Control System Design

Lecture 12

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Elective Course in Mechatronics Engineering
Credits (2/2/3)

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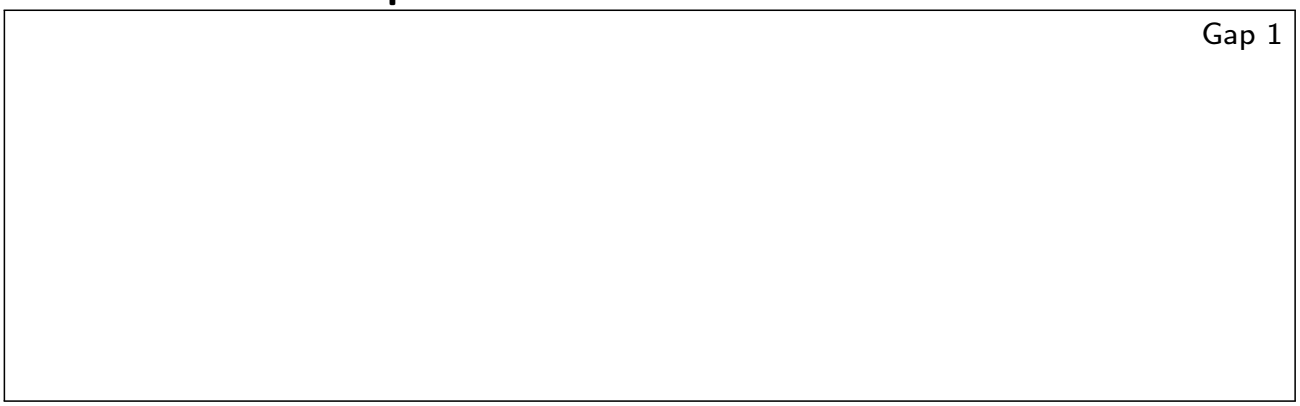
Disturbance Feedforward: Basic Situation

Basic Feedback Loop



Assumption

- Disturbance signal d is directly measurable

Idea

- Compensate disturbance by additional controller component that "feeds forward" the measured disturbance signal

Disturbance Feedforward: Design Equation

Transfer Functions

$$\frac{Y(s)}{R(s)} = \frac{G_1(s)G_2(s)C(s)}{1 + G_1(s)G_2(s)C(s)} \text{ is unchanged}$$

$$\frac{Y(s)}{D(s)} = \frac{G_2(s)(G_d(s)G_1(s) - 1)}{1 + G_1(s)G_2(s)C(s)} \text{ contains feedforward term}$$

Disturbance Compensation

$$G_d(s)G_1(s) - 1 \Leftrightarrow G_d(s) = \frac{1}{G_1(s)}$$

Conditions

- $G_d(s)$ has to be stable with a non-negative relative degree
  $\Rightarrow$ Extend $G_d(s)$ by first-order lag elements if $G_1(s)$ has positive relative degree $r > 0$: $G_d(s) = \frac{1}{G_1(s)} \frac{1}{(1 + s\tau)^r}$
  $\Rightarrow$ Do not compensate instable zeros in $G_1(s)$

Disturbance Feedforward: Feedback Loop

Feedback Loop for Disturbance Feedforward

Gap 2

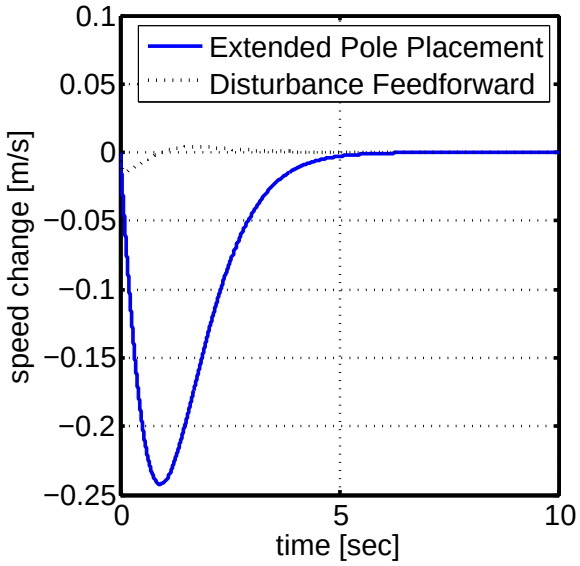
Disturbance Feedforward: Vehicle Control Example

Example

Gap 3

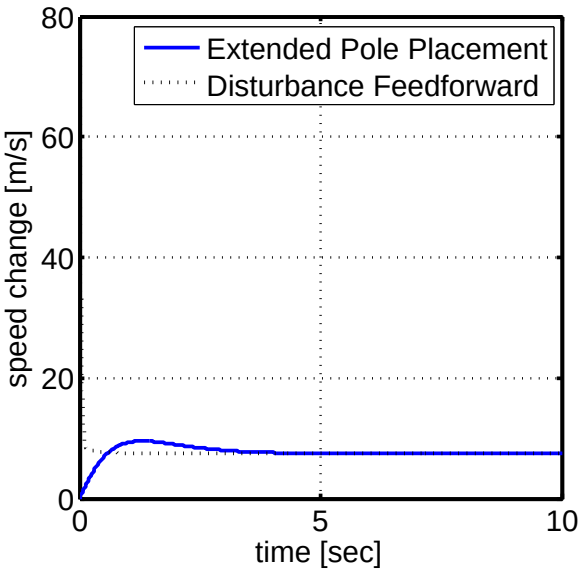
Disturbance Feedforward: Vehicle Control Example

Disturbance Step



⇒ Better disturbance rejection with disturbance feedforward

Control Output Signals



⇒ Faster input reaction for disturbance feedforward