MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONIC ENGINEERING)

EEE 311: CONTROL SYSTEMS II

DATE: 14/12/2021 **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

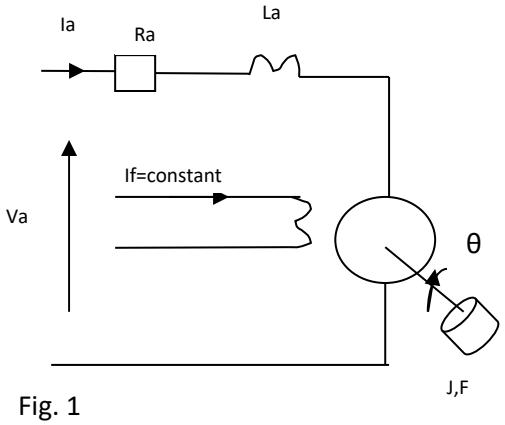
Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS)

a) Sketch pole zero plot for phase lag network. (2 marks)

b) Draw a block diagram representation of a state model of a linear multi-input-multi-output system. (3 marks)

c) An electromechanical system and its block diagram are shown in fig. 1. Choosing state variables as $x1 = \theta, x2 = \frac{d\theta}{dt}, and\ x3 = ia$, determine the state variable model. θ is output (9 marks)



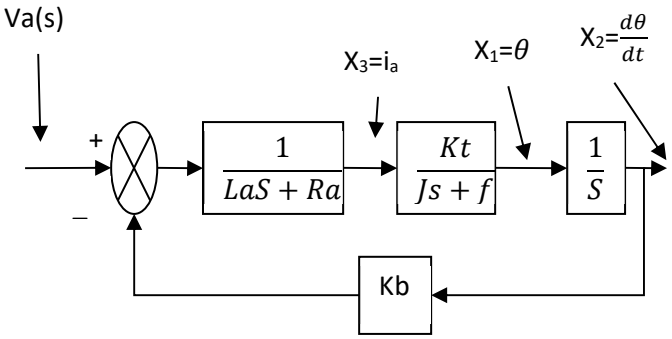


Fig. 1

d) Design a phase lag compensating network to achieve a phase margin of 60^o for a system whose transfer function is given by:- 10 marks)

$$G_{(s)} = \frac{10}{S(1+0.1S)(1+0.01S)}$$

e) With of diagrams briefly discuss how a two position controller works. Give one example of an area of application. (4 marks)

f) Define proportional band of a proportional controller. (2 marks)

QUESTION TWO (20 MARKS)

a) Explain what controllability of a system means. (3 marks)

b) The simplified block diagram of an intelligent wheel chair and its controller are shown in fig. 2. Write down the canonical state variable form for the complete system. Also draw its block diagram in the state variable form. (7 marks)

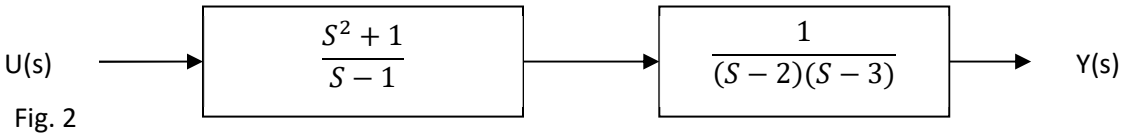


Fig. 2

c) Explain the purpose of a compensator in a controlled system. (3 marks)

d) With aid of diagrams, explain the three ways in which a compensator may be added into a system. (7 marks)

QUESTION THREE (20 MARKS)

a) Draw a network that can be used to realize a lag compensator and give derive its transfer function. (4 marks)

b) A liquid level control system LINEARLY converts a displacement of 2-3 meters into 4-20 milliampere control signal. A relay serves as the two position controller to open or close an inlet valve. The relay closes at 12mA and opens at 10mA. Find:

i) The relationship between displacement level and current.

ii) Displacement gap (neutral zone) in meters. (6 marks)

c) State the disadvantage of a proportional controller. (2 marks)

d) The circuit in fig.3 is a proportional plus integral controller and applied error signal.

