2201/304
2203/304
2204/304
CONTROL SYSTEMS
Oct./Nov. 2008
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ELECTRONIC 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
1 Nichols Chart
Mathematical tables/Eletronic Calculator.

*Answer any **FIVE** of the following **EIGHT** questions.*
***ALL** questions carry equal marks.*
Maximum marks for each part of the question are shown.

This paper consists of 9 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and no questions are missing.

 Turn over

1. (a) Differentiate between the following as used in control systems:

(i) manipulated variable and controlled variable;
(ii) feedback element and feedback path. (4 marks)

(b) (i) State any **three** factors to be considered when selecting a pneumatic actuator for a particular purpose.

(ii) A stepper motor has 10° per step and must rotate at 250rpm. Calculate the input pulse rate. (5 marks)

(c) (i) Prepare a scaled computer flow diagram to obtain the following differential equation:

$\ddot{x}+70\dot{x}+6400x=5000x_i(t)$

where $x_i(t)$ is step input of one machine unit.

Take $X_{max} = 2$; $\dot{x}_{max} = 125$ and time scale factor = 10

(ii) State any **two** reasons why time scaling of the above equation in c(i) is necessary. (11 marks)

2. (a) (i) State the **three** steps used to derive the transfer function of an electrical network.

(ii) Figure 1 shows a control system used to maintain constant water level in the tank.

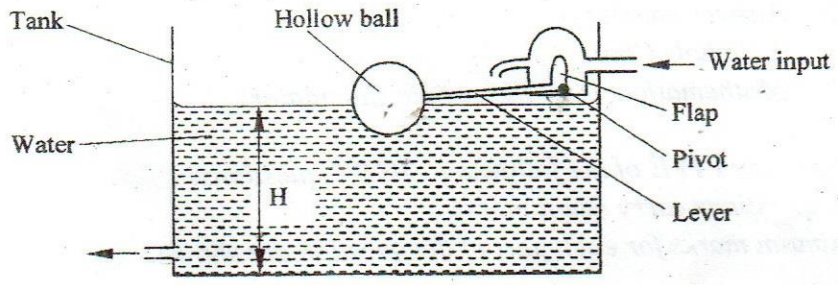


Figure 1

Identify the following:

I Controlled variable
II Error Signal
III Correction element
IV Measuring device.

(iii) State whether it is an open loop or closed loop system. (8 marks)

(b) For the system in Figure 2, determine:

(i) open loop transfer function
(ii) closed loop transfer function
(iii) error ratio.

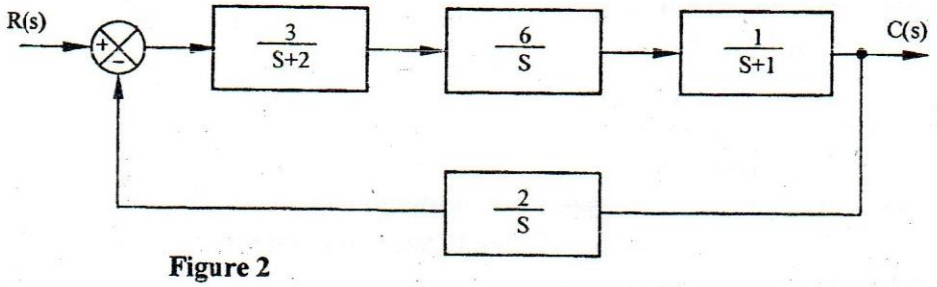


Figure 2

(4 marks)

(c) (i) Determine the transfer function of Figure 3.

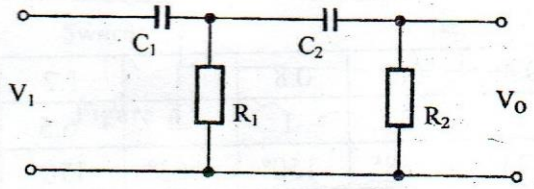


Figure 3

(5 marks)

(d) An amplifier has open loop gain of 10 and inherent distortion of 20%. It has a negative feedback of 10%.

Determine:

(i) closed loop gain;
(ii) closed loop distortion. (3 marks)

3. (a) State the effect of increasing the damping ratio for under damped system on the following:

(i) system response
(ii) overshoot
(iii) response time. (3 marks)

(b) For the open-loop response of control system shown in table 1.

