DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

SMA 3121: COMPLEX ANALYSIS CAT ONE TIME: 1 HOUR

(a) Given $Z_1=5+7i$ and $Z_2=8-i9$, Determine $Z_1.Z_2^{-1}$

(b) Compute the $\lim_{z\to 1+i\sqrt{3}} \frac{z^2-2z+4}{z-1-i\sqrt{3}}$

(c) Find the image of the line $y=2x+1$, under the mapping $T(z)=\frac{1}{z}$

(d) Discuss the Conformality of the function $f(z)=e^z$ throughout the Z-Plane

(e) Determine the Locus of all the Points z , that are equidistant as $w_1=i9$ and also equidistant as $w_1=1+i3$

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

SMA 3121: COMPLEX ANALYSIS CAT 2 1 HOUR

a. Evaluate the integral $\int \frac{z^2}{(z^2+1)(z+4)} dz$, at the point $z = -4$ (5 Marks)

b. Determine the Laurent series given $f(z) = z\cos\left(\frac{1}{z}\right)$, at point. $z=0$ (5 Marks)

c. From Schwarz-Christofel, show that $(\pi-\alpha_1)+(\pi-\alpha_2)+---+(\pi-\alpha_n)=-2$. (4 Marks)

d. Evaluate $\ell^{-1}\left(\frac{1}{(s^2+1)^2}\right)$ using the residue theorem. (8 Marks)

e. State and derive the Cauchy Riemann equations. (8 Marks)

f. Explain Harmonic function hence, given $U=x^2-y^2-2xy-2x+3y$, show that its harmonic and find its harmonic conjugate V . (7 Marks)

g. Explain the following terms and for each give an example

- Removable singularity. (1 Mark)
- A pole of order n . (1 Mark)
- An essential singularity. (1 Marks

EM II CAT II EEE3103 July 23,2024

Q1. a) i) Sketch a typical hysteresis loop of a magnetic material and state its significance with reference to intercepts on the coordinate axes. ii)Describe and differentiate between any three types of magnetic materials.

b) Current I flows through each of two infinitely long, parallel wires spaced d meters. Determine the magnetic flux density at point midway between the conductors if the current through them flows in the i) same direction and ii) Opposite direction.

Q2. a) Derive an expression for the equivalent inductance of two coils connected in series aiding.

b) Two coils of self inductances 6H and 14 H with mutual inductance as 0.5H, find the equivalent inductance of the **four** possible combinations of the coils.

Q3. a) i) Derive Maxwell's equations in integral form. ii) Explain the physical significance of these equations.

b) i)Determine the inductance per unit length of a coaxial cable. ii) Determine the force on the charge Q= 5 C having the velocity v=4i+2j-3k m/sec, under the influence of both **E**= -12i+5j-10k V/m and **B**= -6i+4j+3k T fields simultaneously.

Q4. A squarer coil of side 2cm has100 turns. Find the mutual inductance between this coil and an infinite straight wire with 5A current and placed parallel to one of the side of the coil.

EEE/ETI3103 CAT I EM II Class 18/6/24.

Question 1. a) i) With the help of an equivalent circuit of Ohm's law in electrostatics, explain the analogous magnetic circuit.

ii) State and define the symbols used in magnetostatics analogous to the terms for E, D, and ε in electrostatics.

Q1b) A point charge of Q= -1.5C has velocity v=2i+5j-7k m/sec. Find the magnitude of the force exerted on the charge if it is simultaneously influenced by both E = -9i+5j-7k V/m and B= 6i+4j+3k T fields.

Question 2. a) Determine the value of equivalent inductance of inductors in series aiding with the values as given below: Self inductances : $L_{1=}10\ \mu H, L_{2=}12\ \mu H\ and\ L_{3=}12\ \mu H$ and Mutual inductances: $M_{12} = 1.5\ \mu H,\ M_{23} = 2.5\ H\ and\ M_{31} = 3.5\ \mu H$.

Q2.b) A circular cast iron ring of mean diameter 12 cm and a square cross-sectional area of a 2 cm-side produces flux density B = 1.2 Tesla. If the coil magneto motive force is 1200 AT, Determine magnetic field intensity 'H' in the ring. Calculate the reluctance of the ring.

Question 3. A toroid has a tightly wound coil with 1500 turns. The inner and the outer radii of the magnetic core are 8 cm and 10 cm, respectively, and a cross-section of 2.5 sq. cm The length of the air gap is 1.5 cm. If the current in the coil is 4 A and the relative permeability of the magnetic material is 1200, determine the

i) Flux density in the magnetic circuit.

ii) Draw the equivalent magnetic circuit, if an air gap of 1 cm is introduced in the core. Hence obtain magnetic flux in the air gap.

Question 4.a) i) Starting from Faraday's and Amper's laws and using Stoke's theorem, derive Maxwell's equations in integral form.

ii) Explain the physical significance of these equations.

Q.4 b i) Obtain the boundary conditions for H and B fields at a current free boundary.

ii) Derive the law of refraction (tangent rule) for magnetic flux lines at a boundary with no surface current

Date: July 8, 2024 CAT I (out of 25) Time: 7 am – 8 am

a. For transfer functions, give at least two classifications of magnitude responses and two classifications of phase responses. (2 marks)

b. What is the difference between bilinear and biquad transfer functions? (1mark)

c. Use the circuit shown in Fig. Q(c) to answer the questions that follow.

i. Obtain the transfer function $T(s) = \frac{V_C(s)+V_L(s)}{V_i(s)}$. (3 marks)

ii. By writing the denominator in the form: $s^2 + \frac{\omega_0}{Q}s + \omega_0^2$, obtain the expressions for Q and ω_0. (2 mark)

iii. Write $T(s)$ as a function of s, Q and ω_0. (1 mark)

iv. By making the substitution $s = j\omega$, write $T(\omega)$. (1 mark)

v. Obtain the magnitude response $|T(\omega)|$. (1 mark)

vi. Obtain the phase response $\theta(\omega)$. (1 mark)

vii. Estimate the magnitude response at $\omega = 0$, $\omega = \omega_0$, and $\omega = \infty$. (3 marks)

viii. Sketch the magnitude response. (2 marks)

ix. Estimate the phase response at $\omega = 0$, $\omega = \omega_0$, and $\omega = \infty$. (3 marks)

x. Sketch the phase response. (2 marks)

xi. Classify the phase and magnitude responses of the transfer function. (1 mark)

xii. What kind of magnitude response would you get if the output was $v_R(t)$? (1 mark)

d. Why is it undesirable to have a lowpass filter with a high Q value? (1 mark)

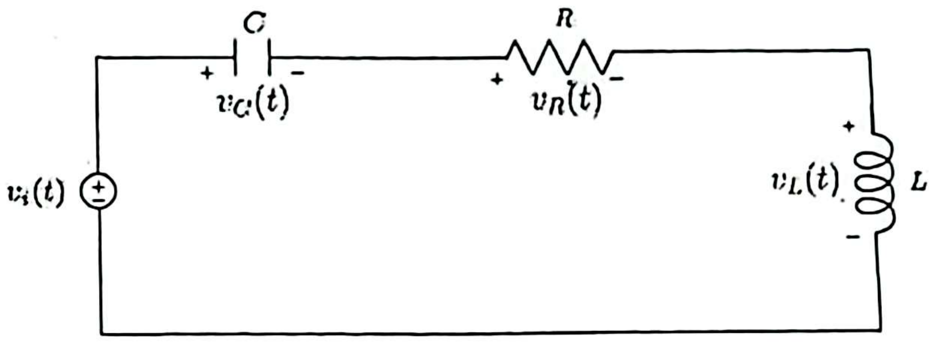


Fig. Q(c)