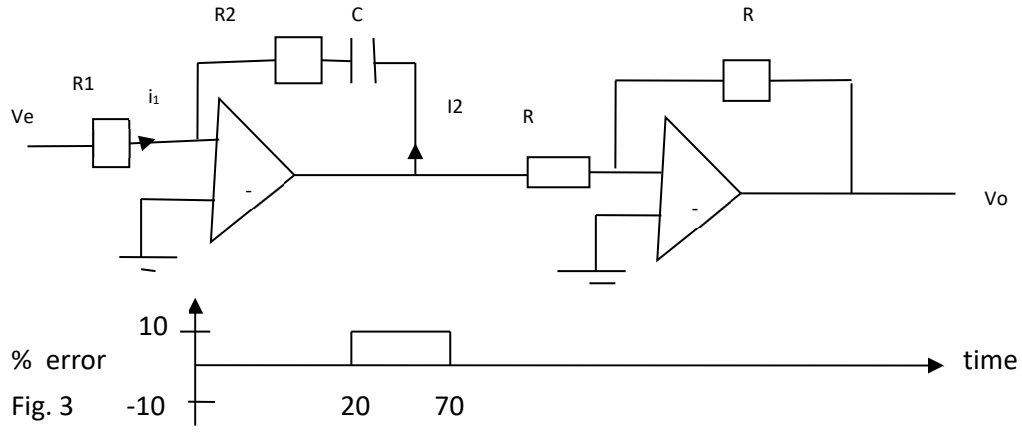


Fig. 3

i. Derive the output expression.

ii. Determine the values of R1 and R2 to give a proportional gain of 2 and integral action of 50 seconds. Use a 10 micro Farad capacitor. If the controller has an output of 32% at t=0, using the error graph given determine the controller output at t=60 seconds. (8 marks)

QUESTION FOUR (20 MARKS)

a) Construct the state model for the system characterized by the differential equation, and give block diagram representation of the state model. (5 marks)

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y = u$$

b) Sketch a labeled diagram of a proportional plus integral plus derivative controller. Explain the advantages introduced by each of the three actions. (6 marks)

c) Design a phase lead compensating network to achieve a phase margin of 50^o for a system whose transfer function is given by: - (9 marks)

$$G(s) = \frac{20}{S(1 + 0.2S)}$$

QUESTION FIVE (20 MARKS)

a) State advantage of using physical variable in state model. (2 marks)

b) Draw a circuit that can be used to implement an ideal derivative controller using operational amplifier and derive the output expression. (5 marks)

c) Ideal derivative controller mode is never used. Show the output of an ideal controller to the error signal given in fig.4 to support the above statement. (3 marks)

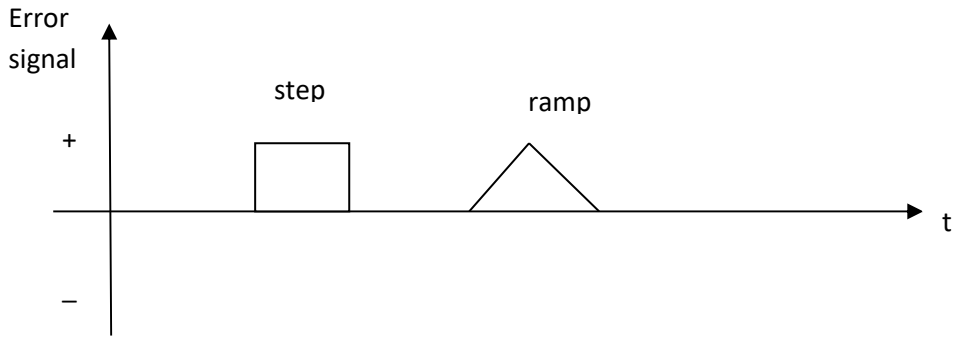


Fig. 4

d) Draw a network that can be used to realize a lead lag compensator. Derive the expression of the transfer function and sketch the bode plots. From the bode plots state the region used for compensation. (10 marks)