FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF MINING ENGINEERING

ELECTRICAL PRINCIPLES

EMN 1203 / EMG 1203 / ESG 1206

Final Examination Paper

June 2024

This examination paper consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Mr. K. Garapo

INSTRUCTIONS

1. Answer all questions in **Section A**, and any three questions in **Section B**.
2. Begin each solution for a new question on a new page and show all working.
3. **Section A** consists of **four** questions carrying **10 marks** each.
4. **Section B** consists of **four** questions carrying **20 marks** each.
5. Use of calculators is permissible.

Additional Requirements

None

MARK ALLOCATION

Questions	Marks
Question 1	10
Question 2	10
Question 3	10
Question 4	10
Question 5	20
Question 6	20
Question 7	20
Question 8	20
Total Attainable	100

SECTION A (40 Marks): Answer all questions

Question 1

The Zimbabwe sub-transmission system comprises of 66 kV, 88 kV, 110 kV and 132 kV systems.

a) State the (i) maximum, and (ii) minimum steady-state sub-transmission per-unit (pu) voltages allowed in the transmission of electricity during normal operation. [2]

b) Use the per-unit values you gave in a) to determine the maximum values of the steady-state voltages for the (i) 88 kV and (ii) 110 kV systems. [4]

c) Use the per-unit values you gave in a) to determine the minimum value of the steady-state voltage for the 66 kV systems. [2]

d) Why are 330 kV substation transformers part of the sub-transmission system? [2]

Question 2

Determine the resistance across points A and B in the circuit shown in Figure A1. [10]

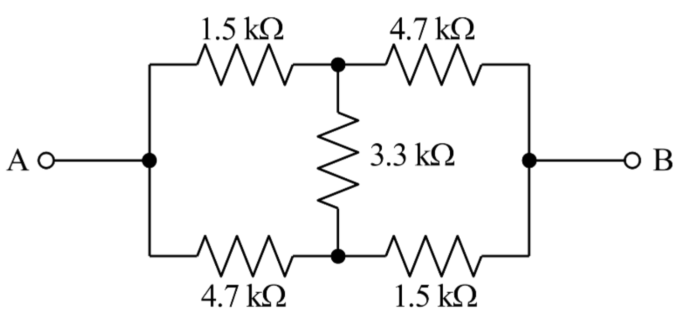

Figure A1

Question 3

Given the circuit of an ideal OPAMP, as shown in Figure A2, determine the output voltage phasor $\boldsymbol{V}_{\text{out}}$, [10]

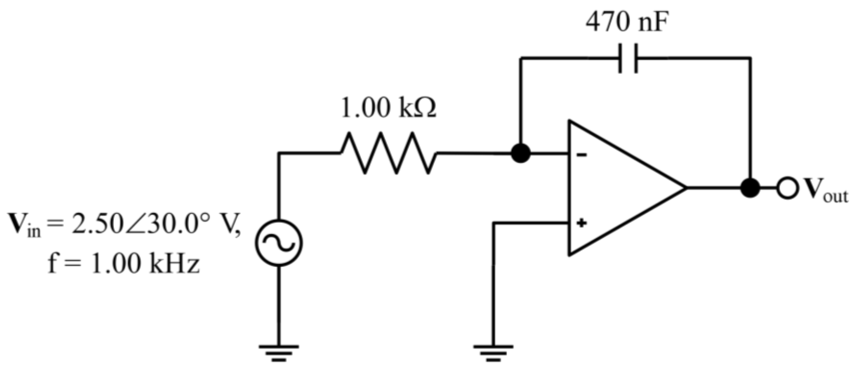

Figure A2

Question 4

a) With reference to a transformer, briefly describe the phenomenon of mutual induction. [5]

b) Describe a step-down transformer. [3]

c) State <u>one</u> instance where a step-up transformer is used in an electrical network. [2]

SECTION B (60 Marks): Answer any three questions

Question 5

Apply Thévenin's theorem to the unbalanced Wheatstone bridge shown in <u>Figure B1</u> and determine the current measured by the galvanometer, given the following values: $V = 0.200$ kV, $R_1 = 3.00$ kΩ, $R_2 = 1.50$ kΩ, $R_3 = 0.400$ kΩ, $R_4 = 0.600$ kΩ and the internal resistance of the galvanometer $R_m = 40.0$ Ω. [20]

