2506/202
2507/202
ELECTRONICS AND CONTROL SYSTEMS
Oct./Nov. 2017
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.
*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 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.

Turn over

SECTION A: ELECTRONICS (60 marks)

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

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

I. atomic number;
II. orbit.

(ii) With the aid of a labelled diagram, describe the formation of a p-type semiconductor. (8 marks)

(b) (i) State **three** applications of Zener diodes.

(ii) Draw a labelled construction diagram of an n-channel junction field effect transistor, indicating the bias voltages. (6 marks)

(c) Figure 1 shows a circuit diagram of an OP-AMP based amplifier. Assuming an ideal OP-AMP, derive the expression for the output voltage, Vo. (6 marks)

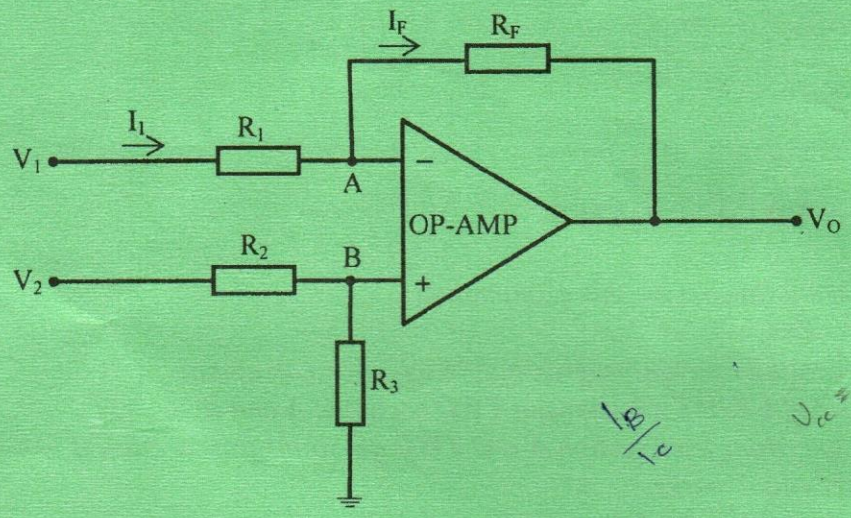

Fig. 1

2. (a) (i) State any **two** merits of light emitting diodes when used as display devices.

(ii) Draw the electrical equivalent circuit of a piezoelectric crystal and sketch its response curve. (6 marks)

(b) An audio frequency class-A power amplifier draws a mean collector current of 8 mA from a 12 V dc supply. When a sinusoidal input signal is applied, the collector current varies between 11 mA and 5 mA while the collector voltage varies between 4 V and 20 V. Determine the:

(i) dc power input;
(ii) ac power output;
(iii) efficiency of the amplifier. (6 marks)

(c) Figure 2 shows a circuit diagram of a bistable multivibrator. Describe its operation. (4 marks)

