

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Robustné PID-regulátory s obmedzeniami

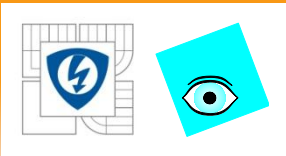
Robust Constrained PID Control

Experiment support

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Ing. Peter Ťapák, Ph.D.

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



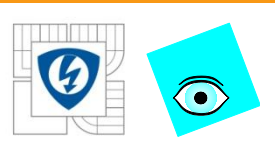
uDAQ28/LT

THERMAL-OPTICAL PLANT

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uDAQ28/LT

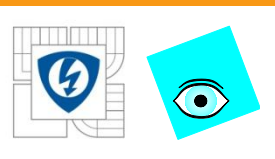
- Communicates with PC via USB
- Two plants in one
 - Thermal
 - Optical



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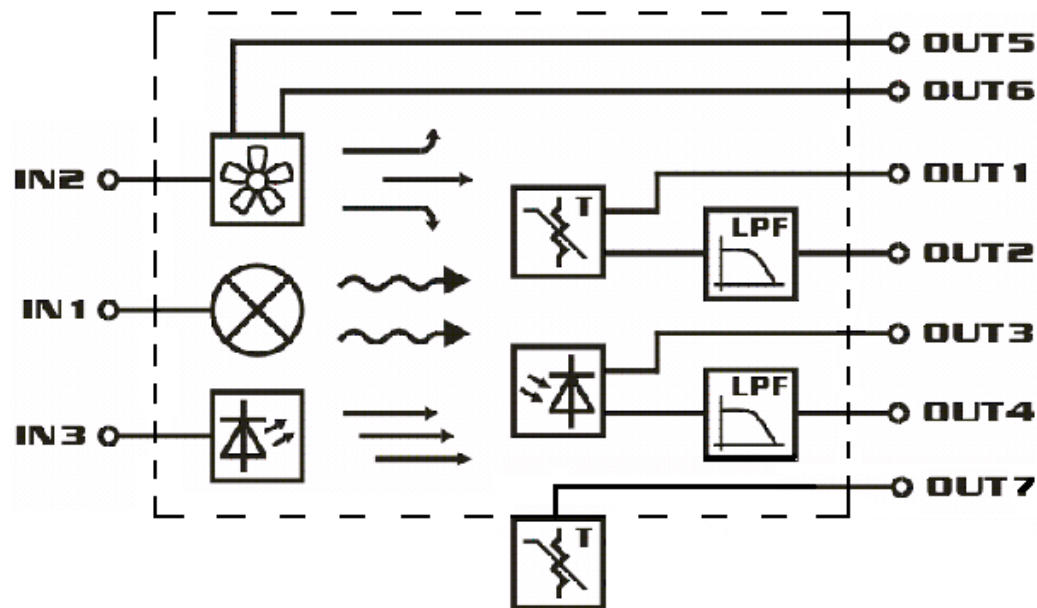




