

# 16.06 Lecture 8

## Dominant Modes

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September 18, 2003

### **Today's Topics**

1. Dominant mode concept
2. "Invasion" of a first-order system
3. Examples of high-order systems

**Reading:** 1.8, 4.4, ln

# 1 Dominant mode concept

Example 4.5.1 from text: Step response of a DC motor position servo.

- (a)  $G(s) = \frac{0.5}{s(0.25s+1)}$  is the transfer function from field voltage to shaft position of the motor. Draw the closed-loop system using a proportional controller:

$$C(s) =$$

$$R(s) =$$

Draw the pole-zero diagram for  $C(s)$  with  $K = 1$ :

(b) The PFE is:

(c) Graphical residues:

(d) Step response:

(e) Plot each piece of the step response:

(f) What happens if we increase  $K$ ?

Type 1 system: Velocity error constant = .

There is a conflict between

## 2 First-order system "invaded" by a single pole

Consider the following example, where  $T_2$  varies.

See Fig. 2.18 on the next page for response plots.

Observations:

- at  $t = 0$  slope of  $c(t)$  is zero for two-pole system and finite for one-pole system
- in case 2, the magnitude of the residue at -10 is 0.1 times the magnitude of the residue at -1
- in case 3, the magnitudes of the residues at -1 and -2 are not widely different, so case 1 is not as good an approximation

insert fig 2.18 here

### 3 Examples of high-order systems

(a) Consider the following systems:

(b) In each case, high-order poles are about ten times removed from the dominant pole.

Question: Are they important in each case?

(c) Consider  $G_1(s)$ :

$$c_1(t) =$$

The residue of the complex pair contribution is small.

(d) Consider  $G_2(s)$ :

$$c_2(t) =$$

The residues of the faraway poles are comparable in magnitude to the residue of the pole at -1. But the residues of the two faraway poles have nearly equal and opposite magnitudes, therefore they cancel each other and the pole at -1 is dominant. In particular, the pole at -1 is a good approximation for  $t > 4$  (2% from the final value).

(e) See Figure E2.2 on the next page.

Insert Fig. E2.2 here.

## **4 What is important?**

## **5 F-8 example**

As part of your reading for this week, review the attached example on longitudinal response modes for the F-8 aircraft.