EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Robustné PID-regulátory s obmedzeniami
Robust Constrained PID Control

Experiment support

prof. Ing. Mikuláš Huba, Ph.D.
Ing. Peter Ťapák, Ph.D.

Tato prezentace je spolufinancována Evropským sociálním fondem a státním rozpočtem České republiky.

uDAQ28/LT

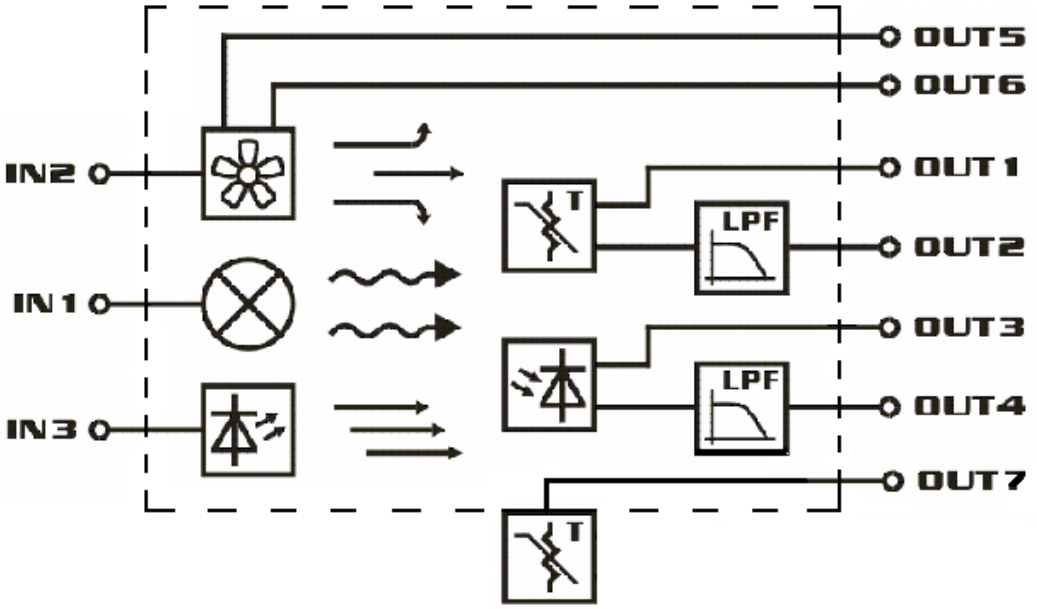
THERMAL-OPTICAL PLANT

uDAQ28/LT

- Communicates with PC via USB
- Two plants in one
  - Thermal
  - Optical

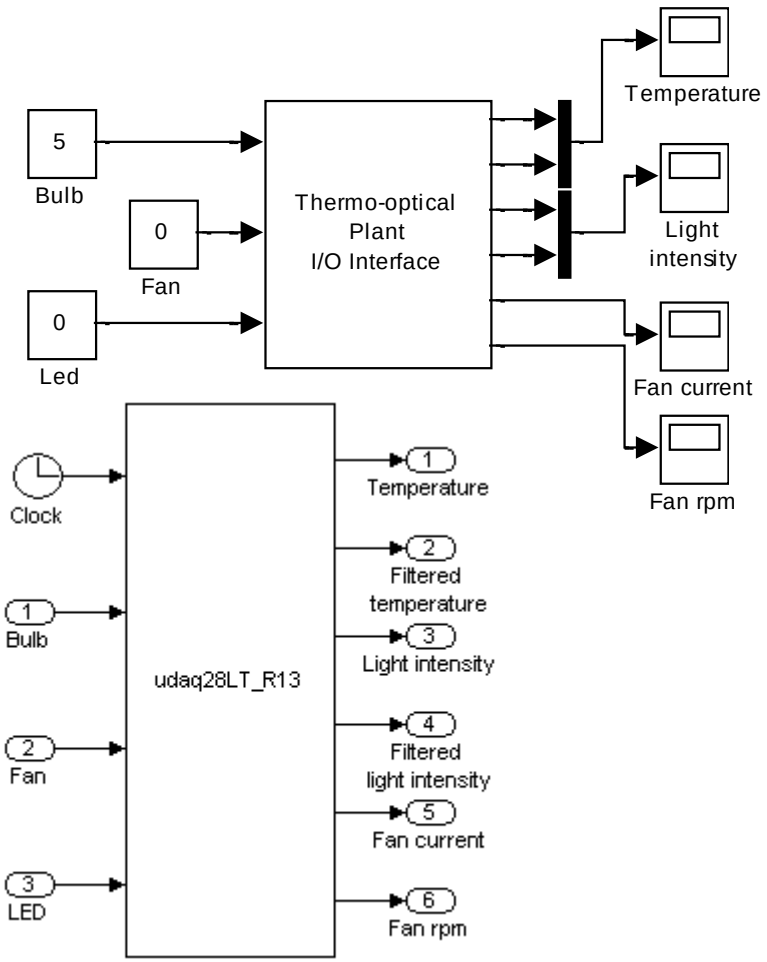
Inputs/Outputs

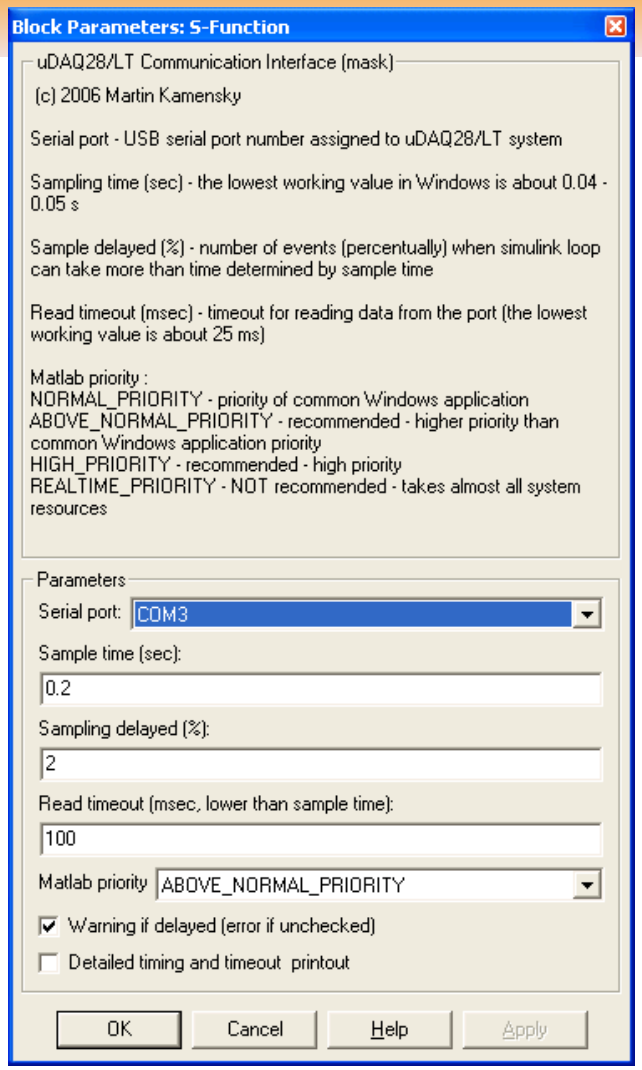
- **3 inputs**
  - Bulb voltage (heating + light emission)