Inputs/Outputs

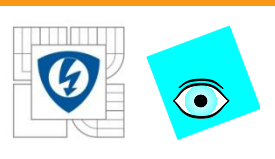
•3 inputs

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

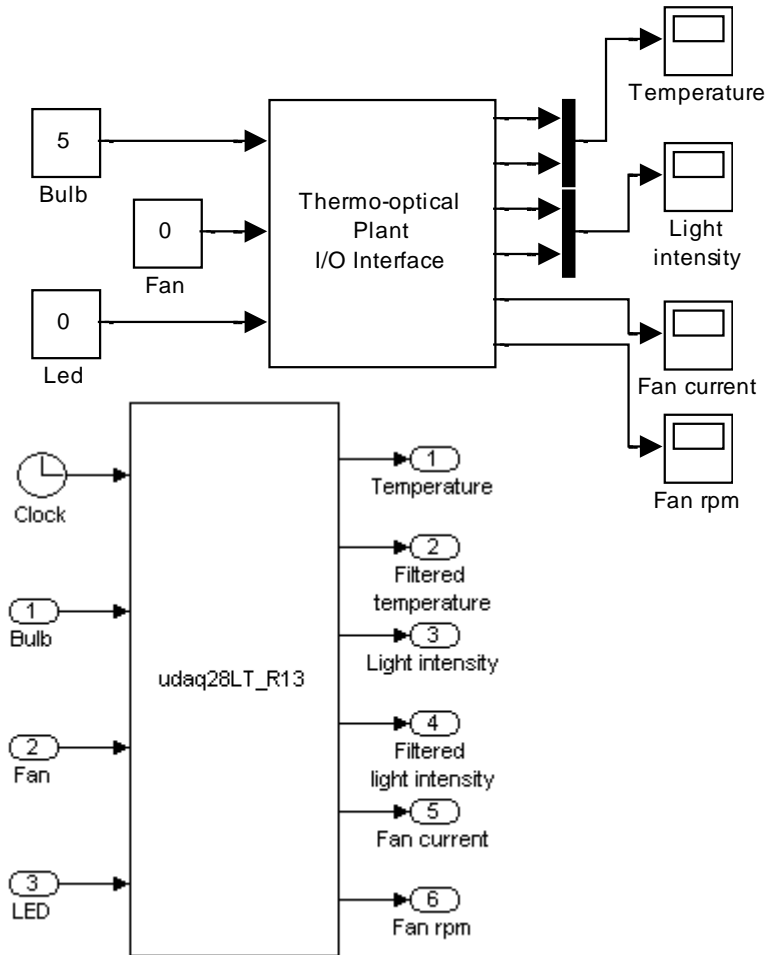


•6-7 outputs (depend on FW)

- Temperature
- Filtered temperature
- Light intensity
- Filtered light intensity
- Fan current
- Fan speed



Simulink Model



Block Parameters: S-Function

uDAQ28/LT Communication Interface (mask)

(c) 2006 Martin Kamensky

Serial port - USB serial port number assigned to uDAQ28/LT system

Sampling time (sec) - the lowest working value in Windows is about 0.04 - 0.05 s

Sample delayed (%) - number of events (percentually) when simulink loop can take more than time determined by sample time

Read timeout (msec) - timeout for reading data from the port (the lowest working value is about 25 ms)

Matlab priority :
 NORMAL_PRIORITY - priority of common Windows application
 ABOVE_NORMAL_PRIORITY - recommended - higher priority than common Windows application priority
 HIGH_PRIORITY - recommended - high priority
 REALTIME_PRIORITY - NOT recommended - takes almost all system resources

Parameters

Serial port: **COM3**

Sample time (sec):
 0.2

Sampling delayed (%):
 2

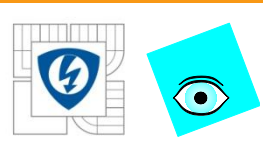
Read timeout (msec, lower than sample time):
 100

Matlab priority: **ABOVE_NORMAL_PRIORITY**

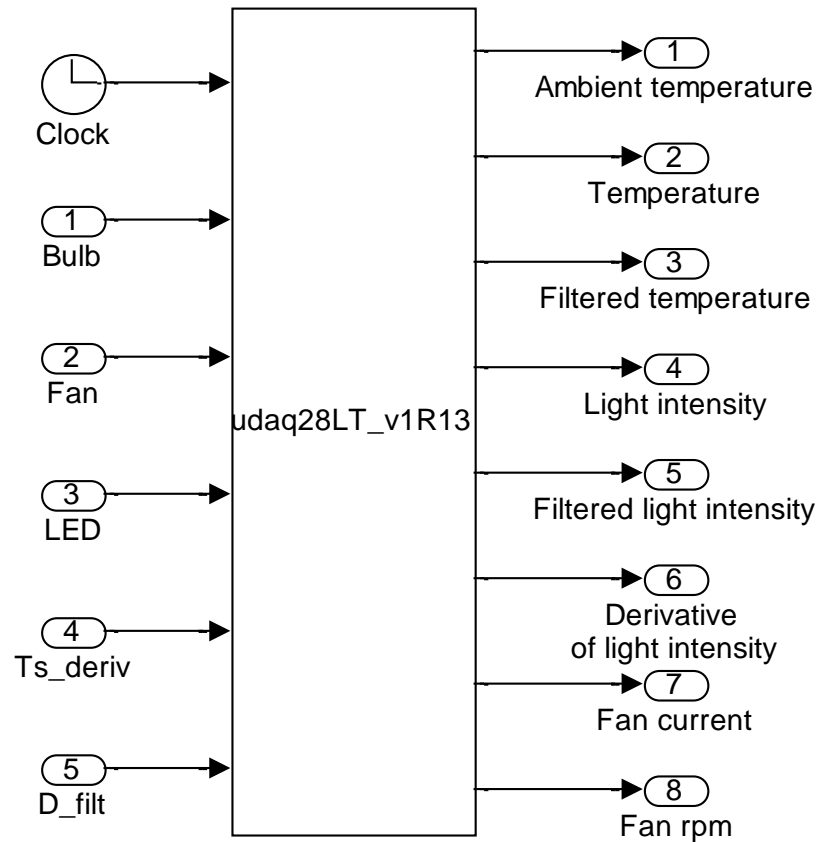
☒ Warning if delayed (error if unchecked)

