**2506/202**
**2507/202**
**ELECTRONICS AND CONTROL SYSTEMS**
**June/July 2020**
**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;*
- *Nyquist polar curve.*

*This paper consists of **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 7 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.**



**Turn over**

## SECTION A: ELECTRONICS

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

1. (a) Define each of the following as used in semiconductor devices:

(a) drift;
(b) diffusion;
(c) recombination.

(3 marks)

(b) Describe the formation of depletion layer in a P.N junction diode. (5 marks)

(c) With the aid of V.I characteristic curve, describe the operation of a tunnel diode. (7 marks)

(d) A germanium PN junction diode has a saturation current of 250 mA at 300 k. Determine the voltage to be supplied across the junction to cause a forward current of $10^5$ A to flow. (5 marks)

2. (a) State **two** types of feedback connections in feedback amplifiers. (2 marks)

(b) An R-C coupled amplifier has a voltage gain of 1000, lower cut off frequency $f_1$ of 50Hz, upper cut off frequency $f_2$ of 200 kHz and a distortion of 5% without feedback. If a negative feedback at a feedback ratio of 0.01 is introduced, determine the new:

(i) amplifier voltage gain;
(ii) lower cut off frequency $f_1$;
(iii) upper cut off frequency $f_2$.
(iv) distortion.

(8 marks)

(c) (i) State **two** applications of differentiating circuits.

(ii) With the aid of a circuit diagram and waveforms, explain the operation of a diode positive clipper circuit.

(10 marks)

3. (a) State **three** areas of applications of Liquid Crystal Display (LCDs). (3 marks)

(b) Figure 1 shows a d.c bias circuit of a common emitter transistor amplifier.

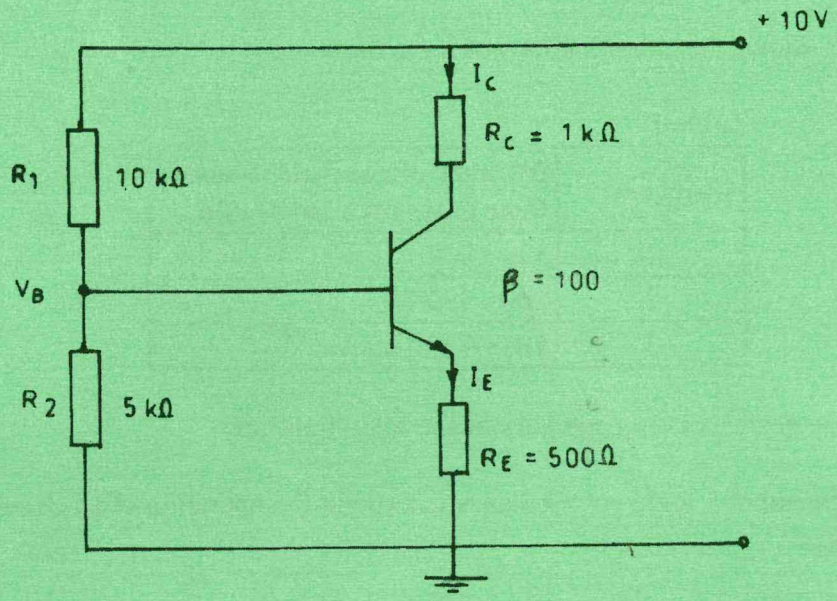


Fig. 1

Assuming $V_{BE} = 0.7$ V, determine the:

(i) base voltage, $V_B$;
(ii) emitter voltage, $V_E$;
(iii) emitter current, $I_E$;
(iv) collector emitter voltage, $V_{CE}$.

(8 marks)

(c) (i) Perform each of the following arithmetic operations in the given bases:

(I) $(0101)_2 + (1111)_2$;

(II) $(7F)_{16} + (BA)_{16}$.

(ii) Represent the decimal number 4096 in

(I) BCD code;

(II) excess - 3 code.

(9 marks)

4. (a) Simplify the following Boolean expression using K-map:

$$F(A, B, C, D) = \Sigma(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13)$$ (6 marks)

(b) Table 1 shows the classifications of logic families.