(i) Draw a Nichol's plot.

(ii) Determine:

I Resonant peak value
II Resonant frequency
III Bandwidth
IV Gain margin
V Phase margin.

Table 1

Wrads	0.2	0.4	0.6	0.8	1	1.2	1.4	1.8
GdB	14.3	7	3	-1	-4	-6.5	-9	-13.5
Phaseø	-105°	-123°	-138°	-150°	-163°	-170°	-180°	-192°

(iii) Sketch the closed-loop response curve from Nichol's plot.

(14 marks)

(c) State the electrical equivalent for the following mechanical quantities:

(i) Mass M
(ii) Spring stiffness K
(iii) Viscous friction coefficient β. (3 marks)

4. (a) Differentiate the following as used in control systems.

(i) Linear and time variant systems
(ii) Reference input and actuating input. (4 marks)

(b) (i) State the **two** main reasons for using dc machines in control systems.
(ii) State the **two** limitations of Routh's stability criterion.
(iii) Explain one method of overcoming the limitations in b(ii).
(8 marks)

(c) For figure 4;

(i) Explain the operation of the system
(ii) State the functions of switches A and B.

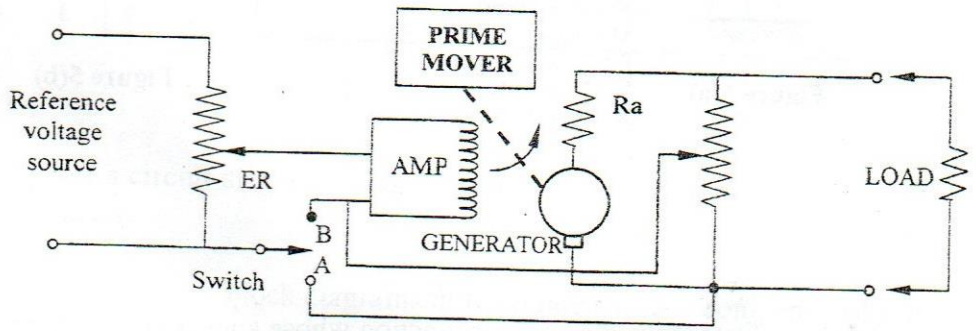


Figure 4

(8 marks)

5. (a) (i) State the nature of roots and system behaviour for the following damping ratio.

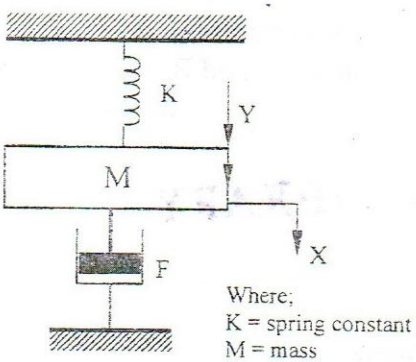
I $\delta > 1$

II $\delta = 0$ (4 marks)

(b) Figure 5(a) shows a mechanical vibratory system. When 12N of force is applied to the system, the mass oscillates as shown in Figure 5(b).

Determine the values of the following constants.

I K II M III F



Where;
K = spring constant
M = mass
F = viscous friction
Y = input force
X = displacement

Figure 5(a)

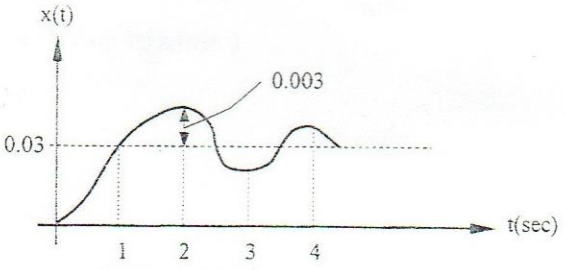


Figure 5(b)

(16 marks)

6. (a) Determine the transfer function whose approximate asymptotic plot is shown in figure 6.

