

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.**

**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. *5- Rebo value* (8 marks)
- (b) (i) State **three** applications of Zener diodes. *5- more electronic devices*
- (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,  $V_o$ . (6 marks)

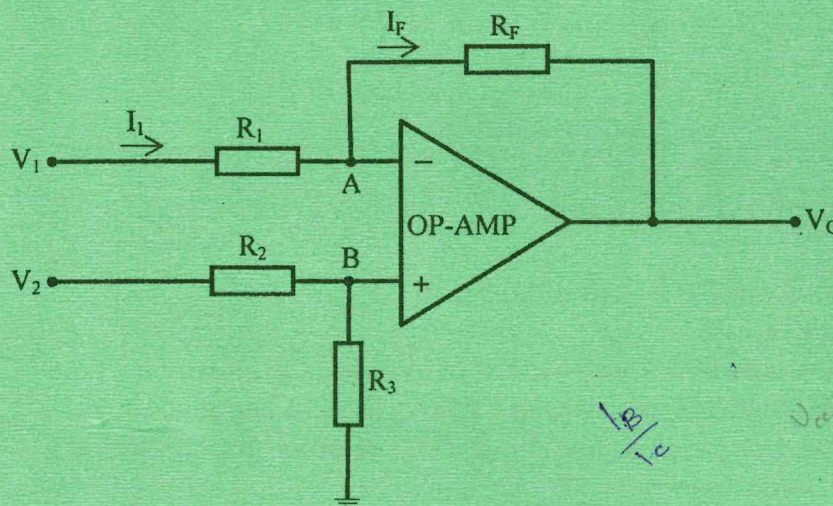


Fig. 1

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:
- dc power input;
  - ac power output;
  - efficiency of the amplifier.

(6 marks)

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

(4 marks)

