University of Kurdistan
Department of Electrical Engineering

Linear Control Systems

Homework 6: Bode plot, Nyquist Diagram, Stability via frequency response method, Design via root locus and frequency response method

Instructor: Dr. Q. Shafiee **Teaching Assistant:** N. Mohammadi

1. Bode Plot & Nyquist Diagram

1.1) Sketch the Bode asymptotic magnitude and asymptotic phase plots for the following systems.

$a)\ G(s) = \frac{1}{s(s+1)(s+3)}$ $b)\ G(s) = \frac{-80(s-5)}{s(s+1)(s+10)}$

$c)\ G(s) = \frac{20(s+2)}{s^2+4s+13)(s-2)}$ $d)\ G(s) = \frac{60}{s^2(s+8)(s+3)}$

1.2) Draw the Nyquist diagram for each of the systems in Figure 1.

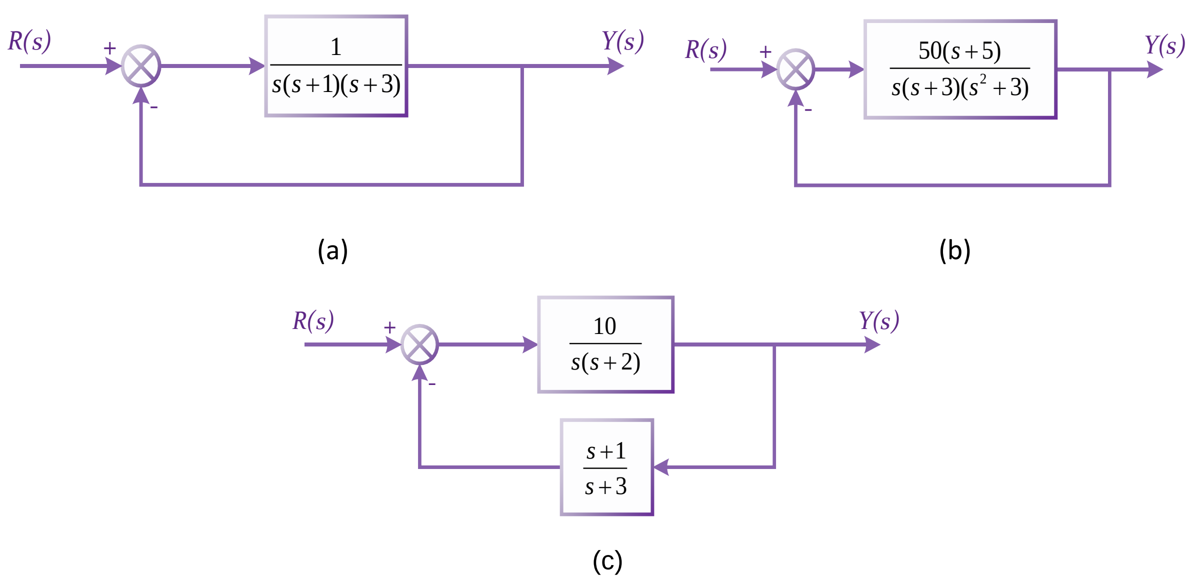


Figure 1

1.3) Estimate $G(s)$, Whose Bode log-magnitude and phase plots are shown in Figure 2.