Date: Aug 6, 2024 **CAT II (out of 30)** **Duration: 1hr 10 mins**

a. The transfer function for the circuit in Fig. Q1(a) is

$$T(s) = \frac{V_{OUT}(s)}{V_{IN}(s)} = \frac{1}{1 + C_1(R_1 + R_2)s + R_1R_2C_1C_2s^2}$$

i. Write the expressions for Q and ω_0 and obtain the expressions for the sensitivities $S_{R_1}^{\omega_0}$, $S_{R_1}^{\omega_0}$, $S_{C_1}^{\omega_0}$, and $S_{C_2}^{\omega_0}$. (5)

ii. If R_1 and R_2 are reduced by 1% and C_1 and C_2 are increased by 0.5%, what is the new ω_0 if the old $\omega_0 = 1000$ rad/s? (2)

b. You are to design a lowpass filter using a Butterworth approximation to meet $\omega_p = 200$ rad/s, $\omega_s = 800$ rad/s, $\alpha_p = 0.5$ dB and $\alpha_s = 20$ dB. Order n Butterworth response is given by:

$$|H(j\omega)| = \frac{1}{\sqrt{1 + \epsilon^2\left(\frac{\omega}{\omega_p}\right)^{2n}}}$$

i. Calculate ϵ by substituting $\alpha_p = -20\log_{10}|H(j\omega_p)|$. (1)

ii. Using $\alpha_s = -20\log_{10}|H(j\omega_s)|$, calculate minimum required n. (4)

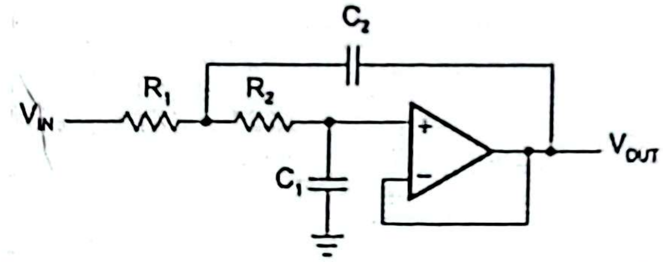
iii. Write the filter's transfer function, $H(s)$, from the table in Fig. Q1(b). (1)

iv. Using the circuit in Fig. Q1(a) and starting from $R_1 = R_2 = 1$, calculate normalized values for C_1 and C_2 for the second order section of $H(s)$ in b(iii). (2)

v. The value of ω that makes the $|H(j\omega)| = 1/\sqrt{2}$ is ω_0. Calculate ω_0. (3)

vi. Use ω_0 calculated in b(v) to scale $H(s)$ in obtained in b(iii). (1)

vii. Use ω_0 calculated in b(v) and $R_1 = R_2 = 1$ kΩ to scale the values of C_1 and C_2 calculated in b(iv). (1)



(a) Sallen-Key Biquad

n	
1	$s+1$
2	$s^2+\sqrt{2}s+1$
3	$(s^2+s+1)(s+1)$
4	$(s^2+0.76536s+1)(s^2+1.84776s+1)$

(b) Butteworth denominator polynomials

Fig. Q1

c. Draw asymptotic bode plot (magnitude and phase) for the following transfer function. First, write its individual terms, then draw the magnitude and phase plots for each of them. Finally, draw the combined magnitude and phase response.

$$T(s) = 10\frac{(s+2)}{s(s^2+s+4)}$$

(10)

$(s^2+4)\ s-2)$.

$s^2 - 2s + 2s - 4$.

$s^2 - 4$

EEE 3104 & ETI 3104: Digital Electronics I

Date: July 4, 2024 **CAT I (out of 20)** **Time: 7 am – 8 am**

a) Convert 2783.65_8 to decimal. **(1 mk)**

b) Carry out the operation $1001_2 - 1101_2$ using 2's complement arithmetic. Give your answer in sign and magnitude format. **(2 mks)**

c) Show how the XNOR gate can be implemented using the THREE basic gates (AND, OR and NOT gates). **(3 mks)**

d) Obtain the reduced form of the following Boolean algebra expression.

$$F = (A + B)(A + \bar{C})$$ **(3 mks)**

e) Simplify the Boolean expression $F(A, B, C, D) = \sum(4, 6, 8, 10, 12, 14)$. You can use a K-map. **(3 mks)**

f) During the selection process for an engineering course at a university, THREE subjects are considered. A pass in mathematics is compulsory. A pass in either or both Physics and Chemistry guarantees one a place. However, a fail in both guarantees a rejection. Draw a truth table to represent the selection criteria, then obtain a reduced logical expression that a computer program can use for selection. **(3 mks)**

g) Write the logic function implemented by the circuit of **Figure Qg**. Can the function be implemented with fewer gates? Give a reason for your answer. **(2 mks)**

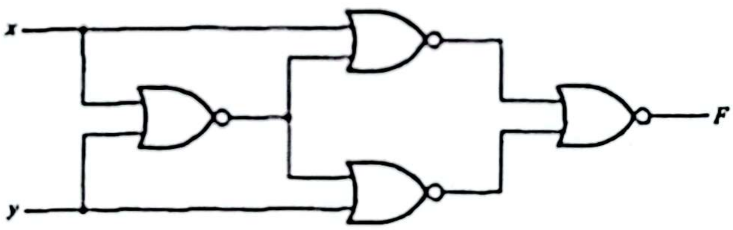


Figure Qg

h) Digital electronics uses binary logic by and large. If digital circuits were implemented using multilevel logic circuits (logic circuits with more than two levels), give an advantage and a disadvantage that such implementation would lead to when compared to binary logic. **(2 mks)**

i) Why would one choose an analog computer over a digital computer for an application? **(1 mk)**

Adv: Fewer inputs required for implementation.
Disadv: Increased difficulty in circuit design.

