Assignment (3)

1. Referring to the system shown in Figure (1) , determine the values of K and k such that the system has a damping ratio ζ of 0.7 and an undamped natural frequency ω_n of 4 rad/sec.

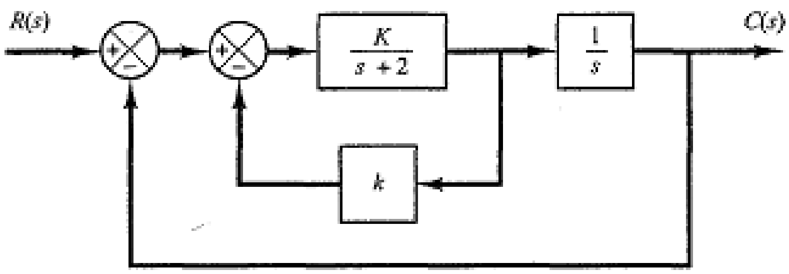


Fig. 1. Block diagram of a system.

2. Consider the system shown in Figure (2). Determine the value of k such that the damping ratio ζ is 0.5. Then obtain the rise time tr, peak time tp, maximum overshoot Mp, and settling time ts in the unit-step response.

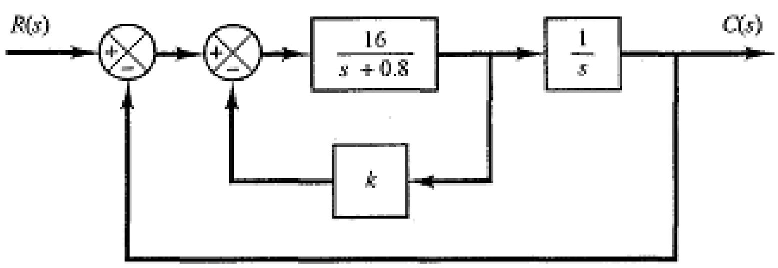


Fig. 2. Block diagram of a system.

3. Figure (3) shows three systems. System I is a positional servo system. System II is a positional servo system with PD control action. System III is a positional servo system with velocity feedback. Compare the unit-step, unit-impulse, and unit-ramp responses of the three systems. Which system is best with respect to the speed of response and maximum overshoot in the step response?

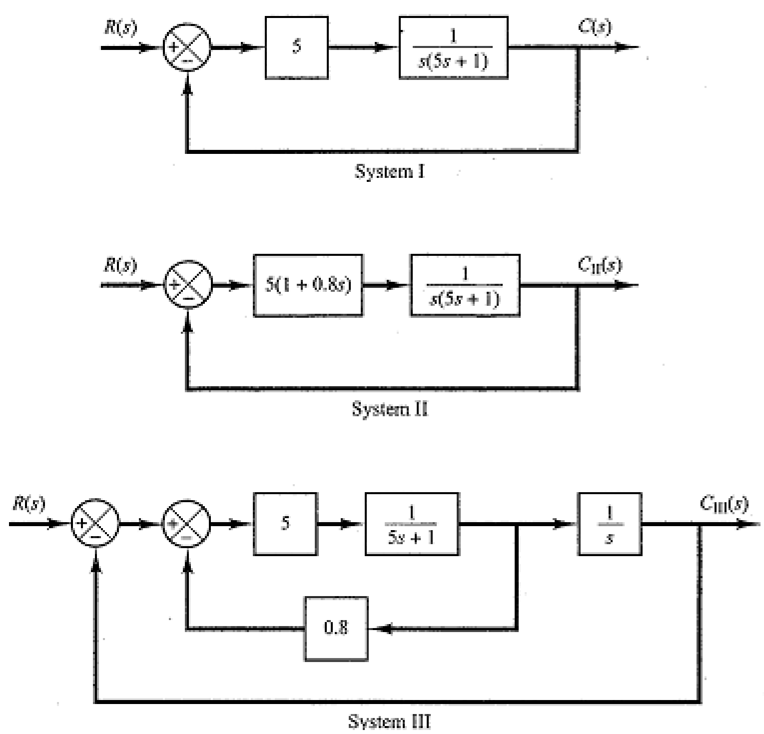


Fig. 3. Positional servo system (System I), positional servo system with PD control action (System 11), and positional servo system with velocity feedback

4. Consider the system shown in Figure 4-a. The damping ratio of this system is 0.158 and the undamped natural frequency is 3.16 rad/sec. To improve the relative stability, we employ tachometer feedback. Figure 4-b shows such a tachometer-feedback system. Determine the value of K, so that the damping ratio of the system is 0.5.Draw unit-step response curves of both the original and tachometer-feedback systems. Also draw the error-versus-time curves for the unit-ramp response of both systems.