☐ Detailed timing and timeout printout

OK Cancel Help Apply



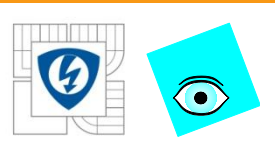
Simulink Model



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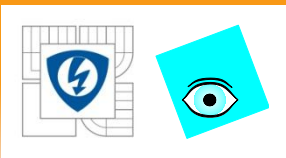
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First experience (exnum:1)

- 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

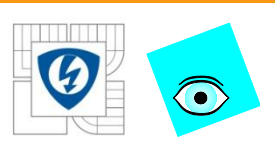


I/O CHARACTERISTIC MEASUREMENT

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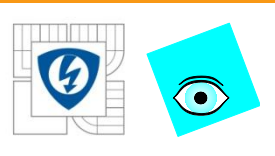
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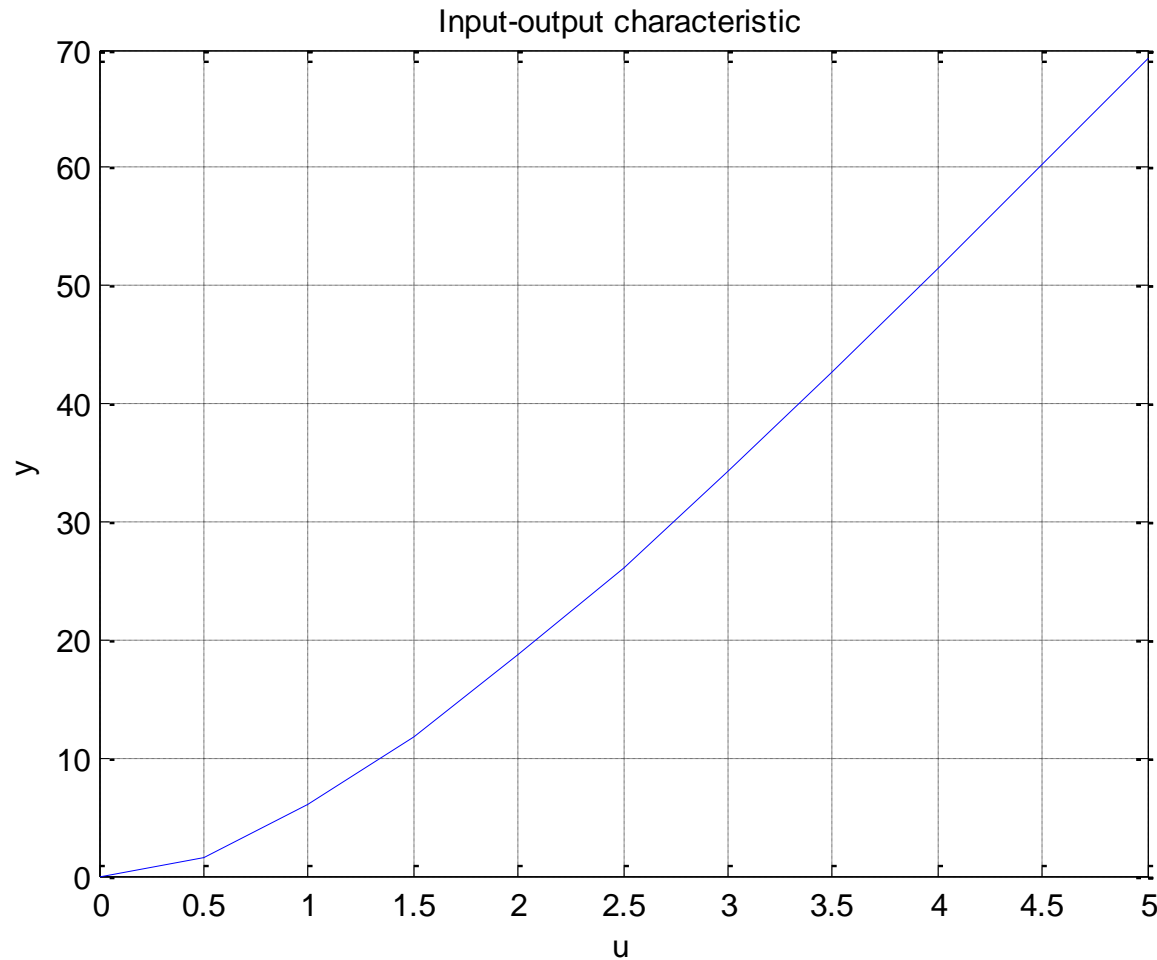