**Table 1**

| Category | Number of equivalent basic logic gates on a single clip |
|---|---|
| 1 | 12 - 99 |
| 2 | 100 - 999 |
| 3 | 10,000 and above |

State the corresponding category of the logic families. (3 marks)

(c) With the aid of a logic circuit diagram, explain the operation of an edge triggered J-K flip flop. (8 marks)

(d) State **three** advantages of using metal oxide semiconductor (MOS) devices over Bipolar type devices. (3 marks)

5. (a) State **three** applications of shift registers. (3 marks)

(b) Define each of the following with respect to analogue - to - digital converters:

(i) monotonicity;
(ii) resolution;
(iii) accuracy.

(3 marks)

(c) Wit the aid of circuit diagram, explain the principle of operation of a Dynamic RAM (DRAM) memory cell. (6 marks)

(d) **Figure 2** shows an electronic logic circuit.

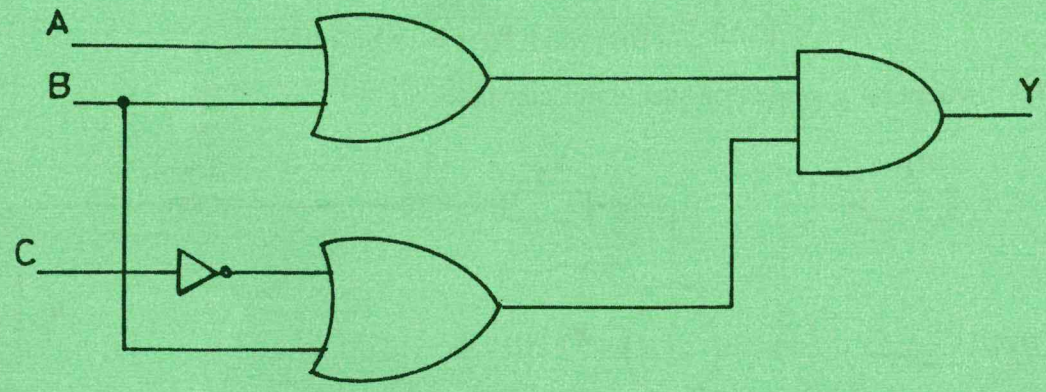


Fig. 2

(i) Draw its truth table.

(ii) Obtain the output Boolean expression.

(8 marks)

## SECTION B: CONTROL SYSTEMS

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

6. (a) Define the following with respect to control systems:

(i) reference variable;
(ii) controlled variable.

(2 marks)

(b) State **two** advantages of open loop over closed loop control systems. (2 marks)

(c) **Figure 3** shows an R-C network. Determine its transfer function. (6 marks)

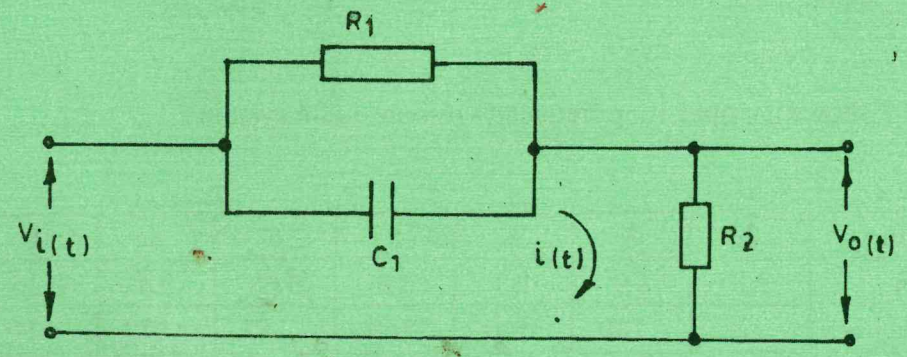


Fig. 3

(d) **Figure 4** shows an equivalent circuit of a d.c generator. Show that its transfer function is given by.

$$\frac{E_2(s)}{E_f(s)} = \frac{KrR_2}{(R_f + SL_f)(Ra + R_2 + SLa + SL_2)}$$

where Kr = generator back e.m.f constant.