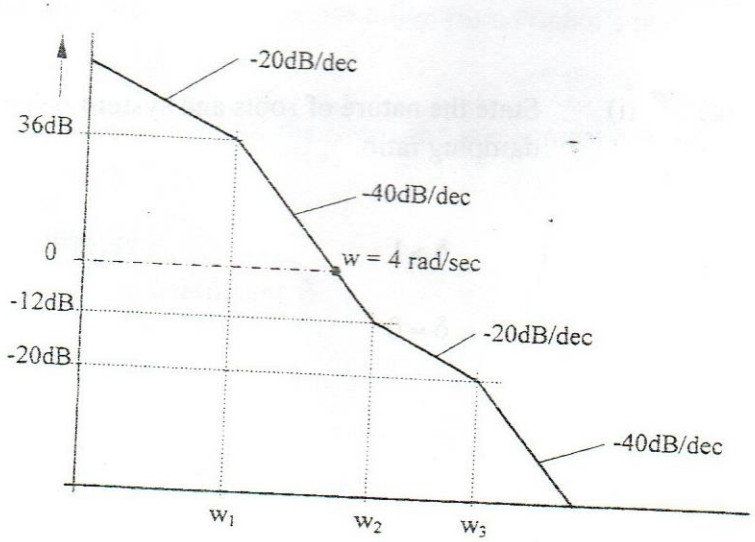


Figure 6

(9 marks)

(b) Figure 7 is a block diagram of a feedback control system employing error rate damping.

(i) In the absence of derivative feedback Ko, determine:

I. Natural frequency
II. Damping ratio
III. Steady state error resulting for unit ramp input.

(ii) Determine the derivative constant Ko which will increase the damping ratio of the system to 0.6.

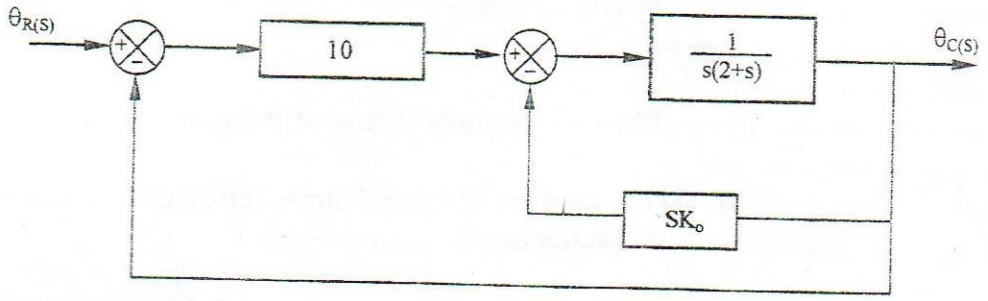


Figure 7

(11 marks)

7. (a) Draw a circuit diagram of lag-lead network and derive its transfer function. (6 marks)

(b) With the aid of block diagrams differentiate cascade compensated and feed back compensated systems. (4 marks)

(c) For figure 8

(i) Derive the expression for output f
(ii) Draw equivalent simplified logic diagram (8 marks)

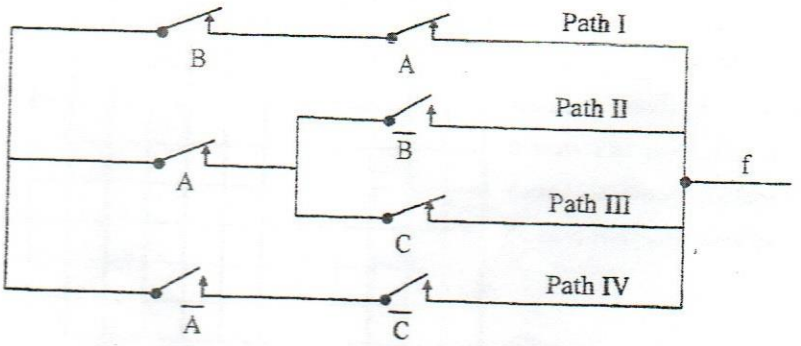


Figure 8

(d) State any **two** advantages of PLC over relay board panels. (2 marks)

8. (a) (i) Differentiate between control lag and process lag.

(ii) Compare digital controller and analog controller. (5 marks)

(b) With the aid of a block diagram describe the features of a digital control system. (8 marks)

(c) An analog digital converter has 12-bits output.
Determine:

(i) its resolution;
(ii) dynamic range.

(4 marks)

(d) (i) Draw an electronic circuit of Proportional-plus Integral controller.

(ii) For the error of figure 9 draw corresponding waveform of the controller output in d(i).