Experiments

- 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 T_d range



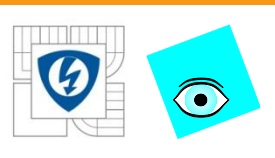
I/O characteristic



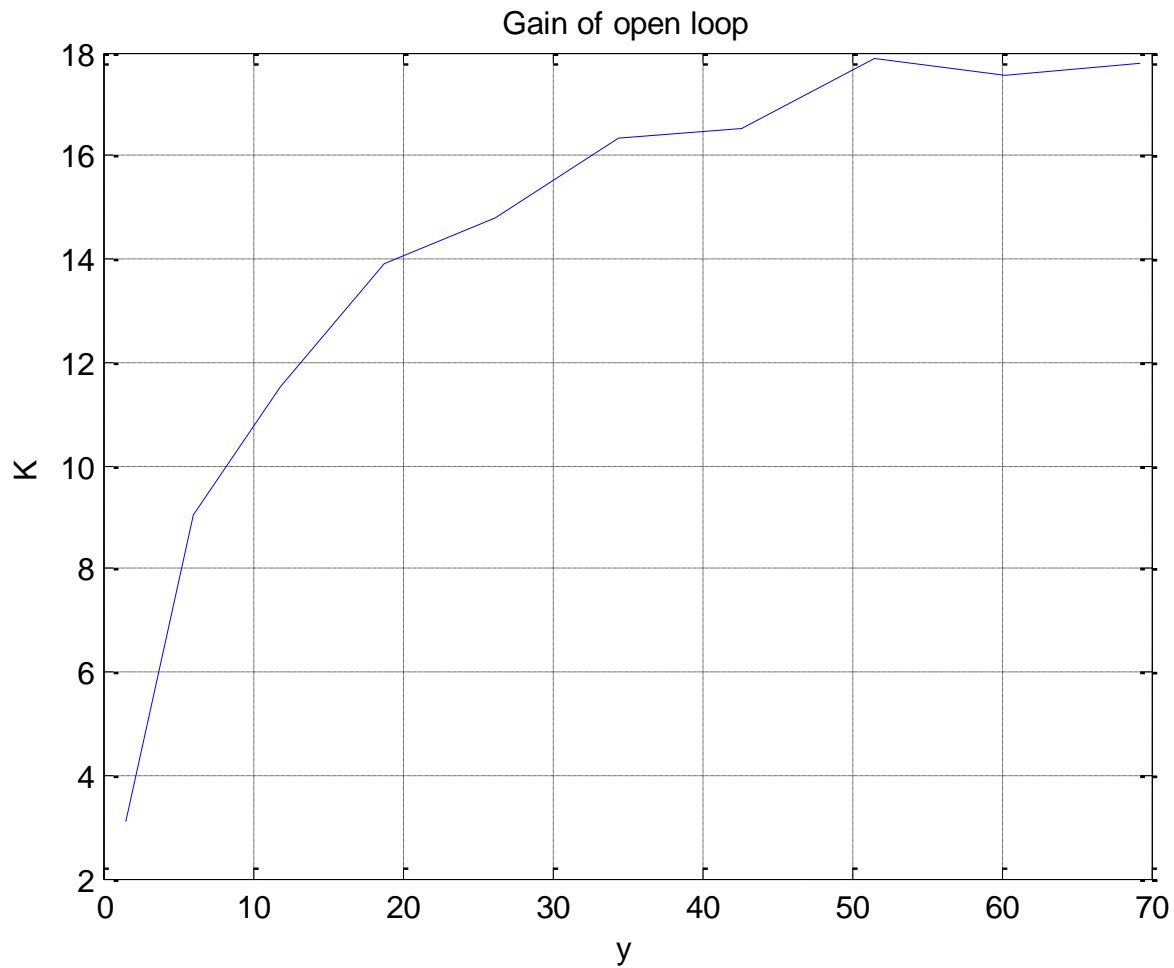
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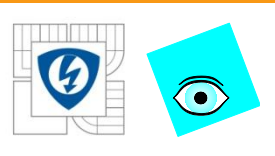
Process Gain