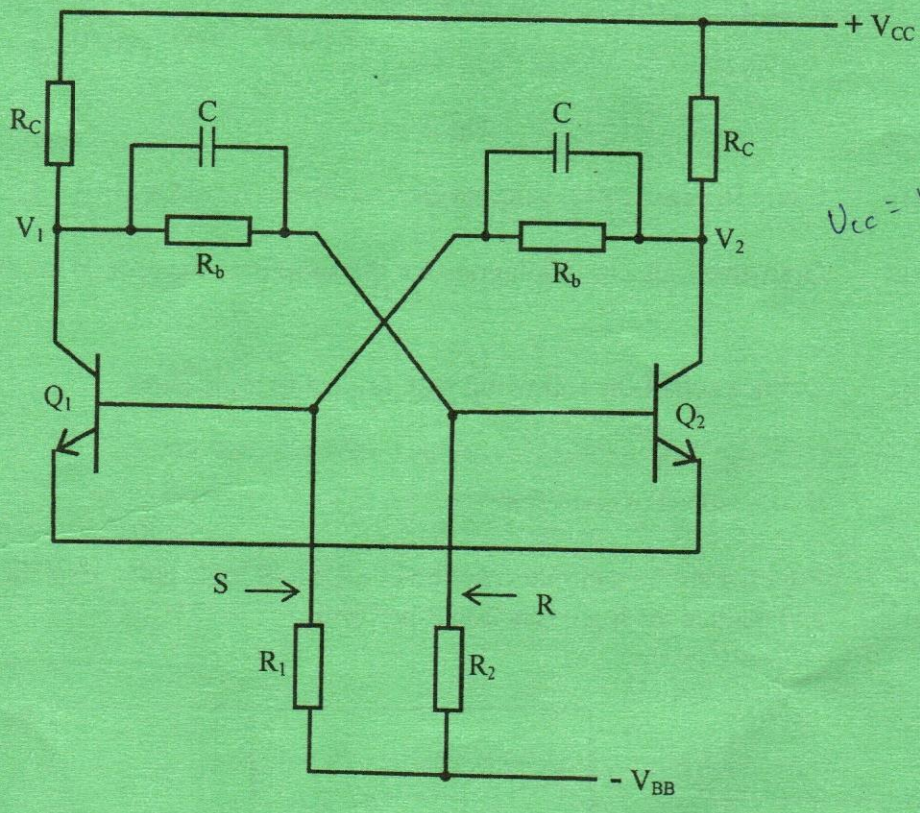

Fig. 2

(d) A single-phase bridge rectifier is supplied from a 340 V peak, 50Hz source. It feeds a pure resistive load of 47 Ω. Determine the:

(i) dc load voltage;
(ii) dc load current. (4 marks)

3. (a) Perform each of the following:

(i) convert $26A_{16}$ to binary;
(ii) multiply 101.01_2 by 11.1_2;
(iii) convert binary number 11011011 to its Gray code equivalent;
(iv) add 8_{10} to 6_{10} in Excess-3 code and express the answer in Excess-3 code. (9 marks)

(b) Figure 3 shows a logic circuit diagram of a logic network. Obtain the minimized expression for the output F. (4 marks)

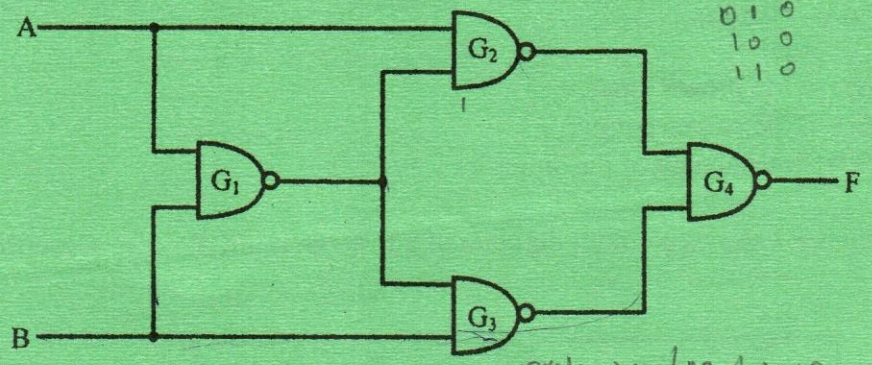

Fig. 3

(c) (i) Using Boolean rules, simplify the expression F = (A + B)(B + C).

(ii) Draw the logic circuit diagram for the simplified expression in (c)(i).

(7 marks)

4. (a) (i) Define each of the following with respect to logic gates:

I. fan-in;
II. speed of operation.

(ii) Figure 4 shows a circuit diagram of a CMOS logic gate. Explain its operation and deduce the logic function it performs. (7 marks)

