2506/202
2507/202
ELECTRONICS AND CONTROL SYSTEMS
Oct/Nov 2023
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.
*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 9 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

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

1. (a) Distinguish between:

(i) intrinsic and extrinsic semiconductors;
(ii) majority and minority charge carriers. (4 marks)

(b) The voltage-ampere equation of a semiconductor diode is given by

$$i_D = I_0(e^{\frac{V_D}{\eta VT}} - 1)$$

(i) Identify each parameter.
(ii) Sketch the diode characteristic.
(iii) Derive the expression for the dynamic resistance of the diode,

$$dV_D / di_D$$ (8 marks)

(c) (i) With aid of a sketch, describe transistor load line and state its significance.
(ii) Differentiate biasing of class A and class B push-pull transistor amplifiers. (8 marks)

2. (a) Perform each of the following arithmetic operations in the given number systems:

(i) $(AFCD)_{16} + (9AAC)_{16}$;

(ii) $(467)_8 - (276)_8$;

(iii) $0111\ 1001_{BCD} + 0011\ 0111_{BCD}$ (6 marks)

(b) Simplify each of the following Boolean expressions:

(i) $(D + \overline{E})(D + E)$

(ii) $WXY + W\overline{X}Y + WX\overline{Y} + W\overline{X}\,\overline{Y}$. (6 marks)

(c) Table 1 shows the truth table of a 2-bit multiplier with inputs A_1A_0, B_1B_0 and output $P_3P_2\ P_1P_0$.

(i) Complete the truth table.
(ii) Draw a logic circuit diagram to implement the multiplier using 3-to-8 decoders and gates. (8 marks)

Table 1

Input				Output			
A_1	A_0	B_1	B_0	P_3	P_2	P_1	P_0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0
0	0	1	0	–	–	–	–
0	0	1	1	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	1	0	0	0	1
0	1	1	0	–	–	–	–
0	1	1	1	0	0	1	1
1	0	0	0	0	0	0	0
1	0	0	1	–	–	–	–
1	0	1	0	0	1	0	0
1	0	1	1	0	0	1	1
1	1	0	0	0	0	0	0
1	1	0	1	–	–	–	–
1	1	1	0	0	1	1	0
1	1	1	1	1	0	0	1

3. (a) Define a transistor model. (1 mark)

(b) Figure 1 shows a circuit diagram of a common-emitter amplifier. The silicon transistor Q has $\beta = 200$, $V_{BE} = 0.7\,V$ and the resistance of the emitter diode $r = \frac{25}{I_E(mA)}\Omega$.

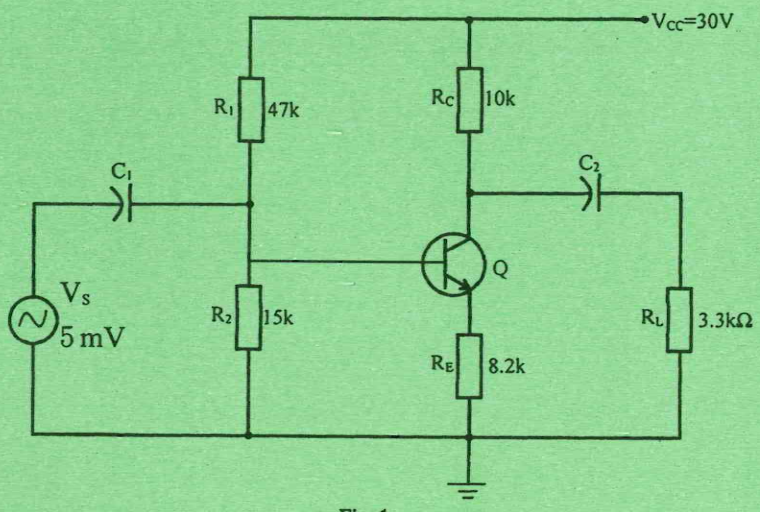

Fig. 1

(i) Draw the equivalent circuit diagram of the amplifier.

