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CONTROL SYSTEMS
Oct./Nov. 2011
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRONICS ENGINEERING
DIPLOMA IN TELECOMMUNICATION ENGINEERING
DIPLOMA IN ELECTRICAL ENGINEERING (POWER)

CONTROL SYSTEMS

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Log linear graph paper;
Polar graph paper;
Mathematical tables/Electronic calculator.

*Answer any **FIVE** of the **EIGHT** questions in this paper.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.

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.

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(a) With the aid of a block diagram describe a closed loop control system, giving an example. (5 marks)

(b) Figure 1 shows a circuit diagram of an electric system. Determine its transfer function. (4 marks)

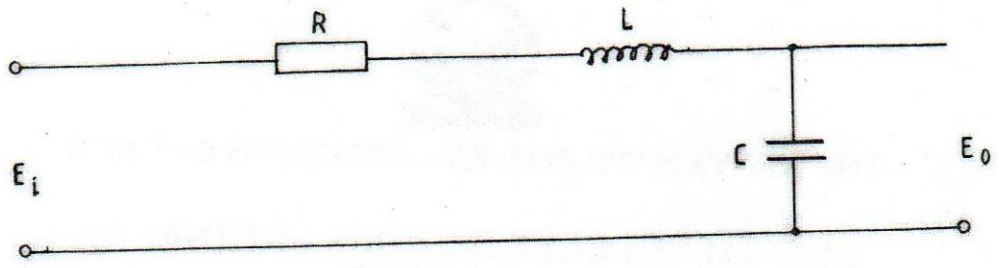


Fig. 1

(c) Figure 2 shows a block diagram of a closed loop control system. For the system:
(i) reduce it to its canonical form;
(ii) determine the closed loop transfer function.

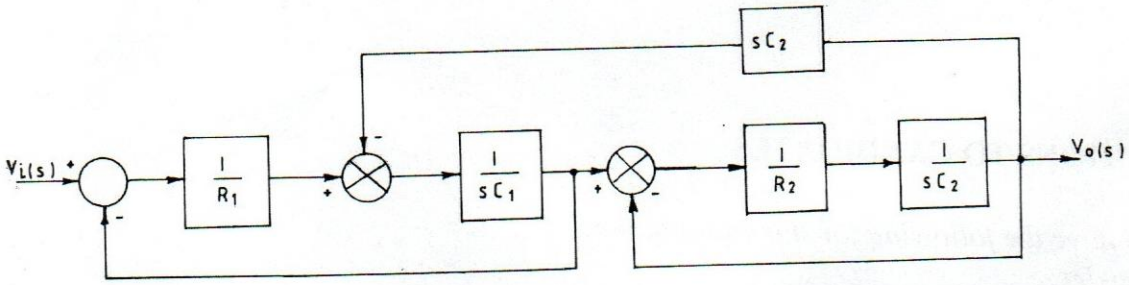


Fig. 2

(11 marks)

2. (a) Draw response curves for the following damped systems:
(i) critically damped;
(ii) under damped. (4 marks)

(b) A second order control system having a damping ratio of 0.5 and an undamped frequency of 6 rad/s is subjected to a unit stop input.
Determine the:
(i) rise time;
(ii) time to first overshoot;
(iii) settling time, assuming 2% tolerance. (7 marks)

(c) Figure 3 shows a closed loop system and its response curve when subjected to a unit step input. From the response curve determine the gain K and the time constant T of the system. (9 marks)

