# Homework #11: ECE 461/661

Meeting specs in the z-plane, Bode plots, Nichols charts, Gain & Lead Compensation

## Meeting Specs in the z-Plane

Assume T = 0.1 seconds:

$$G(s) = \left(\frac{20}{(s+0.5)(s+2)(s+5)}\right)$$

1) Design a digital controller which results in

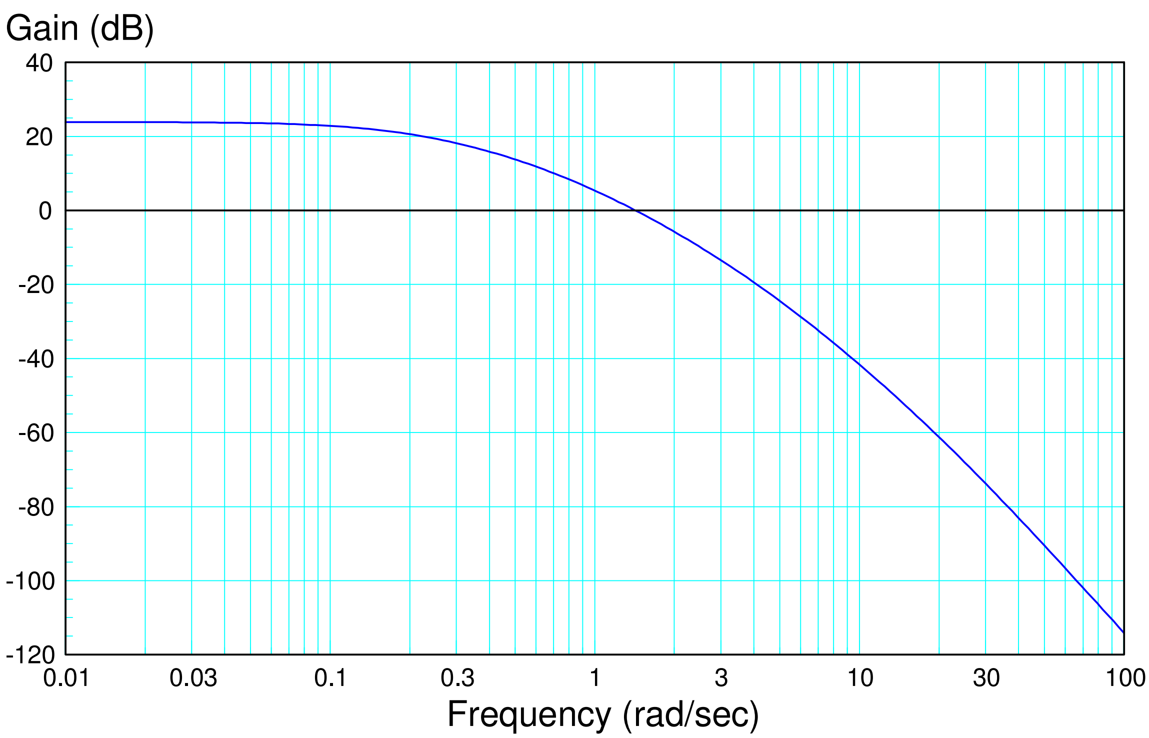
- No error for a step input
- A 2% settling time of 3 seconds, and
- 20% overshoot for a step input

