THE KENYA POLYTECHNIC

ELECTRICAL/ELECTRONICS ENGINEERING

DEPARTMENT

HIGHER DIPLOMA IN ELECTRICAL ENGINEERING

END OF YEAR II EXAMINATIONS

NOVEMBER 2006

CONTROL SYSTEMS

3 HOURS

INSTRUCTIONS TO CANDIDATES:

You should have the following for this examination:

Answer booklet

Calculator/Mathematical tables

Answer any FIVE of the following EIGHT questions.

All questions carry equal marks and the maximum marks for each part of a question are as shown.

This paper consists of 5 printed pages.

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1. (a) State the need for compensation in control systems. (2 marks)

(b) (i) Draw labeled bode plots for:

I. A phase lead network

II. A phase lag network

(ii) Name any TWO effects for each of the networks in (b)(i) on a control system. (8 marks)

(c) (i) Show that the maximum phase shift provided by a lead network is given by: $\phi_{\max} = Tan^{-1}\left(\frac{1-\alpha}{2\sqrt{\alpha}}\right)$. State all the assumptions made.

(ii) Design a compensating network for a system whose open loop frequency response is given in table 1 for a phase margin of at least 65^0. (12 marks)

Table 1:

ω	1	2	3	5	10	12	14	20
Magnitude (dB)	3	-7	-13.5	-22	-34	-37	-40	-46
Phase lag (degrees)	135	153	162	169	174	175	176	177

2. (a) (i) Explain how the stability of a control system may be determined from a Nyquist plot.

(ii) State the disadvantages of the Nyquist plot over the Bode plot. (5 marks)

(b) Derive expressions for radii of the constant magnitude (M) circles and constant phase (Φ) circles for a closed loop system. (5 marks)

(c) A control system with feedback has an open loop transfer function $G(S) = \frac{10}{S(1+0.1S)(1+0.5S)}$.

(i) Draw the Nyquist diagram.

(ii) Determine the phase and gain margins.

(iii) Deduce whether the system is stable or not. (10 marks)

3. (a) Draw a labeled diagram of a process control system and explain the function of each block. (10 marks)

(b) A control system with unity negative feedback has a forward transfer function given by $\frac{K}{S(S+1)(S+3)}$. Determine:

(i) The value of K when the damping ratio is 0.5.

(ii) The value of the breakaway point. (10 marks)

4. (a) State TWO advantages of numerical machine tool control over conventional machine control. (2 marks)

(b) Explain with the aid of a block diagram how integral control may be used to eliminate steady state error. (11 marks)

(c) A unity feedback system has an open loop transfer function given by $G(S) = \frac{100}{S^2(0.1S+1)}$. Determine the steady state error. (7 marks)

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

(i) Gain cross over frequency

(ii) Phase cross over frequency (2 marks)

(b) A system has an open loop transfer function given by $G(S) = \frac{10}{S(1+S)(1+0.02S)}$. The phase plot details are given in table 2.

ω rad/s	1.0	2	3	4	5	6	10	50
Arg G(jω) degrees	-136	-156	-165	-171	-175	-178	-186	-224

Using asymptotes, draw the bode plot and determine:

(i) The phase cross over frequency

(ii) The gain cross over frequency

(iii) The gain and phase margins

(iv) The stability of the system (10 marks)

(b) The open loop frequency response of a unity feedback control system is given in table 3:

Table 3:

ω rad/s	0.1	0.5	1.0	1.5	2.5	3.5	4.5	5.5
GH (dB)	34	19.7	12.6	7.8	-0.7	-4.7	-9	-12.7
Phase lag (degrees)	94	109	127	140	160	174	184	192

Plot a Nichol's chart and determine:

(i) The closed loop frequency response

(ii) The maximum magnitude (Mp) and frequency (ωp) at which it occurs

(iii) The bandwidth of the system (8 marks)

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

(i) Set point (ii) Offset (2 marks)

(b) With the aid of a labeled block diagram describe the operation of a typical Direct Digital Control System. (10 marks)

(c) Explain with the aid of a labeled diagram a microprocessor temperature control system. (8 marks)

7. (a) State THREE advantages of using programmable logic controllers (PLCs) in industrial control systems. (3 marks)

(b) With the aid of a block diagram describe the basic components of a PLC stating their functions. (11 marks)

(c) Draw ladder diagrams to carry out the following tasks:

(i) Switch on a lamp if there is an input from sensor A or sensor Y, then activate the solenoid valve if sensor A only gives an input. If both sensors A and Y are "ON" a relay should be switched on.

(ii) Switch on a motor by pressing a spring-return push-button start switch. The motor should remain on until another spring-return push-button stop switch is closed. (6 marks)

8. (a) (i) Outline the merits of using stepper motors in digital control circuits.

(ii) Explain with the aid of a block diagram a flow chart how a stepper motor can be controlled directly by a microprocessor.

(13 marks)

(b) With the aid of a diagram, describe a light intensity detector buffer.

(4 marks)

(c) Draw the logic diagram of a 4-to-1 data selector. (3 marks)