2506/202
2507/202
ELECTRONICS AND CONTROL SYSTEMS
June/July 2022
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;
Mathematical tables / Non-programmable scientific calculator;
Log-linear graph paper;
Drawing instruments.
*This paper consists **EIGHT** questions in **TWO** sections; **A** and **B**.*
*Answer **THREE** questions from section **A** and **TWO** questions from section **B** in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.

This paper consists of 6 printed pages and 1 insert.

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

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

1. (a) Define each of the following with respect to atomic structure of an atom:

(i) atomic number;
(ii) valency. (2 marks)

(b) With aid of a labelled diagram, describe the formation of a N-type semiconductor. (6 marks)

(c) (i) With aid of a V - I characteristic curve, explain the operation of a Zener diode.
(ii) State **two** applications of Zener diodes. (8 marks)

(d) (i) Explain the need for biasing transistors.
(ii) State **two** types of transistor bias. (4 marks)

2. (a) With aid of a circuit diagram, describe the operation of a transistor-based Hartley oscillator. (6 marks)

(b) A Colpits oscillator has an inductor and capacitors in the tank circuit as, L = 50 mH, C_1 = 150 pF and C_2 = 450 pF. Determine the:

(i) effective capacitance;
(ii) frequency of oscillation;
(iii) feedback factor. (6 marks)

(c) A full-wave rectifier with a 220 V rms sinusoidal input has a load resistance of 1 kΩ. Assuming ideal diodes, determine the:

(i) d.c voltage at the load;
(ii) required peak inverse voltage (PIV) of the diodes;
(iii) maximum current through each diode, during conduction;
(iv) power rating of each diode. (8 marks)

3. (a) Convert the hexadecimal number $E7B_{16}$ into:

(i) binary;
(ii) base 4;
(iii) octal;
(iv) decimal. (8 marks)

(b) Table 1 shows the truth table of a logic circuit.

Table 1

Inputs				Output
A	**B**	**C**	**D**	**F**
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	x
1	0	0	1	x
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	x
1	1	1	0	1
1	1	1	1	1

(i) Using a K-map, derive the minimum logic expression for output F.
(ii) Implement the output, F, using NAND gates only. (8 marks)

(c) Simplify the following Boolean expression:

$$\overline{A}\cdot\overline{B}\cdot C+\overline{A+B+\overline{C}}+\overline{A}\cdot\overline{B}\cdot\overline{C}\cdot D$$ (4 marks)

4. (a) With aid of sketches, describe each of the following with respect to logic gates:

(i) noise margin;
(ii) propagation delay. (6 marks)

(b) (i) Draw the truth table for an S - R flip-flop.
(ii) Draw a schematic block diagram to implement a 4-bit serial-in parallel-out (SIPO) shift register using D-flip flops.
(iii) State **two** applications of shift registers. (8 marks)

(c) Draw a circuit diagram of a CMOS inverter and explain its operation. (6 marks)

5. (a) (i) Draw truth table of a binary full-subtractor.
(ii) Realize the full subtractor logic circuit using:

I. 3-to-8 decoder and OR-gates;
II. 4-to-1 multiplexers. (12 marks)

(b) Define each of the following with respect to converter circuits:

(i) resolution;
(ii) conversion time. (2 marks)

(c) With the aid of a schematic-block diagram, describe the operation of a successive approximation analog-to-digital converter. (6 marks)

SECTION B: CONTROL SYSTEMS

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

6. (a) With aid of block diagrams, explain each of the following control systems:

(i) open loop;
(ii) feedback. (8 marks)

(b) Figure 1 shows a block diagram of a control system.

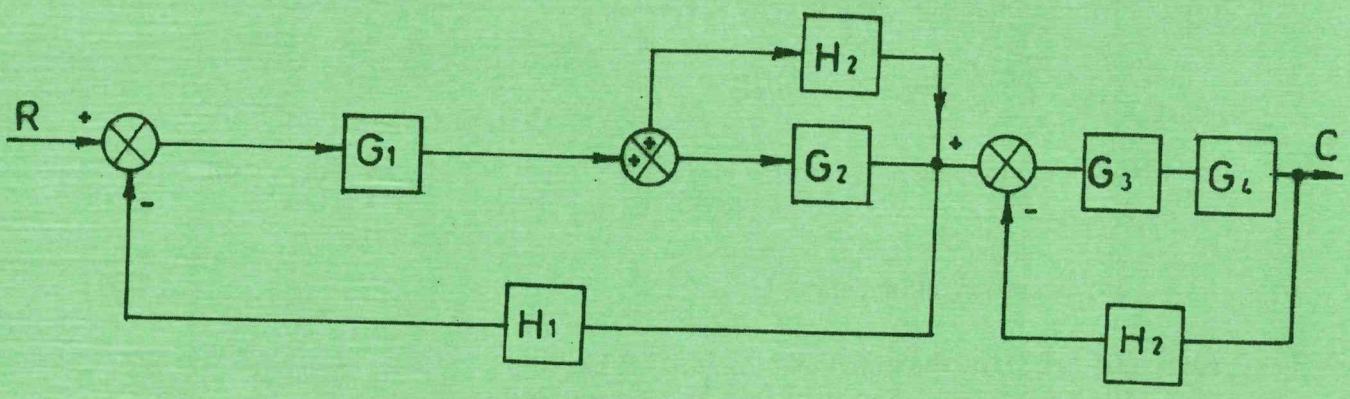


Fig. 1

(i) Determine the transfer function using block reduction techniques.
(ii) Draw a signal flow diagram for the block diagram. (10 marks)

(c) State **two** ways of modelling control systems. (2 marks)

7. (a) With aid of a diagram, describe the Nyquist stability criterion. (4 marks)

(b) State **three** merits of Bode plots. (3 marks)

(c) A transfer function for a control system is described by:

$$G(s) = \frac{20}{s(s+5)(s+2)}$$

(i) Determine the corner frequencies.

(ii) Using asymptotic approximations, draw the Bode plot.

(iii) From the Bode plot, determine the:

I. phase margin;
II. gain margin.

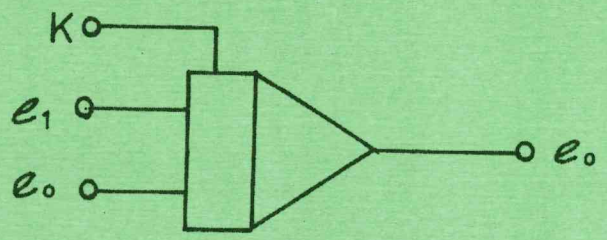
(iv) Comment on the stability of the system. (13 marks)

8. (a) Explain the following with respect to analog computing:

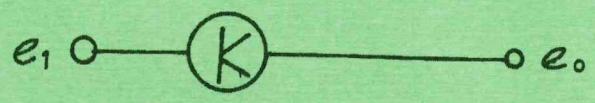
(i) amplitude scaling;
(ii) time scaling. (4 marks)

(b) Identify each of the following block diagrams as used in analog computer simulation:

(i)



(ii)



(2 marks)

(c) Draw analog computer diagrams to simulate the following simultaneous differential equations:

$$\ddot{y} - 6y - 3x = 0$$
$$\ddot{x} + 5\dot{x} + 2x = 6$$

(10 marks)

(d) State:

(i) **two** control system compensation methods;
(ii) **one** characteristic of each method in (d)(i). (4 marks)

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