MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS
2023/2024 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF TECHNOLOGY EDUCATION
IN
ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE CODE: TEE 312

COURSE TITLE: POWER SYSTEMS II

DATE: FRIDAY 08/12/2023 TIME: 8: 00 AM – 2:00 AM

INSTRUCTIONS TO CANDIDATES

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS.
QUESTION ONE CARRIES 30 MARKS AND ALL OTHERS 20 MARKS EACH.

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

Question One (30 marks)

(a) Define the following terms:

i) fuse. **[1 mark]**

ii) breaking capacity of a circuit breaker **[1 mark]**

iii) isolator **[1 mark]**

(b) Give two advantages of feeder reactors. **[2 marks]**

(c) Explain the importance of calculating short circuit currents. **[4 marks]**

(d) Mention four assumptions made when analysing unsymmetrical faults. **[4 marks]**

(e) 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%. Determine the maximum fault MVA which the circuit breakers on:

i) low voltage side,

ii) high voltage side may have to deal with. **[5 marks]**

(f) In a 3-phase, 4-wire system, currents in R, Y and B lines under abnormal conditions of loading are:

$$\bar{I}_R = 150 \angle 45^\circ \text{ A} ; \bar{I}_Y = 250 \angle 150^\circ \text{ A} ; \bar{I}_B = 100 \angle 300^\circ \text{ A}$$

Calculate the zero, positive and negative phase sequence currents in the R-line and return current in the neutral connection. **[6 marks]**

(g) With the help of a diagram, describe the balanced earth protection for small-size alternators. **[6 marks]**

Question Two (20 marks)

a) (i) Define reactors. **[1 mark]**

(ii) Mention three reasons why generator reactors are not commonly used in modern power stations. **[3 marks]**

b) Name and discuss the different types of bus-bar arrangements. **[5 marks]**

c) Fig 2.1 shows the single line diagram of a 3-phase system. The percentage reactance of each alternator is based on its own capacity. Find the short-circuit current that will flow into a complete 3-phase short-circuit at F. **[5 marks]**

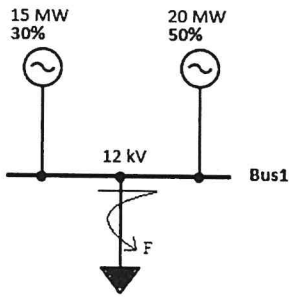

Figure 2.1. Single line diagram

d) A 10 MVA, 6·6 kV, 3-phase star-connected alternator having a reactance of 20% is connected through a 5 MVA, 6·6 kV/33 kV transformer of 10% reactance to a transmission line having a resistance and reactance per conductor per kilometre of 0·2 Ω and 1 Ω respectively. Fifty kilometres along the line, a short-circuit occurs between the three conductors. Find the current fed to the fault by the alternator. **[6 marks]**

Question Three (20 marks)

(a) Explain why a three-phase symmetrical fault is more severe than a three-phase unsymmetrical fault. **[2 marks]**

(b) Prove that:

$$\frac{1-a}{1+a^2} = 1 - a^2$$ **[3 marks]**

(c) A 3-phase, 11 kV, 10 MVA alternator has sequence reactances of X_o= 0·05 p.u., X_1 = 0·15 p.u. and X_2 = 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. **[4 marks]**

(d) The zero sequence, positive sequence components of red phase are as under:

$\overline{E_{R0}} = (0.5 - j0.866)$ V $\quad \overline{E_{R1}} = 4\angle 0°$ V $\quad \overline{E_R} = 5\angle 0°$ V

Find the negative sequence component of red phase and the phase voltages $\overline{E_Y}$ and $\overline{E_B}$. **[4 marks]**

(e) A delta connected load is supplied from a 3-phase supply. The fuse in the B line is removed and current in the other two lines is 20 A. Find the symmetrical components of line currents for each of the lines. **[7 marks]**

Question Four (20 marks)

(a) i) State four types of circuit breakers if the basis of classification is the medium used for arc extinction. **[2 marks]**

ii) Explain the various methods of arc extinction in a circuit breaker and mention where they are employed. **[3 marks]**

(b) Mention the duties a circuit breaker is required to perform under fault conditions. **[3 marks]**

(c) Give three disadvantages of using oil as an arc quenching medium. **[3 marks]**

(d) Explain the principle of operation of low-oil circuit breakers. **[4 marks]**

(e) A 50 Hz, 15 kV, 3-phase alternator with earthed neutral has a reactance of 10 ohms per phase and is connected to a bus-bar through a circuit breaker. The distributed capacitance up to circuit breaker between phase and neutral in 0·03 μF. Determine:

i) peak re-striking voltage across the contacts of the breaker, **[1 mark]**
ii) frequency of oscillations, **[2 marks]**
iii) the average rate of rise of re-striking voltage up to the first peak. **[2 marks]**

Question Five (20 marks)

a) i) Mention the principal relays and systems used for transformer protection. **[2 marks]**

ii) State the faults each of the systems in (i) above protect against. **[2 marks]**

b) Give two advantages and two disadvantages of using overhead ground wires to provide protection against direct lightning strokes to transmission lines. **[4 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 175 A. Calculate the value of earthing resistance to be provided in order to ensure that only 10% of the alternator winding remains unprotected. **[6 marks]**

d) With the help of a diagram, describe the Merz-Price voltage balance system for the protection of feeders. **[6 marks]**