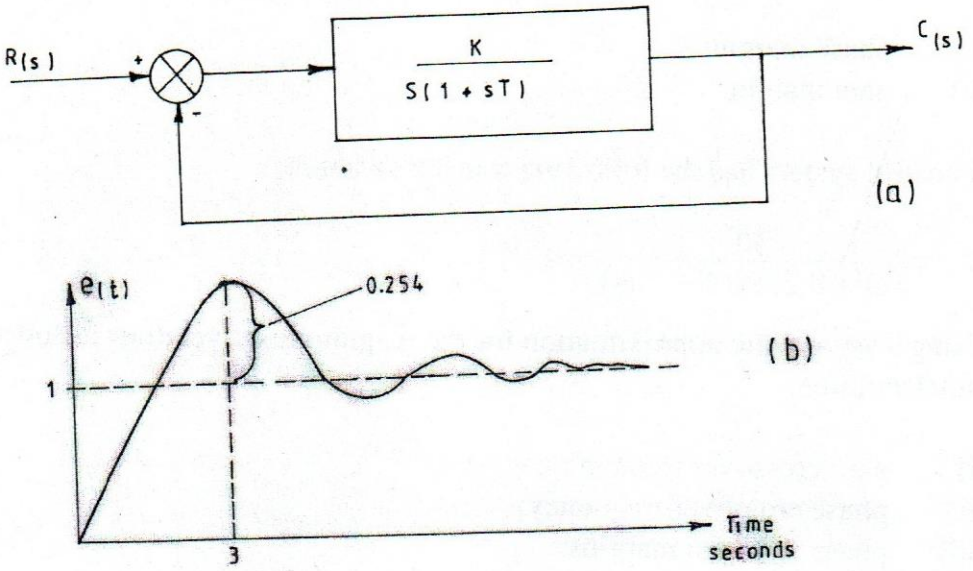


Fig. 3

3. (a) Define an actuator with respect to a control system. (1 mark)

(b) Draw a table comparing any **three** characteristic of a.c. and d.c. serve motors. (6 marks)

(c) Figure 4 shows a schematic block diagram of a water level control system incorporating an actuator. With the aid of a sketch explain how a pneumatic relay can be connected to the actuator to control the opening and closing of the valve. (11 marks)

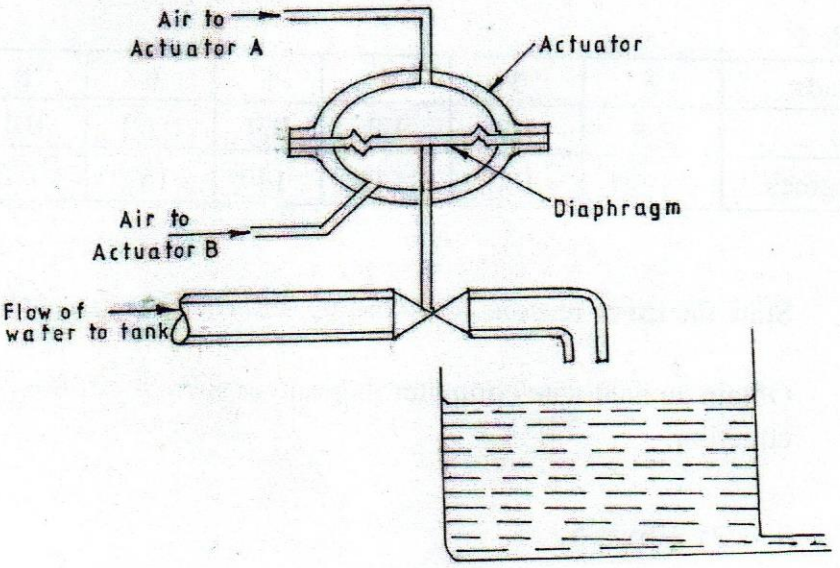


Fig. 4

(d) State any **two** advantages of pneumatic actuators over hydrautic actuators. (2 marks)

4. (a) Define the following with respect to system stability:

(i) phase margin;
(ii) gain margin. (2 marks)

(b) A control system has the following transfer function:

$$G_{(s)} = \frac{50}{s(1+0.25s)(1+0.1s)}$$

Using a asymptotic approximation for the magnitude curve, draw a Bode diagram and determine,

(i) gain crossover frequency;
(ii) phase crossover frequency;
(iii) phase and gain margins. (18 marks)

5. (a) (i) Explain the Routh-Hurwitz stability criterion.
(ii) Determine using Routh's method the stability of a system whose characteristic equation is given by:

$$s^4 + 2s^3 + 6s^2 + 4s + 1 = 0$$ (11 marks)

(b) Table 1 shows the open loop frequency response of a system.
(i) plot the Nyquist diagram and determine the stability margins.
(ii) comment on the stability of the system. (9 marks)

Table 1

W. rads	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
ø degrees	- 120°	- 130°	- 140°	- 149°	- 157°	- 170°	- 180°	- 200°

6. (a) (i) State the **three** reasons for avoiding differentiators in analogue computing.

(ii) Obtain an analogue computer diagram to solve the following differential equation.

$$\ddot{Y} + 7\dot{y} + 6y = 5.$$ (11 marks)

(b) (i) State the **three** reasons for time scaling when solving computing problems.

(ii) Obtain a scaled flow diagram for the equation $8\dot{x} + x = 0$ given that $x_{max} = 50$ and $x_o = 50$. (9 marks)

7. (a) Define the following with respect to process control.

(i) process lag;
(ii) self regulation;
(iii) control lag; (3 marks)

(b) Describe the operation of the following modes with respect to programmable controllers.