EEE 3104 and ETI 3104: Digital Electronics I

Thursday August 1, 2024 CAT II (out of 30) Duration: 1 hour

1. Explain the **differences** between the following terms
   a. ***Flip-flops*** and ***latches.*** (1 mark)
   b. ***Sequential logic circuits*** and ***combinational logic circuits.*** (1 mark)
   c. ***Level triggering*** and ***edge triggering.*** (1 mark)

2. Why is it more difficult to design sequential logic circuits using level triggering compared to edge triggering? (1 mark)
3. Design and implement a full subtractor (inputs: A, B, $Borrow_{in}$, outputs: D, $Borrow_{out}$)
   a. using a 4-1 multiplexer. (6 marks)
   b. using a generic binary decoder. (2 marks)

. Implement a JK flip-flop using the D flip-flop. (5 marks)
Design an asynchronous counter that counts from 0 to 2 using T flip-flops. (3 marks)
Design a synchronous counter that counts even numbers falling within the range 10 to 13 using D flip-flops (4 marks)
Using a block diagram, suggest how you can use a **counter** and a **multiplexer** to convert 8-bit parallel data to serial data. (3 marks)
Design a 2-bit binary-to-Gray encoder. (3 marks)

Date 04/ 07/ 2024 EEE/ETI 3105 CAT 1 (30 marks) Time 53mins **B**

1. Using the principle of electromagnetic induction and aid of diagram, explain how DeKUT substation receives 33 kV, 50MVA from a 220 kV, 90 MVA, Nyeri Substation. [6]

2. For a single-phase transformer having primary and secondary turns of 440 and 880 respectively, determine the transformer kVA rating if half load secondary current is 7.5 A and maximum value of core flux is $2.25mWb$. [4]

3. A single-phase transformer with a ratio of 6600/400 V (primary to secondary voltage) takes to no-load current of 0.7 A at 0.24 power factor lagging. If a current of 120 A at a power factor of 0.8 lagging is supplied by its secondary. Estimate the current drawn by the primary winding. [5]

4. The open circuit and short circuit tests on a 10 kVA, 125/250V , 50 Hz, single phase transformer gave the following results:

   O.C test: 125 V, 0.6 A, 50 W (L.V. side)

   S.C test: 15 V, 30 A, 100W- (H.V. side)

Calculate (i) copper loss on full load (ii) full load efficiency at 0.8 leading p.f. (iii) half load efficiency at 0.8 leading p.f. (iv) regulation at full load, 0.9 leading p.f. [15]

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY UNIVERSITY

UNIVERSITY EXAMINATION 2024/2025

THIRD YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING, BACHELOR OF SCIENCE IN TELECOMMUNICATION AND INFORMATION ENGINEERING, AND BACHELOR OF EDUCATION IN TECHNOLOGY (ELECTRICAL AND ELECTRONIC ENGINEERING).

EEE/ETI 3103 ELECTROMAGNETICS II

DATE: 15TH AUGUST 2024 **TIME: 11.00 A.M.-01.00 P.M.**

.Instructions:

i. This examination paper contains **five** questions.

ii. Question **ONE** is **Compulsory** and carries **30 Marks.**

iii. Attempt any **TWO** of the remaining four questions carrying 20 marks each.

QUESTION ONE-30 MARKS (COMPULSORY)

a)

i) Define the self-inductance L of a coil and the mutual inductance M between two coils. **(2 marks)**

ii) State the dot rule for M between the coils. **(1 marks)**

iii) State the relation between the mutual and self-inductances between two coils **(1 marks)**

iv) Differentiate between the types of couplings between two coils. **(2 marks)**

b) Describe and differentiate between any three types of magnetic materials. **(6 marks)** c)

i) Describe a typical hysteresis loop of a magnetic material **(2 marks)**

ii) State its significance **(2 marks)**

iii) Explain the terms "Residual flux' and "Coercive force". **(2 marks)**

d) $\mathbf{B} = 0.4y\mathbf{a_z}$ T in a magnetic material of $\chi m = 3.1$. Find: μ, **H**, J and M. The symbols carry usual meanings. **(5 marks)**

e) State Maxwell's equations of electromagnetic fields in

i. Differential form **(3 marks)**

ii. Integral form **(3 marks)**

iii. State units of each symbol in (i) and (ii) above. **(1 marks)**

QUESTION TWO-20 MARKS

a)

i) An infinitely long, straight, filamentary wire along the z axis, carries current I through it. Using Biot-Savart law, Obtain magnetic field intensity H at a point in z=0 plane. **(5 marks)**

ii) Using Ampere's law verify your answer in (i) above. **(5 marks)**

b) Two infinitely long parallel wires separated by 1.5 m in air, each carry 0.4A current. Determine the magnetic flux density at point *P* midway between the conductors if the current through them flows in:

i. The same direction. **(2 marks)**

ii. Opposite direction. **(2 marks)**

c)

i) Derive an expression for the equivalent inductance of two coils connected in series opposing. **(3 marks)**

ii) Two coils of self-inductances 2.5H and 1.5 H with mutual inductance as o.4H, find the equivalent inductance of the four possible combinations of the coils. **(3 marks)**

QUESTION THREE-20 MARKS

a)

i) Starting from Faraday's and Ampere's laws derive Maxwell's equations in integral form. **(4 marks)**

ii) Explain the physical significance of these equations. **(3 marks)**

b)

i) Obtain the boundary conditions for H and B fields at a current free boundary.

(3 marks)

ii) Derive the law of refraction (tangent rule) for magnetic flux lines at a boundary with no surface current. **(4 marks)**

c)

i) Two materials one with 15 times more magnetic than the other have z=0 as their boundary. If the magnetic flux density in the stronger magnetic medium is expressed as B=1.2i+0.8j+0.4k Tesla, Find the Magnetic field intensity H in both media. **(4 marks)**

ii) Verify the law of refraction at the boundary. **(2 marks)**

QUESTION FOUR-20 MARKS

a)

i) Explain the concept of scalar and vector magnetic potentials. **(3 marks)**

ii) Given: $A = 20\rho^2 a_z$ Wb/m. Obtain B at the point (2, π, 0). **(3 marks)**

b) The outer radius of the inner conductor and the inner radii of the outer conductor of a coaxial transmission line are a and b, respectively. Determine the inductance per unit length of the line. **(6 marks)**

c) A circular cast iron ring with outer and inner diameters of 10 cm and 6 cm respectively, has square cross section of 2 cm-side. MMF of 500 AT produces flux density of 1 Tesla. Determine:

i. Magnetic field intensity in the ring and **(1.5 marks)**

ii. Reluctance of the ring. **(1.5 marks)**

d) A rectangular coil is composed of 150 turns of a filamentary conductor. Find the mutual inductance in free space between this coil and an infinite straight filament on the z axis carrying 2A current, if the four corners of the coil are located at (0,1,0), (0,3,0), (0,3,1), and (0,1,1). **(5 marks)**

QUESTION FIVE-20 MARKS

a)

i) With the help of an equivalent circuit of Ohm's law in electrostatics, explain the analogous magnetic circuit. **(3 marks)**

ii) State and define the symbols used in magneto statics analogous to the terms for E, D and ε in electrostatics. **(3 marks)**

b) A point charge of Q= -1.2 C has velocity v=5i+2j-3k m/sec. Find the magnitude of the force exerted on the charge if it is under the influence of both E= -18i+5j-10k V/m and B= -4i+4j+3k T fields simultaneously. **(5 marks)**

c) A toroid has tightly wound coil with 1500 turns. The inner and the outer radii of the magnetic core are 10 cm and 12 cm, respectively and of cross section 4 Sq. cm. The length of the air gap is 1 cm. If the current in the coil is 4 A and the relative permeability of the magnetic material is 1200, determine the

i. Flux density in the magnetic circuit. **(4 marks)**

ii. Draw the equivalent magnetic circuit, if an air gap of length 1 cm is introduced in the core. Hence obtain magnetic flux in the air gap. **(5 marks)**

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

UNIVERSITY EXAMINATIONS 2024/2025

THIRD YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING, BACHELOR OF SCIENCE IN TELECOMMUNICATION AND INFORMATION ENGINEERING, AND BACHELOR OF EDUCATION IN TECHNOLOGY (ELECTRICAL AND ELECTRONIC ENGINEERING)

EEE/ ETI 3104 DIGITAL ELECTRONICS I

DATE: 21ST AUGUST 2024 TIME: 02.00-04.00 P.M.

