« Energy and System »

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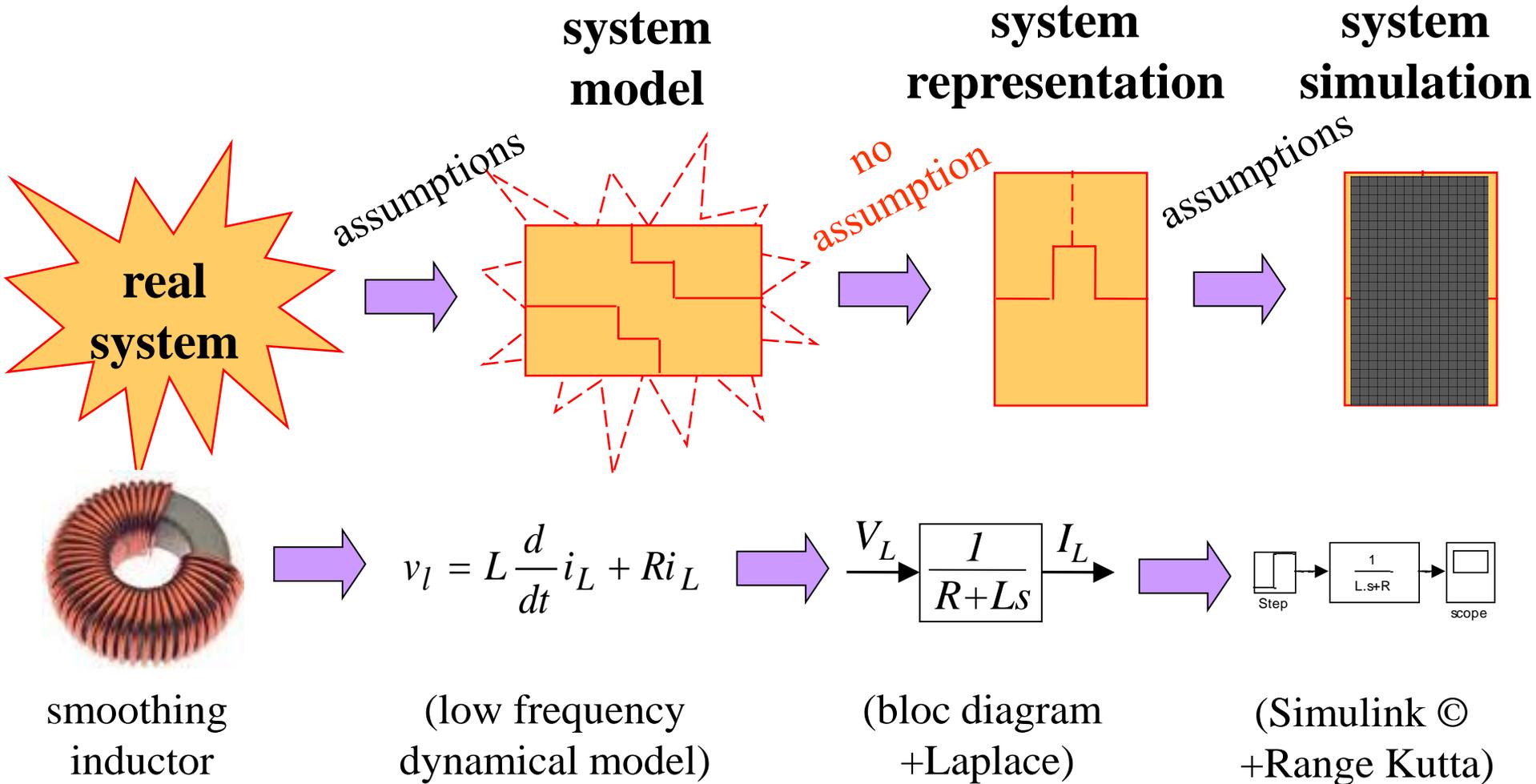
(University of Hong-Kong, China)

