MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONIC ENGINEERING)

EEE311: CONTROL SYSTEMS II

DATE: **TIME:**

INSTRUCTIONS:

- Answer Question ONE and any other two questions.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Explain FOUR characteristics of a good control system. (4 marks)

b) The transfer function of a given system is given by:

$$\frac{C_s}{R_s} = \frac{S^2 + 1}{(s-1)(s-2)(s-3)}$$

Write down the canonical state variable form for the system and draw its block diagram also in the state variable form. (6 marks)

c) Briefly explain the main disadvantage of frequency domain analysis and design of feedback control systems. (4 marks)

d) Figure 1, is Bode plot for phase lead network transfer function. By derivation, proof that $\omega_M = \frac{1}{\tau\sqrt{\alpha}}$ (6 marks)

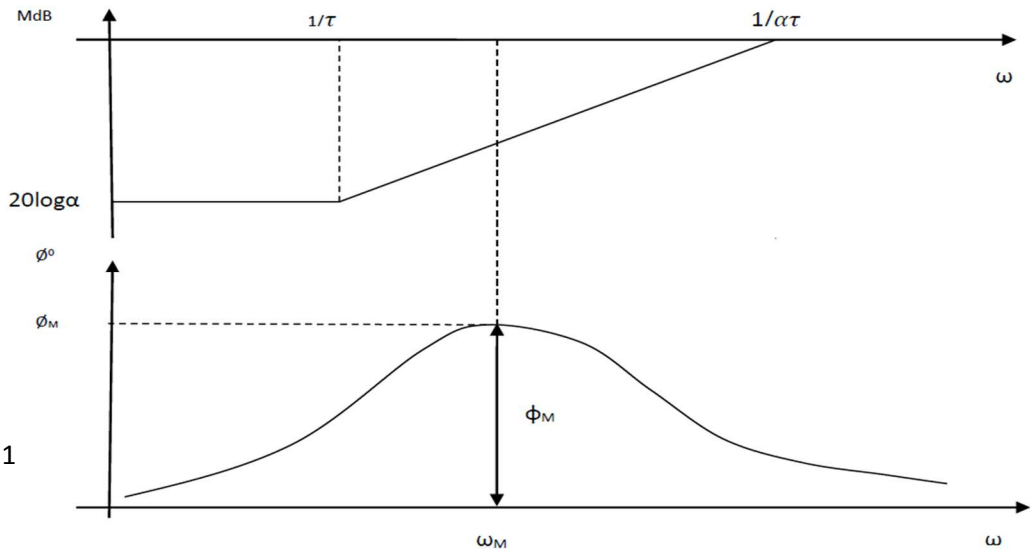

Fig. 1

e) Determine the values of R_1 and R_2 of an electronic PI- controller in fig.2 with a proportional gain of 2 and an integral action of 50 seconds. Use 10 μF capacitor. If the controller has no output at t=0, using the error graph given below, deermine the controller output at the following times:

i. At t=15 seconds
ii. At t=75 seconds
iii. At t=90 seconds. (10 marks)

