ECE141 - Principles of Feedback Control

Homework 5 , Due: 2/22/19, 9:00am

Problem 1. Hand sketch the asymptotes for the Bode magnitude and phase plots for each of the following open-loop transfer functions. Then verify your plot using `bode` command in MATLAB. Please submit both hand-sketched plots along with the MATLAB plots:

(a)
$$L(s) = \frac{\frac{1}{2}\left(\frac{s}{5}+1\right)\left(\frac{s}{10}+1\right)}{s(s+1)(s+100)}$$

(b)
$$L(s) = \frac{-s}{(s+1)(s-1)}$$

(c)
$$L(s) = \frac{1-s}{s(s+1)}$$

(d)
$$L(s) = \frac{4\left[\left(\frac{s}{2}\right)^2+1\right]}{s(s^2+1)}$$

(e)
$$L(s) = \frac{\frac{1}{10}(s+1)^2}{s^3\left(\frac{s}{10}+1\right)}$$

(f)
$$L(s) = \frac{e^{-0.2s}}{s(s+1)}$$

(g)
$$L(s) = \frac{10(s+1)}{s(s^2+20s+100)}$$

(h)
$$L(s) = \frac{1+0.5s}{s^2}$$

Problem 2. Effect of Additional Zero on the 2nd-Order Time and Frequency Responses: Consider the following 2nd-order loop transfer function with a zero at $s=-z$:

$$L(s) = \frac{\frac{s}{z}+1}{s^2+s+1}$$

We want to see how both the time response and the frequency response of the system would change as the location of the zero varries relative to the location of the poles in the 2nd-order system. For $z = 0.01, 0.1, 1, 10, 100$, use `step`, `stepinfo`, `bode`, and `getPeakGain` functions in MATLAB to:

(a) Plot step reponses of the system for the different values of z, all on the same figure.

(b) Find the maximum percentage overshoot for the different values of z.

(c) Plot the frequency response of the system (both magnitude and phase) for the different values of z, all on the same figures (i.e., one figure for all magnitude responses and one for all phase responses)

(d) Find the resonant peak in the frequency response for different values of z.

(e) Please discuss how the varying zero location is impacting your time and frequency response.

Please submit both your MATLAB code along with the plots and the tables of percentage overshoot and resonant peak values.

Problem 3. Effect of Additional Pole on the 2nd-Order Time and Frequency Responses: Consider the following loop transfer function:

$$L(s) = \frac{1}{\left(\frac{s}{p}+1\right)(s^2+s+1)}$$

These homework problems are compiled using the different textbooks listed on the course syllabus

We want to see how both the time response and the frequency response of the system would change as the location of the 3rd pole varries relative to the location of the the other two poles in the 2nd-order system. For $p = 0.01, 0.1, 1, 10, 100$, use `step`, `stepinfo`, `bode`, and `getPeakGain` functions in MATLAB to:

(a) Plot step reponses of the system for the different values of p, all on the same figure.

(b) Find the maximum percentage overshoot for the different values of p.

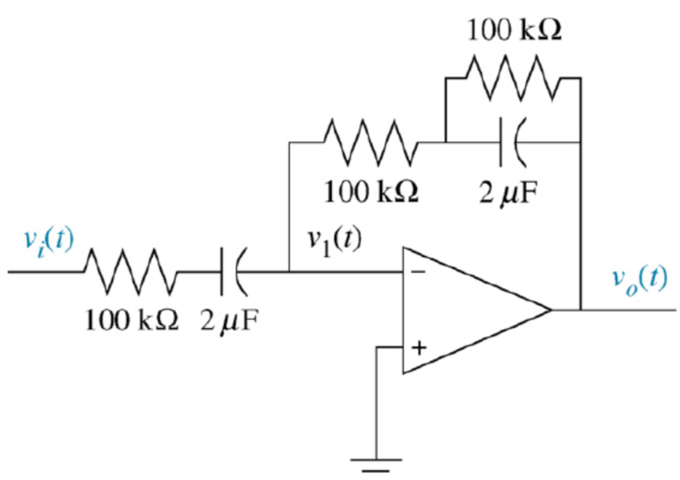
(c) Plot the frequency response of the system (both magnitude and phase) for the different values of p, all on the same figures (i.e., one figure for all magnitude responses and one for all phase responses)

(d) Find the resonant peak in the frequency response for different values of p.

(e) Please discuss how the varying 3rd pole location is impacting your time and frequency response.

Please submit both your MATLAB code along with the plots and the tables of percentage overshoot and resonant peak values.

Problem 4. Consider the following OpAmp compensator. Assume an ideal OpAmp with very large open-loop gain.



