16.06 Lecture 25
Compensator Design

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Today's Topics

1. Phase-lag compensator design
2. PID control
3. PD control

Reading: 6.5, l.n.

1 Phase-lag compensator design

The design procedure for a phase-lag compensator is as follows:

1. Draw the root loci for a proportional gain controller
2. Determine the desired position of the dominating pair of closed-loop poles on these loci from the specifications.
3. Determine the root locus gain at the position (using the magnitude condition) and hence the value of K_c for P-control.
4. For this value of K_c, determine the value of the factor z/p needed to satisfy the specifications on steady-state accuracy.
5. Choose p and z with this ratio and close enough to the origin that the vector angles to the dominant poles differ only a few degrees.
6. Draw the loci of the compensated system and find the dominating poles. Reduce K_c if needed to counter any reduction of the relative stability.

Phase-lag compensator design example:

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

Design $G_c(s)$ to meet the following closed-loop specifications:

(i) $\zeta = 0.5$

(ii) Steady-state error less than 5%

- Step 1

- Step 2

  From specifications: closed-loop poles are at

- Step 3

  Magnitude condition:

$$K_c =$$

- Step 4

  Loop gain function is:

  Loop gain is:

  $e_{ss} =$

  To satisfy error specification, must increase loop gain to

  Therefore, $z/p =$

- Step 5

  Choose

  $$G_c =$$

  Draw the new root locus:

2 PID Control

Consider the osprey tiltrotor aircraft. We will look at the altitude hold autopilot.

The dynamics of the plant are:

$$G(s) =$$

Plot the P-control root locus:

Consider the following controller:

$$G_c =$$

Draw the compensated root locus:

Let us write the controller in a slightly different form:

$$G_c =$$

Draw the block diagram:

The 'I' component creates

The 'D' component creates

insert osprey handout here

3 PD control

(a) Consider a motor position servo with the following transfer function:

We feedback the position:

(b) Consider P-control, $G_c = K_c$:

C.E. is

(c) Consider PD control, $G_c = K_c + K_d s$

C.E. is