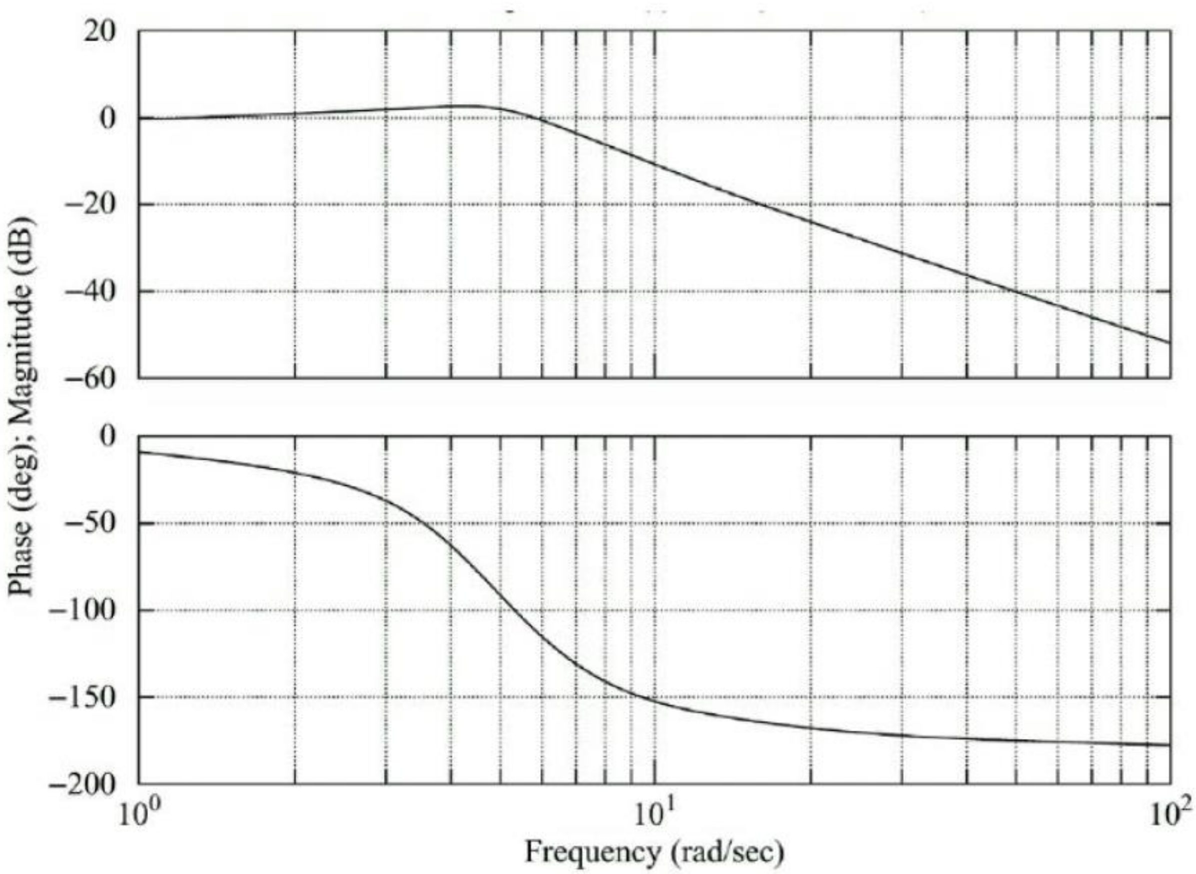
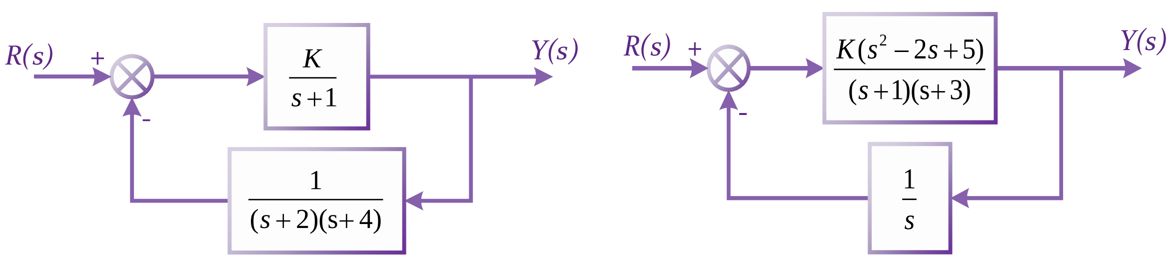


Figure 2

2. Stability via Frequency Response Methods

2.1) Using the Nyquist criterion, find the range of K for stability for each of the systems in Figure 3.



(a) (b)

Figure 3

2.2) Find the gain margin and phase margin for each of the systems in Figure 3 if the value of the gain K is 100.

3. Design via Root Locus and Frequency Response Methods

3.1) A DC motor control system with unity feedback has the form shown in Figure 4. Select K_1 and K_2 so that the system response has a settling time (with a 2% criterion) less than 1 second and an overshoot less than 5% for a step input.

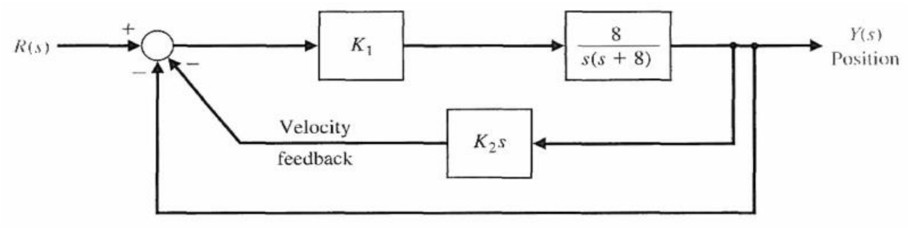


Figure 4

3.2) For the unity feedback system with $G(s)$ as forward path transfer function,

$$G(s) = \frac{K}{(s^2 + 20s + 101)(s + 20)}$$

The damping ratio for the dominant poles is to be 0.4, and the settling time is to be 0.5 second.

(a) Find the coordinates of the dominant poles.

(b) Find the location of the compensator zero if the compensator pole is at -15.

(c) Find the required system gain.

(d) Compare the performance of the uncompensated and compensated systems.

3.3) Given a unity feedback system with

$$G(s) = \frac{K}{s(s+2)(s+5)}$$

design a PID controller to yield zero steady-state error for a ramp input, as well as a 20% overshoot, and a peak time less than 2 seconds for a step input. Use only frequency response methods.

4. Simulation

4.1 A unity feedback system has the loop transfer function

$$L(s) = G_c(s)G(s) = \frac{1}{s(s+2p)}$$

Generate a plot of bandwidth versus the parameter p as $0 < p < 1$.

4.2 Consider the feedback system in Figure 5. Obtain the Bode plots of the loop and closed-loop transfer functions using an m-file.

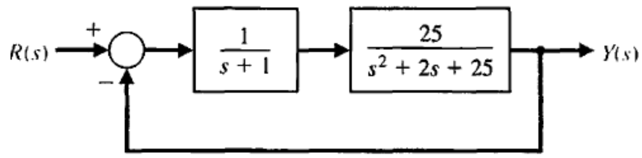


Figure 5

4.3 Write a program in MATLAB that will do the following:

a) Plot the Nyquist diagram of a system.

b) Display the real-axis crossing value and frequency.

"Your success as an engineer will be directly proportional to your ability to communicate!"

•Charles K. Alexander•