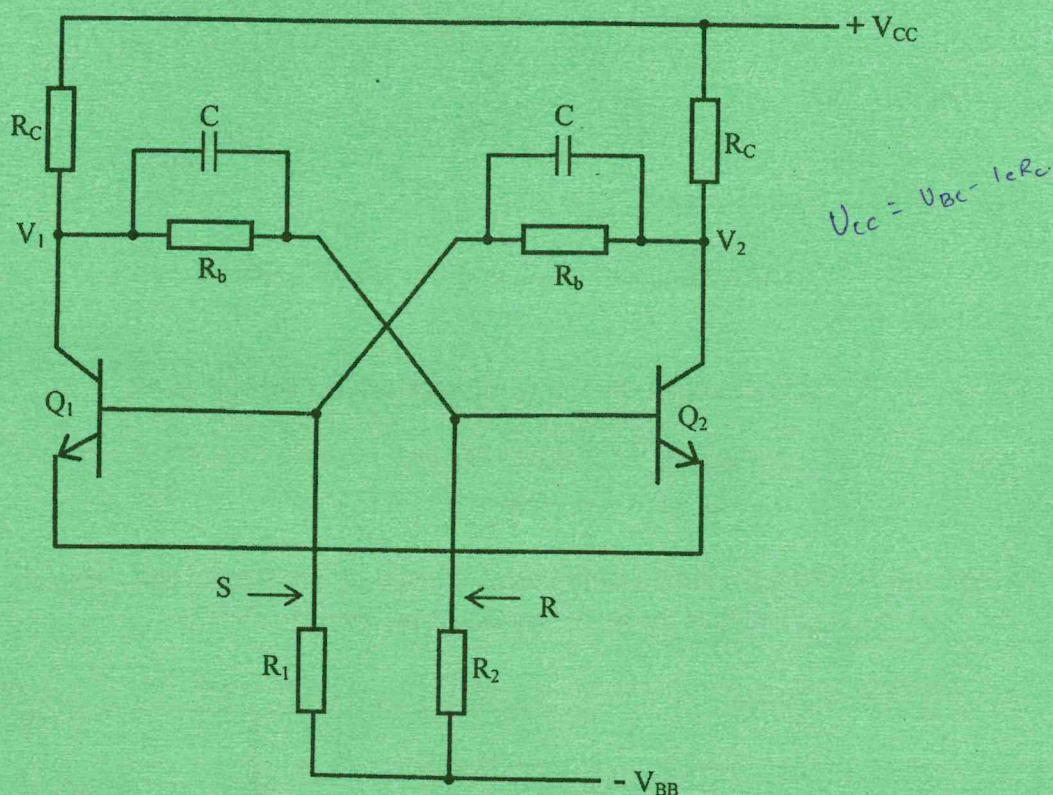


Fig. 2

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

- dc load voltage;
- dc load current.

(4 marks)

3. (a) Perform each of the following:

- convert  $26A_{16}$  to binary;
- multiply  $101.01_2$  by  $11.1_2$ ;
- convert binary number 11011011 to its Gray code equivalent;
- 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)

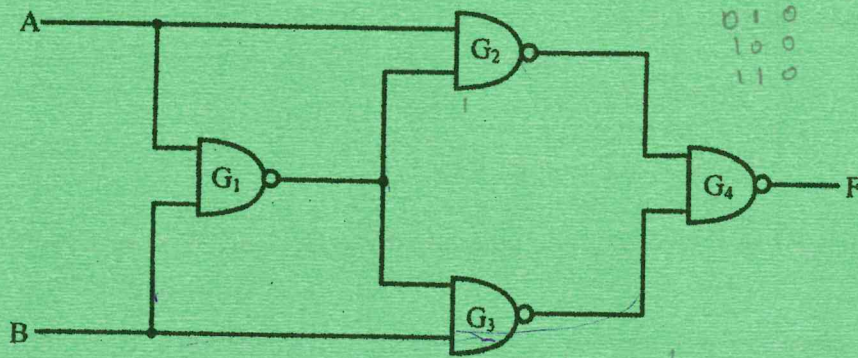


Fig. 3

- (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)

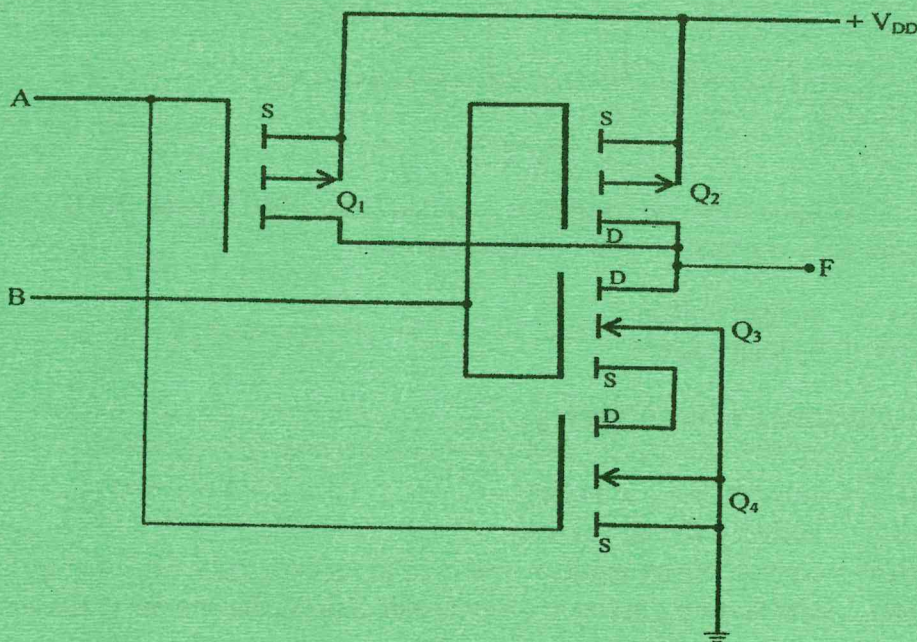


Fig. 4

(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)