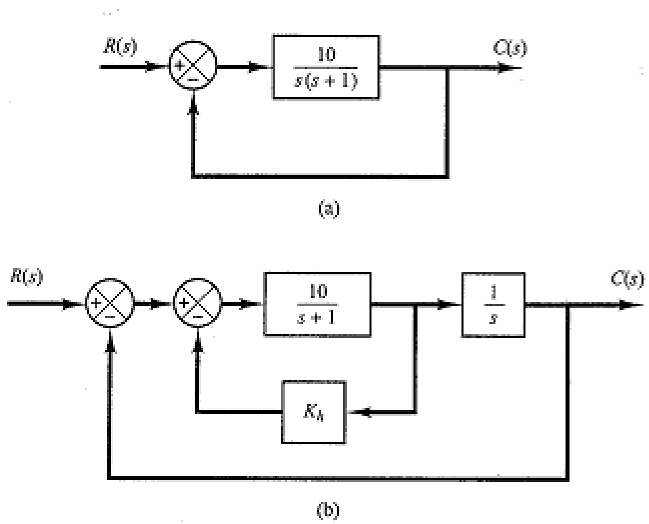


Fig. 4. (a) Control system; (b) control system with tachometer feedback

5. Consider the closed-loop system in Figure 5, where:

$$G_c(s)G(s) = \frac{s+1}{s^2+03s} \text{ and } H(s) = K_a.$$

(a) Determine the closed-loop transfer function T(s) = Y(s)/R(s).
(b) Determine the steady-state error of the closed-loop system response to a unit ramp input, $R(s) = 1/s^2$.
(c) Select a value for Ka so that the steady-state error of the system response to a unit step input, R(s) = 1/s, is zero.

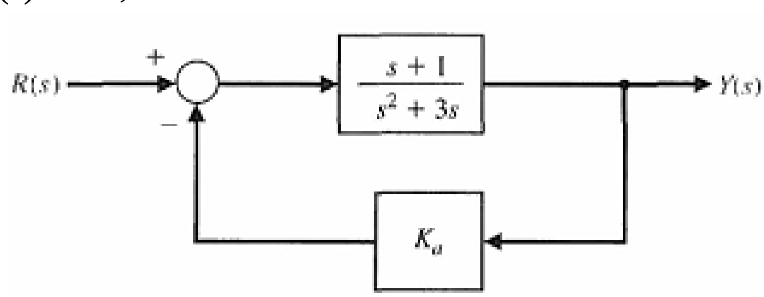


Fig. 5. Feedback system

6. For the system with unity feedback shown in Figure 6 , determine the steady-state error for a step and a ramp input when

$$G(s) = \frac{20}{s^2 + 14s + 50}.$$

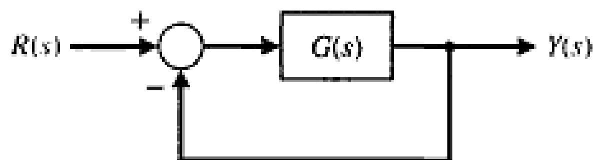
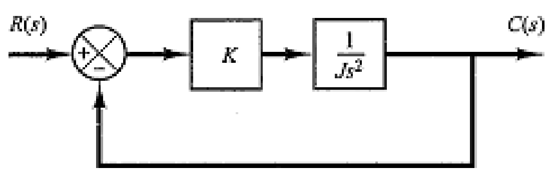


Fig. 6. Feedback system

7. Consider the satellite attitude control system shown in Figure (7-a). The output of this system exhibits continued oscillations and is not desirable. This system can be stabilized by use of tachometer feedback, as shown in Figure (7-b). If K/J = 4, what value of K_h will yield the damping ratio to be 0.6?