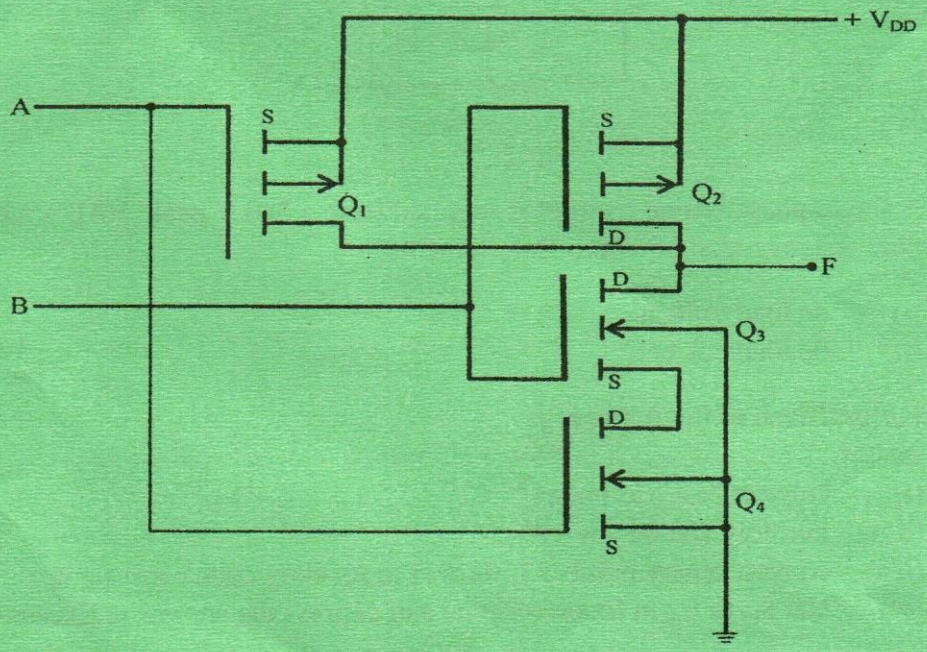

Fig. 4

(b) Figure 5 shows a block diagram of 4-to-1 multiplexer.

(i) Draw its truth table.
(ii) Obtain the Boolean expression for the output Y from the truth table in (b)(i).
(iii) Implement the expression in (b)(ii) using logic gates. (6 marks)

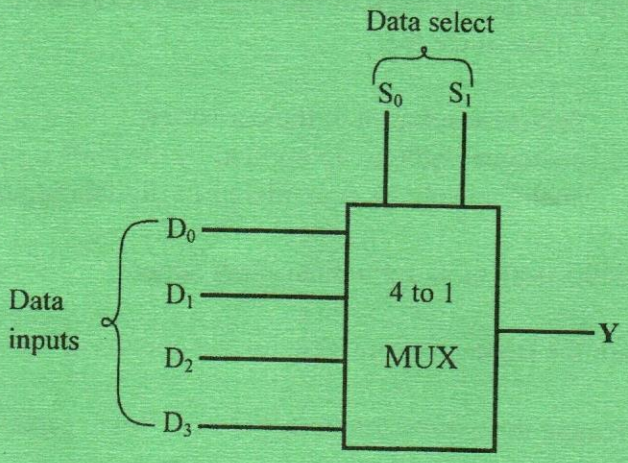

Fig. 5

(c) (i) State the **two** methods used in overcoming the switching difficulties associated with strobed operation of flip flops.

(ii) Figure 6 shows a logic circuit diagram of a binary counter. Assuming the flip flops are initially reset:

I. draw the timing diagrams for Q_A, Q_B and Q_C due to application of clock pulses;
II. determine the counting sequence of the counter. (7 marks)