EMR'22, Sion, June 2022

system model

system representation

system simulation

real system

assumptions

no assumption

assumptions

Limitation to main phenomena in function of the objective

Organization of the model to highlight some properties
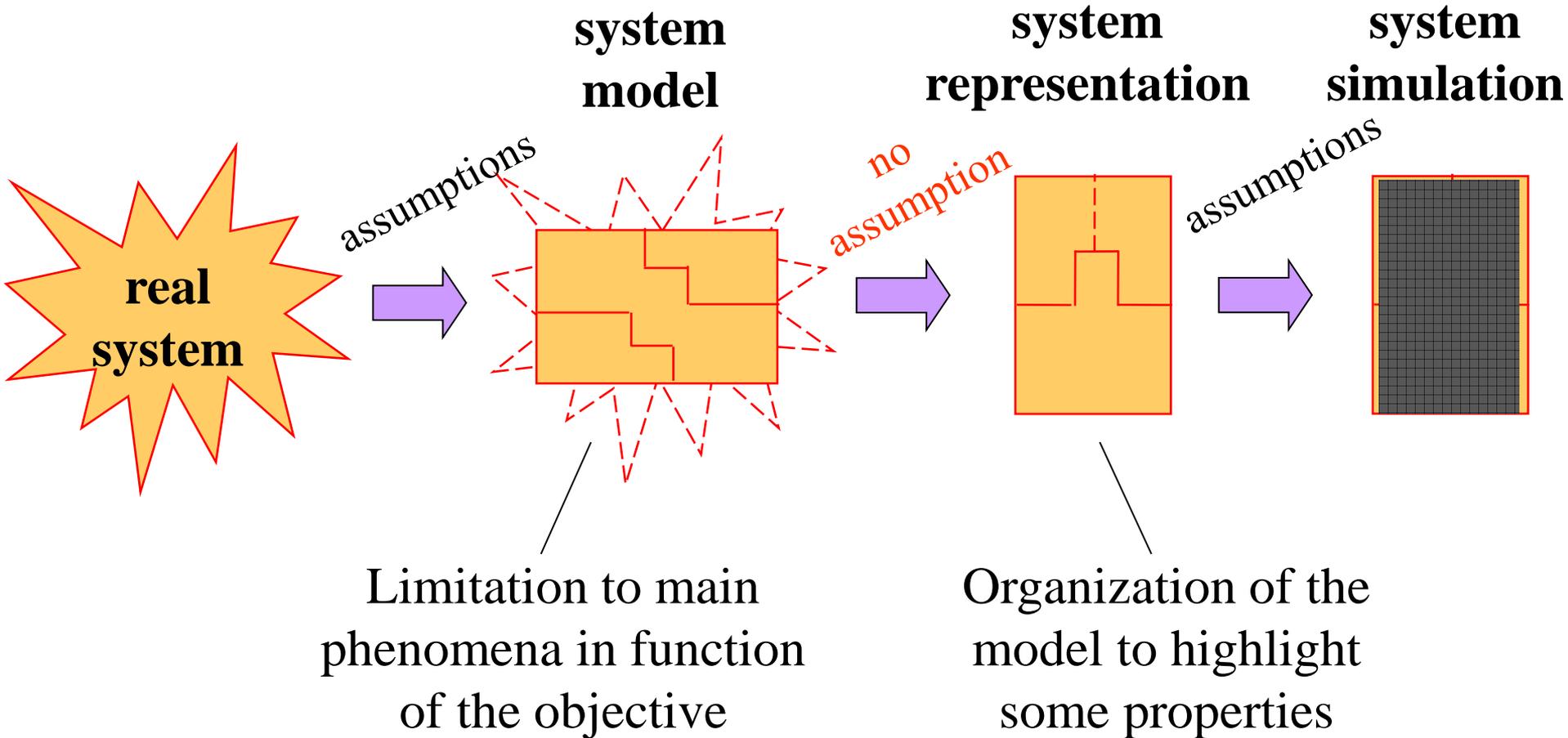
Intermediary steps are required for complex systems

system model

system representation

system simulation

assumptions

no assumption

assumptions

real system

smoothing inductor

$$v_l = L \frac{d}{dt} i_L + R i_L$$

(low frequency dynamical model)

$$V_L \rightarrow \boxed{\frac{1}{R+Ls}} \rightarrow I_L$$

(bloc diagram +Laplace)

Step — $\frac{1}{L.s+R}$ — scope

(Simulink © +Range Kutta)

Different possibilities at each step according to the objective

1 **System & Interaction**

2 **Energy & Causality**

3 **Graphical descriptions**
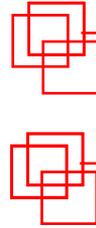
« 1. System & Interaction »