  - LED voltage (add. light source)
  - Fan voltage (cooling)



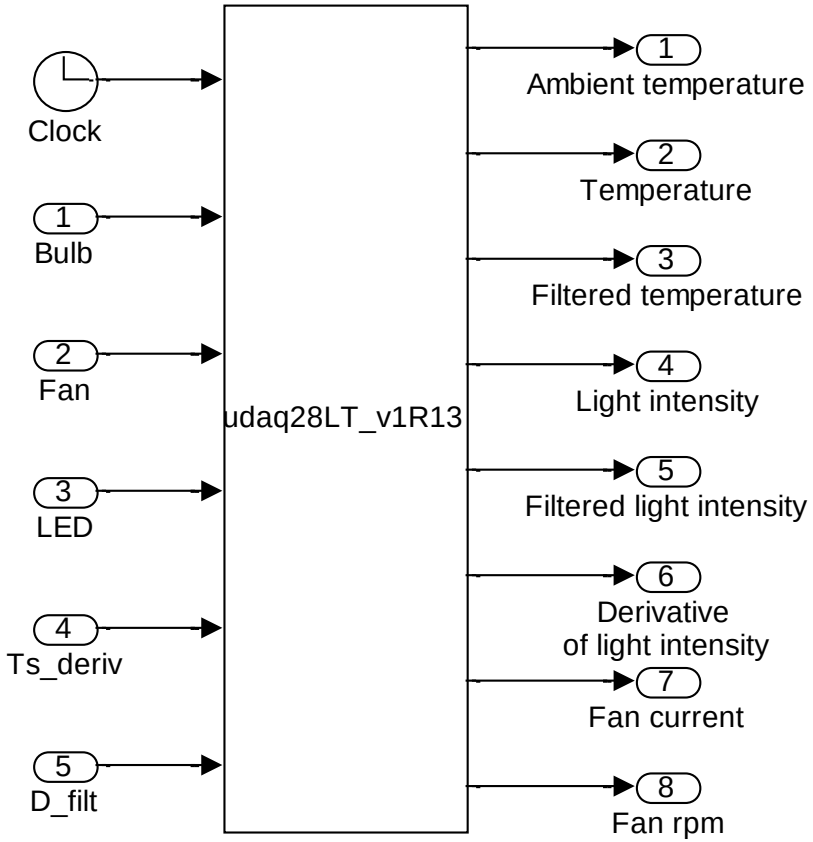
- **6-7 outputs (depend on FW)**
  - Temperature
  - Filtered temperature
  - Light intensity
  - Filtered light intensity
  - Fan current
  - Fan speed

Simulink Model





Simulink Model



First experience (exnum:1)

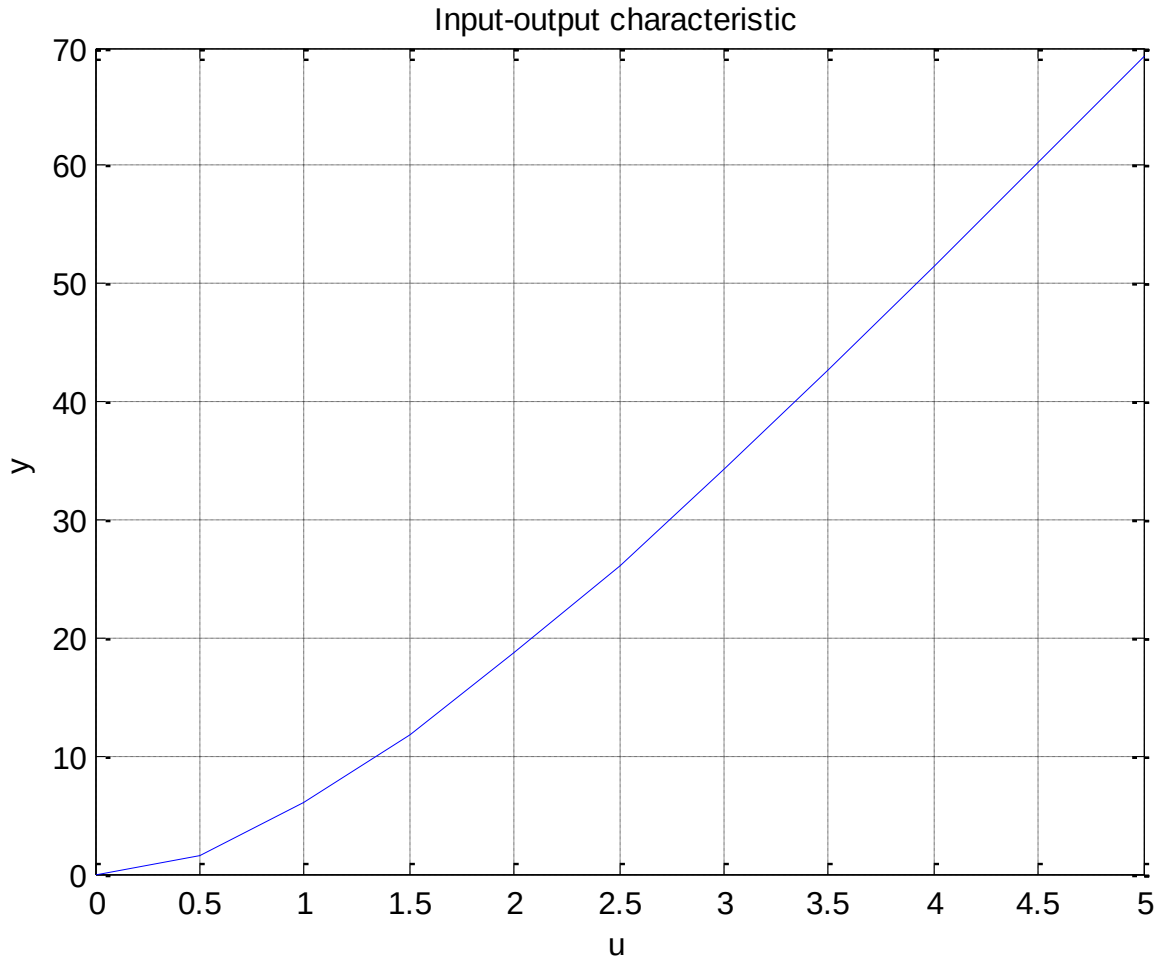
- Set the bulb voltage to 5V, then watch the output of the light channel
- Watch the change of the light channel output when changing the LED voltage
- Watch the thermal channel output while changing the bulb voltage and fan voltage