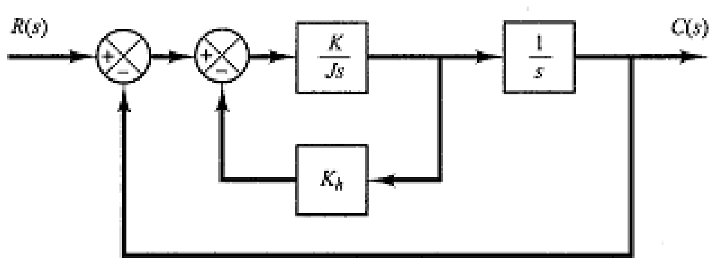


Fig. 7. (a) Unstable satellite attitude control system; (b) stabilized system

8. A feedback system is shown in Figure 8.

(a) Determine the steady-state error for a unit step when K = 0.4 and Gp(s) = 1 .

(b) Select an appropriate value for Gp(s) so that the steady-state error is equal to zero for the unit step input.

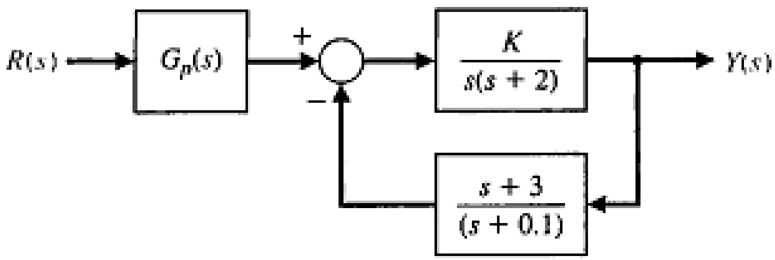


Fig. 8. Control system

9. A system is shown in Figure 9 .

(a) Determine the steady-state error for a unit step input in terms of K and K1, where E(s) = R(s) - Y(s).

(b) Select K1 so that the steady-state error is zero.

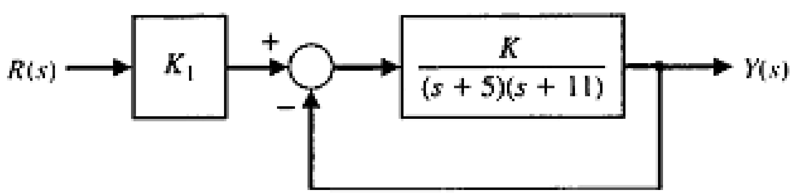


Fig. 9. Control system

10. Consider the following characteristic equation:

$$s^4 + 2s^3 + (4 + K)s^2 + 9s + 25 = 0$$

Using Routh stability criterion, determine the range of K for stability.

11. A feedback control system has a characteristic equation

$$s^6 + 2s^5 + 12s^4 + 4s^3 + 21s^2 + 2s + 10 = 0.$$

Determine whether the system is stable, and determine the values of the roots

12. Consider the unity-feedback control system with the following open-loop transfer function: Is this system stable?

$$G(s) = \frac{K}{s(s+1)(s+2)}$$

13. Determine the range of K for stability of a unity feedback control system whose open-loop transfer function is

$$G(s) = \frac{10}{s(s-1)(2s+3)}$$

14. Consider the servo system with tachometer feedback shown in Figure 10. Determine the ranges of stability for K and K_h. (Note that Ki, must be positive.)

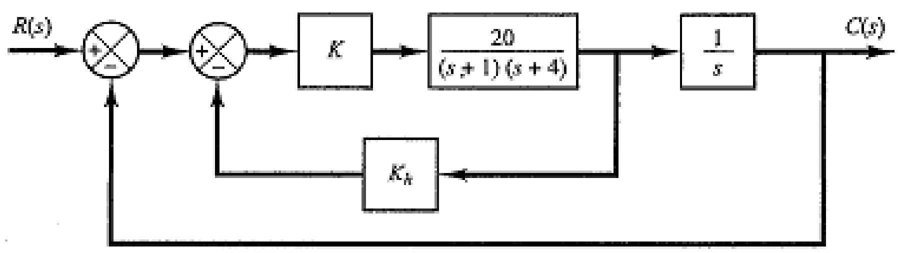


Fig. 10. Servo system with tachometer feedback