How to connect multi-physical subsystems?
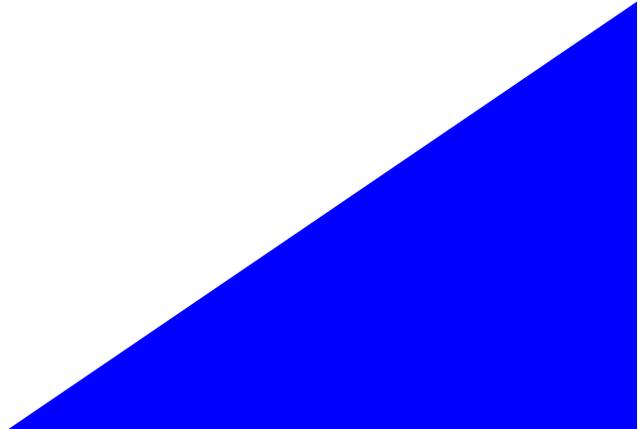
System = interconnected subsystems

Systemic approach
Study of subsystems and their interactions
Holistic property: associations of
subsystem induce new global properties.

Cartesian approach
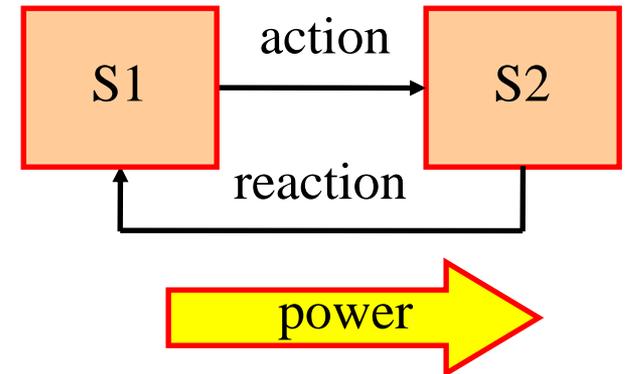The study of subsystems is
sufficient to know the system
behaviour.

Cybernetic systemic
black box approach.
behaviour model

Cognitive systemic
physical laws
knowledge model

**For better performances of a system,
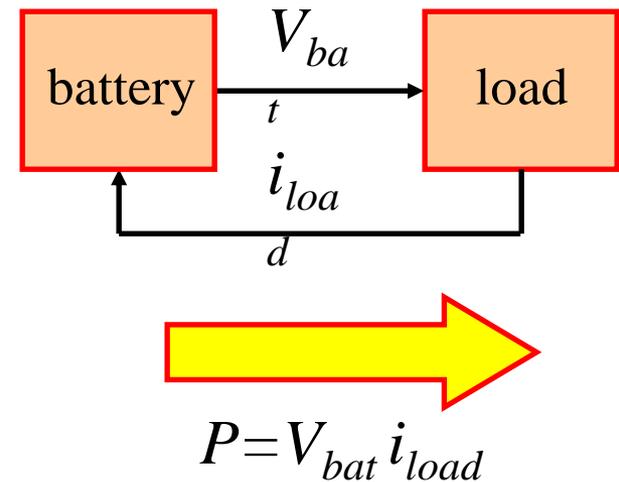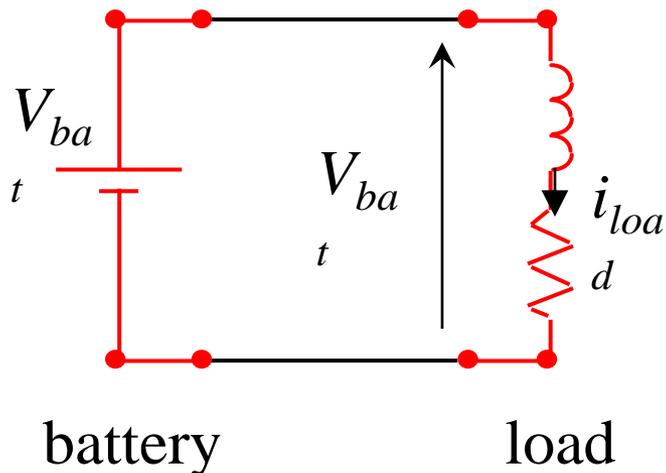Interactions and physical laws must be considered!**

Interaction principle
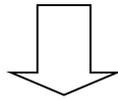Each action induces a reaction