INSTRUCTIONS:

1. This paper contains **FIVE** printed pages with **FIVE** Questions.
2. Answer **QUESTION 1 (COMPULSORY)** and **ANY** other **TWO** questions.
3. Clearly show all your working.

Question 1 (compulsory) - 30 marks

a. What are universal logic gates? **(1 mark)**

b. Show how the following expression can be implemented using

$$X = (A + B)(C + D)$$

  i. NAND gates only **(3 marks)**

  ii. NOR gates only **(3 marks)**

c. Simplify the following expression using Boolean algebra. **(3 marks)**

$$\bar{A}\bar{B}C + \overline{(A + B + \bar{C}\,)} + \bar{A}\,\bar{B}\bar{C}D$$

d. A 16-bit analog to digital converter uses all its possible 16-bit combinations represent analog signals ranging from -10 V to $+10$ V. The converted digital data is stored in sign and magnitude format. Use the information to answer the questions that follow.

  i. For this system, what are the binary numbers that represents -10 V and $+10$ V? **(1 mark)**

  ii. What are the decimal equivalents of the binary numbers in Q1d(i)? **(2 mark)**

iii. How many analog volts does a converted value -48000_{10} represent in this system? **(1 mark)**

e. A logic circuit, its input sequences (for A, B, C, D, E, and F), and the observed output sequence (X) are shown in Fig. Q1(e). Are the three pulses observed at the output correct? **(2 marks)**

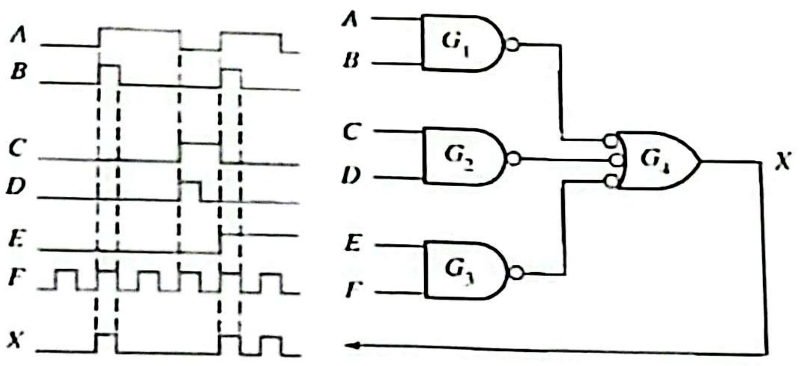


Fig. Q1(e)

f. Carry out the operation $1001_2 - 1101_2$ using 2's complement arithmetic. The sign bit is not included in the two numbers. Give your answer in sign and magnitude format. **(2 marks)**

g. Give a reason why one might select an analog computer over a digital computer for an application. **(1 mark)**

h. Digital electronics uses binary logic by and large. If digital circuits were implemented using multilevel logic circuits (logic circuits with more than two levels), give an advantage and a disadvantage that such implementation would lead to when compared to binary logic. **(2 marks)**

i. Simplify the Boolean expression $F(A, B, C, D) = \sum(4, 6, 8, 10, 12, 14)$ using a K-map. Write your answer in the following formats.

   i. Sum of products **(2 marks)**

   ii. Product of sums **(2 marks)**

j. What are the differences between bistable, monostable, and astable logic devices. **(1 mark)**

k. Use a block diagram to explain the operation of a sequential logic circuit. **(4 marks)**

Question 2 - 20 marks

You are using a (7,4) Hamming code for a data transmission project in your laboratory, you are required to design digital circuits for encoding and decoding. In the code, there are 4 data bits (D_i) and 3 parity check bits (P_j). The structure of the code is shown in Table Q2.

Table Q2(a)

position	6	5	4	3	2	1	0
bit	P_0	P_1	D_3	P_2	D_2	D_1	D_0

Before transmission, the data can be encoded by generating the parity check bits as follows.

$$P_2 = D_2 + D_1 + D_0$$

$$P_1 = D_3 + D_1 + D_0$$

$$P_0 = D_3 + D_2 + D_0$$

where the operation '+' is binary summing operation (not an OR operation) and the carry is discarded. Upon reception of the encoded data, parity checks are done using the sub blocks $P_2D_2D_1D_0$, $P_1D_3D_1D_0$ and $P_0D_3D_2D_0$ as shown in Table Q2. When $C_2C_1C_0 = 111_2$, there is no error in the received code. When $C_2C_1C_0 = 101_2$, then the received code has an error in bit position 5, and so on.

Table Q2(b)

Sub-block	Parity check results	
	Error	No error
$P_2D_2D_1D_0$	$C_2 = 0$	$C_2 = 1$
$P_1D_3D_1D_0$	$C_1 = 0$	$C_1 = 1$
$P_0D_3D_2D_0$	$C_0 = 0$	$C_0 = 1$

Use the provided information to answer the questions that follow.

a. Does the encoding process lead to even parity or odd parity? Give a reason for your answer. (2 marks)

b. Design an encoding circuit that generates P_1 using a 3-to-8 decoder. (6 marks)

c. Design a decoding circuit that generates C_1 using an XOR gate, an XNOR gate, and a 4-to-1 multiplexer. **(8 marks)**

d. Suppose that during testing you receive the code 1011001_2, show that your decoding circuit bit error position in the code and write the correct transmitted code. **(4 marks)**

Question 3 - 20 marks

a. A digital controller is required to control traffic lights at the intersection of a busy main street and an occasionally used side street. Each traffic light has three colors: red, yellow and green. There are two traffic lights; one for the main street and another for the side street. You are to design the combinational logic part of the controller. The combinational logic circuit receives a two-bit (S_1S_0) input from a timing and sequencing circuit that determines the current state of the traffic lights as shown in Table Q3. The state of the traffic lights is the colors by the two traffic lights at any one time.

Table Q3

S_0S_1	**State Name**	**Main Light**	**Side Light**
00	SO_1	Green	Red
01	SO_2	Yellow	Red
11	SO_3	Red	Green
10	SO_4	Red	Yellow

Use the information to answer the questions that follow.

i. Design and draw a logic circuit for a state decoder to decode the input bits (S_1S_0) into to one of the states (SO_k where $k = 1, \dots, 4$). **(6 marks)**

ii. With the traffic light outputs given by MR (main red), MY (main yellow), MG (main green), SR (side red), SY (side yellow), and SG (side green), design a circuit that converts the state names to traffic light outputs. **(8 marks)**

iii. Yellow light marks the transition between red and green in a traffic. Any state with a yellow takes a shorter time than the states without it. A combinational circuit is required to output SHORT and LONG triggering signals for the timing circuits depending on whether the current traffic light states (SO_k) have a yellow or not. Design and draw the triggering circuit using nor gates only. **(4 marks)**

b. Explain the difference between edge triggering and level triggering in digital circuits. **(2 marks)**