(i) I/O scan modes;
(ii) execution mode. (4 marks)

(c) Figure 5 shows an automatic bottle filling system. Describe its operation. (7 marks)

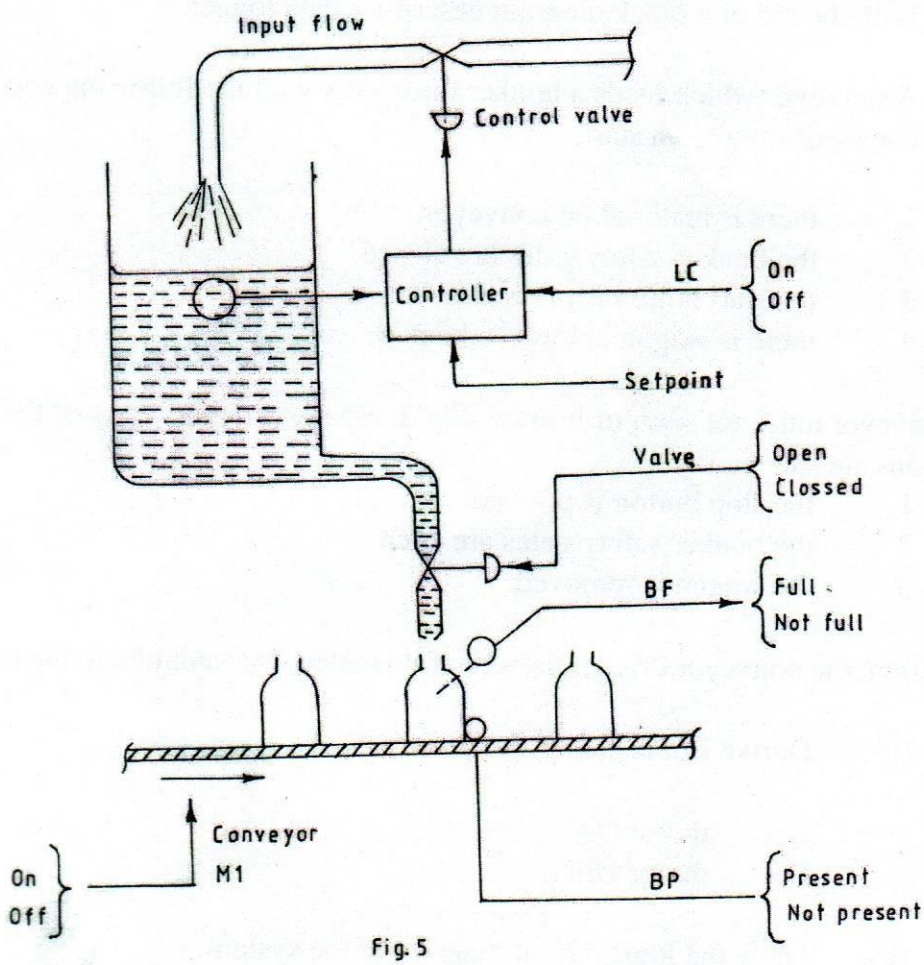


Fig. 5

(d) Figure 6 is a ladder diagram. Write a program to drive the output. (6 marks)

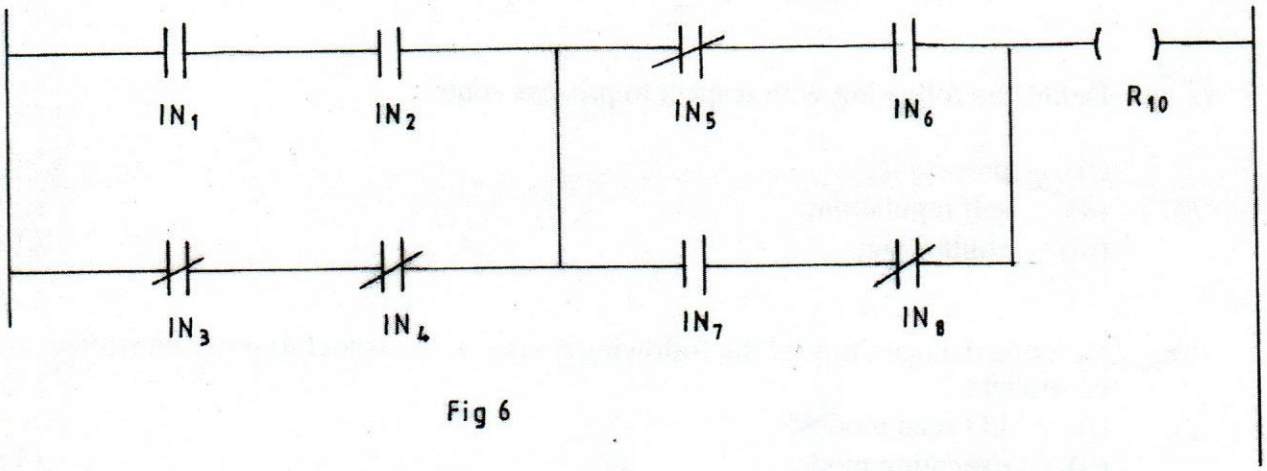


Fig 6

8. (a) State **three** application of computers in industry. (3 marks)

(b) With the aid of a block diagram describe a data logger. (8 marks)

(c) A conveyor which feeds a bunker must satisfy all the following conditions before the conveyor motor can start.