I/O CHARACTERISTIC MEASUREMENT

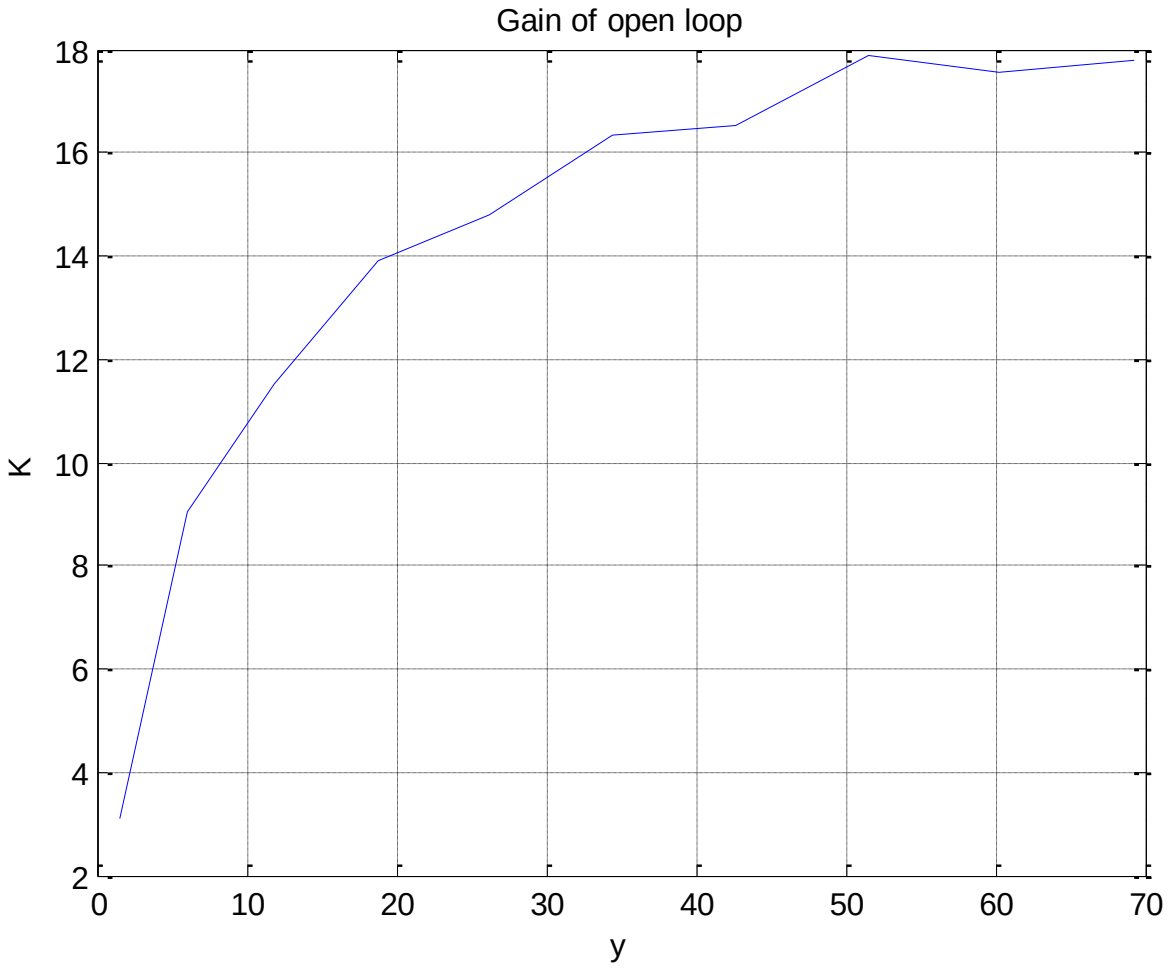
Experiments

- Measure I/O characteristics
  - Use Exnum: 2
- You will be provided by 3 figures as followed in next 3 slides
- Put down intervals in which values of K and Td range