Question 4 - 20 marks

a. Explain the difference between synchronous and asynchronous counters. **(2 marks)**

b. Design a synchronous counter that counts numbers odd numbers between falling within the range 0 to 15. Use D flip-flops in your implementation. **(12 marks)**

c. An application requires a JK flip-flop but you only have a D flip-flop available to you. Show how you can realize a JK flip-flop using a D flip-flop. **(6 marks)**

Question 5 - 20 marks

a. Show how you can use JK flip-flops change clock frequency of digital system from 100 MHz to 12.5 MHz. **(4 marks)**

b. A digital system uses a base clock frequency of 10 kHz. You are to use these clock pulses to sample data at a rate of 1 kHz. Use JK flip-flops and an AND gate to design an asynchronous circuit that can be used to produce 1 kHz sampling pulses. **(8 marks)**

c. You have parallel data from sensors that you need to transmit to a computer for processing using serial interface. Use diagrams to show how you can use a synchronous counter and a multiplexer to convert the parallel data to serial data. **(4 marks)**

d. Design a 3-bit shift-left register using T flip-flops. **(4 marks)**

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY
+UNIVERSITY EXAMINATIONS 2024/2025
THIRD YEAR SEMESTER ONE EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MECHATRONICS ENGINEERING, BACHELOR OF EDUCATION ELECTRICAL ELECTRONICS ENGINEERING AND BACHELOR OF SCIENCE ELECTRICAL ELECTRONICS ENGINEERING & TIE

SMA 3121: COMPLEX ANALYSIS

DATE: 16TH AUGUST 2024 **2 HOURS** **TIME: 11.00AM**

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS

QUESTION ONE (30 MARKS)

(a) Define what is Complex numbers and its form. [1 marks]

(b) Find the Laurent series of $\frac{\sin z}{z-\pi}$; $z = \pi$ [3 marks]

(c) Solve, in complex numbers, the quadratic equation $Z^2 - 8(1-i)z + 63 - 16i = 0$ [3 marks]

(d) Determine θ *and* r of $z = -1 - i\sqrt{3}$ and represent it graphically [3 marks]

(e) Show that it is analytic Z^2 [3 marks]

(f) Let $f(z) = 2iz + 6\bar{z}$. .Find u and v and the value of f at $z = \left(\frac{1}{2}\right) + 4i$ [3 marks]

(g) Solve the limit $\lim_{z \to -i} \frac{z^4-1}{z+1}$ [2 marks]

(h) Determine the pole type and residue of $f(z) = \frac{ze^{zt}}{(z-3)^2}$ [3 marks]

(i) In aerodynamics and fluid mechanics, the functions ϕ and ψ in a complex function $f(z) = \varphi + i\psi$,where f(z) is analytic, are called the velocity potential and the stream function respectively. Given that $\varphi = x^2 + 4x - y^2 + 2y$

i. Find ψ

ii. Determine f(z) . [4 marks]

(j) Evaluate using residue theorem at $\oint \frac{1}{z(z+2)^3} dz, |z| = 3$ [5 marks]

QUESTION TWO (20 MARKS)

a. Show that the following function are discontinuous at the following points
$f(z) = \frac{z^2+1}{z+i}$, $z_0 = -i$ [3 marks]

b. If $f(z) = \ln\left(\frac{1+z}{1-z}\right)$ expand f(z) in a Taylor series about z = 0. [5 marks]

c. Use Cauchy's integral formula to evaluate

$$\oint \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)(z-2)} dz$$ where c is the circle $|z| = 3$. [6 marks]

d. Find the Laurent series of $f(z) = \frac{1}{z^2(z+2)^3}$ [6 marks]

QUESTION THREE (20 MARKS)

i. Evaluate $\int_{1+i}^{2+4i} z^2 \, dz$

Along a parabola x = t, y = t^2 where $1 \le t \le 2$
Along the straight line joining 1+i and 2 +4i
Along the straight line from 1+i to 2+i and then to 2+4i [10 marks]

ii. Evaluate $\int_0^{2\pi} \frac{\cos 2\theta}{5+4\cos\theta} d\theta$ [7marks]

iii. Show it is analytic $f(z) = e^{-x}cosy - ie^{-x}siny$ [3marks]

QUESTION FOUR (20 MARKS)

a) Evaluate $\int_0^{2\pi} \frac{e^z}{(z-1)(z+3)^2} dz$; $|z| = \frac{3}{2}$, $|z| = 10$ using residue theorem [7 marks]

b) Evaluate using Residue theorem $\int_0^{2\pi} \frac{d\theta}{5+3\sin\theta}$; $|z| = 4i$ [7 marks]

c) Find the image of a triangle with vertices at i, 1+i, 1-I in the z-plane under the transformation $w = 3z + 4 - 2i$ [6 marks]

QUESTION FIVE (20 MARKS)

(a) Expand $e^{i\theta} = \cos\theta + i\sin\theta$ [3 marks]

(b) Find the Laurent series of $z^{-4}\sin z$ [4 marks]

(c) Evaluate the following $(8 - i8\sqrt{3})^{\frac{1}{4}}$ [6 marks]

(d) Use Cauchy integral formula to evaluate $\oint \frac{5z^2-3z+2}{(z-1)^3} dz$ [4 marks]

(e) Verify that $v = x^2 - y^2 - y$ is harmonic, and find its harmonic conjugate. [3 marks]

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

UNIVERSITY EXAMINATIONS 2024/2025

THIRD YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 3102 CIRCUIT AND NETWORK THEORY III

DATE: 19TH AUGUST 2024

TIME: 02.00-04.00 P.M.

INSTRUCTIONS:

1. This paper contains **EIGHT** printed pages with **FIVE** Questions.
2. A table of **Butterworth polynomial coefficients** is provided in the last page.
3. Answer **QUESTION 1 (COMPULSORY)** and **ANY** other **TWO** questions.
4. You have been provided with **SEMILOG PAPER** for **QUESTION THREE.**

Question 1 (compulsory) - 30 marks

a. An engineer is asked to build a filter to realize the following transfer function.

$$T(s) = \frac{3s^6 + 1}{s^5 + 2.5s^4 + (1 + 3.9i)s + 0.6}$$

i. Is the transfer function realizable? **(1 mark)**

ii. List two items that are wrong with the transfer function. **(2 marks)**

b. A normalized transfer function of a filter design is specified by

$$T(s) = \frac{2(s^2 + 9.32)}{s^4 + 1.322s^3 + 0.976s^2 + 0.750s + 1}$$

The final design requires $\omega_0 = 10$ rad/s. Write the scaled transfer function. **(2 marks)**

c. Figure **Q1(c)** shows a passive implementation of a third-order lowpass Chebyshev response. Use the figure to answer the questions that follow.