1. there is material on conveyor.
2. the bunker safety gates are closed.
3. the start button is pressed.
4. there is wagon below the bunker.

The conveyor must not start, or it must stop if already running if any of the following conditions are satisfied.

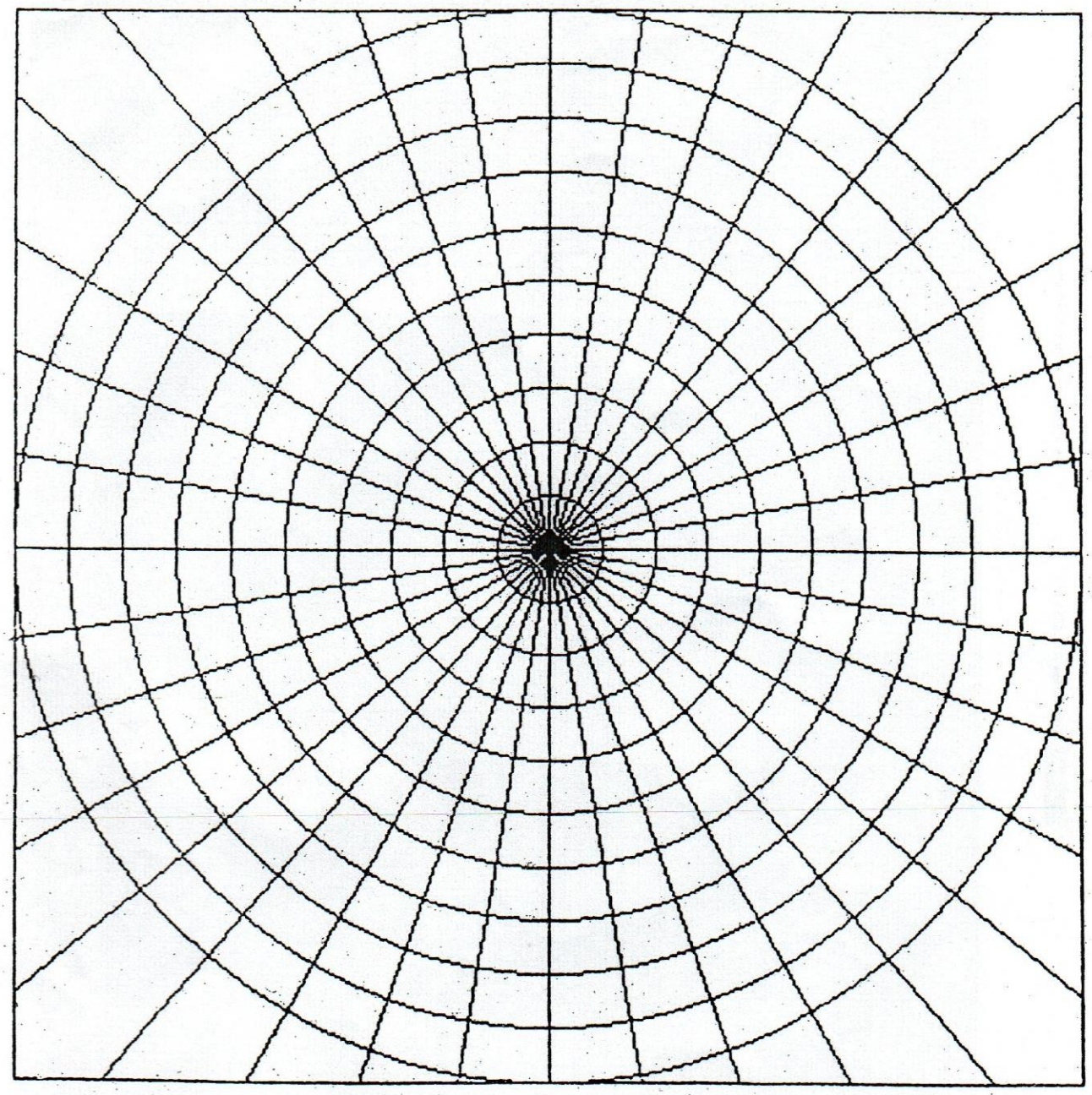
1. the stop button is pressed.
2. the bunker safety gates are open.
3. the wagon is removed.