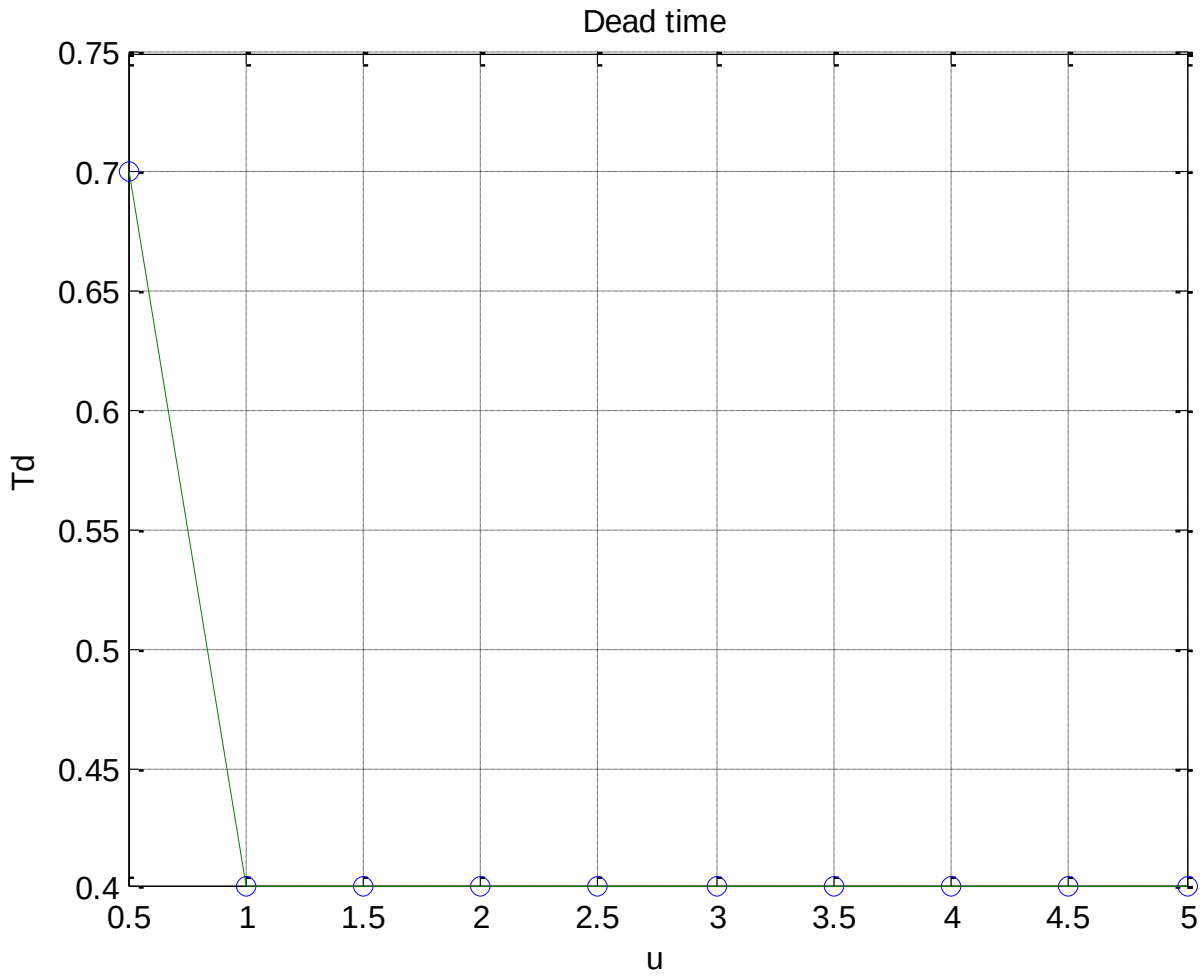
I/O characteristic



Process Gain

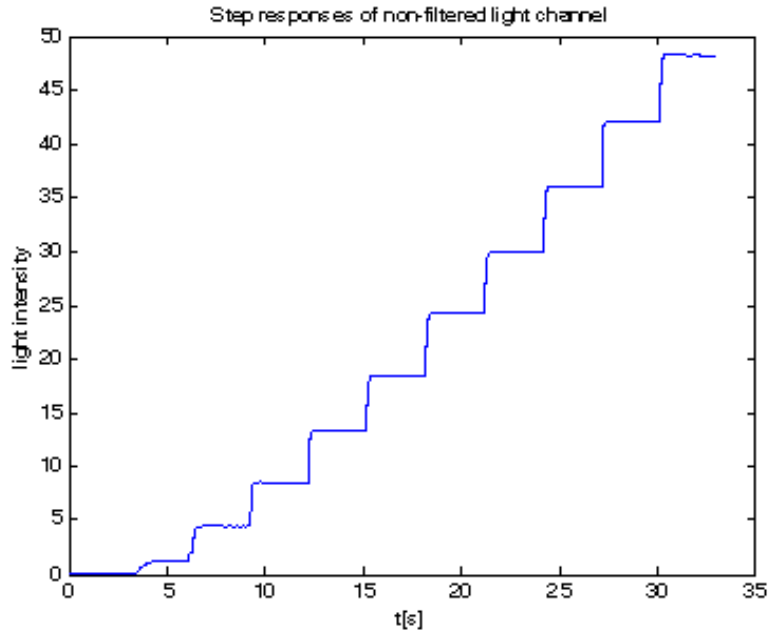


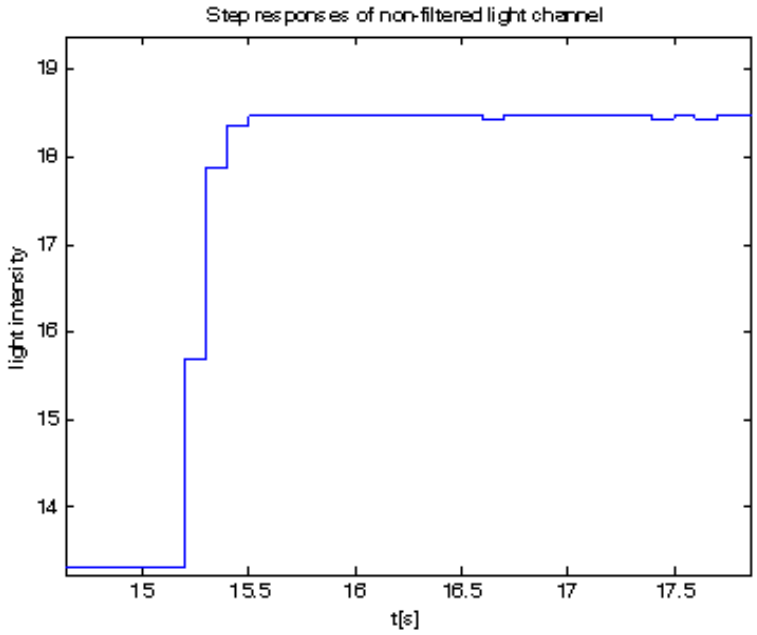
Dead time



FYI- Step responses

- To plot step responses which is the I/O characteristics obtained from use
- stairs (yl (: , 1) , yl (: , 4) , ’ k : ’)

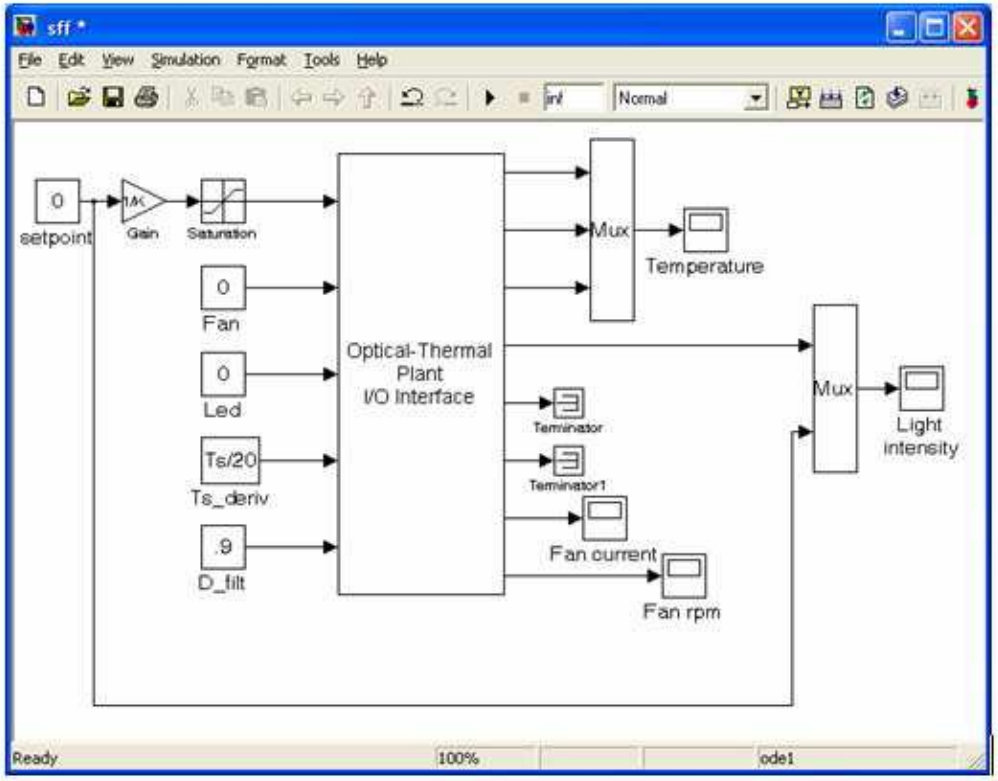




FEED FORWARD -> I_0-CONTROLLER

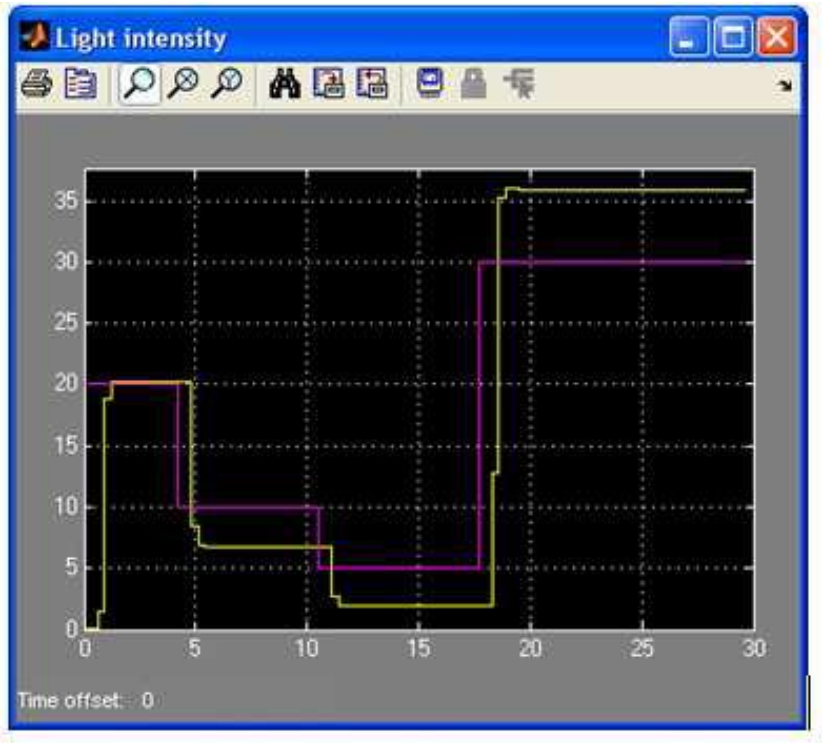
Static feed forward

- Modify the Simulink model to use the inverse process gain to control the plant
- Do not forget to add the input saturation in the model, the bulb voltage is limited from 0V to 5V
- Add the setpoint signal to the light intensity scope.
- Set the simulation time to infinity.



Static feed forward

- Make multiple setpoint steps in a wide operational range.
- It can be done while the experiment is running.

