

« Inversion-Based Control deduced from EMR »

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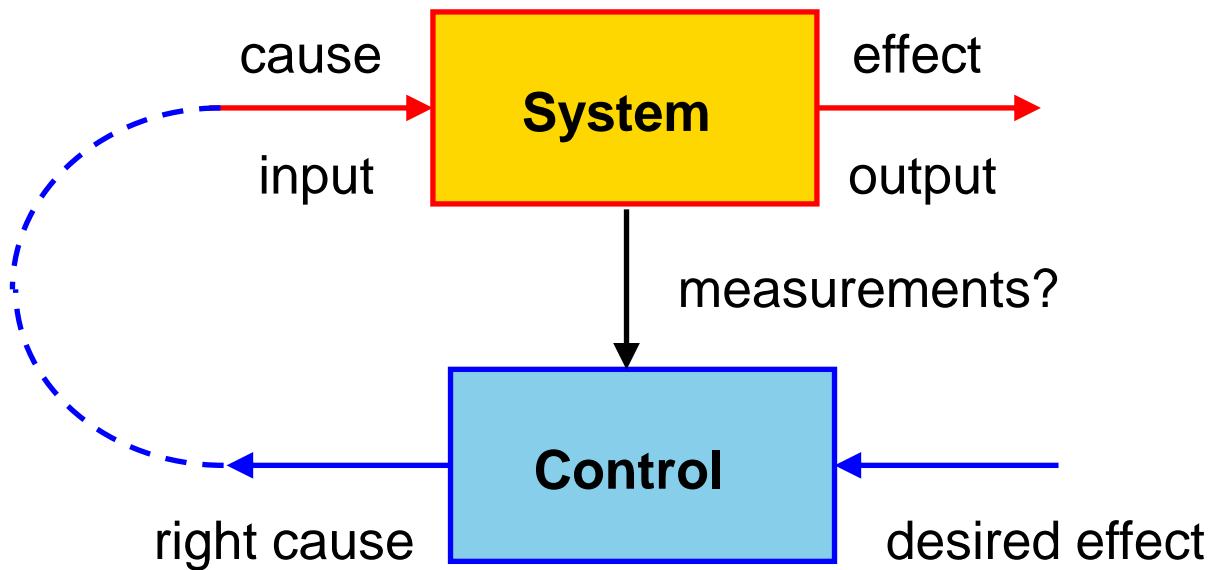
- 1** Principle of Model-Based Control
- 2** Inversion of EMR Elements
- 3** Inversion-Based Control Scheme



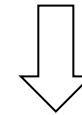
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« Principle of Model-based Control »

[Hautier 96]



$$\text{Model } out = f(in)$$



$$\text{Control } in = g(out_{ref})$$

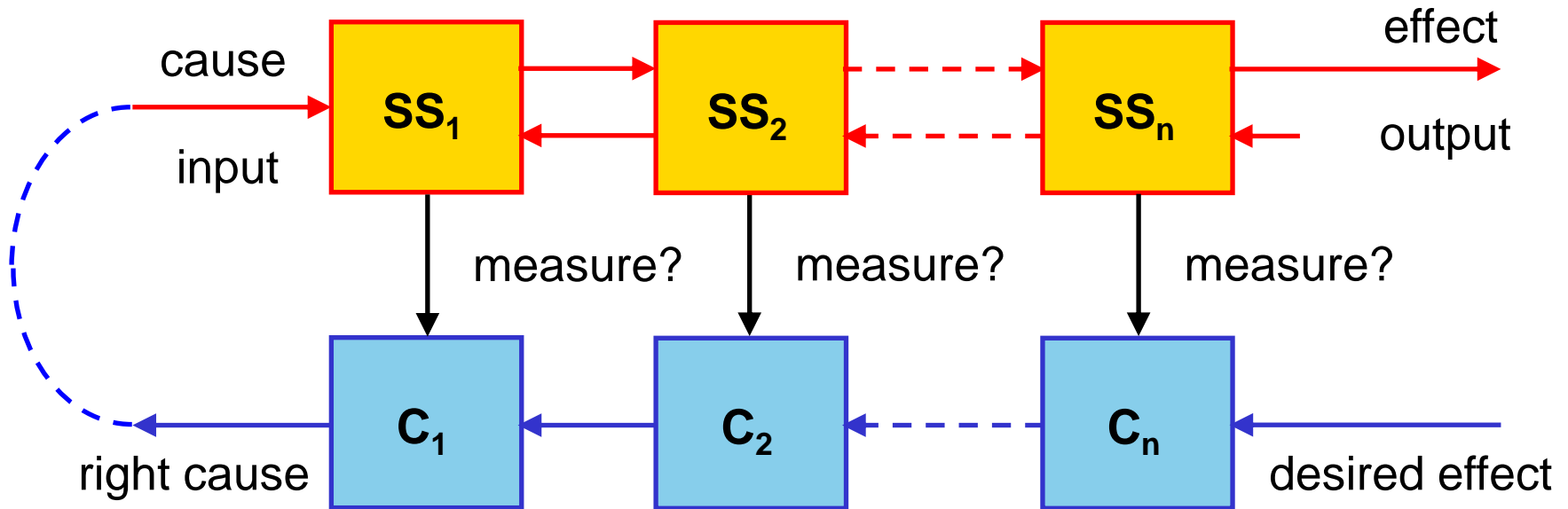
control = inversion of the system functionality