In addition, the conveyor drive must stop if no material is supplied to the conveyor for 10s.

(i) Derive Boolean expression for:

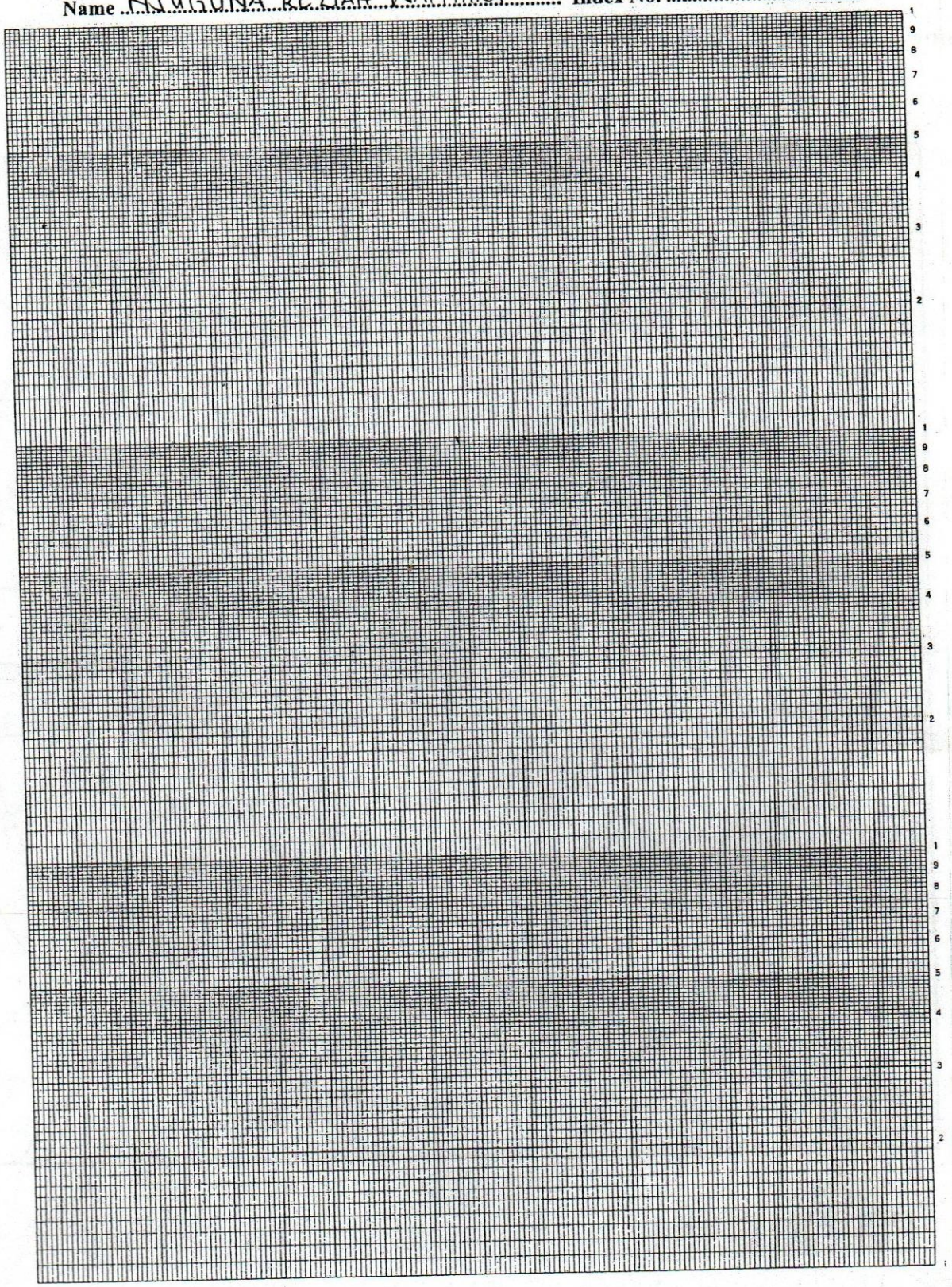
I. motor ON;
II. motor OFF.

(ii) Draw the logic circuit diagram of the system. (9 marks)



POLAR CURVE

Name NJUGUNA KEZIAH WAITHIRA Index No. 40108616045



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