Advanced Automatic Control MDP 444

Benha University
Mechanical Engineering Department (Production)

Shoubra Faculty of Engineering
4th year (Design section) 2016/2017

Assignment (4)

1. Several studies have proposed an extravehicular robot that could move around in a NASA space station and perform physical tasks at various work sites. The arm is controlled by a unity feedback control with loop transfer function.

$$L(s) = G_c(s)G(s) = \frac{K}{s(s/5 + 1)(s/100 + 1)}.$$

Draw the Bode diagram for K = 20, and determine the frequency when 20 log |L(jω)| is 0 dB.

2. Consider the system shown in Figure (1). Draw a Bode diagram of the open-loop transfer function G(s). Determine the phase margin and gain margin.

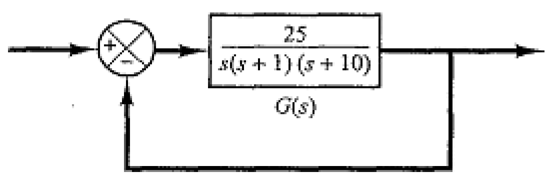

Fig. 1. Block diagram of a system.

3. A robotic arm has a joint-control loop transfer function

$$L(s) = G_c(s)G(s) = \frac{300(s + 100)}{s(s + 10)(s + 40)}.$$

Show that the frequency equals 28.3 rad/s when the phase angle of L(jω) is -180°. Find the magnitude of L(jω) at that frequency

4. A feedback system has a loop transfer function

$$L(s) = G_c(s)G(s) = \frac{100(s - 1)}{s^2 + 25s + 100}.$$

(a) Determine the corner frequencies (break frequencies) for the Bode plot, (b) Determine the slope of the asymptotic plot at very low frequencies and at high frequencies, (c) Sketch the Bode magnitude plot.

5. Consider the feedback control system in Figure (2) .Sketch the Bode plot of G(s) and determine the crossover frequency, that is, the frequency when $20\log_{10}|G(j\omega)| = 0$ dB.

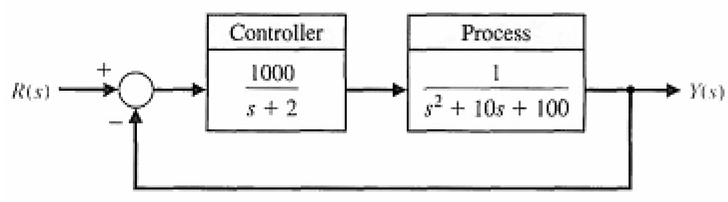

Fig. 2. Block diagram of a system.

6. Consider the system shown in Figure (3). Compute the loop transfer function L(s), and sketch the Bode plot. Determine the phase margin and gain margin when the controller gain K = 5.

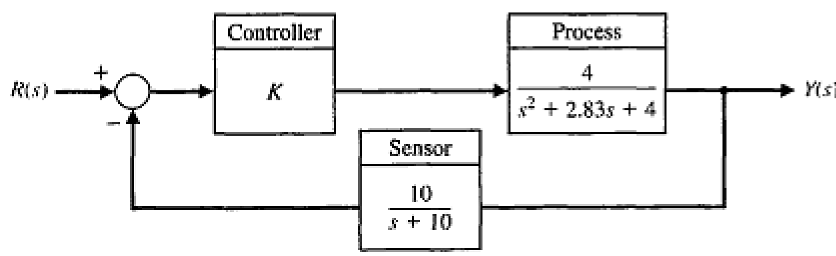

Fig. 3. Block diagram of a system.

7. Consider the system represented in state variable form (a) Determine the transfer function representation of the system, (b) Sketch the Bode plot

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\mathbf{x} + \begin{bmatrix} 0 \\ 5 \end{bmatrix}u$$

$$y = [1 \quad -1]\mathbf{x} + [0]u$$

8. Consider a unity-feedback control system with the open-loop transfer function Determine the value of the gain K such that the phase margin is 50''.What is the gain margin with this gain K?

$$G(s) = \frac{K}{s(s^2 + s + 4)}$$

9. Consider the system shown in Figure (4). Draw a Bode diagram of the open-loop transfer function, and determine the value of the gain K such that the phase margin is 50°. What is the gain margin of this system with this gain K?