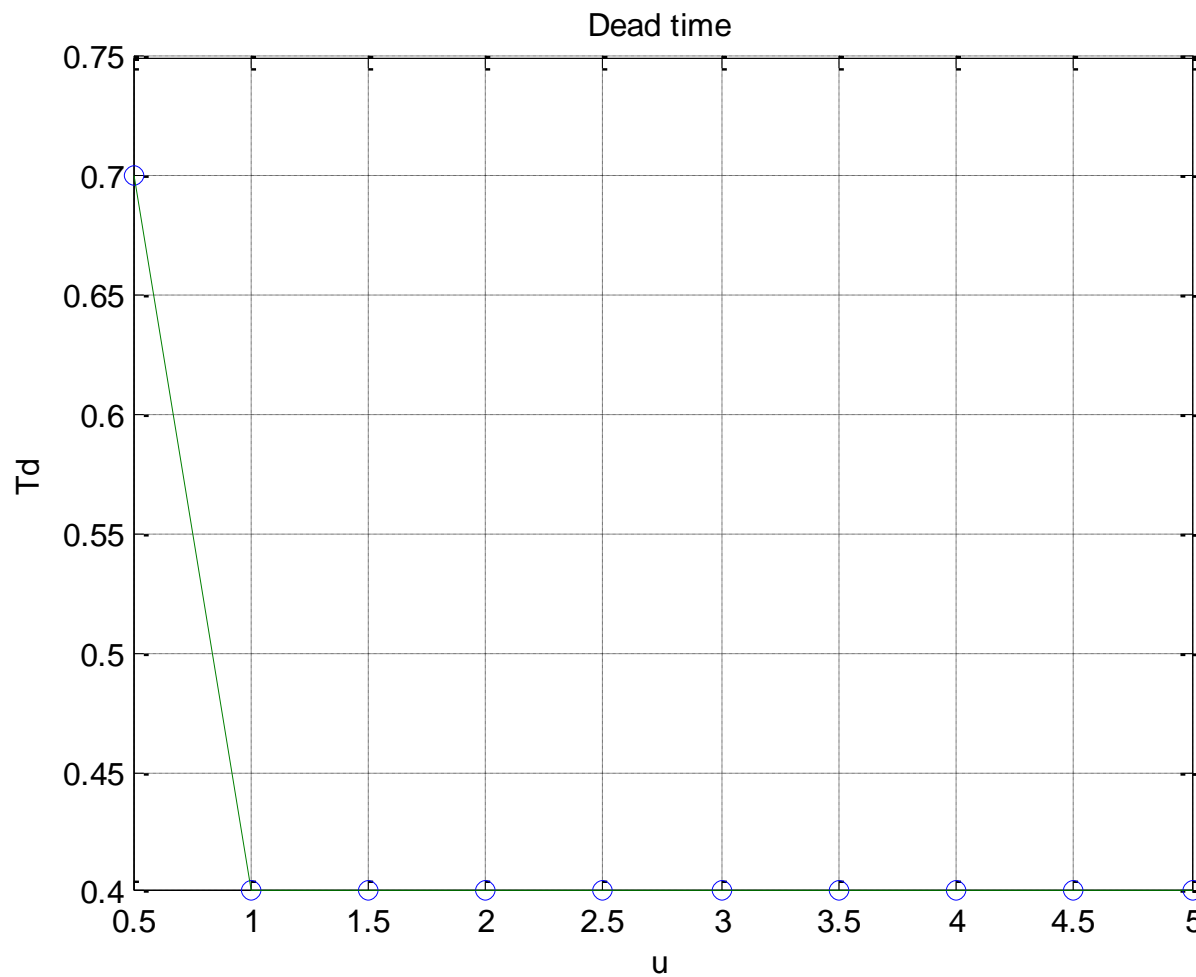
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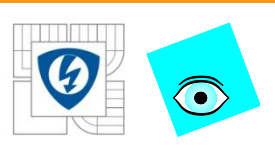
Dead time