Inversion-Based Control deduced from EMR

- Principle of Model-based Control -

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EMR = system decomposition in basic energetic subsystems (SS_n)



Remember,
divide and conquer!

Inversion-based control: systematic inversion of each subsystem



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« Inversion of EMR elements »

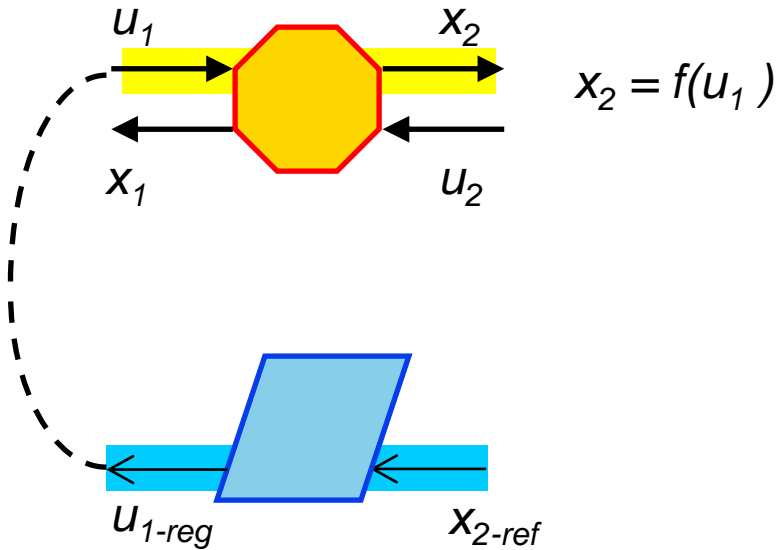
Model $out = f(in)$ \Rightarrow Control $in = g(out_{ref})$

I/O relation without delay \longrightarrow direct inversion

I/O relation with delay \longrightarrow Indirect inversion
(closed-loop control)

