PHILIPS CTT Hogeschool van Utrecht

Systeem en Regeltechniek
FMT / Mechatronica

Deel 3: Vervolg regeltechniek
Blok 6: Verdere inleiding in de regeltheorie

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Cursus Systeem en Regeltechniek
Overzicht

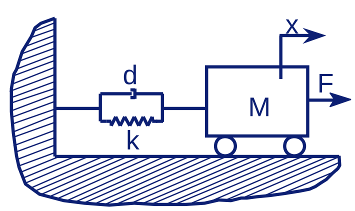
Deel 1 *Wo. 14-04*	Blok 1. Blok 2. Blok 3.	Inleiding Basisprincipes modelvorming massa-veersystemen De regelaar als veer-demper combinatie
Deel 2 *Wo. 21-04*	Blok 4. Blok 5.	Frequentie-domein beschrijving Basisconcepten in de regeltheorie
Deel 3 *Wo. 28-04*	Blok 6. Blok 7.	Verdere inleiding in de regeltheorie De PD regelaar als veer-demper combinatie
Deel 4 *Wo. 12-05*	**Stabiliteit van regelsystemen**	
Deel 5 *Wo. 19-05*	**Toepassing: PID regelaarontwerp**	
Deel 6 *Wo. 26-05*	**Extra regeltechniek**	

What is a feedback system?

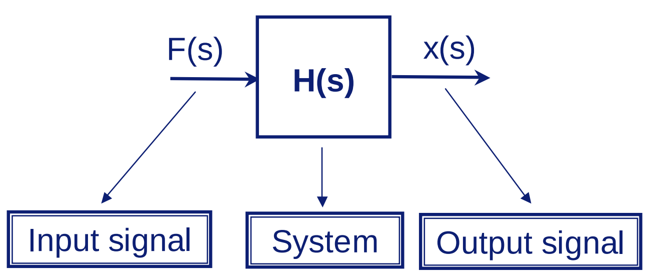
?

Block scheme representations

$$H(s) = \frac{x(s)}{F(s)} = \frac{1}{Ms^2 + ds + k}$$

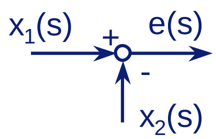


Laplace domain representation in block scheme:



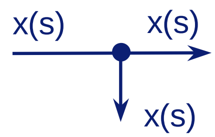
Block scheme representations

Summing joint:

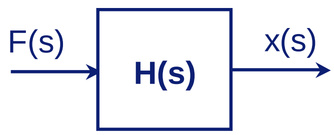


$e(s) = x_1(s) - x_2(s)$

Signal split:



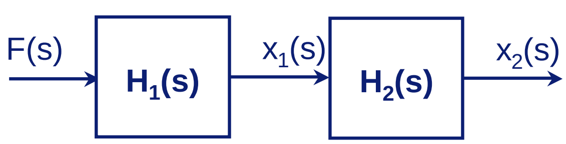
Input-output description:



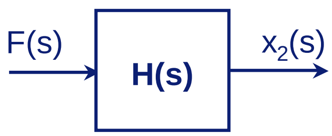
$x(s) = H(s) \cdot F(s)$

Block scheme representations

Cascade connection:



$x_2(s) = H_2(s) \cdot x_1(s) = H_2(s) \cdot H_1(s) \cdot F(s)$



$H(s) = H_1(s) \cdot H_2(s)$

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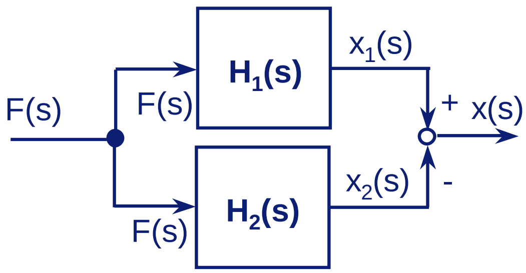
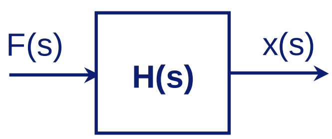
Further introduction in control theory

Block scheme representations

Parallel connection:



$$x(s) = x_1(s) - x_2(s)$$
$$= [H_1(s) - H_2(s)] \cdot F(s)$$



$$H(s) = H_1(s) - H_2(s)$$

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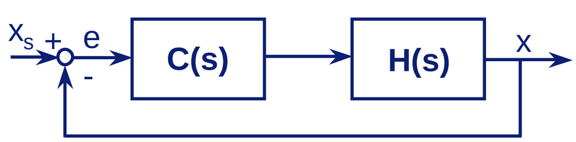
Block scheme representations

Feedback connection:



$$x(s) = C(s) \cdot H(s) \cdot e(s)$$
$$= C(s) \cdot H(s) \cdot [x_s(s) - x(s)]$$
$$= C(s) \cdot H(s) \cdot x_s(s) - C(s) \cdot H(s) \cdot x(s)$$

$$[1 + C(s) \cdot H(s)] \cdot x(s) = C(s) \cdot H(s) \cdot x_s(s) \qquad \frac{x(s)}{x_s(s)} = \frac{C(s) \cdot H(s)}{1 + C(s) \cdot H(s)}$$