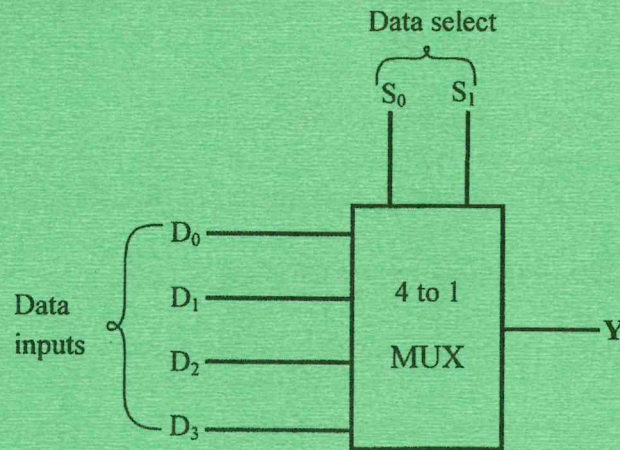


Fig. 5

(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)

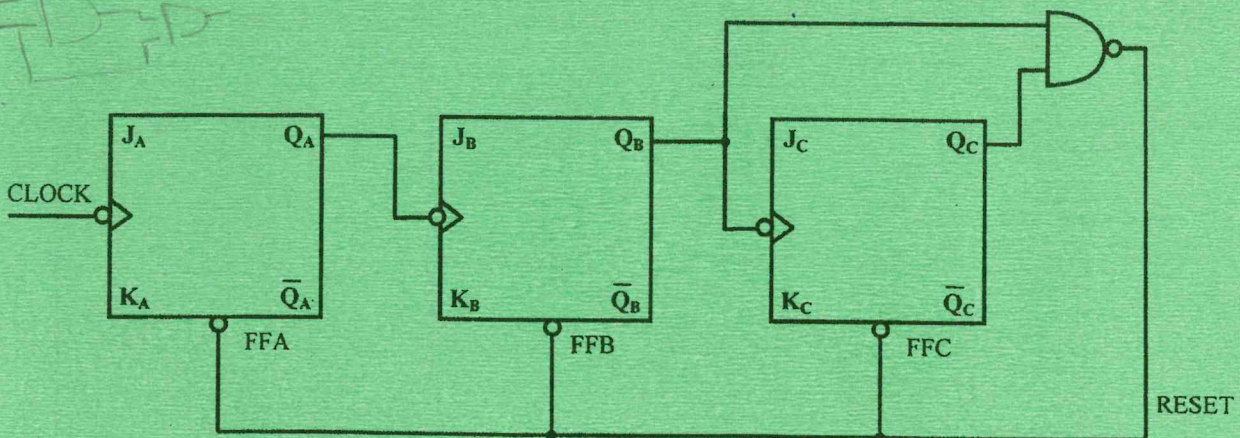


Fig. 6

5. (a) (i) Define each of the following with respect to digital-to-analogue converters:
- I. resolution; *number of bits*
  - 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)