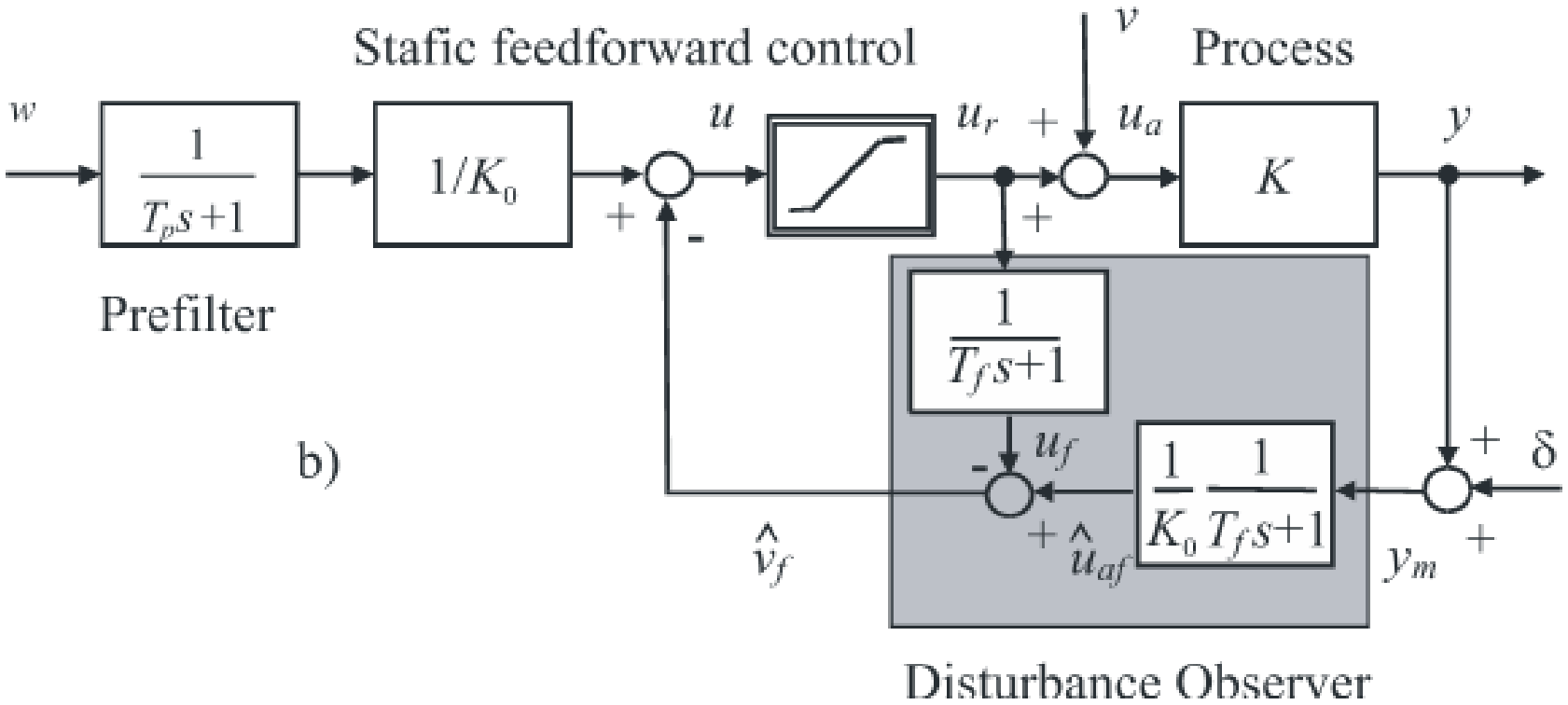


Static feed forward

- You should observe a steady state error in several working points.
- The smallest steady state error can be seen around the point where the process gain was measured.
- It is not difficult to conclude that the process parameters vary through the operational range, in other words the I/O characteristics of the non-filtered light channel is not linear.

FI_0-controller

The disturbance observer can be added to the static feedforward control to compensate the steady state error. To obtain a structure equivallent to I-controller, the pre-filter with time constant equal to the observer time constant has to be added as well.

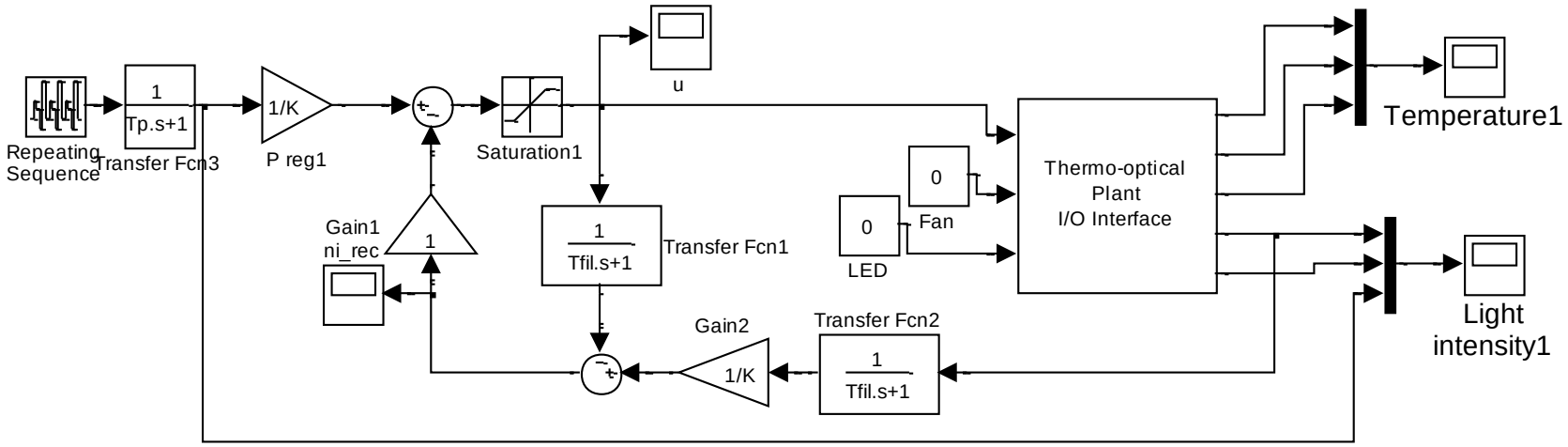


FI_0-controller

- Use exnum: 3 to start experiment with FI_0-controller
- Tuning of the controller requires information on a process gain and approximation of the non-modelled dynamics - usually by the dead time.
- Feel free to modify the model to make your own setpoint steps sequence.
- The goal is to achieve quick non-overshooting transients.
- Use the lowest, the average and the maximum process gain in the controller tuning.