(3 marks)

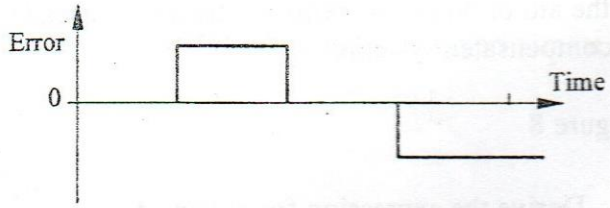


Figure 9

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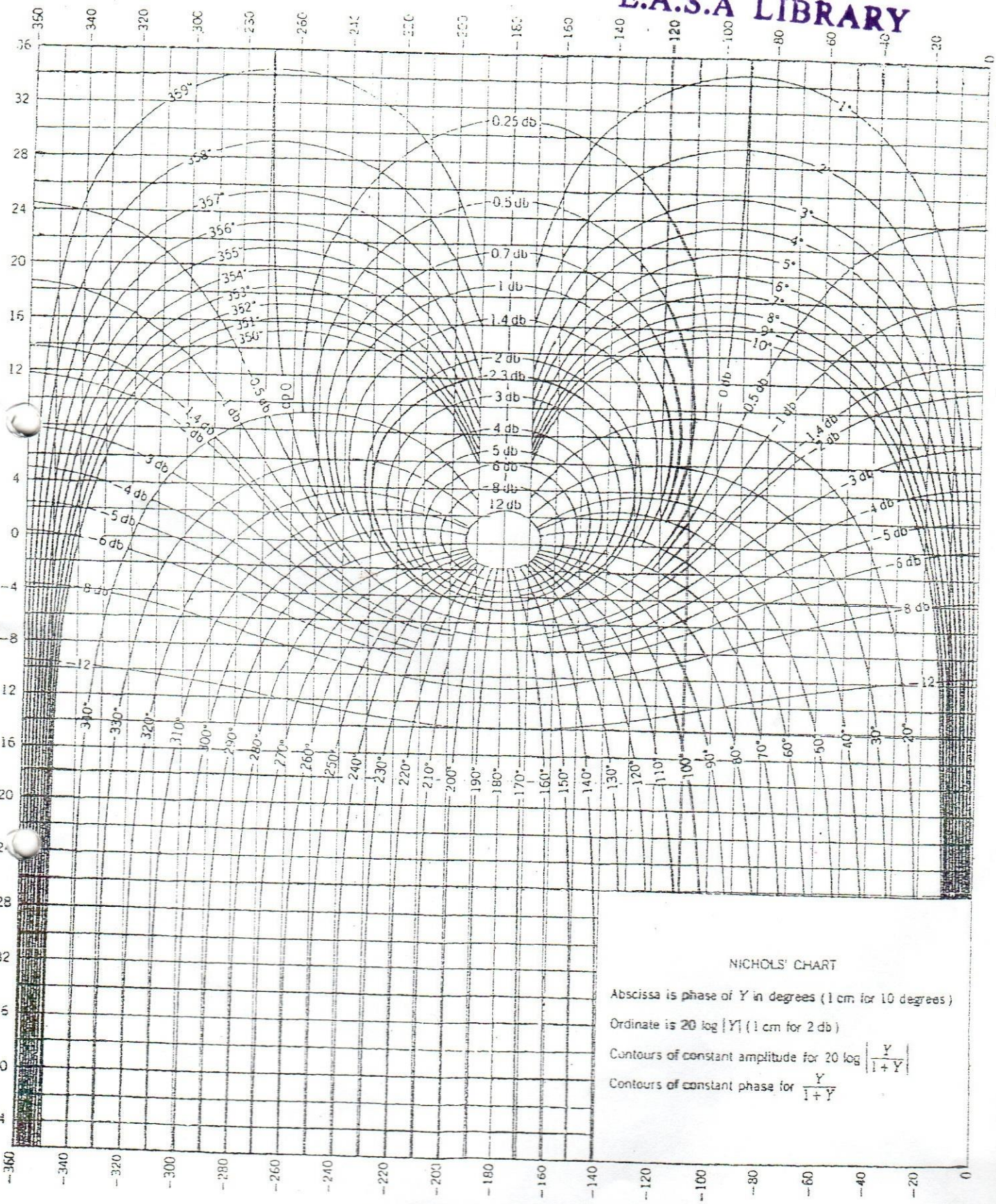

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