2506/202
2507/202
ELECTRONICS AND CONTROL SYSTEMS
June/July 2018
Time: 3 Hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING (AIRFRAMES AND ENGINES OPTION) (AVIONICS OPTION)

MODULE II

ELECTRONICS AND CONTROL SYSTEMS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
- *Answer booklet;*
- *Non-programmable scientific calculator;*
- *Polar chart;*
- *Bode plot.*

*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*
*Answer **THREE** questions from section **A**, and **TWO** questions from section **B**.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.

This paper consists of 7 printed pages and 2 inserts.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

SECTION A: ELECTRONICS (60 marks)

*Answer **THREE** questions from this section.*

1. (a) Distinguish between the following types of semi-conductors:

(i) intrinsic;
(ii) extrinsic.

(2 marks)

(b) With the aid of a sketch, describe the atomic structure of Germanium, $(^{64}_{32}Ge)$.

(6 marks)

(c) (i) Outline **two** applications of varactor diodes.

(ii) With the aid of a construction diagram, explain the operation of a DIAC.

(8 marks)

(d) Figure 1 shows a circuit diagram consisting of a voltage source, a resistor and a silicon diode. Determine the:

(i) voltage drop across the resistor R;
(ii) total circuit current.

(4 marks)

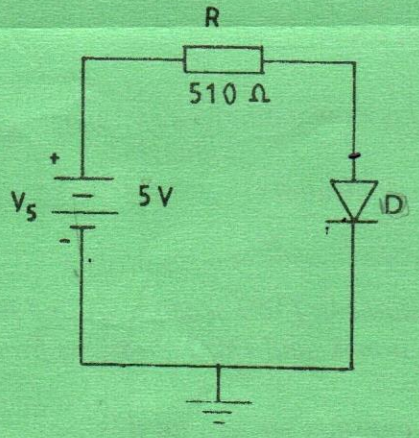

Fig. 1

2. (a) Define the following with respect to power amplifiers:

(i) efficiency;
(ii) distortion.

(2 marks)

(b) With the aid of schematic block diagrams, explain the following types of amplifier feed back connections:

(i) current-series;
(ii) current-shunt.

(6 marks)

(c) Figure 2 show a circuit diagram of a small signal amplifier stage. The h-parameters of a transistor used are, $h_{ie} = 1.0k\Omega$, $h_{re} = 10 \times 10^{-4}$, $h_{fe} = 50$ and $h_{oe} = 100m\Omega$. The transistor is supplied from a signal source of resistance 1000 Ω.

(i) Draw the H-parameter equivalent circuit.
(ii) Determine the:
(I) current gain;
(II) input resistance;
(III) output resistance.

(10 marks)

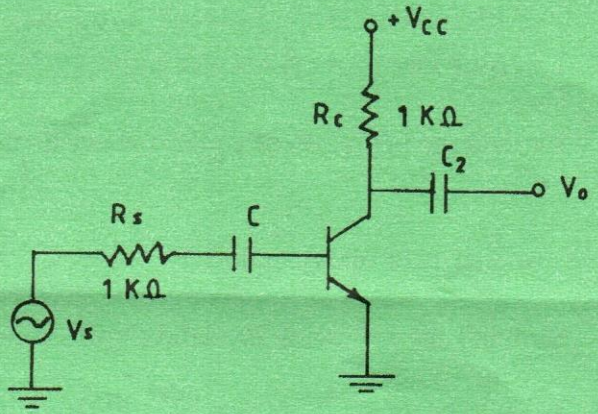

Fig. 2

(d) Outline **two** importance of biasing in BJT transistor amplifiers. (2 marks)

3. (a) Outline **two** advantages of integrated circuits over discrete components. (2 marks)

(b) With the aid of a diagram, explain the operation of a Liquid Crystal Display (LCD). (6 marks)

(c) Figure 3 shows an OP-Amp based amplifier. Assuming an ideal OP-Amp. Determine the:

(i) closed loop gain;
(ii) output voltage.

(4 marks)

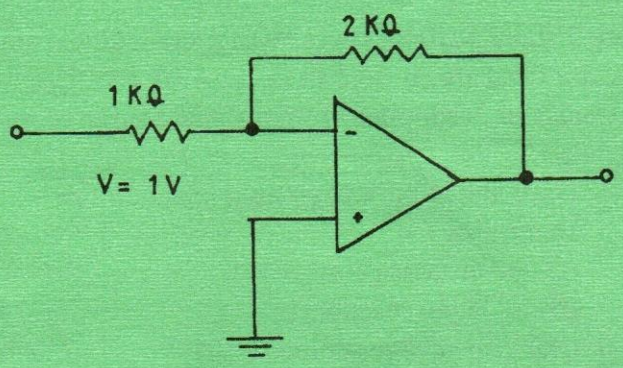

Fig. 3

(d) (i) List **four** merits of crystal oscillator.

(ii) Explain the operation of a piezzo electric oscillator.

(8 marks)

4. (a) Outline **two** merits of binary codes. (2 marks)

(b) (i) Simplify the following Boolean Expressions:

(I) $A + \overline{A}$;
(II) $A + \overline{A}B$;
(III) $A \cdot \overline{A}$.