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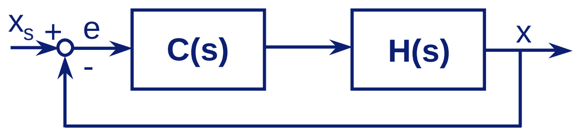
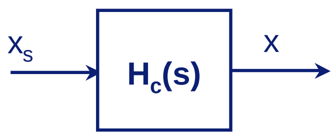
Block scheme representations

Feedback connection:





$$H_c(s) = \frac{x(s)}{x_s(s)} = \frac{C(s) \cdot H(s)}{1 + C(s) \cdot H(s)}$$

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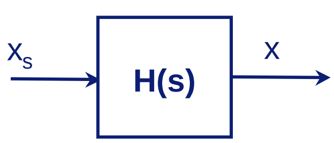
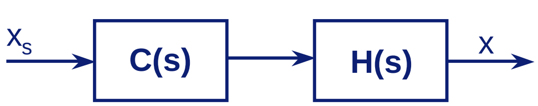
Why feedback?

Open loop:



$x \neq x_s$

Feedforward:



$x = x_s$ if: $C(s) = H^{-1}(s)$

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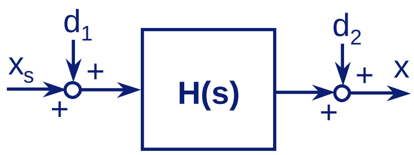
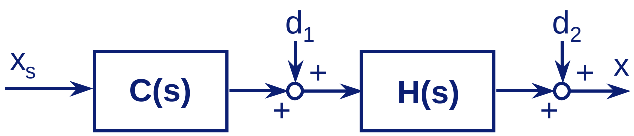
Why feedback?

Open loop with disturbances:



$x \neq x_s$

Feedforward with disturbances:



$x \neq x_s$ if: $C(s) = H^{-1}(s)$

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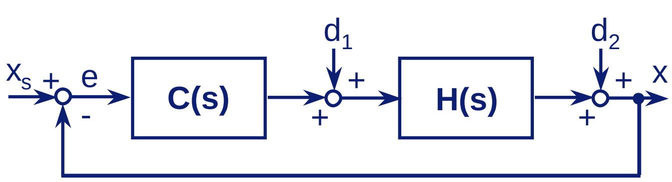
Why feedback?

Feedback with disturbances:



Recall: $H_c(s) = \dfrac{x(s)}{x_s(s)} = \dfrac{C(s) \cdot H(s)}{1 + C(s) \cdot H(s)}$

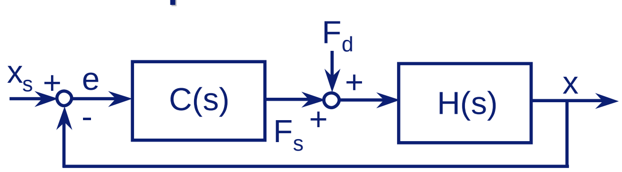
So: $x \approx x_s$ if: $C(s) \cdot H(s) >> 1$

Why feedback?

The aim of feedback is...

Disturbance Suppression

Four important transfer functions



Open Loop: $H_o(s) = \frac{x}{e} = C(s)H(s)$

Closed Loop: $H_c(s) = \frac{x}{x_s}(s) = \frac{C(s)H(s)}{1+C(s)H(s)}$

Sensitivity: $S(s) = \frac{e}{x_s}(s) = \frac{1}{1+C(s)H(s)}$

Process Sensitivity: $H_{ps}(s) = \frac{x}{F_d}(s) = \frac{H(s)}{1+C(s)H(s)}$

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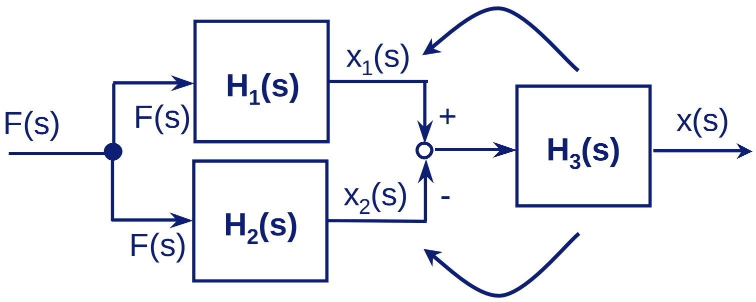
Further introduction in control theory

Further block scheme manipulation

Shift over summing joint:



$$x = H_3 \cdot [x_1 - x_2] = H_3 \cdot [H_1 - H_2] \cdot F = [H_3 \cdot H_1 - H_3 \cdot H_2] \cdot F$$

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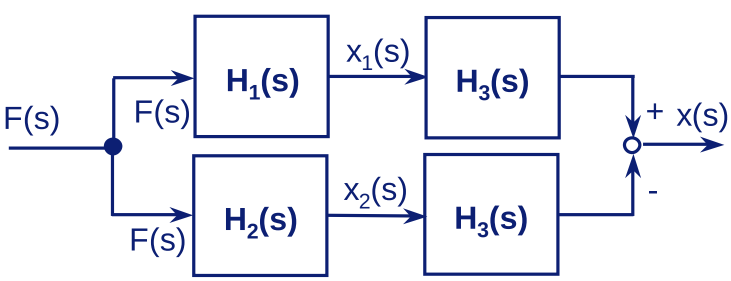
Further introduction in control theory