Provide the following

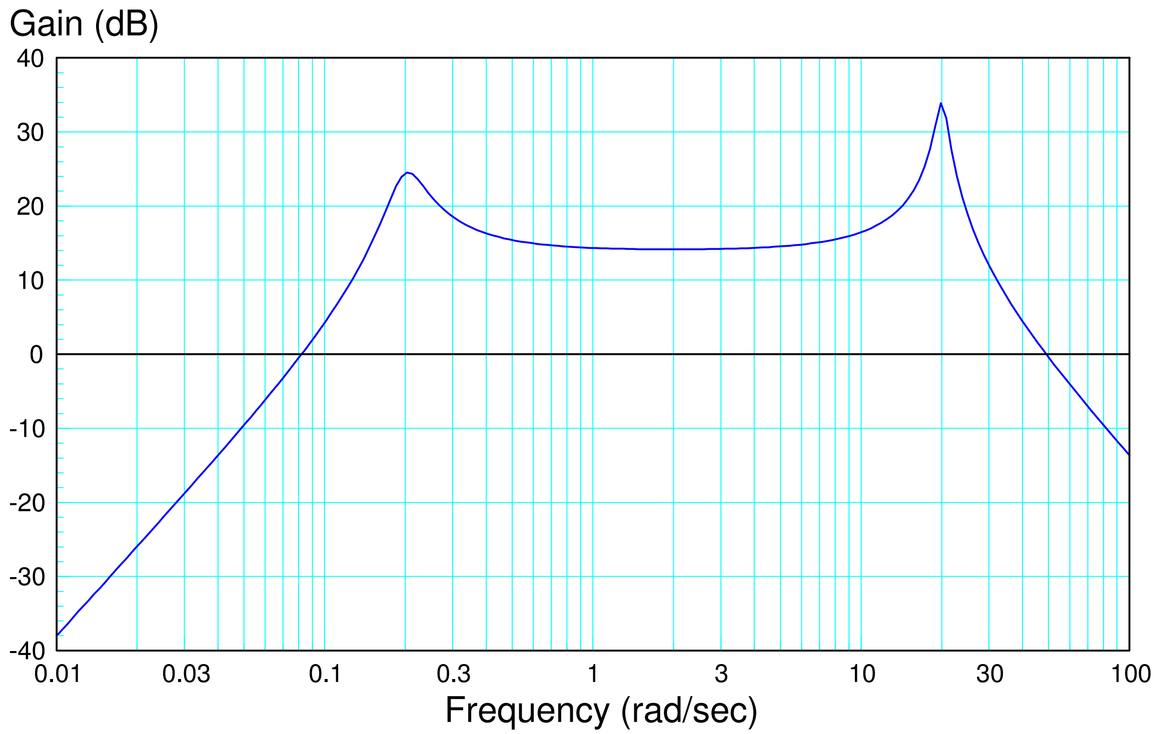
- Closed-loop poles in the s-plane
- Closed-loop poles in the z-plane
- The step response of the closed-loop system

## Bode Plots

2) Find the system, G(s), which has the following gain vs. frequency



3) Find the system, G(s), which has the following gain vs. frequency




## Nichols Charts

4) Assume G(jw) has the following gain vs. frequency

| rad/sec | 2 | 3 | 4 | 6 | 8 | 10 | 12 | 14 |
|---|---|---|---|---|---|---|---|---|
| dB | 14 | 12 | 10 | 5 | 1 | -3 | -7 | -10 |
| degrees | -40 | -74 | -100 | -135 | -159 | -176 | -189 | -199 |

Assuming a unity feedback system, find the feedback gain, k, which results in:

- a) The maximum gain for stability
- b) Mm = 2.00

## Gain Compensation

5) Assume G(s) has the following transfer function

$$G(s) = \left(\frac{20}{s(s+2)(s+5)}\right)$$

Find the feedback gain, k, that results in a 50 degree phase margin.

- Plot the closed-loop step response of this system

6) Assume G(s) has a 200ms delay.

$$G(s) = \left(\frac{20}{s(s+2)(s+5)}\right) \cdot e^{-0.2s}$$

Find the feedback gain, k, that results in a 50 degree phase margin.

- Plot the closed-loop step response of this system

## Lead Compensation

7) Assume G(s) has the following transfer function

$$G(s) = \left(\frac{20}{s(s+2)(s+5)}\right)$$

Design a lead compensator which results in a 50 degree phase margin.

- Plot the closed-loop step response

8) Assume G(s) has a 200ms delay added

$$G(s) = \left(\frac{20}{s(s+2)(s+5)}\right) \cdot e^{-0.2s}$$

Design a lead compensator which results in a 50 degree phase margin.

- Plot the closed-loop step response