Power exchanged by S1 and S2 = action x réaction

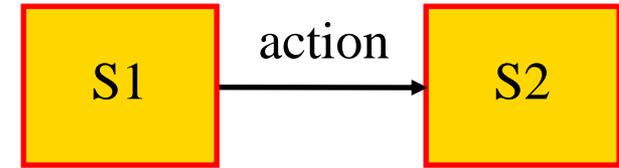*Example*

battery   load

$P = V_{bat} i_{load}$

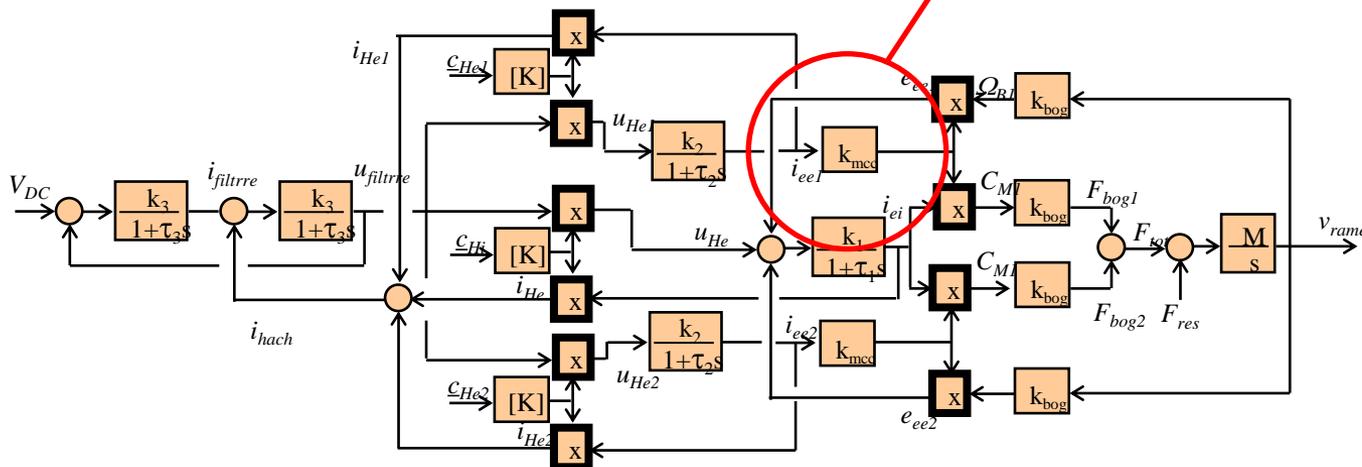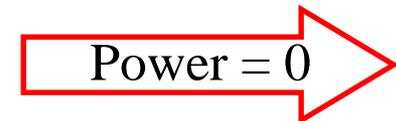If the interaction principle is
not respected for 1 subsystem

⇩

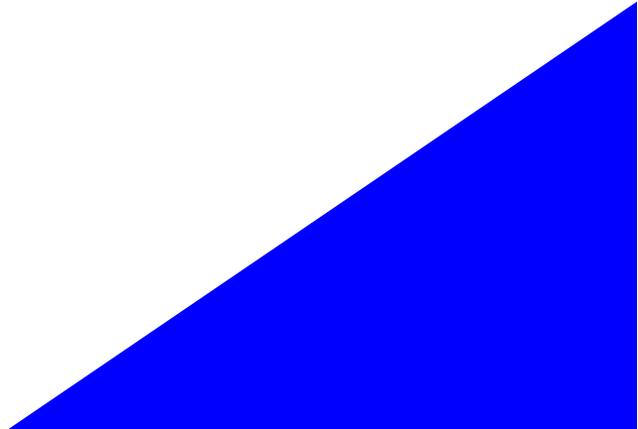Error in the energy analysis
for the whole system

$S1$ — action → $S2$

$(\text{reaction} = 0)$

Power = 0 →

« 2. Energy & Causality »

How to manage energy in the best way?