Further block scheme manipulation

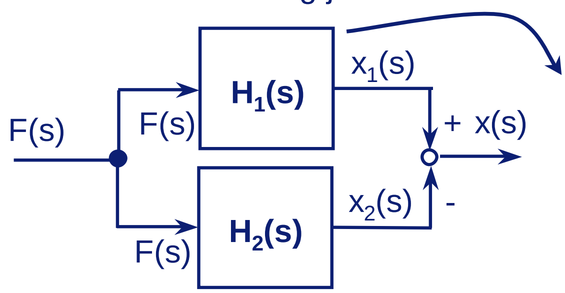
Shift over summing joint:



$$x = H_3 \cdot [x_1 - x_2] = H_3 \cdot [H_1 - H_2] \cdot F = [H_3 \cdot H_1 - H_3 \cdot H_2] \cdot F$$

Further block scheme manipulation

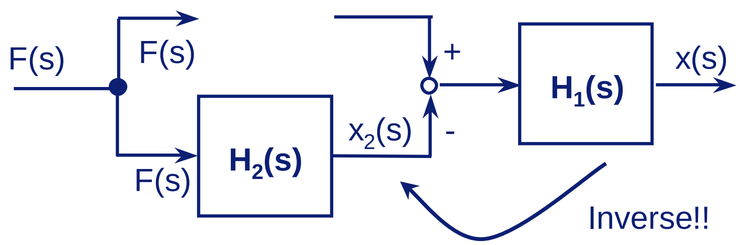
Partial shift over summing joint:



$x = [x_1 - x_2] = [H_1 - H_2] \cdot F$

Further block scheme manipulation

Partial shift over summing joint:



$x = [x_1 - x_2] = [H_1 - H_2] \cdot F = H_1 \cdot [1 - H_2/H_1] \cdot F$

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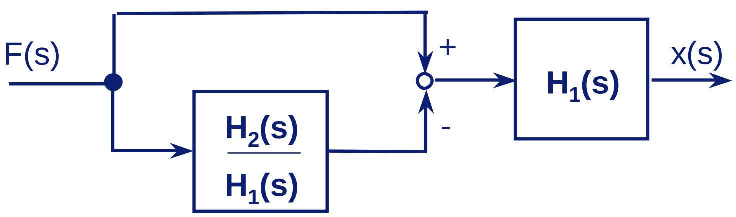
Further block scheme manipulation

Partial shift over summing joint:



$$x = [x_1 - x_2] = [H_1 - H_2]\cdot F = H_1\cdot[1 - H_2/H_1]\cdot F$$

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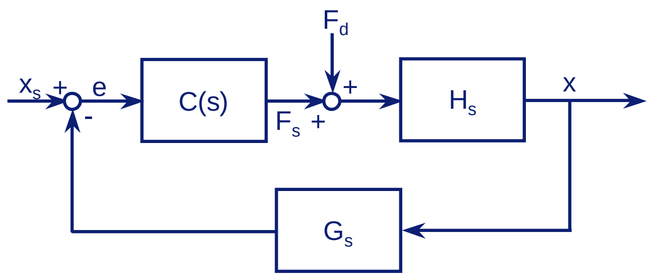
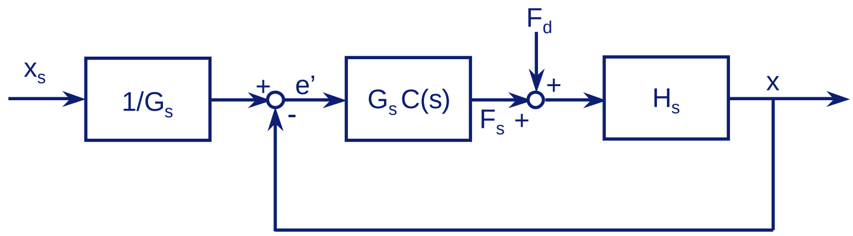
Exercise: block scheme manipulation



1. $H_0(s) =$ ……
2. $H_c(s) = \frac{x}{x_s}(s) =$ ……
3. $S(s) = \frac{e}{x_s}(s) =$ ……
4. $H_{ps}(s) = \frac{x}{F_d}(s) =$ ……

Exercise: block scheme manipulation



1. $H_0(s) = \ldots\ldots$
2. $H_c(s) = \frac{x}{x_s}(s) = \ldots\ldots$
3. $S(s) = \frac{e}{x_s}(s) = \ldots\ldots$
4. $H_{ps}(s) = \frac{x}{F_d}(s) = \ldots\ldots$

Summary

- Block schemes:
  - Summing joint / signal split
  - Series / Parallel / Feedback connection
- Feedback: disturbance suppression
- Block scheme manipulation:
  - Shifting blocks
  - Computation of transfer functions