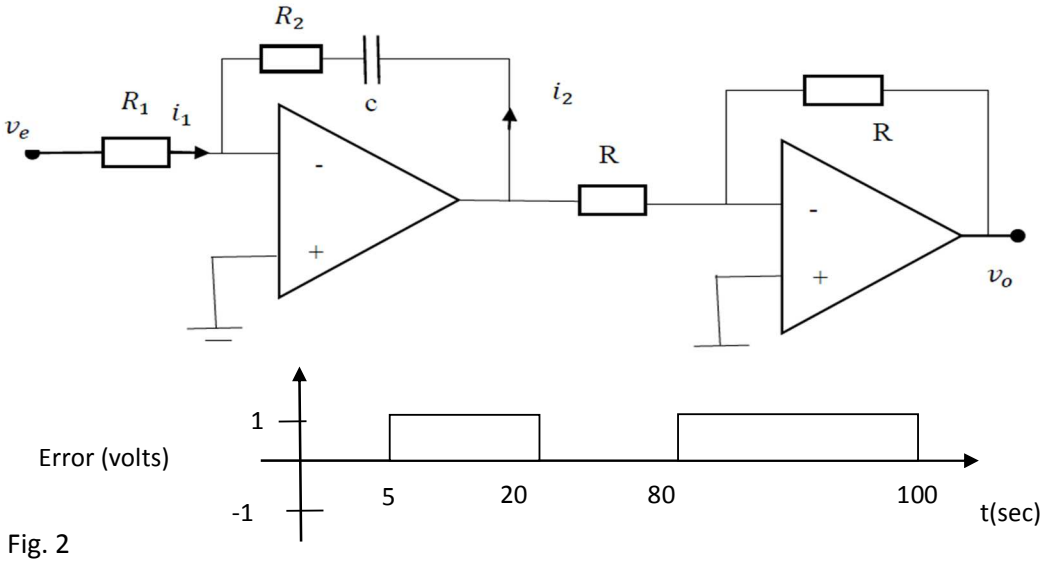

Fig. 2

QUESTION TWO (20 MARKS)

a) Compensators are sub-systems used to compensate the deficiency in the performance of the main system. Using diagrams, explain THREE ways how these sub-systems are introduced in the main system. (6 marks)

b) Briefly explain why dc gain of the lead compensator is set to unity. (3 marks)

c) Diagram in fig. 3 shows the variation of the error signal of an ON-OFF controller. Sketch the waveform of the controller output waveform. (4 marks)

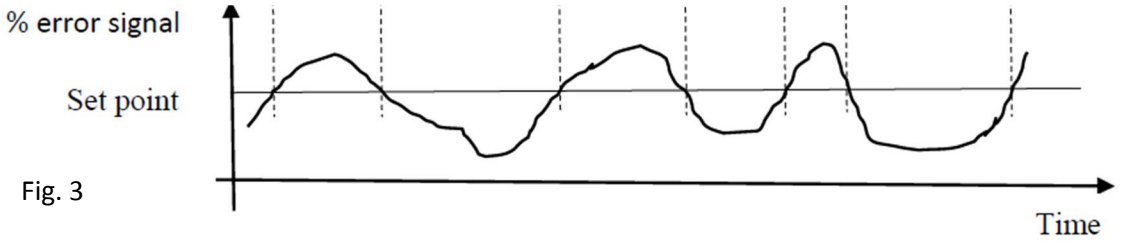

Fig. 3

d) With reference to the proportional controller, explain the term proportional band. (3 marks)

e) Explain what is meant by linear independence while selecting the state variables. (4 marks)

QUESTION THREE (20 MARKS)

a) Sketch a well labelled diagram of a lead lag compensator. (4 marks)

b) For the network shown in fig.4:

i. Derive the transfer function $V_{0(S)}/V_{I(S)}$

ii. Sketch the Bode plot

iii. Explain briefly how it can be used as a compensator. (8 marks)

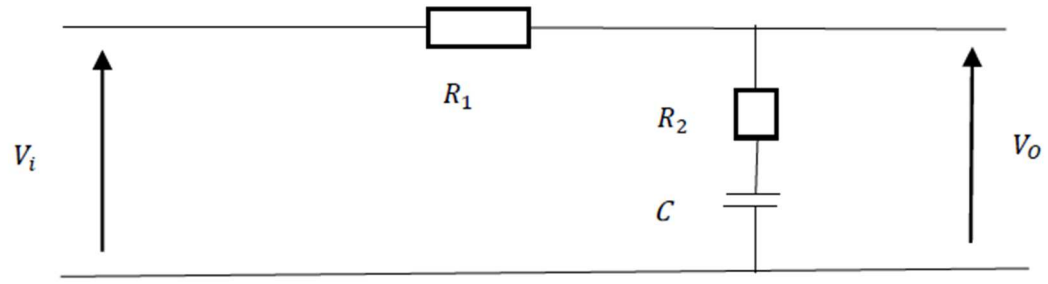

Fig. 4

c) For the electrical network shown in fig.5, find the state space representation if the output is the current through the resistor. (8 marks)