(ii) Determine the:

I. Thevenin input voltage;
II. Thevenin input resistance;
III. emitter-base diode resistance, r_e
IV. output a.c load resistance;
V. voltage gain. (13 marks)

(c) Briefly describe the working of each of the following display devices:

(i) cathode ray tube (CRT);
(ii) liquid crystal display (LCD). (6 marks)

4. (a) Define each of the following with respect to analog-to-digital converters (ADCs):

(i) conversion speed;
(ii) monotonicity. (2 marks)

(b) With aid of a block -schematic diagram, describe the counter-based ADC. (6 marks)

(c) A 32 KX8 RAM is made from 8KX8 RAM chips. The RAM memory starts form address 1000H.

(i) Determine the:

I. number of RAM chips required;
II. memory address range of each RAM chip;
III. size of decoder required.

(ii) Draw a schematic block diagram of the memory implementation. (12 marks)

5. (a) State **three** advantages of field effect transistors (FETs) over bipolar junction transistors (BJTs). (3 marks)

(b) Figure 2 shows the characteristic curve of a MOSFET.

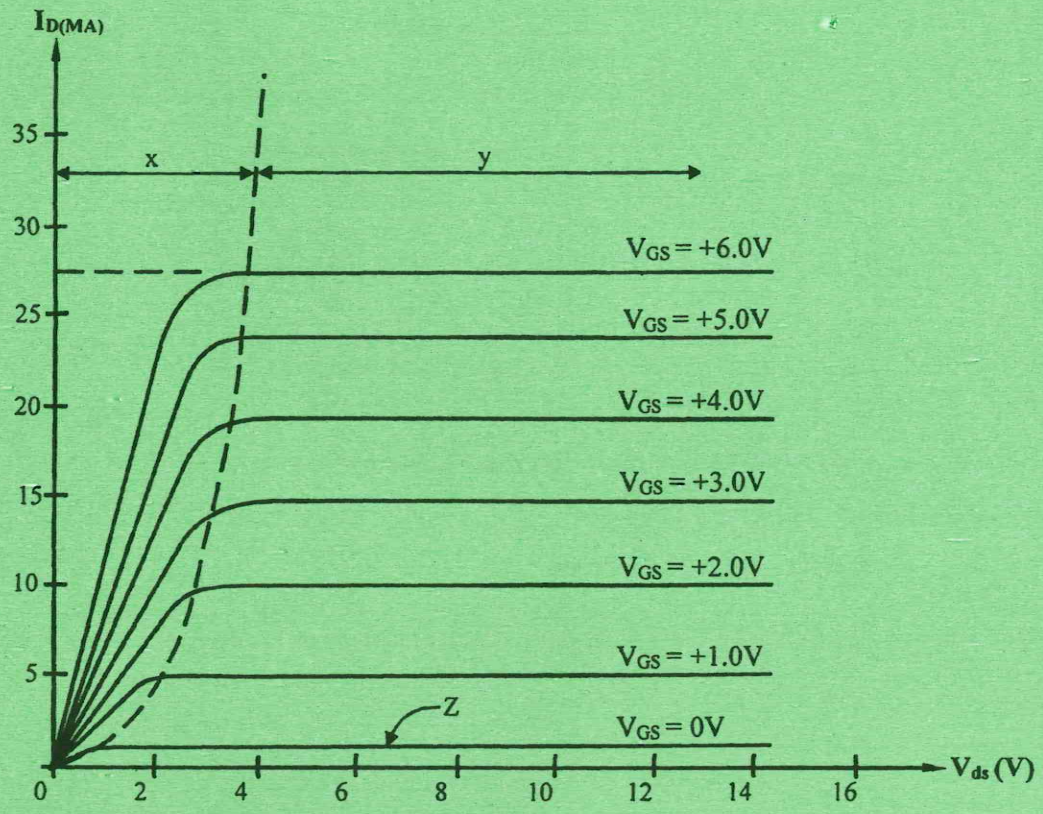

Fig. 2

(i) Identify the regions labelled x, y and z and explain their significance.

