2506/202
2507/202
ELECTRONICS AND
CONTROL SYSTEMS
Oct./Nov. 2016
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:
Scientific calculator (Non-Programmable); and
Answer booklet.
*This paper consists of **EIGHT** questions in **TWO** sections; **A** and **B**.*
*Answer any **THREE** questions from section **A**, and any **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 shown.
Candidates should answer the questions in English.

This paper consists of 8 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 any **THREE** questions from this section.*

1. (a) (i) State Demorgan's theorems and show how they can be implemented using logic gates. (6 marks)

(ii) Simplify the logical expression $f = A\overline{B}\,\overline{C} + A\overline{B}\,\overline{C}D + A\overline{C}$ using rules of Boolean algebra. (4 marks)

(b) Convert the octal number $(1745.246)_8$ into its equivalent hexedecimal number. (4 marks)

(c) State any **three** merits of Gray code. (3 marks)

(d) Figure 1 shows the interconnection of NOR gates to form a flip-flop.

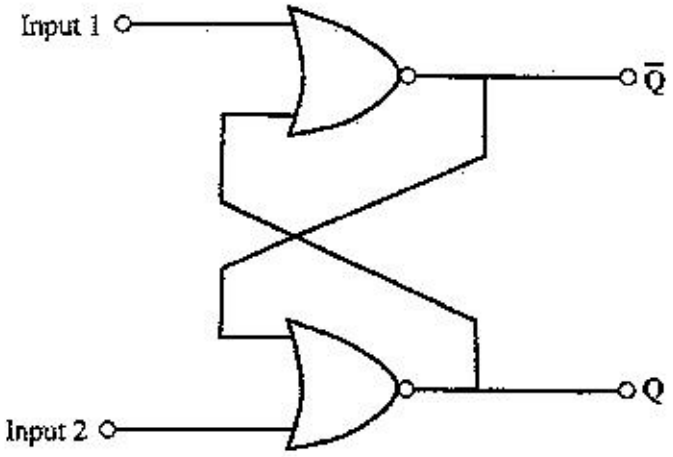

Fig. 1

(i) Identify the type of flip-flop;
(ii) Draw its truth table.

(3 marks)

2. (a) With the aid of a circuit diagram, explain the operation of a dynamic RAM cell. (6 marks)

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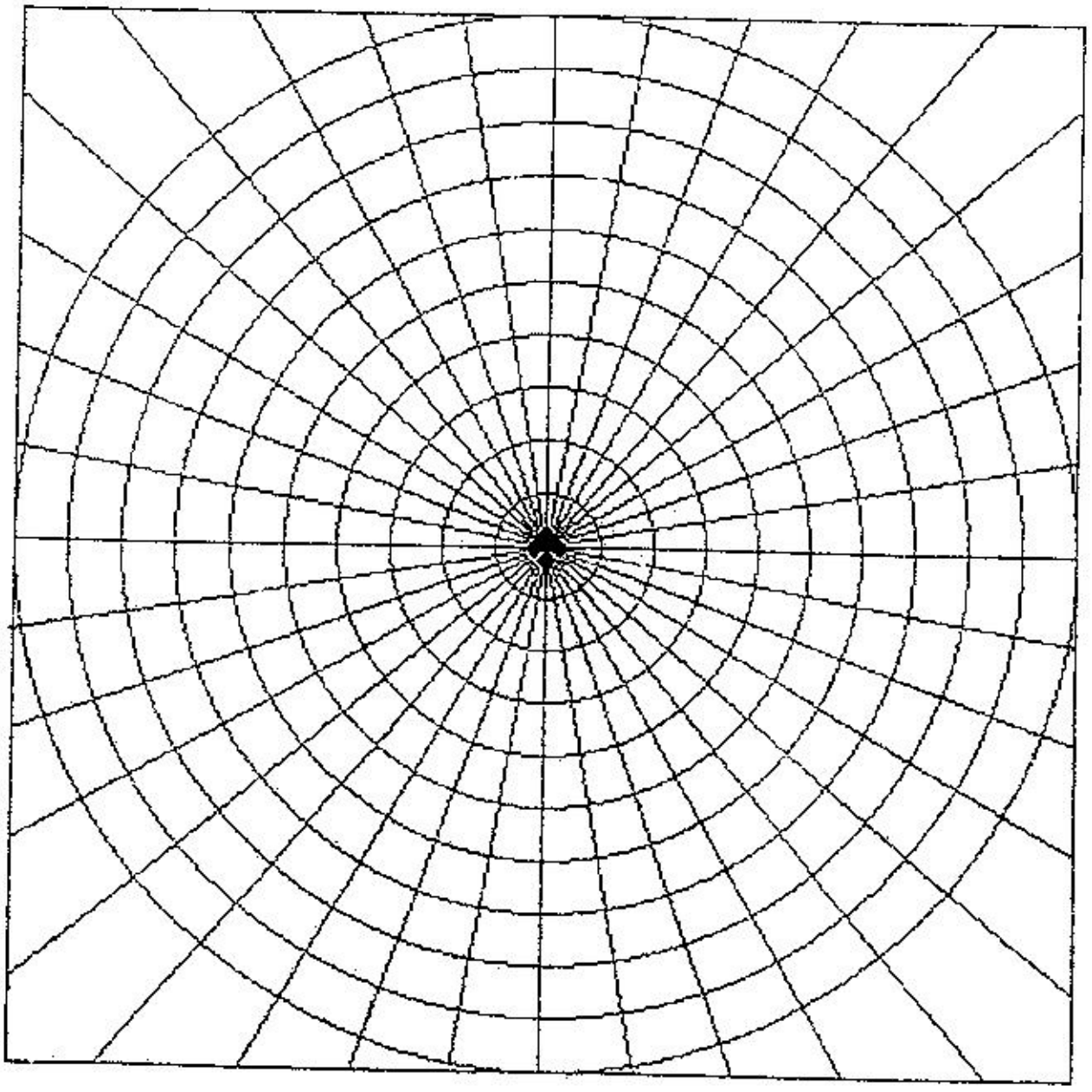