(3 marks)

(ii) Figure 4 shows a logic circuit diagram implemented using logic gates. Obtain the Boolean expression for the output X. (2 marks)

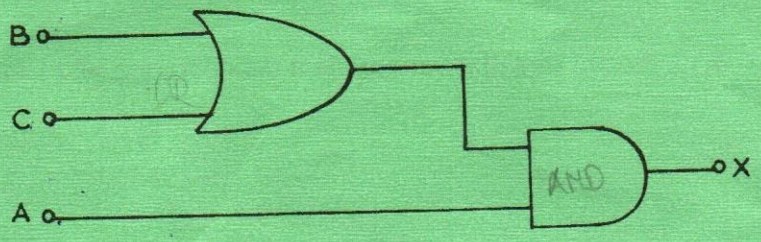

Fig. 4

(c) Perform the following conversions:

(i) 83759_{10} to hexadecimal;
(ii) $1\,0\,0\,1.0\,1\,1_2$ to decimal.

(4 marks)

(d) A digital system is given by the logic expression:
$Z = \overline{A}B + A\overline{B}$

(i) draw the truth table for the logic expression;
(ii) implement the expression using NAND gates only.

(9 marks)

5. (a) (i) Define the following with respect to logic circuits:

(I) fan out;
(II) power dissipation.

(ii) Explain the Bi-stable operation of a flip-flop.

(4 marks)

(b) With the aid of a diagram, explain the implementation of a serial- in serial- out shift register using D-flip-flops. (6 marks)

(c) (i) With the aid of a circuit diagram, explain the operation of a weighted-resistor Digital-to-Analogue converter (DAC).

(ii) A 5-bit DAC produces an output voltage of 0.2 V for a digital input of 00001. Determine the:

(I) analogue output voltage when an input of $1\,1\,1\,1_2$ fed to the DAC;

(II) resolution.

(10 marks)

SECTION B: ENGINEERING CONTROL SYSTEMS (40 marks)

*Answer **TWO** questions from this section.*

6. (a) Outline **two** merits of a closed loop control system. (2 marks)

(b) Describe the following methods of damping with respect to a sinusiodal system response:

(i) error rate damping;
(ii) viscous damping.

(4 marks)

(c) A motor speed control system consists of an amplifier-relay with a transfer function of 400 rev/min per volt and a negative feedback measurement element with a transfer function of 3mV per rev/min.

(i) Draw the block diagram for the system.
(ii) Determine the overall transfer function for the system.

(6 marks)

(d) Figure 5 shows a signal flow graph for a control system. Determine the overall system transfer function using Mason's formula. (8 marks)

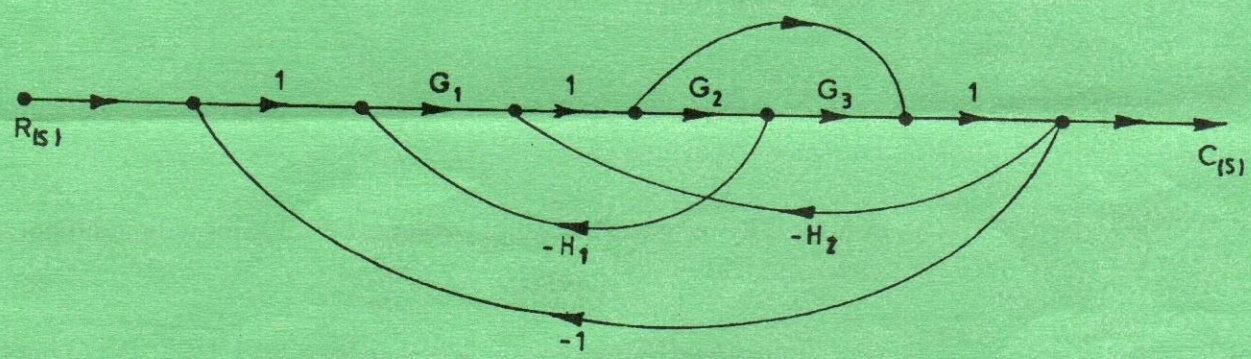

Fig. 5

7. (a) Table 1 shows a control systems analogy for electrical and mechanical equivalents. Complete the table. (3 marks)

Table 1.

S.No	Translational	Electrical
1.	Force (F)	
2.	Mass (m)	
3.	Spring (k)	

(b) Table 2 shows an open-loop frequency response of a control system.

Table 2

Frequency in rad/s	0.1	0.4	1	4	10	40
Gain (db)	43	31	23	11	0	-24
Phase lag (deg)	94	100	108	144	180	244

(i) Plot the bode diagram.
(ii) State the nature of the closed-loop stability of the system.
(iii) Determine the change in Gain required to provide adequate stability, hence state the new gain and phase margin.

(11 marks)

(c) The open loop transfer function of a unity feedback control system is given by:

$G_{(S)} = \frac{25}{s(s+s)}$.

Determine the:

(i) characteristic equation;
(ii) undamped natural frequency;
(iii) damping ratio.

(6 marks)

8. (a) Outline **two** advantages of Nyquist plot over Root locus. (2 marks)

(b) (i) List **two** factors that determine the accuracy of an analogue computer simulation.

(ii) Draw an analogue computer flow diagram to solve the simultaneous differential equations.

$\frac{dy}{dt} = x + 8$

$\frac{dx}{dt} = y + 3$

(8 marks)

(c) (i) Describe compensation with respect to control systems. (2 marks)

(ii) A control system has a transfer function.

$GH_{(s)} = \frac{100}{(s+2)(s+4)(s+8)}$

(I) determine the transfer function in frequency domain;

(II) draw the polar plot for $\omega = 0, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20$ and 100.

(8 marks)

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