(ii) Distinguish between enhanced and depletion modes of operating MOSFETs.

(8 marks)

(c) Figure 3 shows a block diagram of a negative feedback amplifier where A is the gain without feedback and β is the feedback factor.

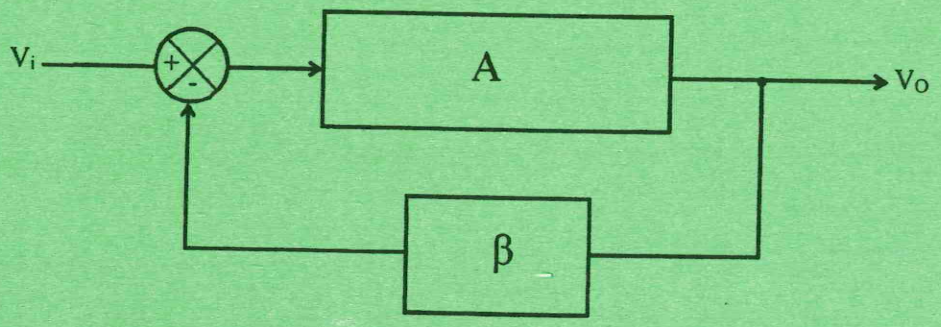

Fig. 3

(i) Derive the expression of the gain with feedback.

(ii) An amplifier has a gain of 1000 and a negative feedback of 0.22. Determine the voltage gain with feedback.

(iii) State **three** effects of negative feedback on an amplifier. (9 marks)

SECTION B: CONTROL SYSTEMS

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

6. (a) A control system is described by the following open-loop expression.

$$G(s)=\frac{10(s+2)(s-4)}{s(s+1)(s+3)}$$

(i) Determine the:

I. poles;
II. zeros.

(ii) Sketch the poles and zeros on a s-plane.

(iii) State with reasons the stability of the system. (9 marks)

(b) A unity feedback system has an open-loop transfer function

$$G(s)=\frac{k}{s(s+10)}$$

(i) Determine the:

I. characteristic equation;
II. value of k so that the system will have a damping ratio of 0.5.

(ii) For this value of k determine, for a unit step input, the:

I. settling time;
II. percentage peak overshoot. (11 marks)

7. (a) With aid of block diagrams, describe each of the following:

(i) transfer function;
(ii) series compensation. (6 marks)

(b) A signal flow graph is described by the following linear equations:

$$y = y_1 + \alpha U$$
$$\dot{y}_1 = -\beta y_1 + y_2 + \alpha_2 U$$
$$\dot{y}_2 = -\beta_2 y_1 + \alpha U$$

(i) Determine the transfer function of the equations using Laplace transforms.

(ii) Draw the signal flow diagram.

(iii) Using Mason's rule, determine the transfer function of the system. (14 marks)

8. (a) State **two** advantages of servomotors over stepper motors with respect to control system. (2 marks)

(b) A unity feedback control system is described by the open-loop transfer function:

$$G(s)=\frac{k}{s(s^2+2s+2)(s^2+6s+10)}$$

Determine each of the following with respect to root locus:

(i) the zeros;
(ii) the poles;
(iii) centroid;
(iv) asymptotic angles. (8 marks)

(c) Figure 4 shows a Nichols plot for a control system. Determine the:

(i) phase margin;
(ii) gain margin;
(iii) peak value of closed-loop gain response, Mp;
(iv) resonant frequency;
(v) bandwidth. (10 marks)