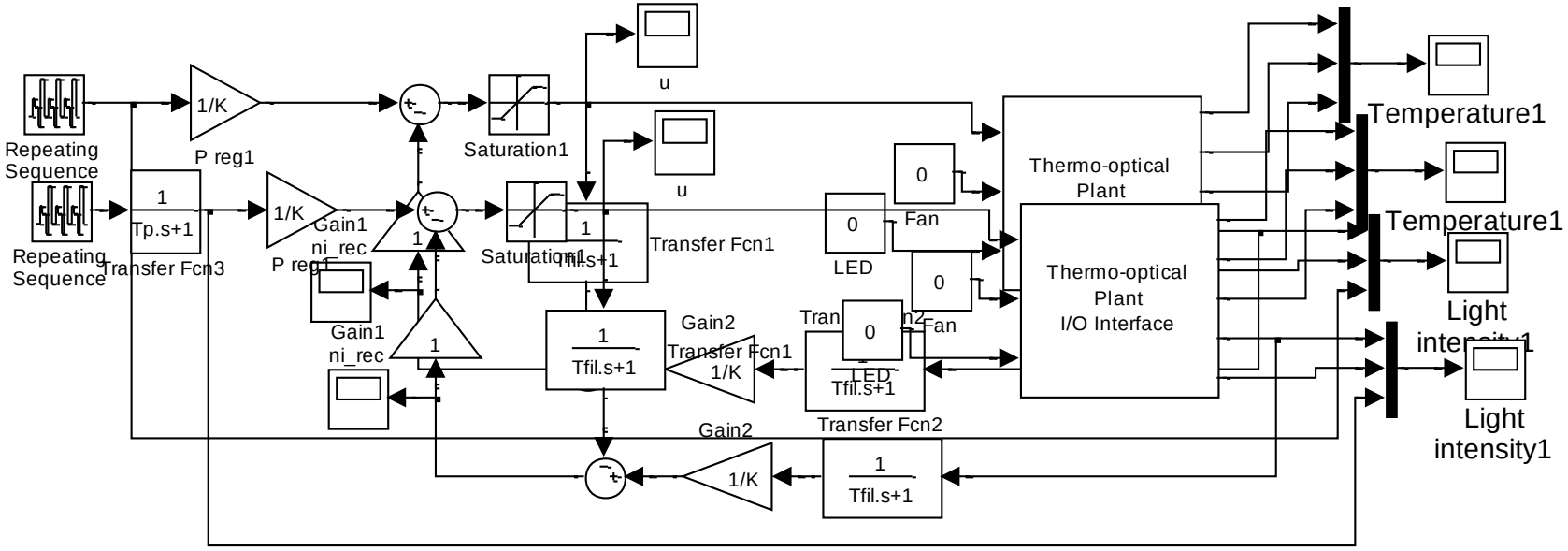
FI_0-controller

- Use exnum: 3 to start experiment with FI_0-controller
- Tuning of the controller requires information on a process gain and approximation of the non-modelled dynamics - usually by the dead time.