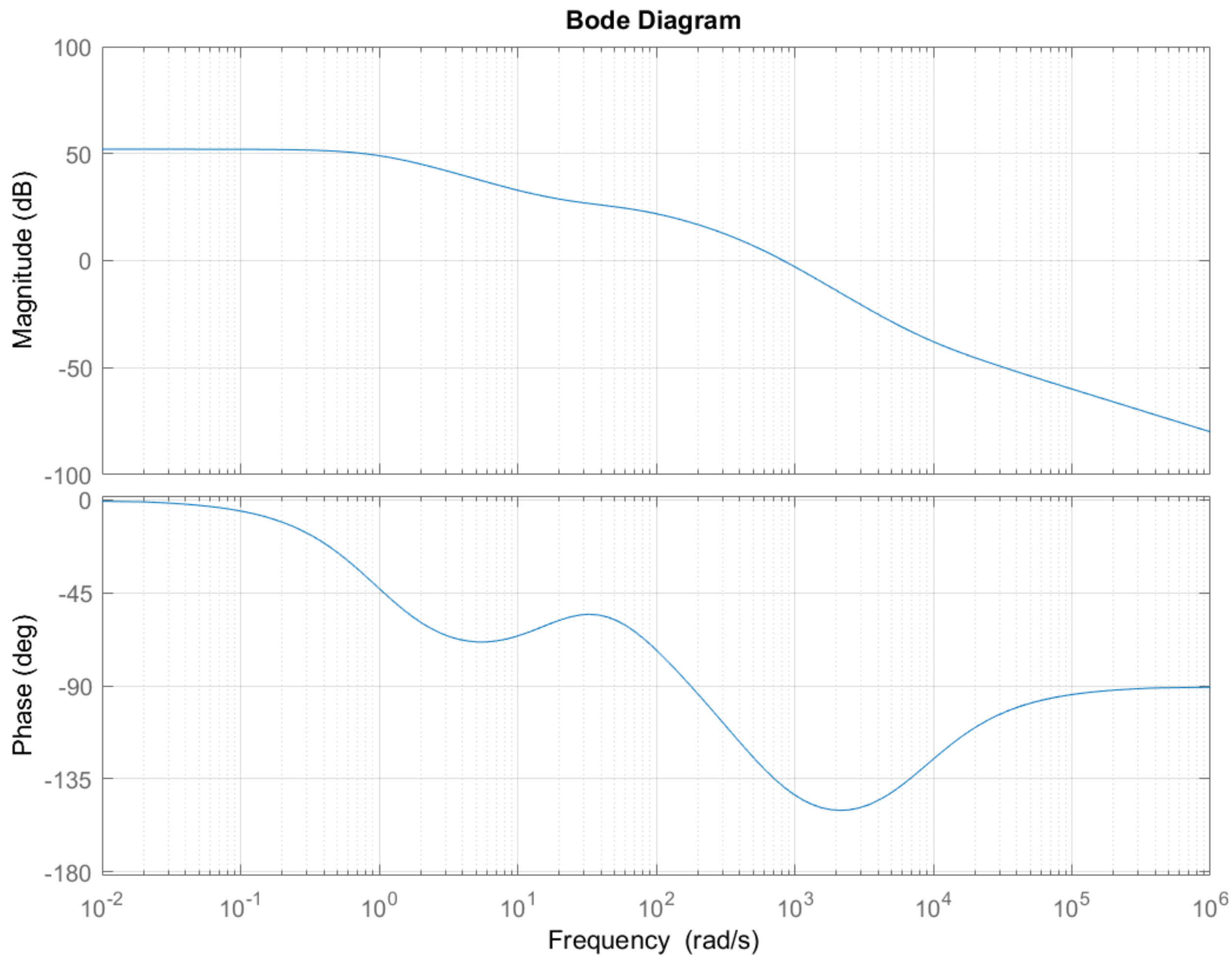
(a) Find the compensator transfer function: $C(s) = \frac{V_o(s)}{V_i(s)}$.

(b) Hand sketch the magnitude and phase Bode plots.

(c) Verify your plots with MATLAB. Please submit both your hand-sketched plots as well as your MATLAB plots, along with your MATLAB code.

(d) Is this a lead or a lag compensator? Why?

Problem 5. The frequency response of a system has been measured as shown in the following picture:

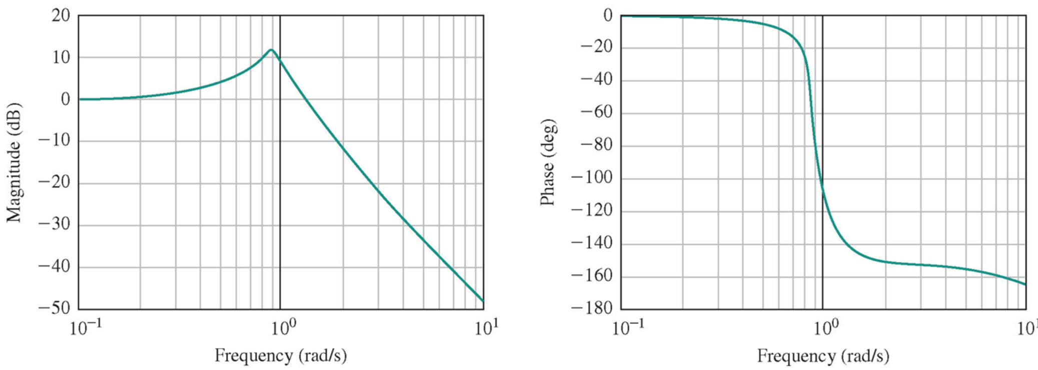


(a) Determine the transfer function of the system $H(s)$.

(b) What is the System Type (i.e., the number of pure integrators) for this system? What is the value of the corresponding static error constant?

(c) If this system is used in a unity-feedback system, what would be the steady-state tracking error for a step reference input?

Problem 6. The frequency response of a closed-loop system $T(s)$ is shown in the following picture. Assume that $T(s)$ has two dominant complex conjugate poles. And in the magnitude diagram, notice that the resonant frequency is at 0.9 rad/sec, and the associated peak gain is 12 dB.



(a) Determine the best second-order approximation for $T(s)$.

(b) Determine the system bandwidth.

(c) What will be the percentage overshoot P.O. and the 2% settling time of this system for a step input?