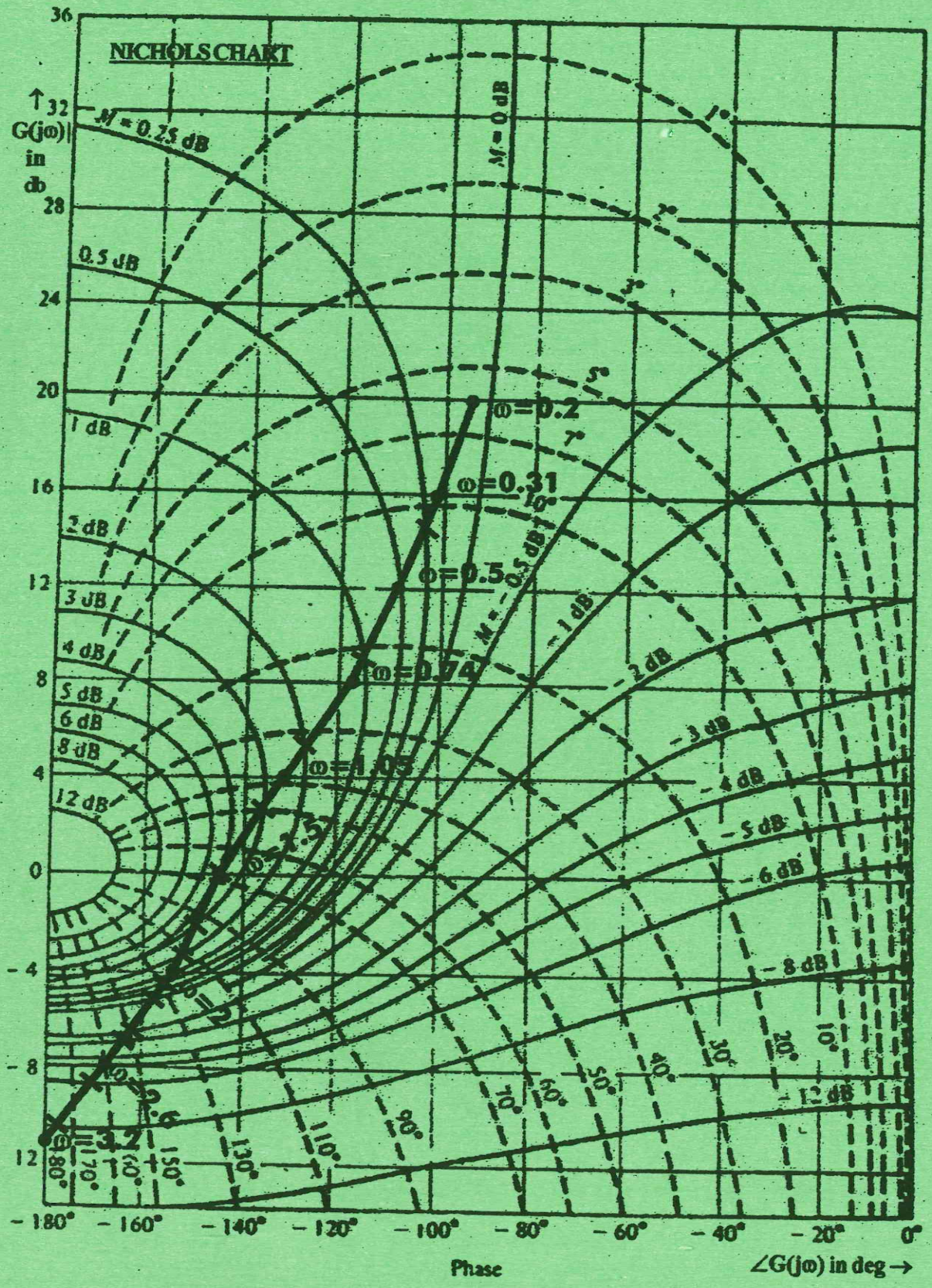

Fig. 4: *Nichols plot of G(jω)*

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