



MACHAKOS UNIVERSITY

University Examinations for 2019/2020 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 311: CONTROL SYSTEMS II

DATE: 24/11/2020

TIME: 2.00-4.00 PM

INSTRUCTIONS

Answer Question One and Any Other Two Questions

Requirements

Bode plot graph paper

QUESTION ONE (30 MARKS)

- a) A system has a transfer function given below. Design a phase lead network to ensure the phase margin is 45 degrees. (10 marks)

$$G(s) = \frac{17.783}{s(1 + 0.5s)(1 + 0.05s)}$$

- b) Discuss the functions of the following controllers PI, PD and PID. (6 marks)
- c) For the system shown in fig.1, choose $v_1(t)$ and $v_2(t)$ as the state variables. Determine the state equations in the vector matrix form. (7 marks)

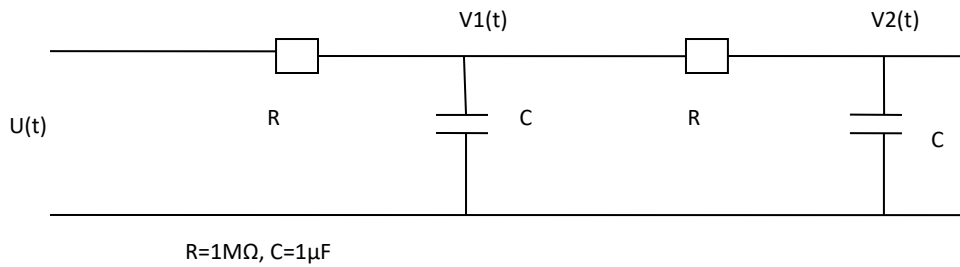


Fig. 1

- d) Name three areas of application for two position controller can be used. (3 marks)
- e) Briefly explain what is meant by ‘the state of a dynamic system’. (4 marks)

QUESTION TWO (20 MARKS)

- a) Derive the transfer function of the electrical network in fig.2. If the network is used as lead-lag compensator, give the general transfer function and sketch its magnitude and phase bode plots. (10 marks)

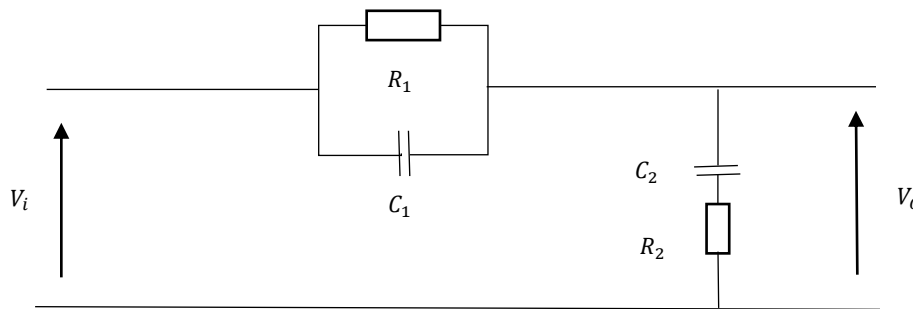


Fig. 2

- b) With aid of a diagram describe proportional band. (4 marks)
- c) Draw the canonical block diagram representation for the system whose transfer function is given below. (6 marks)

$$T(s) = \frac{s^2 + 1}{(s+1)(s+2)(s-3)}$$

QUESTION THREE (20 MARKS)

- a) The Bode plots for a certain electrical network is shown in fig. 3. The network is used as a lag compensator. Discuss the steps used when using the network to compensate a controlled system. (10 marks)

