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KUMARAGURU college of technology
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B.E/B.TECH DEGREE EXAMINATIONS: APRIL/ MAY 2024

(Regulation 2018)

Fourth Semester

AERONAUTICAL ENGINEERING

U18AEI4202**:** Automatic Control Systems

COURSE OUTCOMES

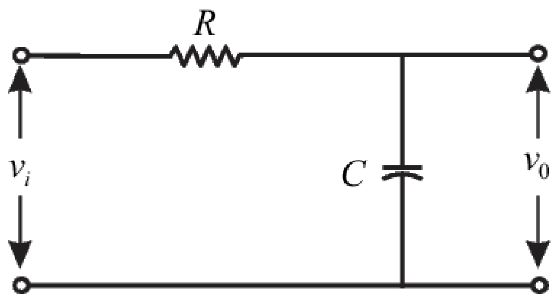
CO1: Determine the transfer function of mechanical and electrical systems.
CO2: Analyze the time response of LTI systems.
CO3: Design compensators/controllers for control systems.
CO4: Explain the behavior of aircraft autopilot systems.

Time: Three Hours **Maximum Marks: 100**

Answer all the Questions:-
PART A (10 x 2 = 20 Marks)
(Answer not more than 40 words)

1. Draw the block diagram of a typical feedback control system. CO1 [K2]

2. Determine the transfer function $V_o(s)/V_i(s)$ for the system shown in figure. CO1 [K3]



3. The unit-step response of a system starting from rest is given by $c(t)=1-e^{-2t}$ for $t \geq 0$. Find the transfer function of the system. CO2 [K3]

4. For a second-order system with ξ = 0.707, and ω_n = 10 rad/s, find the peak time and the settling time. CO2 [K3]

5. For a unity negative feedback system with $G(s)=\dfrac{100500(s+5)(s+14)(s+23)}{s(s+27)(s+\alpha)(s+33)}$, find the value of α to yield a static error constant of 25000. CO2 [K3]

6. What is a major limitation of the simple gain adjustment method using the root locus for getting the desired transient response for a control system? CO3 [K2]

7. For a unity negative feedback system with open-loop transfer function given by $G(s)=\dfrac{K(s+1.5)}{s(s+1)(s+5)}$, show the existence of the root locus on the real-axis of s-plane. CO3 [K_3]

8. What is the functional similarity and difference between PI controller and lag compensator? CO3 [K_2]

9. What is the function of a PID controller, and what are its characteristics? CO3 [K_2]

10. What is the purpose of adding rate feedback as an inner loop in the pitch autopilot system? CO4 [K_2]

Answer any FIVE Questions:-
PART B (5 x 16 = 80 Marks)
(Answer not more than 400 words)

11. The schematic diagram of a control system containing a motor coupled to a tachometer and an inertial load is shown in Figure 1.

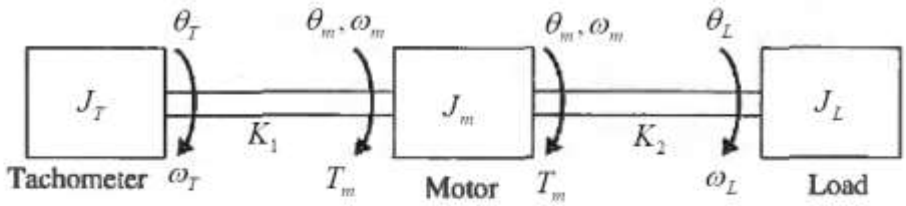


Figure 1.

The following parameters and variables are defined: T_m is the motor torque; J_m is the motor inertia; J_T is the tachometer inertia; J_L is the load inertia; K_1 and K_2 are the spring constants of the shafts; θ_T is the tachometer displacement; θ_m is the motor displacement; θ_L is the load displacement; ω_m is the motor velocity; ω_T is the tachometer velocity; ω_L is the load velocity; and B_m is the motor viscous-friction coefficient.

(i) Write the differential equations of the system. 4 CO1 [K_3]

(ii) Find the following transfer functions: $\dfrac{\theta_m(s)}{T_m(s)}, \dfrac{\theta_L(s)}{T_m(s)}$ 12 CO1 [K_3]

12. A motor whose transfer function is shown in Figure 2 is used as the forward path of a closed-loop, unity feedback system.

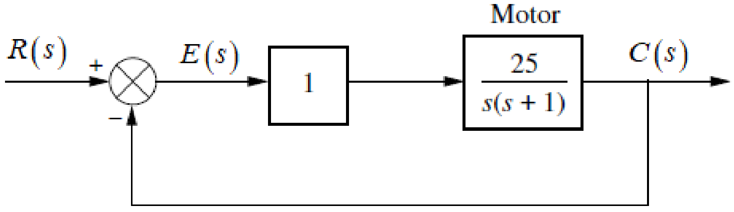


Figure 2.