I/O relation with multiple Inputs \longrightarrow Multiple solutions

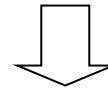
Objective: to control y_2



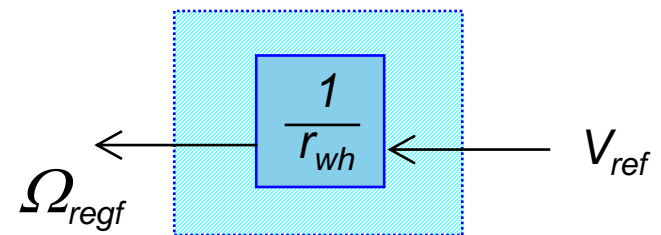
Direct Inversion

Ex : wheel

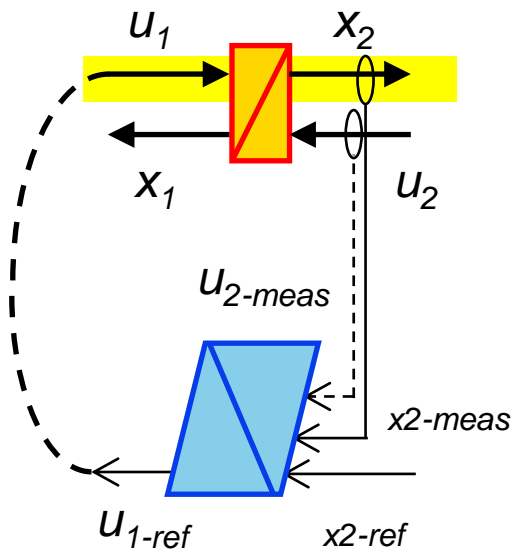
$$\begin{cases} V = r_{wh} \Omega \\ T = r_{wh} F \end{cases}$$



$$\Omega_{ref} = V_{ref} / r_{wh}$$



Objective: to control y_2



$$x_2 = f(u_1, u_2)$$

f is in integral form

direct inversion

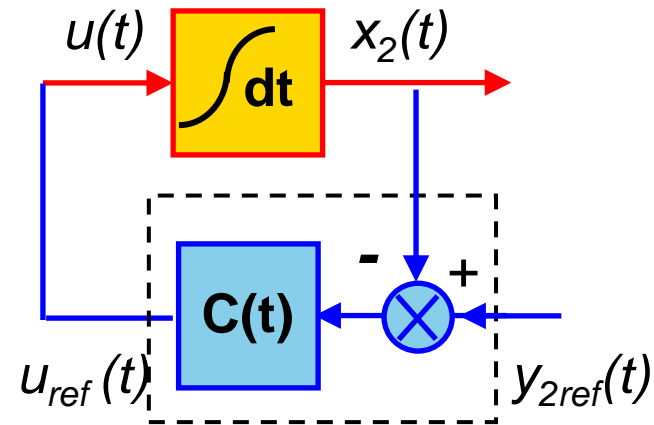
indirect inversion

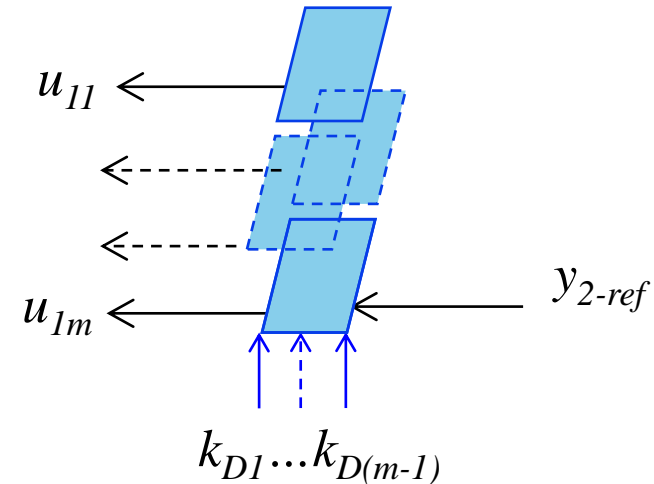
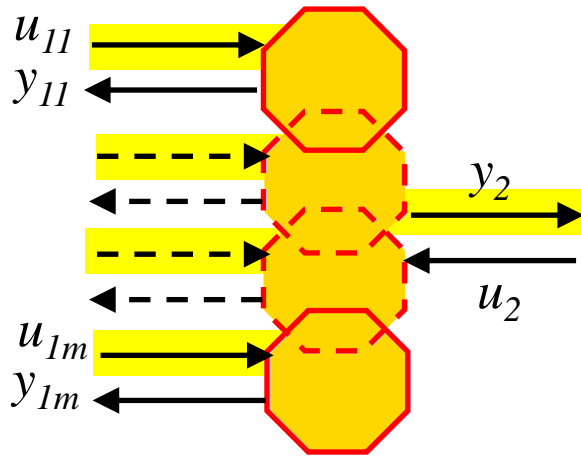
not possible in real-time