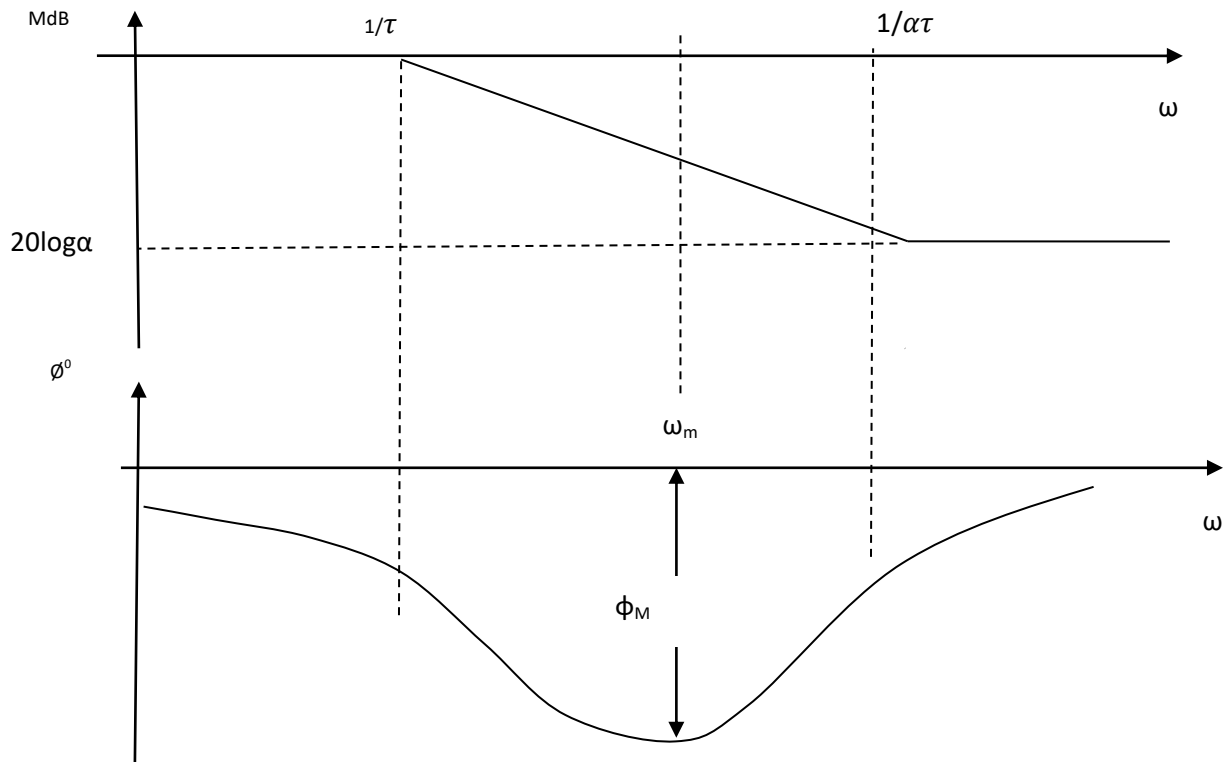


Fig. 3

- b) With aid of well labelled diagram, derive the expression showing the relationship between the input and output signal of a proportional plus integral controller. (6 marks)
- c) Describe the following terms:
- Controllability
 - Observability
- (4 marks)

QUESTION FOUR (20 MARKS)

- a) When using canonical state model, diagonalization of matrix is necessary. This is facilitated by use of eigenvectors. Let $A = \begin{pmatrix} 10 & -8 \\ 4 & -2 \end{pmatrix}$. Find all eigenvalues of A. (8 marks)
- b) With aid of diagrams, discuss three ways in which a compensator can be introduced into a controlled system. (6 marks)
- c) A PI controller has proportional gain of 4 and an integral action of 40. It was subjected to a continuous error signal of 1.0 millivolt. Determine the controller output after 20 seconds. (6 marks)

QUESTION FIVE (20 MARKS)

a) For the controller in fig. 4:

- i. Derive the time domain expression of its output signal.
- ii. Sketch the output waveform from the given input waveform. (10 marks)

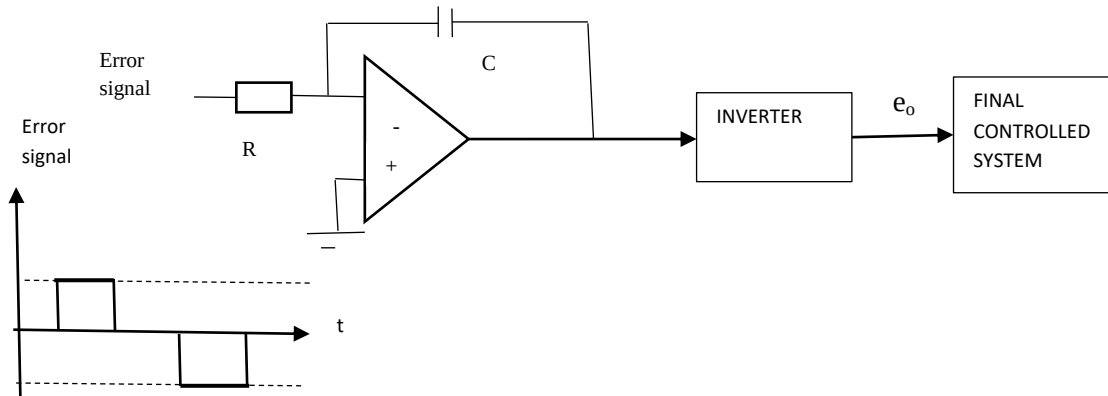


Fig.4

- b) State any THREE effects of phase lead network. (4 marks)
- c) Construct the state model for a system characterized by the differential equation below and give the block diagram representation. (6 marks)

$$\frac{d^3y}{dt^3} + 4\frac{d^2y}{dt^2} + 8\frac{dy}{dt} + 4y = 20u$$