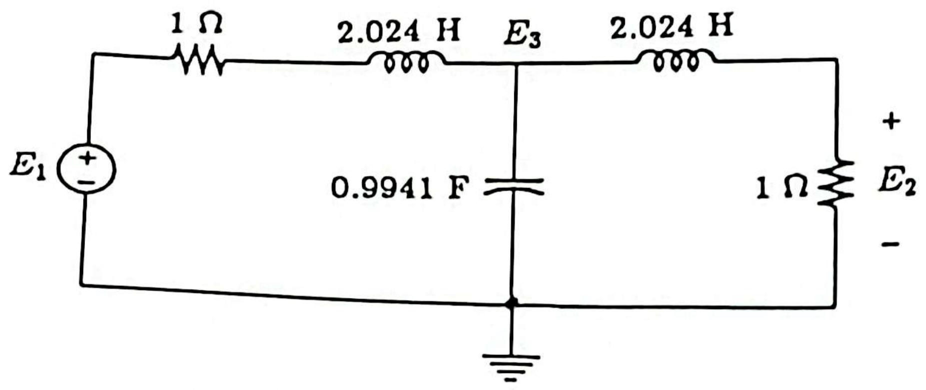


Fig. Q1(c)

i. What is the challenge that one might face while trying to implement the circuit in its current form?

(1 mark)

ii. The transfer function is $T(s) = E_2(s)/E_1(s)$ and its $\omega_0 = 1$ rad/s. An application requires a filter with the same passband and stop band attenuations but with $\omega_0 = 10^7$ rad/s. For the design, resistances of 1 kΩ are available. What values can you use for inductances and the capacitance?

(4 marks)

iii. State two benefits of design using normalized transfer functions. **(2 marks)**

iv. Give two reasons why sensitivity analysis is important in transfer function realization.

(2 marks)

d. Use the circuit in **Fig. Q1(d)** to answer the questions that follow.

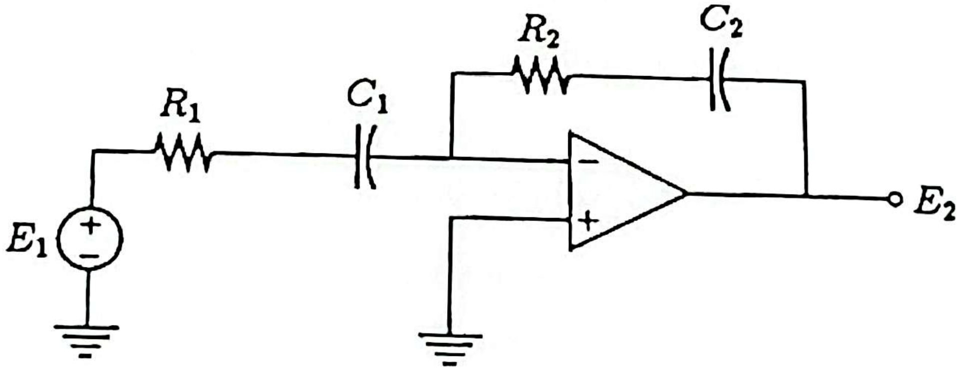


Fig. Q1(d)

i. Write the circuit's transfer function $T(s) = \frac{E_2(S)}{E_1(s)}$.

(3 marks)

ii. Write the expressions for the pole and the zero.

(2 marks)

iii. Starting with $R_1 = 1$, select values of the other passive components to make the circuit to have a lowpass magnitude response.

(2 marks)

iv. Starting with $R_1 = 1$, select values of the other passive components makes the circuit have a highpass magnitude response. **(2 marks)**

v. Suggest how this circuit can be used to obtain a bandstop response. **(2 marks)**

e. Since all-pass filters theoretically have not influence on magnitude response, why should one put effort in designing such a filter at all? **(1 mark)**

f. Using a sketch and brick wall magnitude responses for a low-pass filter,

i. Show the passband, transition band, and the stopband. **(2 marks)**

ii. Show how maximum passband attenuation, α_{max}, and minimum stopband attenuation, α_{min}, are specified in the sketch. **(1 mark)**

iii. On the frequency axis, show the stopband edge, ω_s, and the passband edge, ω_p. **(1 mark)**

Question 2 - 20 marks

a. For transfer functions, give two classifications of magnitude responses and two classifications of phase responses. **(2 marks)**

b. Why is it undesirable to have a lowpass filter with a high Q value? **(1 mark)**

c. Use the circuit shown in **Fig. Q2(c)** to answer the questions that follow.

i. Obtain the transfer function $T(s) = \frac{V_C(s)}{V_i(s)}$. **(1 mark)**

ii. By writing the denominator in the form: $s^2 + \frac{\omega_0}{Q}s + \omega_0^2$, obtain the expressions for Q and ω_0. **(1 mark)**

iii. Write $T(s)$ as a function of s, Q and ω_0. **(1 mark)**

iv. By making the substitution $s = j\omega$, write $T(\omega)$. **(1 mark)**

v. Obtain the magnitude response $|T(\omega)|$. **(1 mark)**

vi. Obtain the phase response $\theta(\omega)$. **(1 mark)**

vii. Estimate the magnitude response at $\omega = 0$, $\omega = \omega_0$, and $\omega = \infty$. **(3 marks)**

viii. Sketch the magnitude response. **(2 marks)**

ix. Estimate the phase response at $\omega = 0$, $\omega = \omega_0$, and $\omega = \infty$. **(3 marks)**

x. Sketch the phase response. **(2 marks)**

xi. Classify the phase and magnitude responses of the transfer function. **(1 mark)**

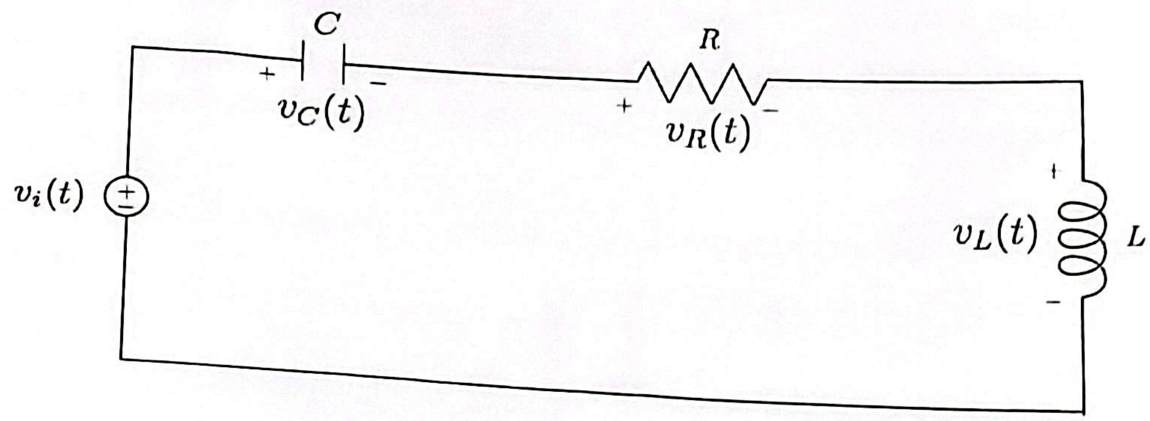


Fig. Q2(c)

Question 3 - 20 marks

a. State two benefits of representing gain and frequency in log scale when plotting. **(2 marks)**

b. State any two benefits of knowing how to sketch bode plots by hand. **(2 marks)**

c. Use the following transfer function to answer the questions that follow. Use the provided semilog paper.

$$T(s) = 2.5\frac{s^2 + s + 100}{s^3 + 25s^2}$$

i. Identify individual terms of the transfer function for a bode plot. **(2 marks)**

ii. Draw the asymptotic bode magnitude plots for each term identified in (i). **(4 marks)**

iii. Draw the asymptotic phase plots for each term identified in (i). **(4 marks)**

iv. Draw a combined asymptotic magnitude plot using the plots in (ii). **(2 marks)**

v. Draw a combined asymptotic phase plot using the plots in (iii). **(2 marks)**

vi. At low frequencies, what kind of response does this function approximate? **(2 marks)**

Question 4 - 20 marks

a. Give one advantage and one disadvantage of Chebyshev filter approximations in comparison to Butterworth filter approximations. **(2 marks)**

b. Give one advantage and one disadvantage of Sallen-Key biquad circuit compared the Tow-Thomas biquad realization. **(2 marks)**

c. You are required to design and realize a lowpass Butterworth filter to reduce high frequency noise for an application. The specifications of the filter for the application are

- a maximum passband attenuation of $\alpha_{max} = -3$ dB,
- a minimum stopband attenuation of $\alpha_{min} = -20$ dB,
- a passband edge is $\omega_p = 10{,}000$ rad/s, and
- a stopband edge is $\omega_s = 50{,}000$ rad/s.