(i) Calculate the overshoot percent and settling time that could be expected. 6 CO2 [K_3]

(ii) Now, you need to improve the response found in Part (i). Since the motor and the motor constants cannot be changed, an amplifier and a tachometer (voltage generator) are inserted into the loop, as shown in Figure 3. Find the values of K_1 and K_2 to yield a 16% overshoot and a settling time of 0.2 seconds. 10 CO2 [K_3]

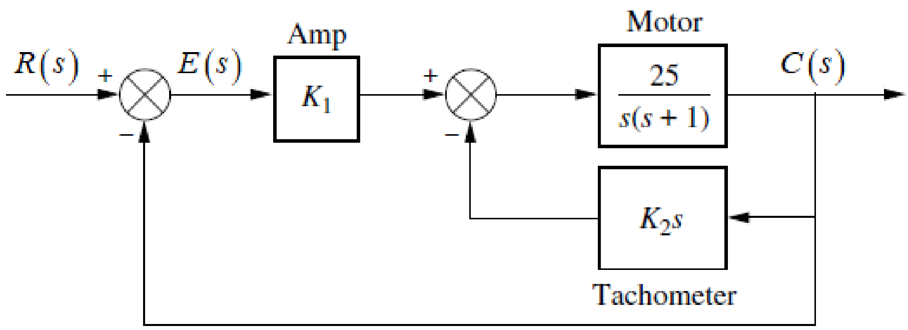


Figure 3.

13. a) The unit-step response of a second-order LTI system is shown in Figure 4. Find the transfer function for the system. 8 CO2 [K_3]

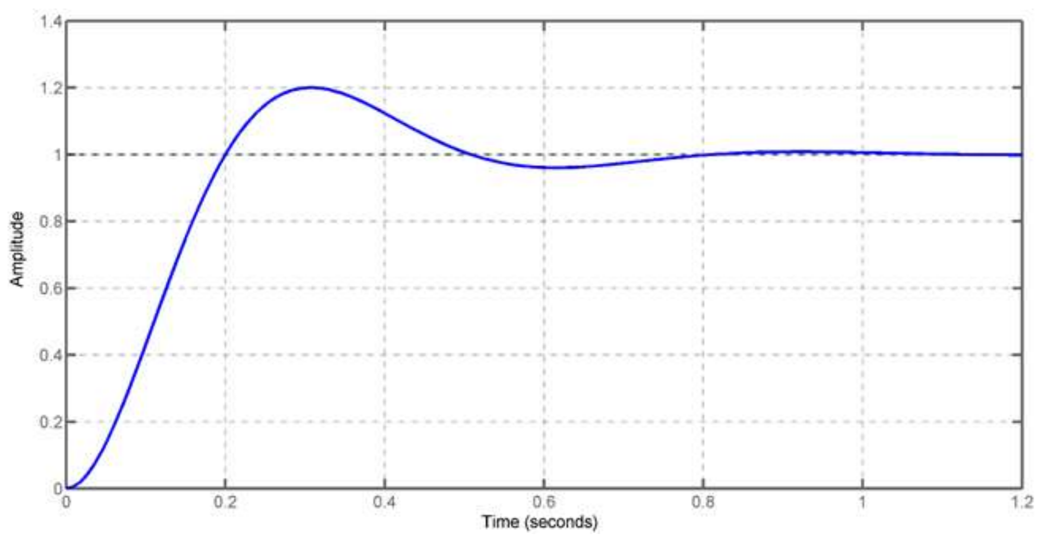


Figure 4.

b) The unit-step response of a second-order system have a maximum value of 2.04 at time t = 1.22 second, with a steady-state or final value of 1.5. Find the system transfer function. 8 CO2 [K_3]

14. A unity negative feedback system with $G(s)=\dfrac{K}{s(s+7)}$ is operating with a closed-loop step response that has 15% overshoot (dominant poles are $-3.5\pm5.79j$). Design a lag 16 CO3 [K_3]

compensator to improve the steady-state error by a factor of 20. Place the compensator pole at '–0.01'. Also, find the loop gain K of the compensated system.

15. A unity negative feedback system with $G(s)=\frac{K}{s(s+7)}$ is operating with a closed-loop step response that has 15% overshoot (dominant poles are –3.5±5.79j). Evaluate the settling time for the system and design a lead compensator to decrease the settling time by three times. Choose the compensator's zero to be at '–10'. Also, find the loop gain K for the compensated system. 16 CO3 [K_3]

16. For a unity negative feedback system with $G(s) = \frac{K}{(s+1)(s+4)}$, design a PID controller using root locus method that will yield a peak time of 1.047 seconds and a damping ratio of 0.8 (dominant poles are –2.5±1.88j), with zero error for a step input. 16 CO3 [K_3]

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