2506/202
2507/202
ELECTRONICS AND
CONTROL SYSTEMS
Oct./Nov. 2021
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;

Drawing instruments;

Laplace transform tables.

*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 8 printed pages.

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) Convert the decimal number 3749 into:

(i) octal;
(ii) binary;
(iii) hexadecimal;
(iv) BCD.

(8 marks)

(b) A Boolean function is defined by

$$f(x_1x_2x_3) = \sum(0,1,3,5)$$

Implement the function using:

(i) minimal gates;
(ii) decoder and OR-gate(s);
(iii) 4-to-1 multiplexer.

(12 marks)

2. (a) (i) Draw an orbital diagram to illustrate the electron arrangement of:

$_{32}Ge^{73}$

(ii) State **two** elements used to produce N-type semiconductors when added to silicon.

(6 marks)

(b) With the aid of a V-I characteristic curve, explain the operation of a tunnel diode.

(5 marks)

(c) Figure 1 shows a circuit diagram of a common-emitter amplifier.

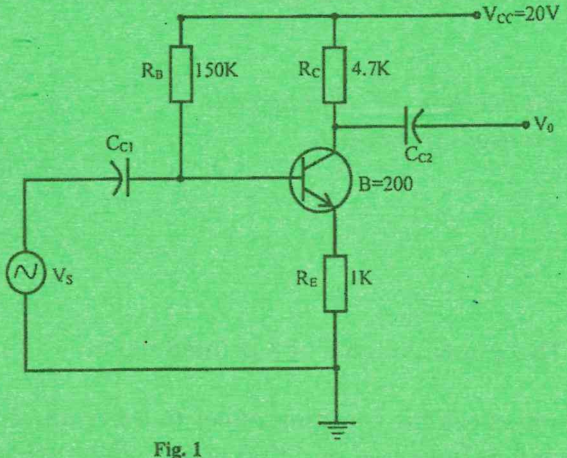

Fig. 1

Determine the values of the:

(i) input resistance looking directly into the base;

(ii) input resistance of the stage;

(iii) voltage gain, in dB.

(9 marks)

3. (a) Distinguish between bistable and astable multi-vibrators. (2 marks)

(b) Figure 2 shows a circuit diagram of an OPAmp-based oscillator.

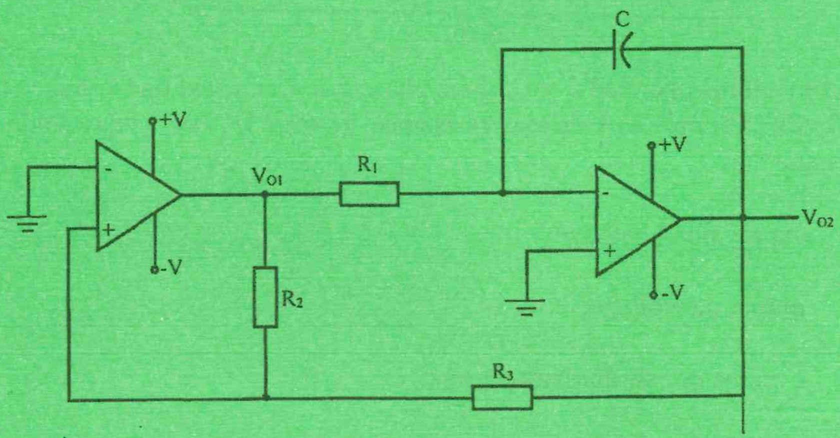

Fig. 2

(i) Draw the waveforms at:

(I) V_{o1};

(II) V_{o2}.

(ii) Explain the working of the circuit.

(8 marks)

(c) State **two** advantages of LCD displays over CRT displays. (2 marks)

(d) Figure 3 shows a circuit diagram of a three-phase half-wave converter.

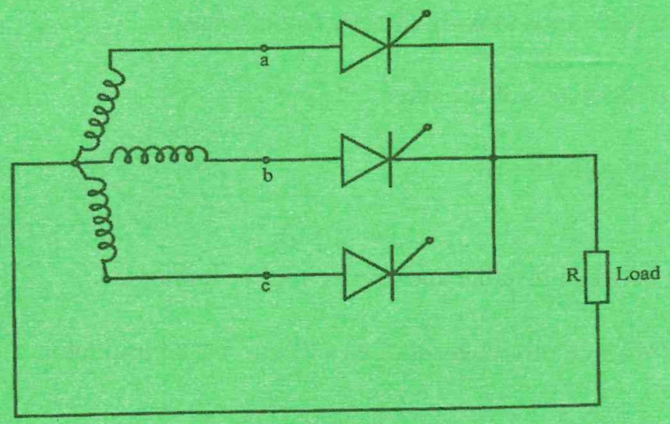

Fig. 3

The converter is operated from a three phase star-connected line voltage of 415 V, 50 Hz supply and the load resistance, $R = 10\ \Omega$. For a delay angle of 67°, determine the:

(i) supply phase voltage;

(ii) output d.c voltage;

(iii) average output thyristor current.

(6 marks)

(e) State **two** merits of three-phase controlled inverters. (2 marks)

4. (a) (i) With the aid of a schematic block diagram describe the operation of a 4-bit serial adder.