Use the given information and the general Butterworth magnitude response,

$$|T(\omega)| = \frac{1}{\sqrt{1 + \epsilon^2 \left[\frac{\omega}{\omega_p}\right]^{2n}}}$$

to answer the questions that follow.

i. At $\omega = \omega_p$, use the α_{max} specification to obtain the parameter ϵ from $|T(\omega)|$.

(3 marks)

ii. At $\omega = \omega_s$ and with the value of ϵ calculated in (c), use the α_{min} specification to obtain the filter order, n, from $|T(\omega)|$. **(3 marks)**

iii. Obtain the normalized Butterworth transfer function from the provided normalized Butterworth filter coefficients. **(1 mark)**

iv. Realize each second order section by selecting the Sallen-Key network shown in Fig. Q3c(iv). Start with $R_1 = 1$. Make simplifications that would simplify the selection of component values. The transfer function of the network is given by

~~transfer function is given by~~

$$T(s) = \frac{V_o(s)}{V_i(s)} = \frac{1}{s^2 R_1 R_2 C_1 C_2 + (R_1 + R_2) C_2 s + 1}.$$

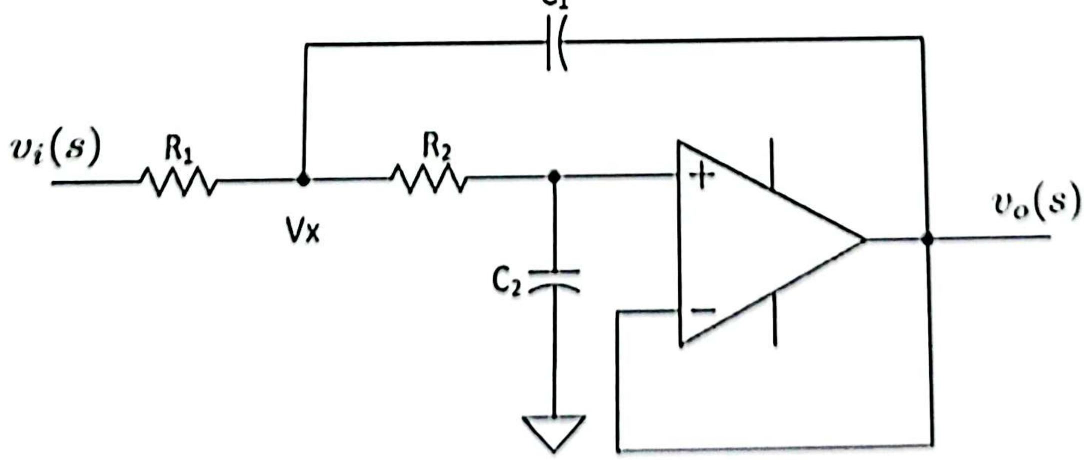


Fig. Q3c(iv)

(3 marks)

v. Calculate the frequency, ω_B, at which $|T(\omega)| = 1/\sqrt{2}$. (3 marks)

vi. Use ω_B to scale component values for the actual implementation. Select an appropriate impedance scaling factor so that, k_z, so $R_1 = 1\ \text{k}\Omega$. (3 marks)

Question 5 - 20 marks

a. Starting from

$$S_x^{T(s)} = \frac{x}{T(s)}\left[\frac{\partial}{\partial x}T(s)\right]$$

answer the following questions.

i. Show that the bode sensitivity of the magnitude frequency response $|T(\omega)|$ of a transfer function $T(s)$ to some circuit parameter x can be written as

$$S_x^{|T(\omega)|} = \text{Re}\left\{S_x^{T(\omega)}\right\}$$

where $\text{Re}\left\{S_x^{T(\omega)}\right\}$ is the real part of $S_x^{T(\omega)}$. **(4 marks)**

ii. Show that the bode sensitivity of the phase frequency response $\theta(\omega)$ of a transfer function $T(s)$ to some circuit parameter x can be written as

$$S_x^{|T(\omega)|} = \frac{1}{\theta(\omega)}\text{Im}\left\{S_x^{T(\omega)}\right\}$$

where $\text{Im}\left\{S_x^{T(\omega)}\right\}$ is the imaginary part of $S_x^{T(\omega)}$. **(2 marks)**

b. The transfer function for the Tow-Thomas biquad circuit in **Fig. Q5(b)** is given by

$$T(s) = \frac{V_2(s)}{V_{1(s)}} = -\frac{R_2}{R_3}\left[\frac{\frac{1}{R_2R_4C_1C_2}}{s^2 + \frac{1}{R_1C_1}s + \frac{1}{R_2R_4C_1C_2}}\right]$$

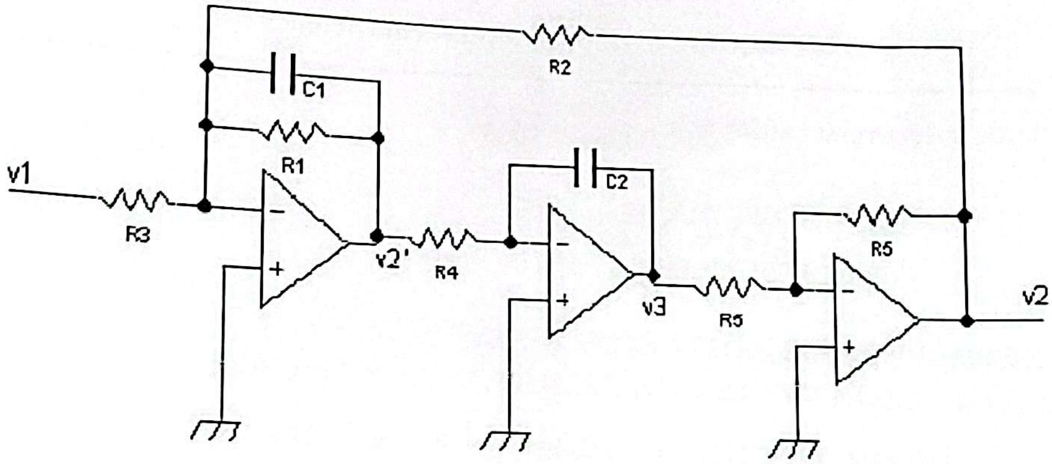


Fig. Q5(b)

i. Write the expressions for ω_0 and Q **(2 marks)**

ii. Obtain the sensitivities of ω_0 to circuit components R_2, R_4, C_1, and C_2. **(2 marks)**

iii. Write an expression of the total sensitivity of ω_0 to variation of all the components in ii) **(2 marks)**

iv. Obtain the sensitivities of Q to circuit components R_1, R_2, R_3, R_4, C_1, and C_2. **(3 marks)**

v. Write an expression of the total sensitivity of Q to variation of all the components in iv) **(2 marks)**

vi. For the circuit, $Q = 2$ and $\omega_0 = 1000$ rad/s. What are the new values of Q and ω_0 if there is a 1% reduction in all the values of the resistances and a 5% increase in all the values of the capacitances? **(3 marks)**