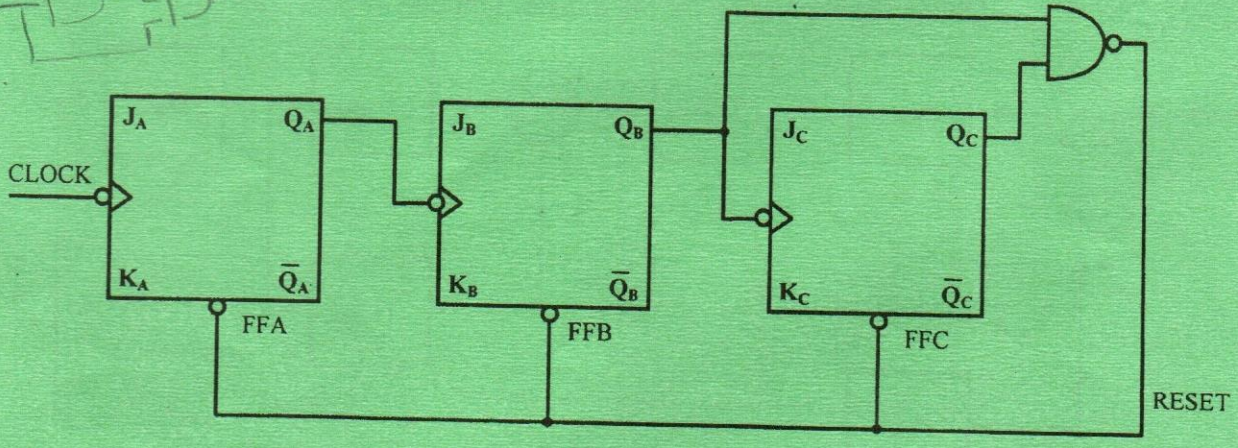

Fig. 6

5. (a) (i) Define each of the following with respect to digital-to-analogue converters:

I. resolution;
II. speed.

(ii) A 6-bit analogue-to-digital converter has a maximum precision supply voltage of 20 V. Determine the:

I. percent resolution of the converter;
II. analogue voltage represented by the least significant bit;
III. analogue voltage equivalent to a digital output of 100110. (8 marks)

(b) (i) Draw the truth table for a binary half adder.

(ii) Obtain the Boolean expression for the outputs of the adder in (b)(i).

(iii) Implement the expression in (b)(ii) using logic gates. (6 marks)

(c) (i) Explain how an EPROM is erased and re-programmed.

(ii) State **two** advantages of bipolar RAMs over mosfet RAMs. (6 marks)

SECTION B: CONTROL SYSTEMS (40 marks)

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

6. (a) State **four** demerits of open loop control systems. (4 marks)

(b) Figure 7 shows a block diagram of a control system.

(i) Simplify the blocks to canonical form.
(ii) Obtain the expression for the transfer function of the system. (9 marks)

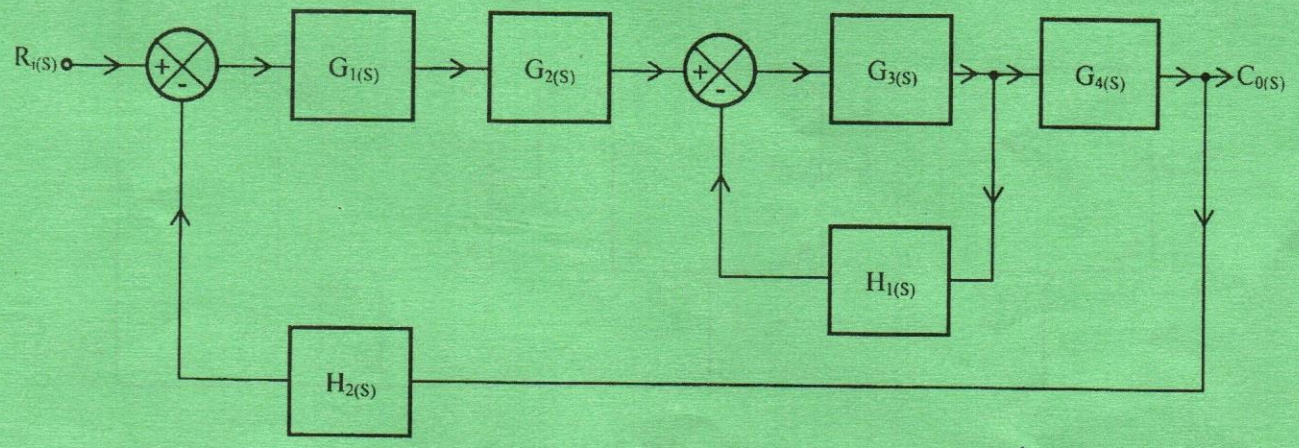

Fig. 7

$TF = G = \frac{1}{G_{(S)} H_{(S)}} R$

(c) The rotor of an electrical machine has a moment of inertia I kg.m^2 and rotates at an angular velocity of ω rad/sec. It develops a torque T Nm when it rotates through an angle θ radians. If the viscous function (rotor bearing friction, windage) coefficient of the moving system is F, derive the expression for the transfer function. (7 marks)

7. (a) (i) Figure 8 shows a diagram of a symbol used in analogue computing systems.