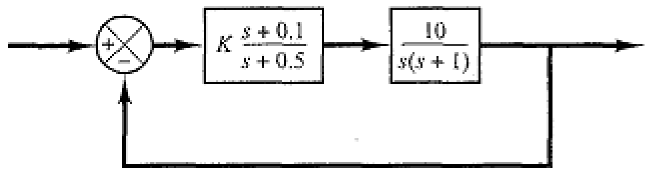

Fig. 4. Block diagram of a system.

10. Referring to the closed-loop system shown in Figure (5), design a lead compensator $G_c(s)$ such that the phase margin is 45°, gain margin is not less than 8 dB, and the static velocity error constant K_v is 4.0 sec^{-1}.

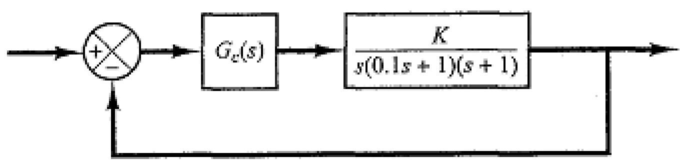

Fig. 5. Block diagram of a system.

11. Consider the system shown in Figure (6). Design a compensator such that the static velocity error constant K_v is 50 sec^{-1} phase margin and is 50°, and gain margin not less than 8 dB.

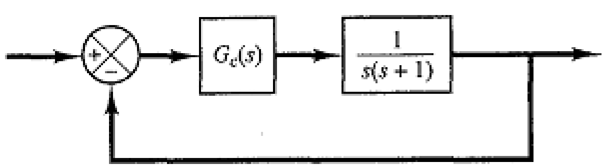

Fig. 6. Block diagram of a system.

12. Consider the system shown in Figure (7). Design a compensator such that the static velocity error constant K_v is 4 sec^{-1} phase margin and is 50°, and gain margin is 8 dB or more.

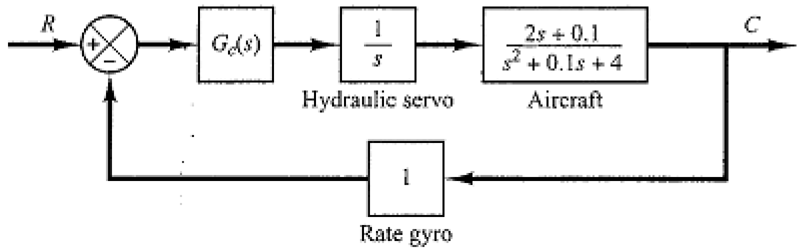

Fig. 7. Control system.

13. Consider the system shown in Figure (8). Design a lag-lead compensator such that the static velocity error constant K_v is 20 sec^{-1} phase margin and is 60°, and gain margin not less than 8 dB

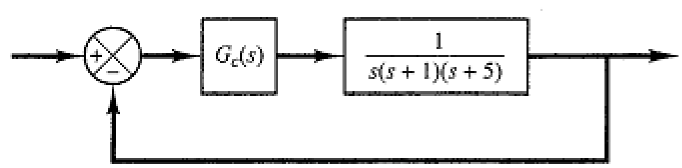

Fig. 8. Control system.

14. Materials testing requires the design of control systems that can faithfully reproduce normal specimen operating environments over a range of specimen parameters. From the control system design viewpoint, a materials-testing machine system can be considered a servomechanism in which we want to have the load waveform track the reference signal. The system is shown in Figure (9).

(a) Determine the phase margin of the system with Gc(s) = K, choosing K so that a phase margin of 50° is achieved. Determine the system bandwidth for this design.

(b) The additional requirement introduced is that the velocity constant K_v be equal to 2.0. Design a lag network so that the phase margin is 50° and $K_v = 2$.

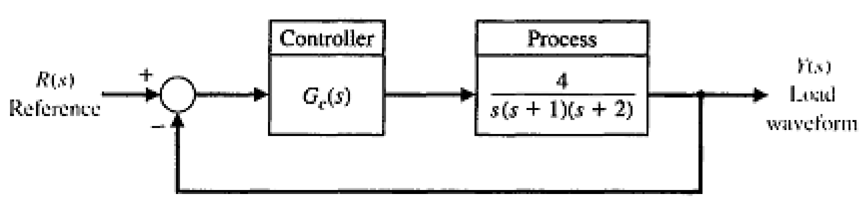

Fig. 9. Control system.