KULINDA AMANI YAKO NA YA WENGINE NI JUKUMU LAKO NA LAN

DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY
University Examinations – 2024/2025
Third Year First Semester Examination for the Degree of
Bachelor of Science in Electrical and Electronic Engineering
&
Bachelor of Science in Telecommunication and Information Engineering
&
Bachelor of Education in Technology (Electrical and Electronic Engineering)

EEE/ETI 3105: ELECTRICAL MACHINES I

DATE: 20TH AUGUST 2024 **TIME: 02.00-04.00 P.M.**

INSTRUCTIONS
This paper consists of **FIVE** questions. Answer questions **ONE** and **ANY OTHER TWO.**

QUESTION ONE. **30 MARKS**

(a) Differentiate D.C. machines from transformers. **[4 Marks]**

(b) Using the principle of electromagnetic induction and aid of diagram, explain how a 10kW, 50Hz, 0.85 p.f. ac motor in the Electrical machines' lab at the RC block, receives 415V, from a 11kV, 90MVA, DeKUT mini-substation. **[6 Marks]**

(c) A 12-pole DC shunt generator has 50 slots on its armature with 12 conductors per slot with wave winding. The armature and field winding resistance is 0.5Ω and 60Ω respectively. The generator is supplying a resistive load of 15Ω at terminal voltage of 300 V when running at a speed of 625rpm. Determine the generated flux per pole. **[5 Marks]**

(d) A 250V d.c. shunt motor has a shunt field resistance of 200Ω and an armature resistance of 0.3Ω. For a given load, motor runs at 1500 r.p.m drawing a current of 22A from the supply. If a resistance of 150Ω is added in series with the field winding, calculate the new armature current and speed. Assume load torque constant and magnetisation curve to be linear.

[7 Marks]

4.7R.

(b) A 0.4 MVA, distribution transformer has full load iron loss of 2.5 kW and copper loss of 3.5 kW. During a day, its load cycle for 24 hours is:

6 Hours 300 kW at 0.8 p.f

10 Hours 200 kW at 0.7 p.f

4 Hours 100 kW at 0.9 p.f

4 Hours No load.

Determine the transformer's all-day efficiency. **[8 Marks]**

QUESTION TWO. 20 MARKS

(a) With reference to electromagnetic circuits in electrical machines define the following terms.

i. Magnetising force. **[1.5 Marks]**

ii. Flemings Right Hand Rule. **[1.5 Marks]**

(b) A single-phase 50Hz transformer has 80 turns on the primary winding and 400 turns on the secondary winding. The net cross-section area of the core is 200cm². If the primary winding is connected to a 240V, 50 Hz supply, determine:

i. The emf induced in the secondary winding. **[2 Marks]**

ii. The maximum value of the flux density in the core. **[3 Marks]**

(c) A 6-pole, 440 V DC motor has 936 wave wound armature conductors. The useful flux per pole is 25mWb. The torque developed is 45.5 kg-m. Calculate the following, if armature resistance is 0.5Ω;

i). Armature current. **[3 Marks]**

ii). Speed of the motor. **[3 Marks]**

(d) A 200 kW, 400 V, separately excited dc motor runs at 600 rpm. It has 864 lap-connected conductors. The full load armature copper loss is 8 kW. Draw the connection diagram of the motor and calculate the useful flux/pole. **[6 Marks]**

QUESTION THREE. 20 MARKS

(a) List three advantages of short pitch windings over full pitch windings. **[3 Marks]**

(b) A short shunt compound d.c generator supplies a current of 75A at a voltage of 225 V. Draw, the circuit diagram and calculate the generated voltage if the resistance of armature, shunt field and series field windings are 0.04Ω, 90Ω and 0.02Ω respectively. **[5 Marks]**

(c) The following test data were obtained from a 10 kVA, 50 Hz, 2500/250V single phase distribution transformer before being dispatched for installation:

O.C. Test:	250V,	0.8 A,	50 W
S.C. Test:	60V,	3A,	45 W

Determine:

i. Equivalent circuit parameters referred to LV side. [4.5 Marks]

ii. The efficiency at full load and 0.8 power factor lagging. [2 Marks]

iii. Load (kVA) at which the maximum efficiency occurs. [1.5 Marks]

iv. Voltage regulation at rated load and 0.8 pf leading. [2.5 Marks]

v. Secondary terminal voltage at rated load and 0.8 pf lagging. [1.5 Marks]

QUESTION FOUR.

20 MARKS

(a) Differentiate an autotransformer from a two winding transformer and further enumerate any four advantages of an autotransformer over a two winding oil immersed transformer. [5 Marks]

(b) A long shunt dc generator running at 1200 rpm supplies 25.1 kW at a terminal voltage of 240 V and an overall efficiency of 86%. The resistances of the armature, shunt field and series field are 0.05 Ω, 120 Ω, and 0.08 Ω respectively. Find:

i). the copper losses. [3 Marks]

ii). the iron and friction losses. [2.5 Marks]

iii). the torque exerted by the prime mover. [1.5 Marks]

(e) A 100kVA pole mount transformer at BOMAS residential area has 400 turns on the primary and 80 turns on the secondary. The primary and secondary resistances are 0.3 Ω and 0.01 Ω respectively and the corresponding leakage reactances are 1.1 Ω and 0.035 Ω respectively. The supply voltage is 2.2 kV. Calculate:

i). Equivalent impedance referred to primary. [3 Marks]

ii). The voltage regulation and the secondary terminal voltage for full load having a power factor of 0.8 leading. [5 Marks]

QUESTION FIVE.

20 MARKS

(a) Differentiate a core type from shell type transformers. **[4 Marks]**

(b) A single-phase transformer of 440/110 V takes a no-load current of 5 A at 0.2 power factor lagging. If the secondary supplies a current of 120A at a p.f of 0.8 lagging, calculate the current drawn by the primary winding. Also draw the phasor diagram. **[7 Marks]**

(c) A 6 pole 500V wave connected shunt motor has 1200 armature conductors and useful flux/pole of 20 mWb. The armature and field resistance are 0.5 Ω and 250 Ω, respectively. What will be the speed and torque developed by the motor when it draws 20 A from the supply mains? Neglect armature reaction. If magnetic and mechanical losses amount to 0.9kW, calculate,

i. useful torque. **[4 Marks]**

ii. motor output in kW. **[3.5 Marks]**

iii. efficiency at this load. **[1.5 Marks]**

....**THE END**..