

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, (${}^{64}_{32}\text{Ge}$).

(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)

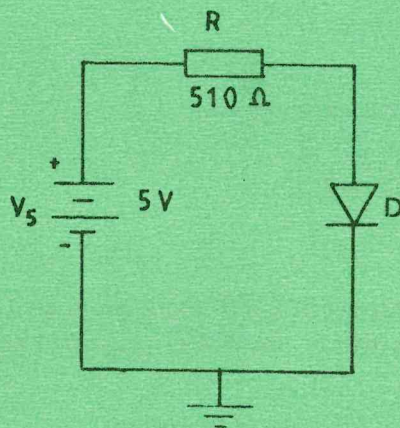


Fig. 1

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:
- current-series;
 - 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, $h_{ie} = 1.0\text{k}\Omega$, $h_{re} = 10 \times 10^{-4}$, $h_{fe} = 50$ and $h_{oe} = 100\text{m}\Omega$. The transistor is supplied from a signal source of resistance $1000\ \Omega$.

- Draw the H-parameter equivalent circuit.
- Determine the:
 - current gain;
 - input resistance;
 - output resistance.

(10 marks)

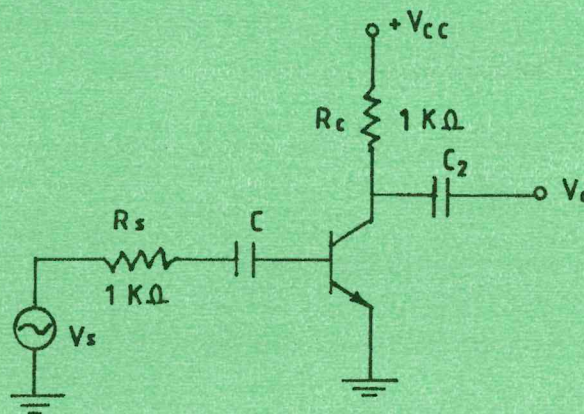


Fig. 2

- (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)

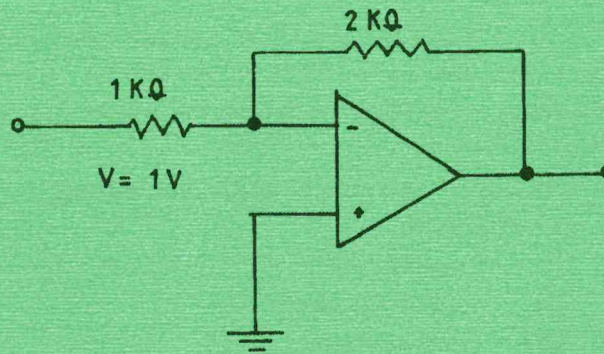


Fig. 3

- (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) $A + \bar{A}$;
- (II) $A + \bar{A}B$;
- (III) $A \cdot \bar{A}$.

(3 marks)

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

(2 marks)

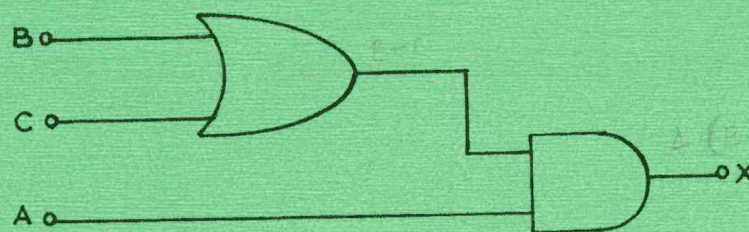


Fig. 4

(c) Perform the following conversions:

(i) 83759_{10} to hexadecimal;

(ii) 1001.011_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 1111_2 fed to the DAC;

(II) resolution.

(10 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 sinusoidal 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)

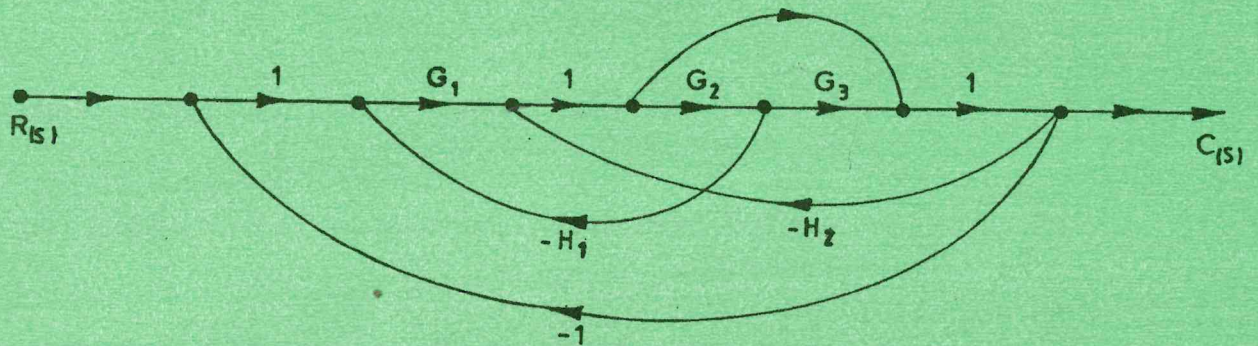


Fig. 5

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:

$$G(s) = \frac{25}{s(s+5)}$$

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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