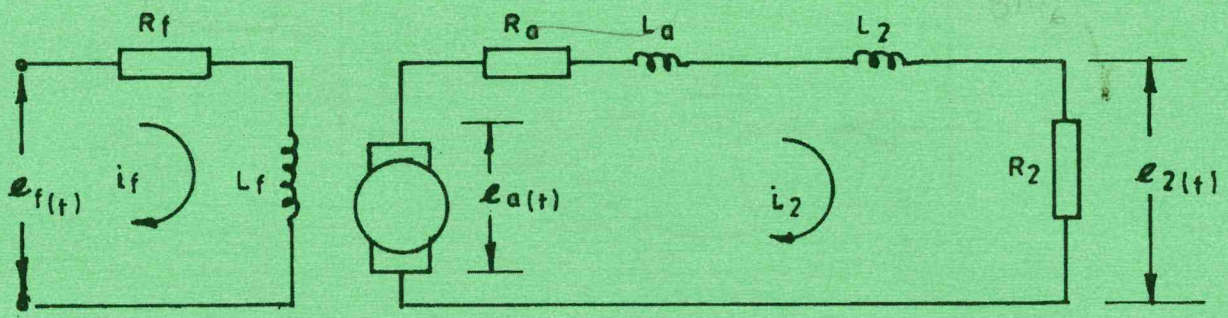


Fig. 4

(10 marks)

7. (a) Define each of the following with respect to system performance:

(i) damping ratio;
(ii) percentage overshoot;
(iii) time constant.

(3 marks)

(b) A second order system is described by the differential equation

$$1.5\frac{d^2\theta_o}{dt^2} + 3\frac{d\theta_o}{dt} + 6\theta_o = 6\theta_i;$$

Determine the:

(i) percentage overshoot of the response;
(ii) time taken to reach this overshoot when the system is subjected to a unit step input.

(6 marks)

(c) Table 2 shows the open loop frequency response of a system.

**Table 2**

| $\omega$ rad/s | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 30 |
|---|---|---|---|---|---|---|---|---|
| Gain | 2.8 | 1.9 | 1.3 | 0.9 | 0.68 | 0.4 | 0.26 | 0.12 |
| $\phi$ degrees | - 120 | - 130 | -140 | -149 | - 157 | - 170 | - 180 | - 200 |

(i) Plot the Nyquist diagram and determine the stability margins.

(ii) Comment on the stability of the system.

(11 marks)

8. (a) Define each of the following with respect to signal flow graphs:

(i) forward path;
(ii) sink node;
(iii) source node.

(3 marks)

(b) Figure 5 shows a signal flow graph for a control system. Determine the system gain using Mason's formula. (10 marks)

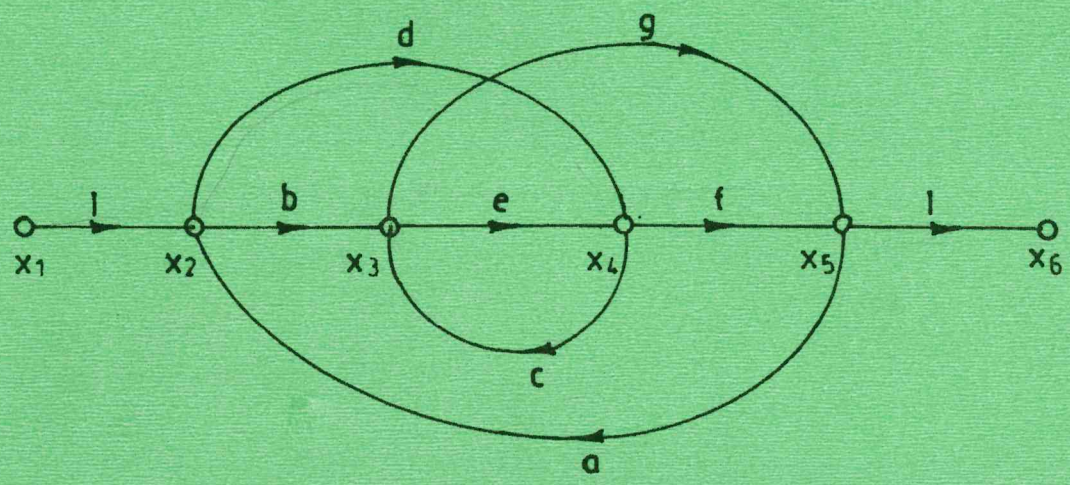


Fig. 5

(c) (i) State the three types of stepper motors.

(ii) State **one** practical application areas of stepper motors.

(iii) Draw a labelled schematic diagram of a stepper motor.

(7 marks)

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