The Open University of Sri Lanka 438
Faculty of Engineering Technology
Department of Electrical & Computer Engineering

Study Programme	: Bachelor of Science Honours in Engineering / Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX3410 Introduction to Electrical Engineering**
Academic Year	: 2022/23
Date	: 01/02/2024
Time	: 0930 – 1230 hrs

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Six (6)** questions in **Six (6)** pages.
3. Answer **Five (5)** questions only, including **all** from Part A and **Two (2)** from Part B.
4. Answer for each question should commence from a new page.
5. Relevant charts / codes / values are provided.
6. This is a Closed Book Examination.
7. Answers should be in clear handwriting.
8. Clearly indicate all formula and calculations for full marks.
9. Do not use red colour pen.

PART A – You are expected to answer all 3 questions Q1 – Q3

Q1

Figure Q1 shows a circular loop of wire A having 10 turns (n = 10) connected to a DC source through a resistor and a switch. Inside this loop another loop of wire is placed (loop B).

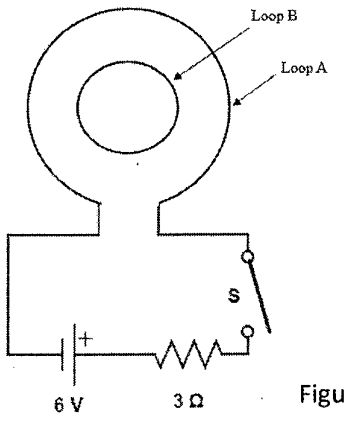


Figure Q1

a. State Faraday's Law. [3]

b. It is observed that a current appears in the loop **B** during the switching and then becomes zero.

   i. Explain this observation using the laws of electromagnetism. [5]

   ii. State the direction of current induced in loop **B**. (clockwise/anticlockwise). Justify your answer. [3]

c. State three changes you can make in the circuit containing loop A, to increase the current induced in loop B? [5]

d. While the switch S is closed, the DC source is replaced with a sinusoidal source. Sketch the expected waveform of the current in loop **B**. [3]

e. Loop **B** wire is now taken out and placed in a magnetic field in which the flux density increases from 1.5 T to 4.8 T in 23 ms. Radius of the circular loop B wire is 25 cm and the flux density makes 45^{o} with the normal to the loop B.

   i. Calculate the change in magnetic flux. [3]

   ii. What is the induced emf? [2]

   iii. Calculate the induced current in the wire with the total resistance is 10 Ω. [1]

Q2

a)

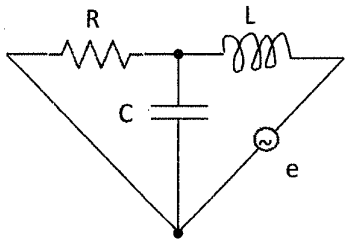


Figure Q2a

In the Circuit of Figure Q2a, it is given that L = 150 mH, C = 2.5 μF, and R = 200 Ω. The source delivers a sinusoidal output.

i) The current and voltage of the Inductor, as measured with an ideal multimeter at AC setting, read 40 mA and 12 V respectively. Calculate the frequency, and currents and voltages of the other 2 passive components. *Consider the current through the Inductor as reference.* [12]

ii) Calculate the supply voltage, and express it in the time domain (in the form $e(t) = E_m \sin(\omega t \pm \phi)$). [1]

iii) Calculate the power dissipated from the circuit, and the power factor of the source. [2]

iv) Draw a phasor diagram for the circuit, using the above values, taking the current through the Inductor as reference. [10]

Draw the phasor diagram (approximately) to scale on a separate page. The phasors in the diagram should match the values from i). Draw the reference horizontal to right.

b)

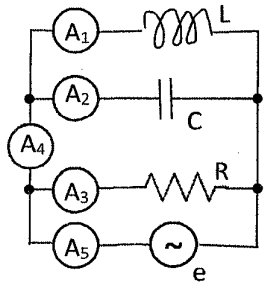


Figure Q2b

i. State the primary characteristic of a circuit at resonance.

You are provided an inductor L = 100 mH, a capacitor C = 10 μF, a resistor R = 200 Ω, a source of variable sinusoidal frequency, and a set of ideal AC ammeters (A) connected as shown in Figure 2b.

When the source is tuned so that the circuit is at resonance, find

ii. the resonance frequency f_o

iii. A_1 reading iv. A_2 reading v. A_3 reading

vi. A_4 reading vii. A_5 reading

viii. Draw to scale the phasor diagram for the circuit. [10]

Q3.

A Common emitter base-bias transistor amplifier is shown in the Figure Q3. The transistor used is silicon *(V_{BE} = 0.7 V)*, and its current gain *(β)* is 50.

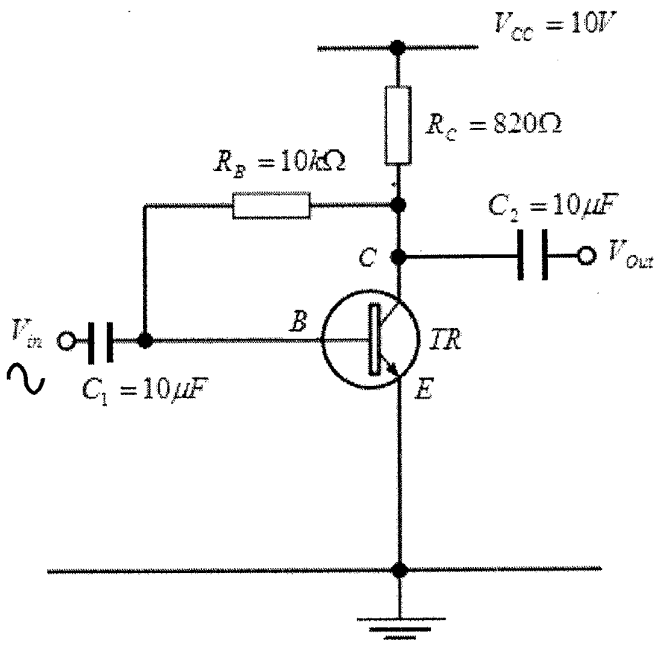


Figure Q3: A Common emitter single base bias transistor amplifier

a. State the value for V_{CE} to get the maximum range of undistorted amplification for the circuit in Figure Q3 , disregarding the given R_B and R_C values. [2]

