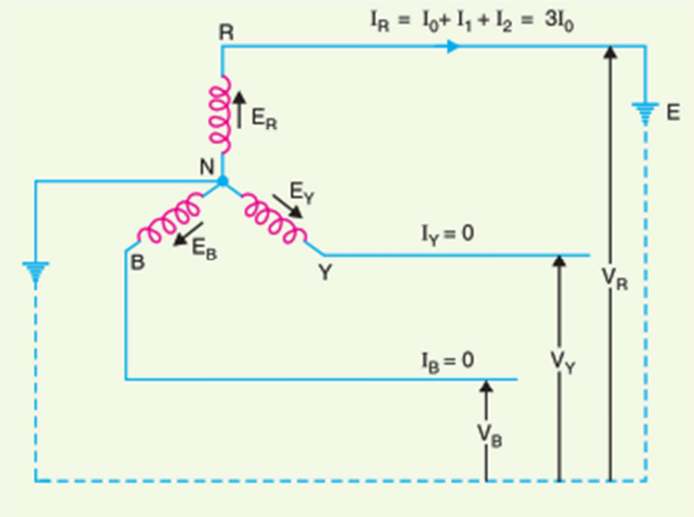

Figure Question 3(b)

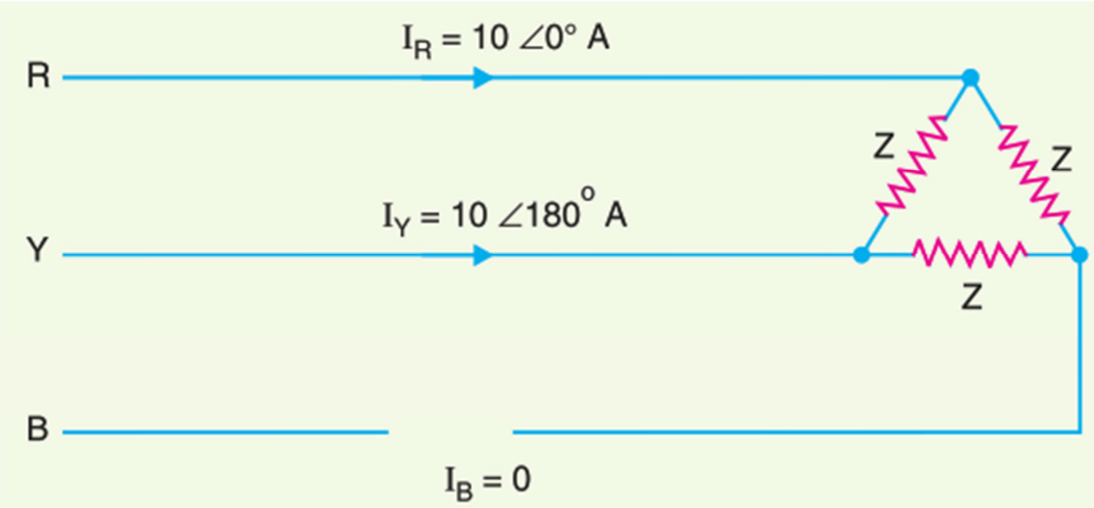

Figure Question 4(a)