~~$$u_{ref}(t) = \frac{d}{dt} x_{ref}(t)$$~~

$$u_{ref}(t) = C(t)[x_{2ref}(t) - x_{2meas}(t)]$$

closed loop controller

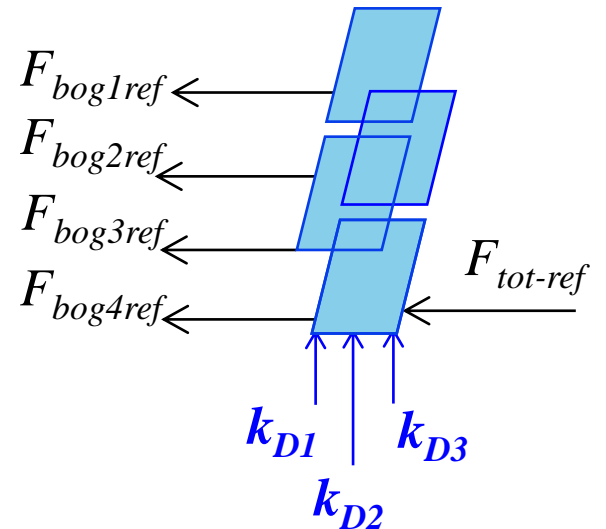
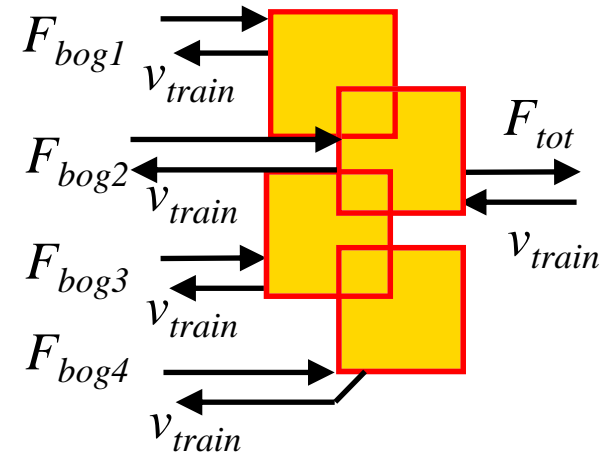




no measurement
no controller
($m - 1$) **distribution variables**

$$\left\{ \begin{array}{l} u_{11} = k_{D1} y_{2ref} \\ \dots \\ u_{1(m-1)} = k_{D(m-1)} y_{2ref} \\ u_{1m} = (1 - \sum k_{Di}) y_{2ref} \end{array} \right.$$

Example: chassis of a train



Inversion-Based Control deduced from EMR

- Inversion of EMR elements -


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Legend

Control = light blue
Parallelograms
with dark blue
contour

 direct
inversion

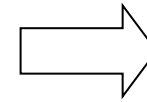
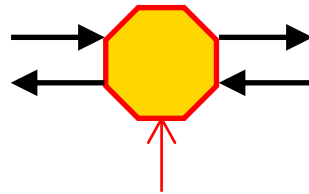
 indirect
inversion

 sensor

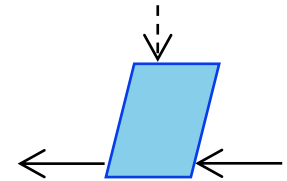
 mandatory link

 facultative link

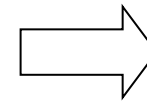
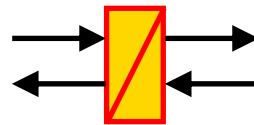
conversion element



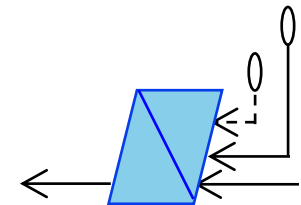
direct inversion +
disturbance rejection



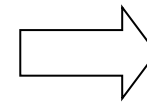
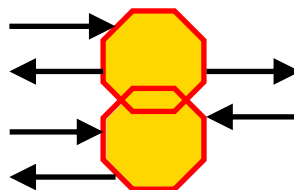
accumulation element