b. Calculate the base current *(I_B)* and the collector current *(I_C)* at the Q point for values given in the circuit in Figure Q3. [5]

c. Draw the DC Load line and mark the operating point (Q- point) on the load line. [6]

d. Calculate the actual maximum undistorted amplification possible at the output based on the given R_B and R_C values. [2]

PART B – You are expected to answer any two questions from Q4 – Q6

Q4

a)

Two capacitors of 9 μF and 4 μF are connected in series with each other and with a DC source of 26 V. Then the charged capacitors are disconnected from the source and from each other, and then reconnected to each other with plates of **opposite** sign together.

By how much does the energy of the system change? [9]

b) A small insulating sphere of radius **a** is concentric with a larger conducting spherical shell with inner radius **b** and outer radius **c** as in figure Q4. The inner sphere has total charge +**q**, and the outer shell has total charge -2**q**. Assume uniform charge distribution in insulating material.

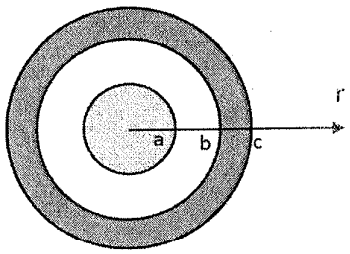


Figure Q4

Derive the electric field (magnitude and direction) in terms of q and the distance r from the common centre for

i) $r \leq a$; ii) $a < r < b$; iii) $b \leq r < c$; iv) $r > c$

v) Show your results in a graph of the radial component of **E** as a function of r. [6]

Hint : Gauss's Law

Q5

A moving coil type indicating instrument requires 50 μA DC current for the full-scale deflection. The resistance of the instrument is 200 Ω.

a) If this instrument is needed to be used in the following scenarios, determine the configuration of external resistance required to be connected and calculate their values for each scenario. (Draw the circuit diagrams)

   i. As an ammeter of 20 mA DC full scale deviation [3]

   ii. As a voltmeter of 50 V DC full scale deviation [3]

b) If the voltmeter prepared in a) ii is used to measure the voltage between the points **A** and **B** in the circuit shown in **figure Q5**, calculate the voltage reading. Assume that the voltage source is ideal. [6]

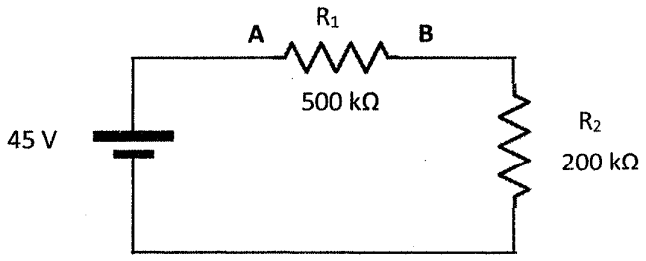


Figure Q5

c) Calculate the percentage error of the metre reading you have calculated in b). [3]

Q6.

a) Give two reasons briefly so as to explain why the electrical energy is superior to all other forms of energy. [3]

b) What factors contributed to the limited interest in transitioning to renewable energy before the mid-2000s, despite the cost advantages and accessibility of renewable sources? [2]

c) What are the transmission levels in Sri Lanka?

Is it convenient to increase the transmission voltage as high as possible? Justify your answer. [3]

d) A 2-wire ring DC distributor (ABCDEA) is shown in figure Q6. The total length of the ring distributer is 1000 m and it is fed at the point A at 220 V. The loads of 10 A, 20A, 30A and 10A are tapped off from the positions B, C, D and E respectively, as shown in the figure. The resistances of each section (forward and return) are as follows:

$R_{AB} = 0.1\Omega$, $R_{BC} = 0.05\Omega$, $R_{CD} = 0.01\Omega$, $R_{DE} = 0.025\Omega$ and $R_{EA} = 0.075\Omega$

Calculate the currents in each section of the distributer (I_{AB}, I_{BC}, I_{CD}, I_{DE} and I_{EA}). [7]

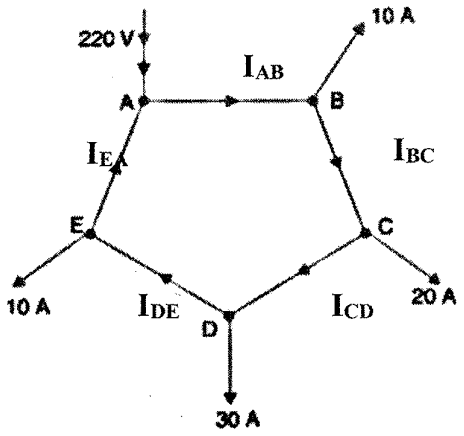


Figure Q6

Hint
According to Kirchhoff's voltage law, the voltage drop in a closed loop is zero!