

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

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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.



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.



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 .

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.



- 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•