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(b) Figure 2 shows a type of sequential logic circuit.

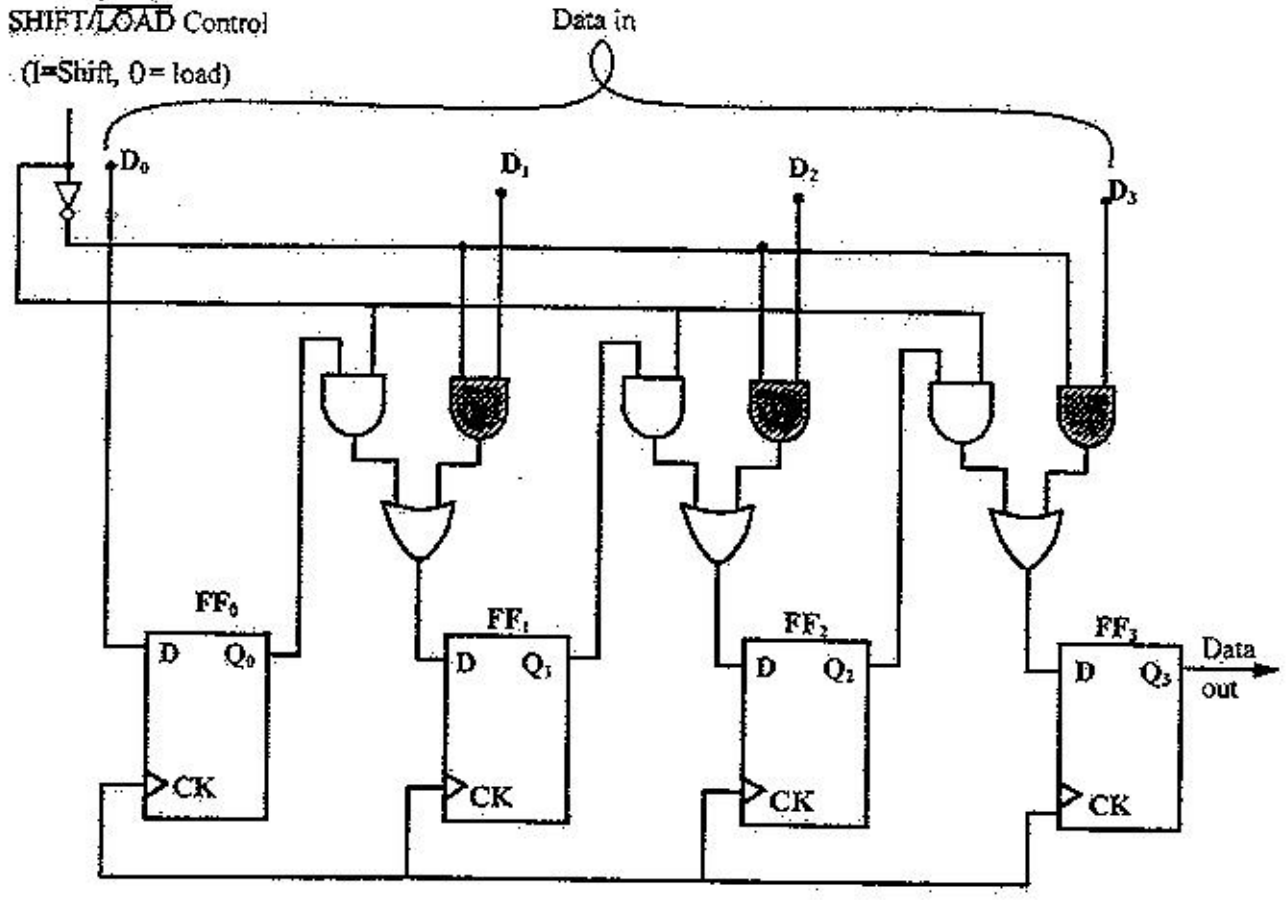

Fig. 2

(i) identify the device;
(ii) explain its operation.

(5 marks)

(c) A combinational circuit has 3 inputs A, B, C and output F. F is true for the following input combinations:

A is false, B is true;
A is false, C is true;
A, B, C are false;
A, B, C are true.

(i) Draw the truth table for F. Use the convention true = 1 and false = 0.

(ii) Using a K-map, write the simplified expression for F.

(iii) Draw the logic circuit diagram using NAND gates only.

(9 marks)

3. (a) State any two applications of a varactor diode in electronics. (2 marks)

(b) (i) Explain each of the following in relation to operational amplifiers:

(I) slew rate;
(II) input offset voltage.

