MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING AND TECHNOLOGY

UNIVERSITY ORDINARY EXAMINATION

2021/2022 ACADEMIC YEAR

YEARSEMESTEREXAMINATION FORBACHELOR

EET308– CONTROL ENGINEERING II

DURATION:2 HOURS

INSTRUCTIONS TO CANDIDATES:

1. Answer question One and Any Other Two questions.
2. Mobile phones are not allowed in the examination room.
3. You are not allowed to write on this examination question paper.

QUESTION ONE (30 MARKS)

a) Define a parallel compensator. Illustrate your solution using a relevant schematic diagram. (3 marks)

b) Explain why Bode plots are commonly used in the frequency domain design. (2marks)

c) A simple and commonly used network is shown in figure 1.0 below

  i. Identify the type compensation network in the figure (1 mark)

  ii. Derive the transfer function of this network taking into account the compensation. (5 marks)

  iii. Sketch the pole zero plot of this compensation network. (2 marks)

d) Define the term state variable. Outline any three advantages of state variable techniques (4 marks)

e) The state equation a LTI system is given by: $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} 4$

Determine the STM. (3 marks)

f) A closed loop control system with unity feedback is shown in figure 2.0. By using derivative control, the damping ratio is to be made 0.7. Determine the value of T_d. The input to the system is a unit step function. (6 marks)

g) With the aid of a relevant diagram, sketch the PLC architecture labelling all parts clearly. (4 marks)

QUESTION TWO (20 MARKS)

a) When a plant required both the transient and steady-state response improvement, a lag- lead compens5tro is employed. With the aid of a relevant schematic diagram. Sketch a lag lead compensator and derive its transfer function. Also obtain the poles and zeros of the transfer function and sketch the pole –zero diagram. (10 marks)

b) A mixer motor is to be automated using a PLC to automatically stir the liquid in the Vat when the temperature and pressure reach present values. An alternate manual push button control of the metre is to be provided. Also, the temperature and pressure sensor switches close their reflective contacts when conditions beach their present values. Using the ladder logic diagram:

  i. Draw its required relay ladder, diagram to control this process and label all components. (4 marks)

ii. Extract the PLC ladder logic program from (i) above and with a ladder logic program to implement and achieve the desired specifications. (6 marks)

QUESTION THREE (20 MARKS)

a) A system is characterised by the following transfer function

$$\frac{y(s)}{u(s)} = \frac{2}{s^3 + 6s^2 + 11s + 6}$$

Find the state and output equation in matrix from and also test the controllability and observability of the system. (10 marks)

b) Design a Cascade compensation for a system whose transfer function is.

$$G(s) = \frac{\text{K}}{s(1 + 0.1s)(1 + 001s)}$$

This design should fulfil the following specifications:

i. Phase margin$\geq 45°$

ii. Velocity constant Kv=1000sec^{-1} (10 marks)

QUESTION FOUR (20 MARKS)

a) A feedback system employing output rate damping is shown in figure 3.0

i. In the absence of derivative feedback (K_0 = 0), determine the damping factor and natural frequency of the system. What is the steady state error resulting from unit ramp input? (5 marks)

ii. Determine the derivative feedback constant K_0 that will increase the damping factor of the system to 0.6. What is the steady state errors resulting from unit ramp input with the setting of the derivative feedback constant? (5 marks)

b) i) Define the terms controllability and observability as used in control engineering. (2marks)

ii) Based on your definition in (i) above, determine the state controllability and observability of the following system.

$$A= \begin{bmatrix} -1 & 1 & 0 \\ 0 & -3 & 2 \\ 0 & 0 & -8 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}, \quad C = [1 \quad 0 \quad 1]$$

(8 marks)