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

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.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.
1. (a) Distinguish between forward biasing and reverse biasing with respect to semiconductor diodes. (2 marks)

(b) (i) State two advantages of full-wave bridge rectifiers over centre-tapped full-wave rectifiers.
(ii) With the aid of a diagram, describe the operation of a centre-tapped full-wave rectifier. (10 marks)

(c) A P-N junction diode having internal resistance (r) of 20 Ω is used for half-wave rectification. The applied voltage, \( V = 50 \sin \omega t \) and load resistance \( R_L = 800 \Omega \). Determine the:
   (i) maximum current \( (I_m) \);
   (ii) direct current \( I_{dc} \);
   (iii) root mean square current \( (I_{rms}) \);
   (iv) d.c output voltage. (8 marks)

2. (a) List two applications of Light Emitting Diodes (LEDs). (2 marks)

(b) Draw the symbols of the following devices:
   (i) silicon controlled rectifier;
   (ii) LED;
   (iii) varactor diode. (6 marks)

(c) State two classes of power amplifiers with respect to their mode of operation. (2 marks)

(d) An amplifier has an open circuit voltage gain of 1,000, an output resistance of 15 Ω and input resistance of 7 KΩ. It is supplied from a signal source of e.m.f 10 mV with internal resistance of 3 KΩ. The amplifier feeds a load of 35 Ω.
   (i) sketch the equivalent circuit for the amplifier;
   (ii) Determine the:
      I. magnitude of the input voltage;
      II. magnitude of the output voltage. (10 marks)
3. (a) State three merits of sinusoidal oscillators.  
(b) With the aid of a diagram, describe the construction of a colpitt's oscillator.  
(c) State three merits of common emitter configuration with respect to bipolar junction transistors (BJTs).  
(d) Figure 1 shows a PNP transistor. The zero signal base current is 20 \( \mu A \) and \( \beta = 50 \).  
   (i) Determine the quiescent (Q) point;  
   (ii) draw the load line.  

![Diagram of a transistor circuit with labeled components: \( V_{BB} \), \( V_{CC} = 12 \text{ V} \), \( R_c = 6 \text{ k\Omega} \).]

Fig. 1

4. (a) Define the following with respect to memories:  
   (i) access time;  
   (ii) memory cell.  

(3 marks)  
(7 marks)  
(3 marks)  
(7 marks)  
(2 marks)
(b) Tables I, II and III show truth tables for different logic gates:

(i) identify the logic gates;
(ii) draw the symbols in (i);
(iii) write the Boolean expressions for the gates in (i). (9 marks)

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(c) With the aid of a logic circuit diagram, describe the operation of a clocked J-K flip-flop. (9 marks)

5. (a) Convert the following:

(i) $27.25_{10}$ into binary;
(ii) $64.075_{10}$ into octal;
(iii) $4 AF.9_{16}$ into octal. (9 marks)
(b) Write the Boolean equivalence of the following:
   (i) \( A \cdot 1 = \);  
   (ii) \( A + 1 =; \)
   (iii) \( A + AB = \)  \( \text{(3 marks)} \)
(c) Add \( 37_{10} \) \text{ and } \( 49_{10} \) in excess 3 code.  \( \text{(4 marks)} \)
(d) Draw a logic circuit of a 2 to 4 decoder.  \( \text{(4 marks)} \)

SECTION B: CONTROL SYSTEMS

Answer \text{TWO questions from this section}

6. (a) Define the following:
   (i) settling time;
   (ii) delay time;
   (iii) peak time. \( \text{(3 marks)} \)
(b) Draw a 2\textsuperscript{nd} order systems response curve showing the following:
   (i) overshoot;
   (ii) rise time;
   (iii) peak time. \( \text{(7 marks)} \)
(c) A unity negative feedback control system has a forward transfer function:
   \[ G(s) = \frac{K}{(s + a_1)(s + a_2)} \]
   (i) draw the block diagram of the system;
   (ii) determine the closed loop transfer function. \( \text{(6 marks)} \)
(d) draw a three-input summer operational amplifier circuit. \( \text{(4 marks)} \)
7. (a) State Routh's stability criterion. (2 marks)

(b) The open loop transfer function of a control system is given by:

\[ G(s) = \frac{K}{s(s^2 + s + 1)(s + 4)} \]

The system has a unity feedback. Determine the characteristic equation. (4 marks)

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

\[ 3 \frac{d^2 \theta_0}{dt^2} + 6 \frac{d\theta_0}{dt} = 12 E \]

Where \( E = (\theta_t - \theta_0) \).

Determine the:

(i) undamped natural frequency;

(ii) damping factor;

(iii) percentage overshoot;

(iv) time taken to reach the overshoot. (8 marks)

(d) With the aid of a diagram, describe components of a servo system. (6 marks)

8. (a) State three advantages of the Bode plots over polar plots. (3 marks)

(b) Figure 2 shows an RLC circuit having a 150 \( \Omega \) resistance, 0.06 H inductor and a 67 \( \mu F \) capacitor.

Determine the:

(i) transfer function;

(ii) resonant frequency. (6 marks)
(c) Figure 3 shows a signal flow graph of a control system. Using Mason’s gain formula determine the closed loop transfer function. (8 marks)

(d) Highlight three characteristics of an ideal operational amplifier (OP - AMP). (3 marks)