(ii) The input to an OP-amp differentiator circuit is a sinusoidal voltage of peak value 10 μV and frequency of 2 kHz. If the values of differentiating components are given as $R = 40K\Omega$ and $C = 3\mu F$.
Determine the output voltage.

(7 marks)

(c) Figure 3 shows a circuit diagram of a triangular-to-square wave shaping circuit. Describe its operation. (5 marks)

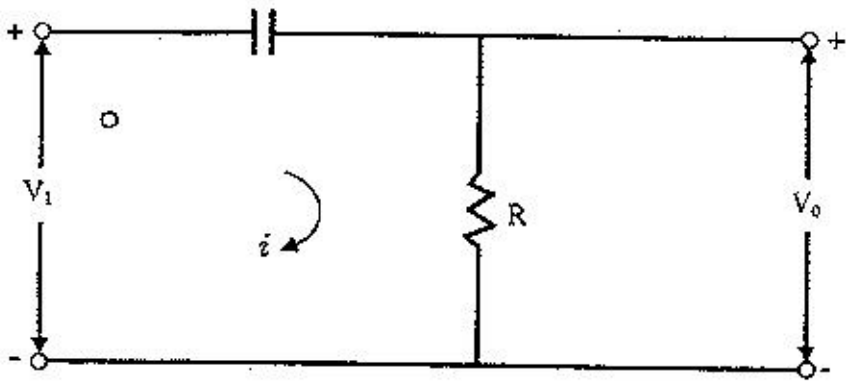

Fig. 3

(d) With the aid of circuit diagram, explain the operation of a positive wave clipper. (6 marks)

4. (a) Define each of the following as applied in semi-conductor theory:

(i) hole;
(ii) doping.

(2 marks)

(b) With the aid of a diagram, explain the formation of an N-type semi-conductor. (7 marks)

(c) Figure 4 shows a BJT transistor biased circuit.

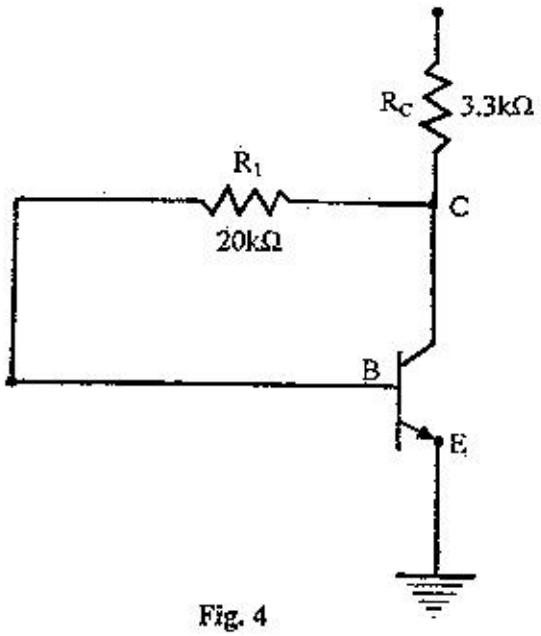

Fig. 4

If $I_E = 2mA$; $V_{BE} = 0.7$ and $\alpha = 0.98$. Calculate:

(i) collector current, I_c;
(ii) current through R_1.