(ii) State **one** merit and **one** demerit of a carry-look-ahead adder. (8 marks)

(b) (i) Define each of the following with respect to computer memories:

(I) memory card;

(II) access time.

(ii) Draw a circuit diagram of a DRAM memory cell and describe its operation.

(8 marks)

(c) A memory is defined as 512K X 8. Determine for the memory:

(i) word size;
(ii) capacity;
(iii) number of address lines. (4 marks)

5. (a) Draw the truth table of a JK-flip flop. (3 marks)

(b) A new clocked X-Y flip flop is defined with two inputs X and Y in addition to the clock input. The flip-flop functions as follows:

- If $XY = 00$, the flip-flop changes state with each clock pulse;
- If $XY = 01$, the flip-flop Q output becomes 1 with the next clock pulse;
- If $XY = 10$, the flip-flop state Q becomes 0 with the next clock;
- If $XY = 11$, no change of state occurs with the next clock pulse.

(i) Draw the truth table for the X-Y flip-flop;

(ii) Write down the excitation table for the X-Y flip-flop;

(iii) Draw a logic circuit diagram to implement the X-Y flip-flop using JK flip-flop and other gates.

(9 marks)

(c) An asynchronous counter counts from O to 13.

(i) Determine the number of flip-flops required to implement the counter.

(ii) Draw a logic circuit diagram of the counter, using JK flip-flops.

(8 marks)

SECTION B: CONTROL SYSTEMS

Answer TWO questions from this section.

6. (a) State **three** standard signals used to test control signals. (3 marks)

(b) A servomechanism, when subjected to a unit-step input, has a response described by:

$c(t) = 1 + 0.5e^{-30t} - 1.5e^{-10t}$.

Determine the:

(i) transfer function;

(ii) undamped natural frequency;

(iii) damping ratio.

(9 marks)

(c) A control system has a characteristic equation

$$S^4 + 6S^3 + 11S^2 + 6S + K = 0$$

Using Routh's array, determine the range of values of K to ensure the system is stable.

(6 marks)

(d) State **two** limitations of Routh-Hurwitz stability criterion. (2 marks)

7. (a) Define a servo system. (1 mark)

(b) With the aid of a circuit diagram, describe the use of synchros to detect alignment errors in remote shafts. (8 marks)

(c) A unity feedback control system has an open-loop transfer function given by:-

$$G_{(s)} = \frac{K}{s(s^2 + 4s + 13)}$$

With respect to root locus technique, determine the following:

(i) centroid;

(ii) number of asymptotes;

(iii) angle asymptotes;

(iv) angle of departure of roots from poles;

(v) value of K and frequency at which the root locus crosses the jw-axis.

(11 marks)

8. (a) Define each of the following with respect to control systems:

(i) feedback;

(ii) control element.

(2 marks)

(b) Figure 4 shows a signal flow diagram of a control system.

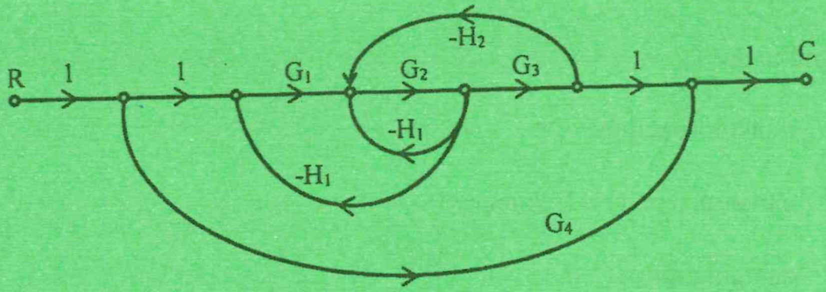

Fig. 4

(i) Draw a block diagram for the control system.

(ii) Determine the transfer function using Mason's gain formula.

(12 marks)

(c) Figure 5 shows a circuit diagram of an electrical network.

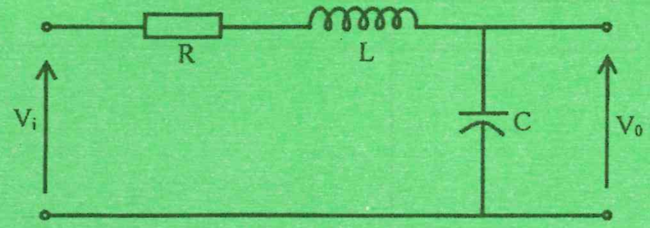

Fig. 5

(i) Derive the differential equations to describe the network.

(ii) Determine the expression for the transfer function.

(6 marks)

Table of Laplace transform pairs

$f(t), t > 0$	$f(s)$
$\delta(t)$	1
e^{-at}	$\frac{1}{s+a}$
$\frac{1}{b-a}(e^{-at} - e^{-bt})$	$\frac{1}{(s+a)(s+b)}$
$Sin\omega t$	$\frac{\omega}{s^2+\omega^2}$
$Cos(\omega t)$	$\frac{s}{s^2+\omega^2}$
t	$\frac{1}{s^2}$
t^2	$\frac{2}{s^3}$
$\frac{1}{\omega} e^{-at} Sin\omega t$	$\frac{1}{(s+a)^2+\omega^2}$
1	$\frac{1}{s}$

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