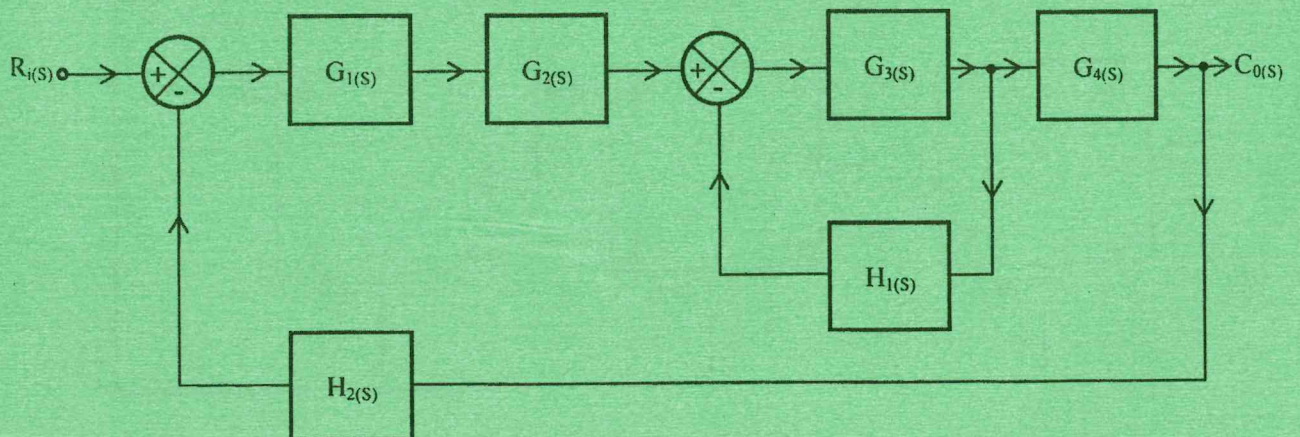


Fig. 7

*TF:  $G = \frac{1}{G_1 G_2} R$*

- (c) The rotor of an electrical machine has a moment of inertia  $I \text{ kg.m}^2$  and rotates at an angular velocity of  $\omega \text{ rad/sec}$ . It develops a torque  $T \text{ Nm}$  when it rotates through an angle  $\theta$  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)

$$G = \frac{\theta}{G \omega}$$

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.

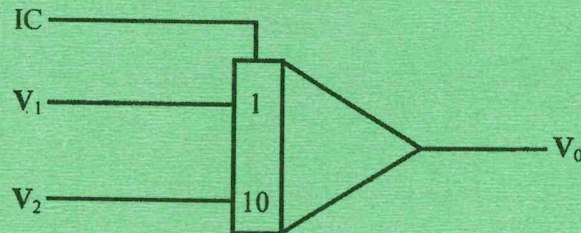


Fig. 8

- (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.

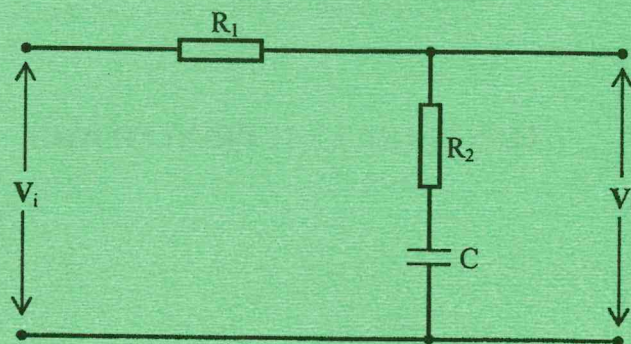
- (ii) A stepper motor has 12 stator slots and 8 rotor slots.

Determine the:

- I. number of steps per revolution;
- II. step angle.  $120^\circ$

(6 marks)

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



$$T.F = \frac{\omega}{\omega + 1}$$

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)

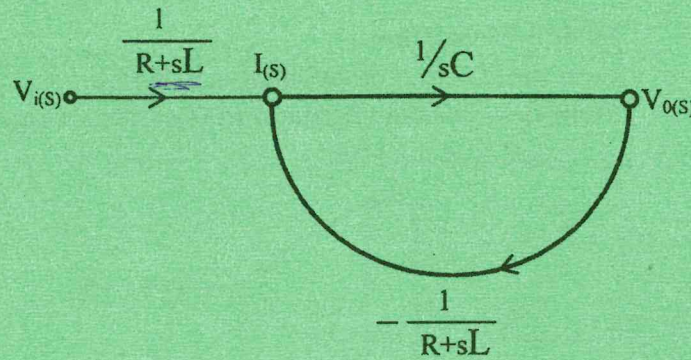


Fig. 10

- (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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