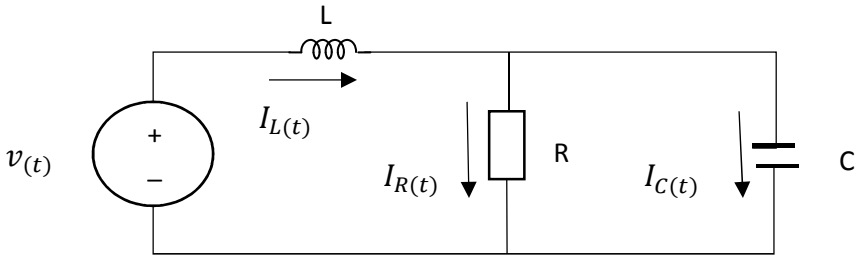

Fig. 5

QUESTION FOUR (20 MARKS)

a) Find the state representation in phase variable form for the given transfer function. (8 marks)

$$\frac{C_{(S)}}{R_{(S)}} = \frac{24}{S^3 + 9S^2 + 26S + 24}$$

b) Figure 6 shows the output of an ideal derivative controller. Sketch a well labelled waveform of the input signal to the controller. (4 marks)

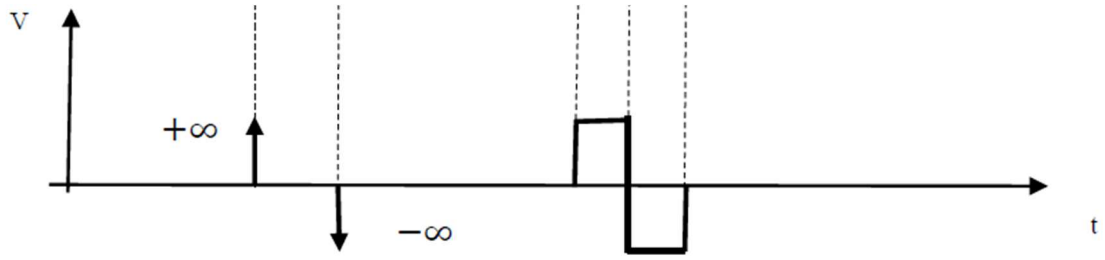

Fig. 6

c) Design a phase lead compensating network to achieve a phase margin of 30^0 for a system whose transfer function is given by: - (8 marks)

$$G_{(s)} = \frac{50}{(S+2)(s+4)(s+5)}$$

QUESTION FOUR (20 MARKS)

a) Explain any THREE advantages of state space analysis and design of feedback control systems compared to frequency domain approach. (3 marks)

b) Design a phase lag network for the following system for a phase margin of at least 50^0. (8 marks)

$$G(S) = \frac{7}{S(1+0.5S)(1+0.167S)}$$

c) Figure 7 shows the output of an integral controller where V_0 is the output at t= 0. Sketch a well labelled waveform of the input signal to the controller. (4 marks)

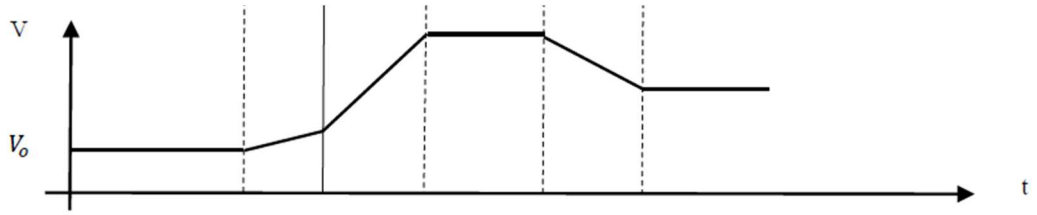

Fig. 7

d) With aid of well labelled diagram, derive the output expression of a proportional controller. (5 marks)