I. Identify the symbol.
II. State the function of the input marked IC.
III. Write down the expression for the output voltage in terms of the inputs.

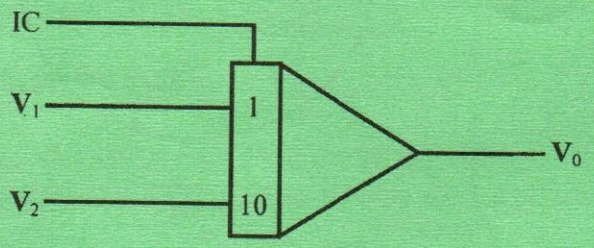

Fig. 8

(ii) Explain the following with respect to analogue computing:

I. amplitude scaling;
II. time scaling. (8 marks)

(b) (i) State **two** advantages of ac servomotors over dc servomotors.

(ii) A stepper motor has 12 stator slots and 8 rotor slots.

Determine the:

I. number of steps per revolution;
II. step angle. (6 marks)

(c) Figure 9 shows a circuit diagram of a phase lag compensating network. Derive its transfer function. (6 marks)

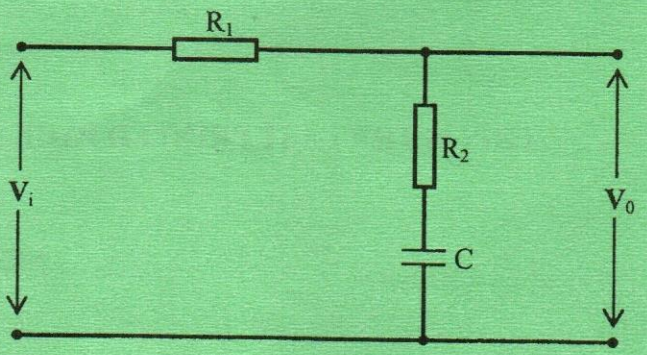

Fig. 9

8. (a) (i) State **two** factors affecting system performance.

(ii) Draw a labelled block diagram showing how velocity feedback damping is applied to a control system. (5 marks)

(b) Figure 10 shows a signal flow graph for an electrical circuit. Obtain its transfer function using Mason's formula. (7 marks)

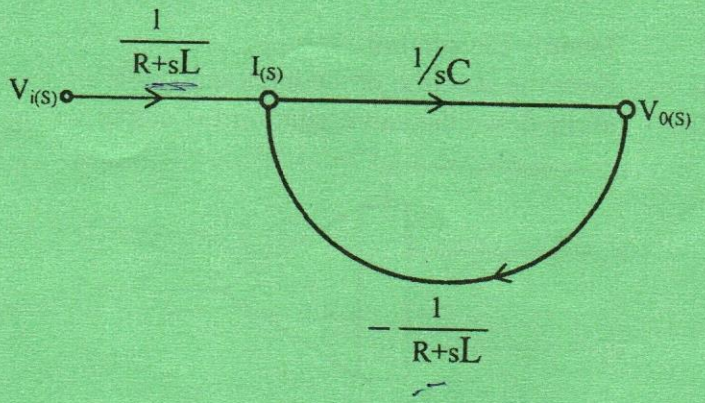

Fig. 10

(c) A closed loop control system has the characteristic equation given by:

$S^3 + 4.5\,S^2 + 3.5\,S + 1.5 = 0$

Using Routh-Hurwitz criterion, determine the stability of the system. (8 marks)

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