Principle of causality
physical causality is integral

input → output

cause → effect
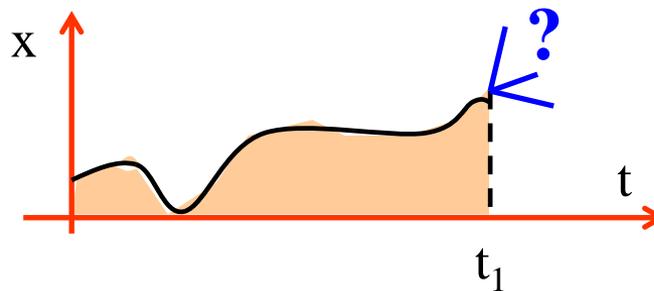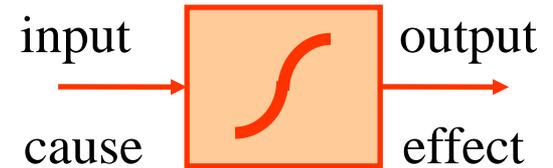
$$\int x\,dt$$ ⟹ area

OK in real-time

⟱

knowledge
of past evolution

slope ⟸ $$\frac{dx}{dt}$$

impossible in real-time

⟱

knowledge
of future evolution

Example

$$i_c = C \frac{d}{dt} v_c + \frac{v_c}{R}$$

$$E_c = \frac{1}{2} v_c^{\ 2}$$

i_c $\quad$ v_C

delay

no energy disruption

v_C $\quad$ $\dfrac{d}{dt}$ $\quad$ i_c
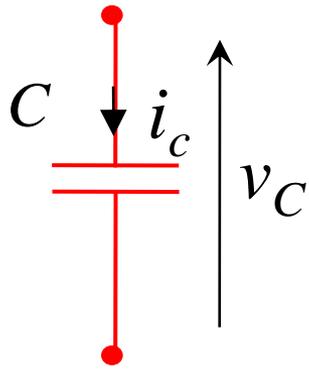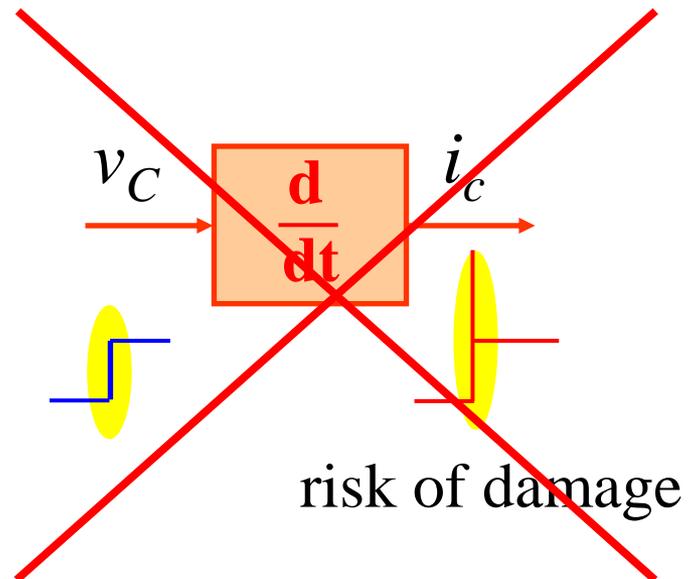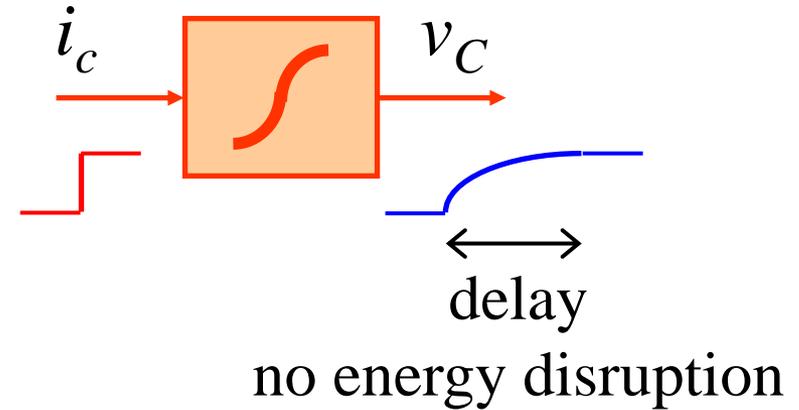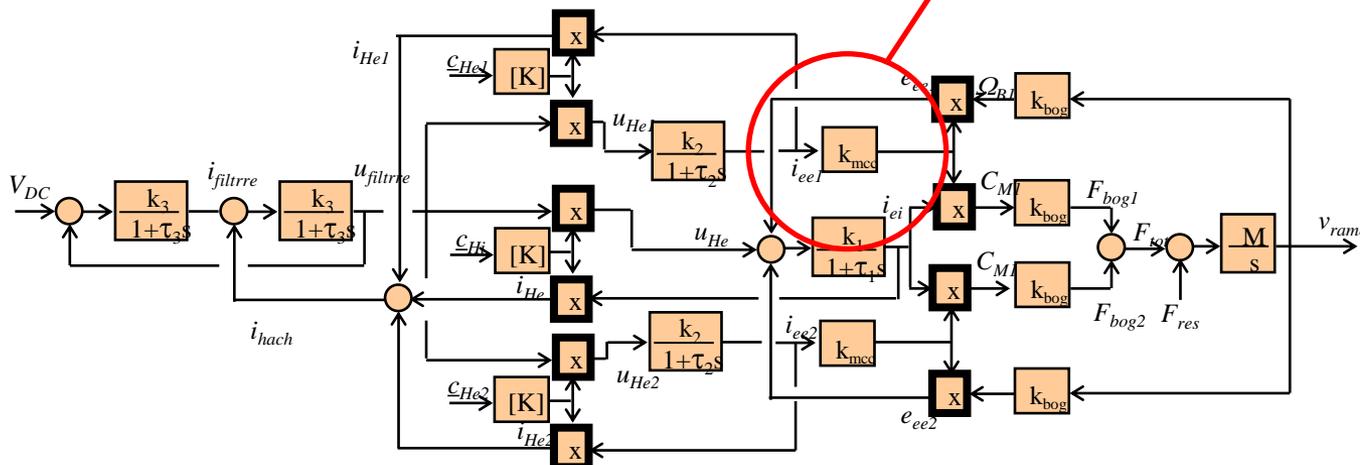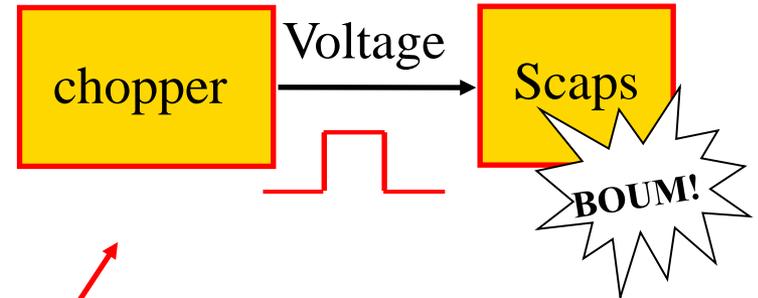
risk of damage