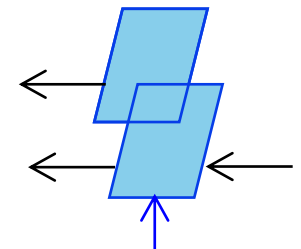
controller +
disturbance rejection



coupling element



distribution criteria

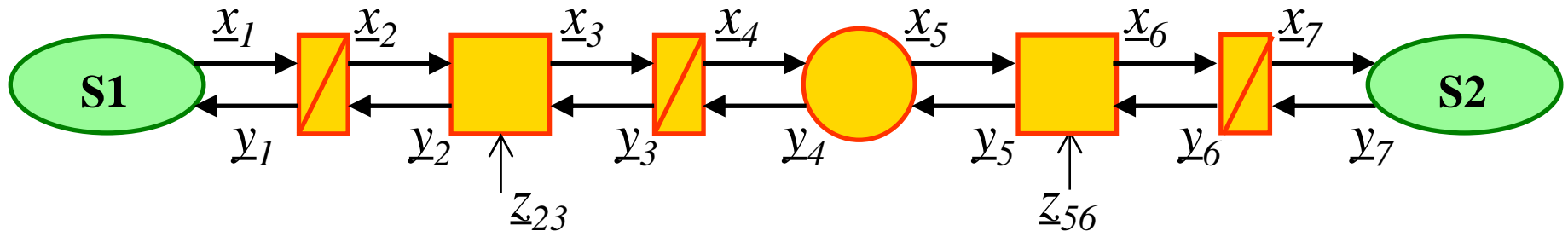




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«**Inversion-Based Control Scheme**»

1. EMR of the system

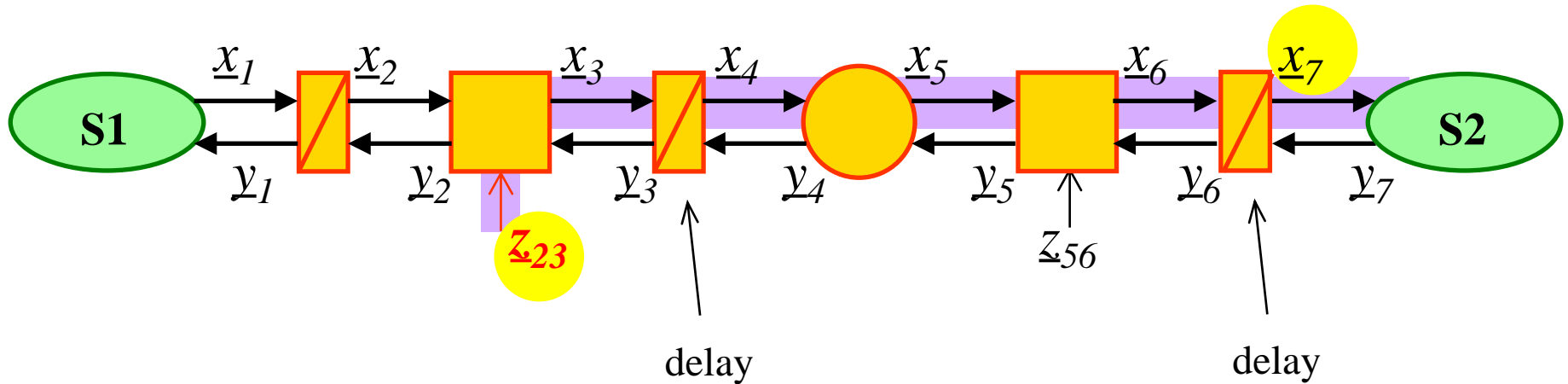


EMR depends on:

- the study objective (limits between system and sources)
- the physical laws of subsystems (physical causality)
- the association of subsystems (systemic approach)

1. EMR of the system

2. Tuning path



The tuning path is:

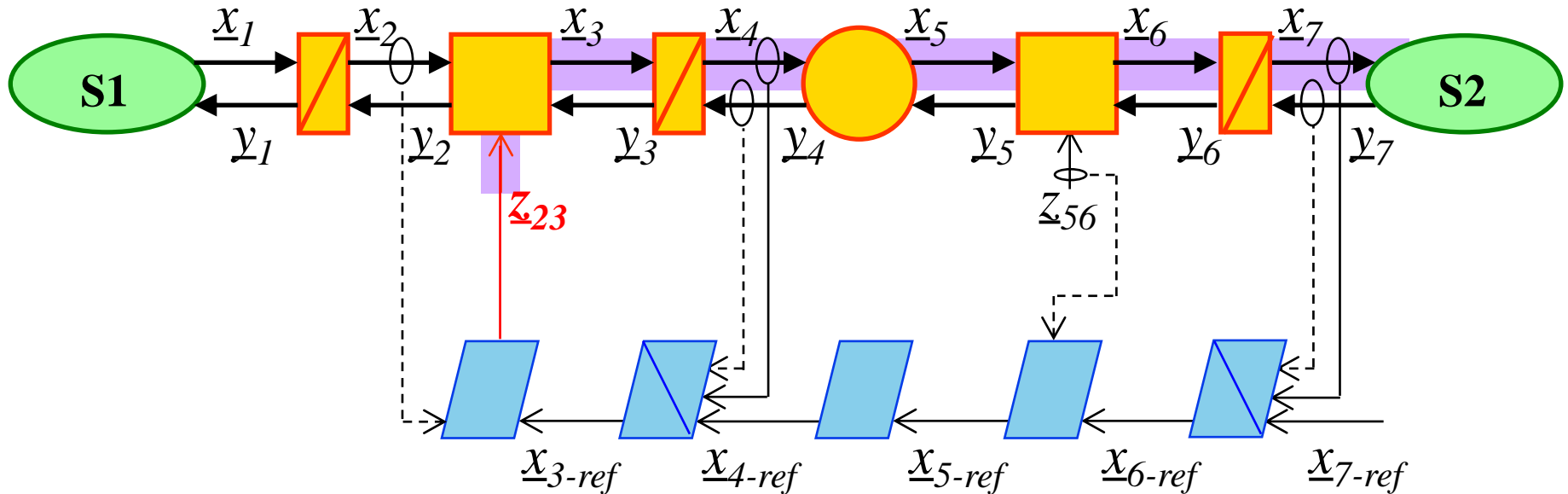
- dependant on the technical requirements (chosen tuning input / output to control)
- **independent of the power flow direction**

1. EMR of the system

2. Tuning path

3. Inversion step-by-step

Strong assumption: all variables can be measured!



Maximal Control Structure (or scheme):

- maximum of sensors
- maximum of operations

Example:

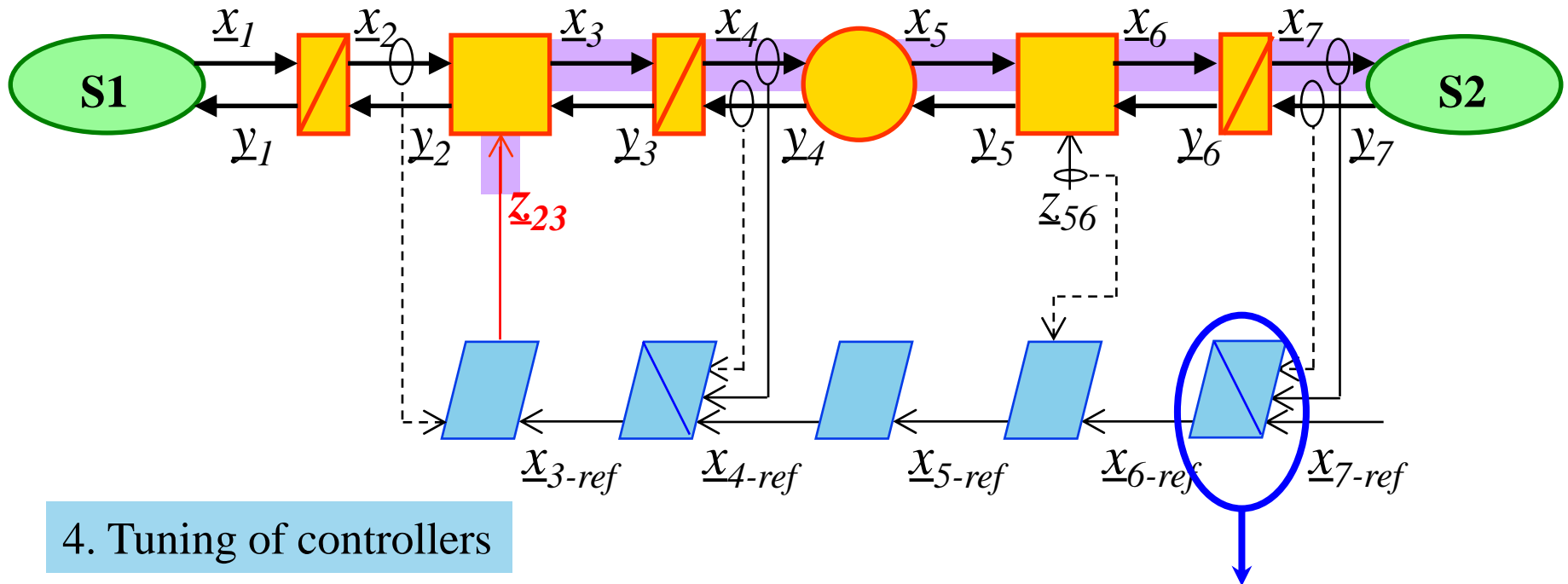
- 5 sensors
- 2 closed-loop controllers

1. EMR of the system

2. Tuning path

3. Inversion step-by-step

Strong assumption: all variables can be measured!



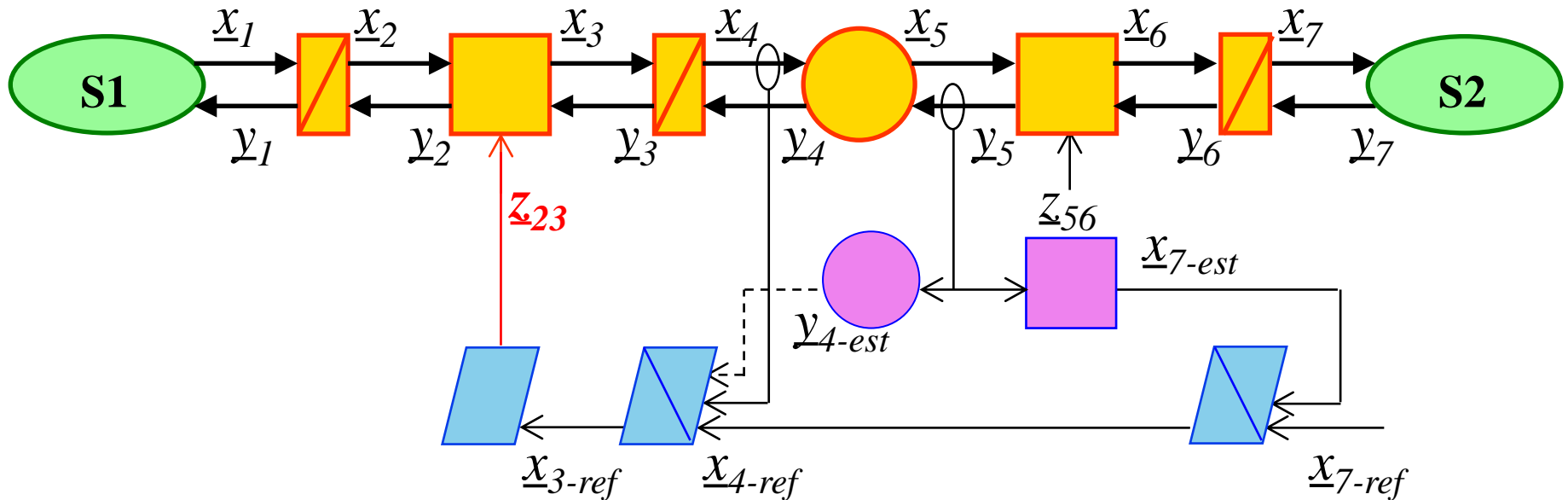
4. Tuning of controllers

PI / PID / fuzzy controller?
Calculation of parameters?

1. EMR of the system

2. Tuning path

3. Inversion step-by-step **Strong assumption: all variables can be measured!**



4. Tuning of controllers

5. Simplification and estimation

« Conclusion »

Inversion based control = inversion of EMR

based on the cognitive systemic
and the causality principle (energy)

Inversion rule for control scheme

closed-loop control to invert accumulation, direct inversion for
conversion element, degrees of freedom for coupling element



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