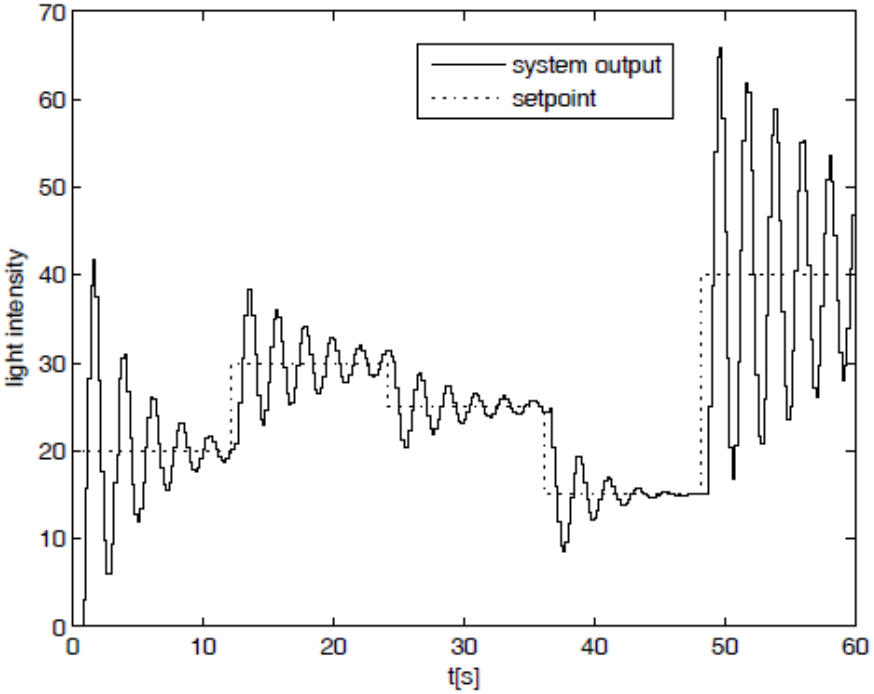


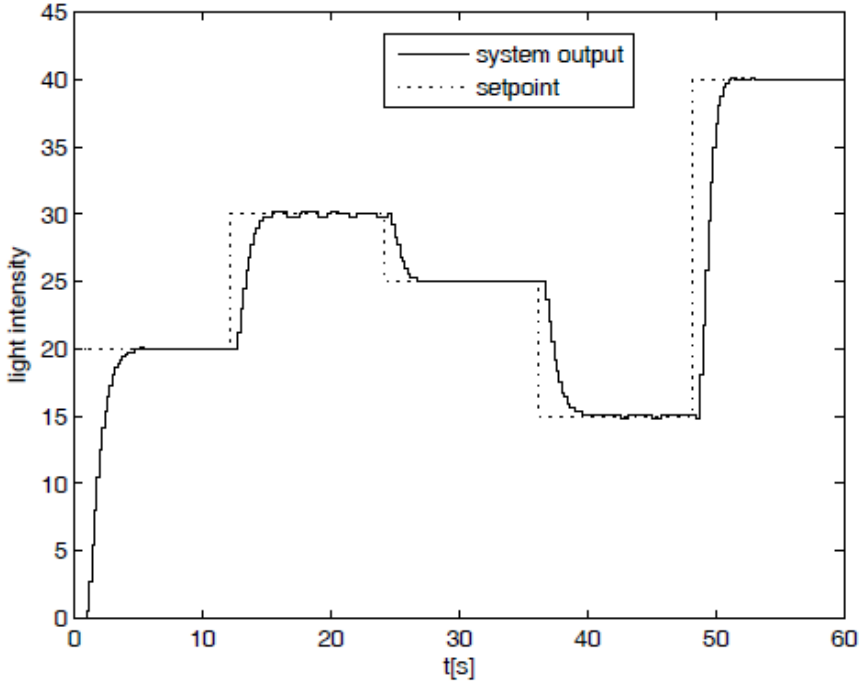
I_0,FI_0-controller

- exnum: 3
- Td=max(Td)
- K = min, avg, max

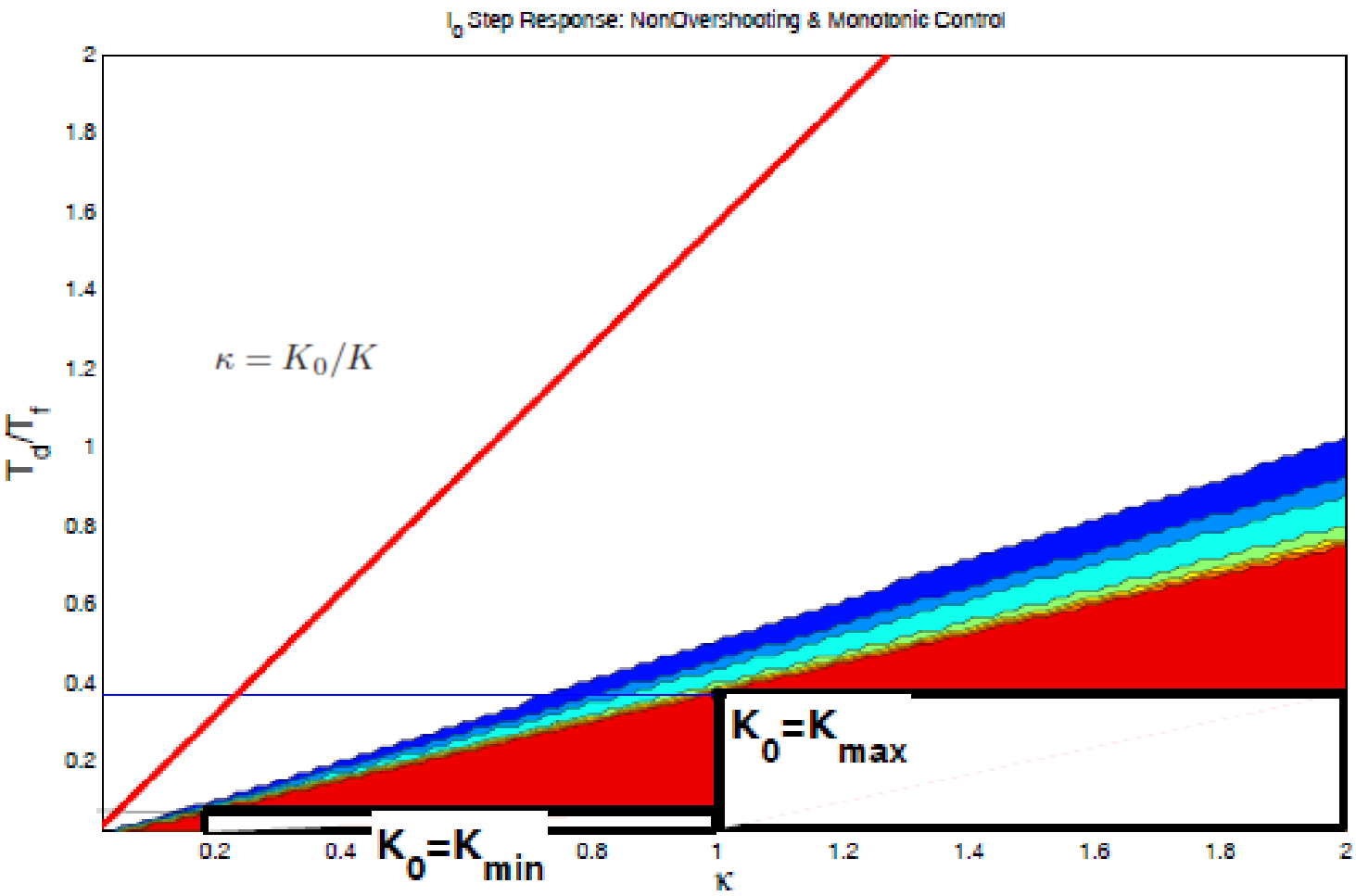


Results


system output
setpoint
light intensity
t[s]
0
10
20
30
40
50
60
70


system output
setpoint
light intensity
t[s]
0
5
10
15
20
25
30
35
40
45
50
60

Robust tuning



Experiments results