For energetic systems
physical causality is VITAL

If the causality principle is not
respected for 1 subsystem

⬇
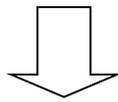
Risk of damage!
No real-time management

Graphical descriptions help to:

Respect interactions: performances require a systemic approach

Respect causality: energy management requires a causal approach

Define cascaded control: organization using inversion rules
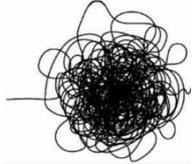
Remember, follow
a disciplined procedure!
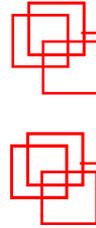
Divide and conquer!

**If
not**
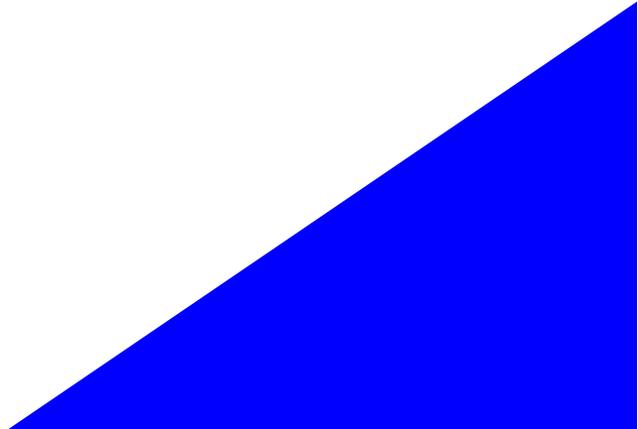
Nightmare
for finding errors

?#@!&?

confidence?
accuracy?

« BIOGRAPHIES AND REFERENCES »

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