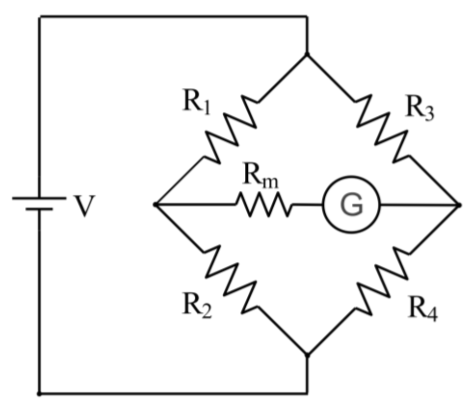

Figure B1

Question 6

a) Three inductive loads each of resistance $75.0\ \Omega$ and inductance $318.4\ \text{mH}$ are connected in delta to a $400\ \text{V}, 50\ \text{Hz}$, 3-phase supply. Answer the following:

i) Determine the phase voltage. [2]

ii) Determine the phase current. [5]

iii) Determine the line current. [3]

b) Three 68 Ω resistors are connected to a 400 V, 3-phase supply. Answer the following:

i) What is the total power dissipated when they are connected in star configuration? [5]

ii) What is the total power dissipated when they are connected in a delta configuration? [5]

Question 7

Given the oscillogram shown in Figure B2, answer the questions that follow.

a) Determine the (i) peak voltage, (ii) period and (iii) angular frequency of the AC component of the signal. [9]

b) Determine the value of the DC component of the signal. [5]

c) The voltage phasor of the AC component of the signal. [6]

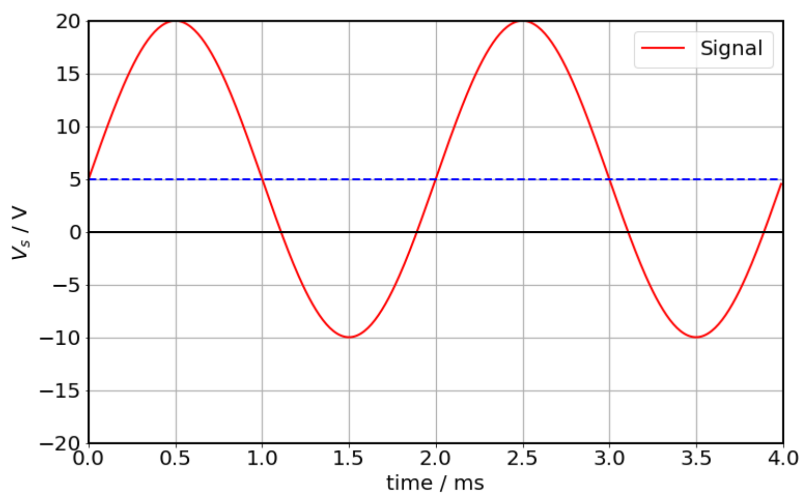

Figure B2

Question 8

a) Apply mesh analysis to determine the mesh currents for each of the three essential meshes in the planar circuit shown in Figure B3. [13]

b) Use the mesh currents determined in (a) to determine the magnitude of the current flowing through each of the seven resistors in Figure B3. [7]

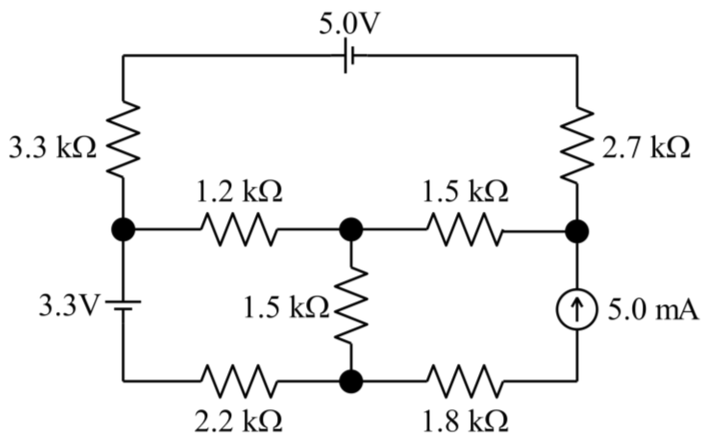

Figure B3