(5 marks)

(d) With the aid of a diagram, explain the construction of a Unijunction Transistor (UJT). (6 marks)

5. (a) (i) Define each of the following terms as applied in Digital to Analog Conversion (DAC):

(I) resolution;
(II) accuracy.

(ii) With the aid of a circuit diagram, explain the operation of a 4-bit Binary-weighted resistor DAC.

(10 marks)

(b) A tuned collector oscillator operates at 22 kHz when a variable capacitor is set to 2 nF. Determine the value of the tuned circuit inductance. (3 marks)

(c) With the aid of a construction diagram, explain the principle of operation of an LED display. (7 marks)

SECTION B: CONTROL SYSTEMS

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

6. (a) Figure 5 shows a signal flow graph for a control system:

(i) Draw its equivalent block diagram;

(ii) Obtain the transfer function using block diagram reduction rules.

(10 marks)

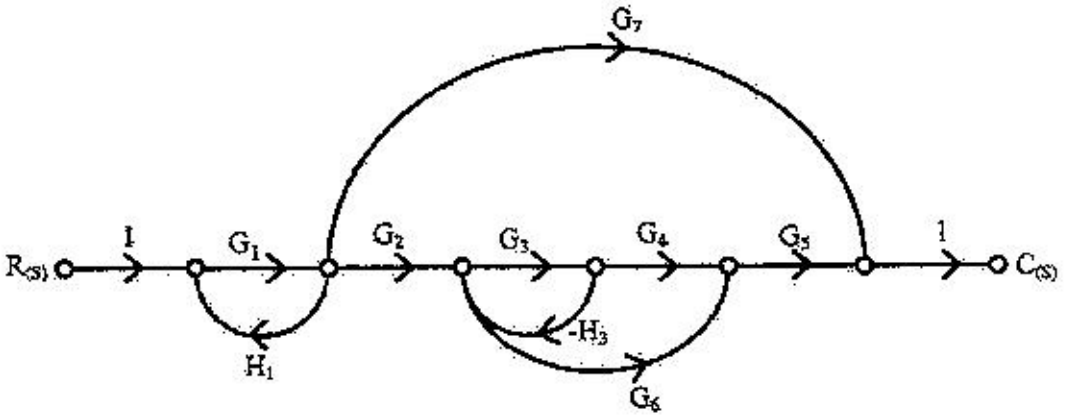

Fig. 5

(b) The open loop transfer function of a unity feedback second order control system is given by $G_{(S)} = \frac{25}{S(S+5)}$

(i) Derive an expression for the characteristic equation;

(ii) Determine:

(I) damping factor;
(II) maximum overshoot;
(III) peak time.

(10 marks)

7. (a) State **three** characteristics of an ideal op-amp. (3 marks)

(b) Table 1 shows the open-loop harmonic frequency response of a control system.

(i) Plot the bode diagram for the system;

(ii) Determine the gain and phase margins;

(iii) Describe the stability of the system.

(10 marks)

Table 1

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

(c) A unity feedback control system has

$$G_{(S)} = \frac{K}{S(S+10)(S^2+4S+5)}$$

Determine the range of K for the closed loop system to be stable.

(7 marks)

8. (a) (i) State **three** essential features of a servo-mechanism.

(ii) Define each of the following in relation to servo-systems:

(I) time lag;
(II) frequency response.

(5 marks)

(b) Figure 6 shows a circuit diagram of an electrical network. Derive its transfer function.

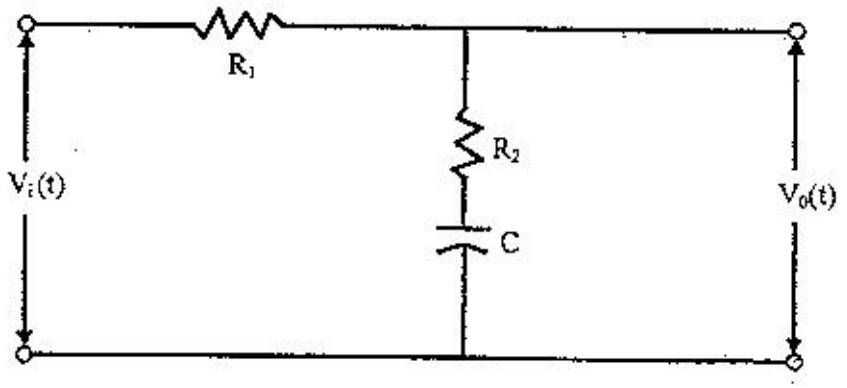

Fig. 6

(5 marks)

(c) The open-loop transfer function of a control system is given by

$$G(S) = \frac{50}{(1+2.5S)(1+0.05S)}$$

Sketch its Nyguist diagram.

(10 marks)

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