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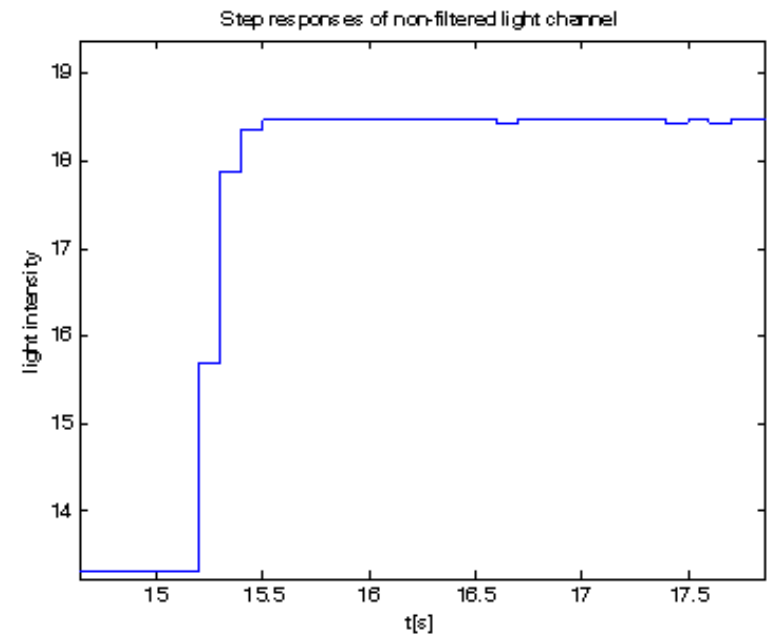
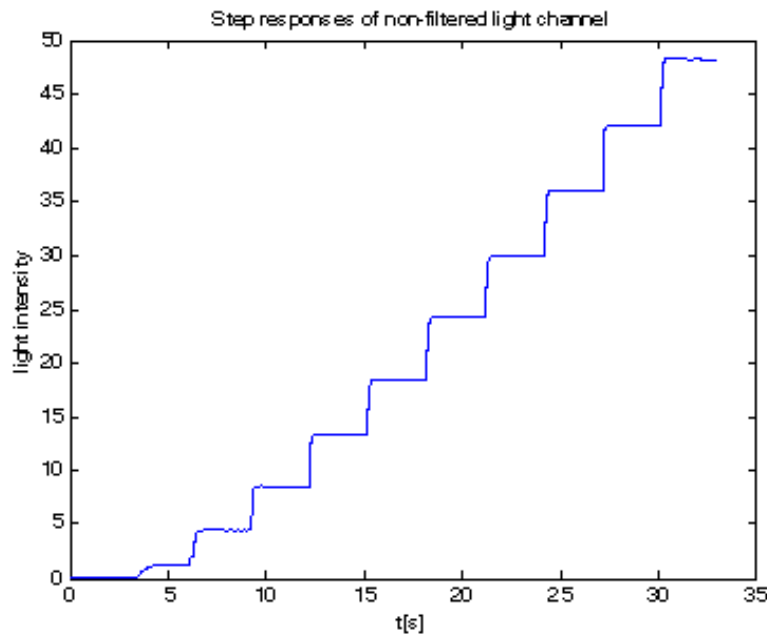
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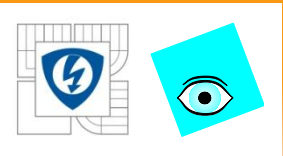




FYI- Step responses

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



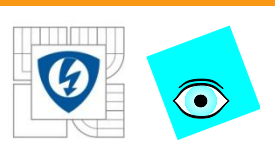


FEED FORWARD -> I_0 -CONTROLLER

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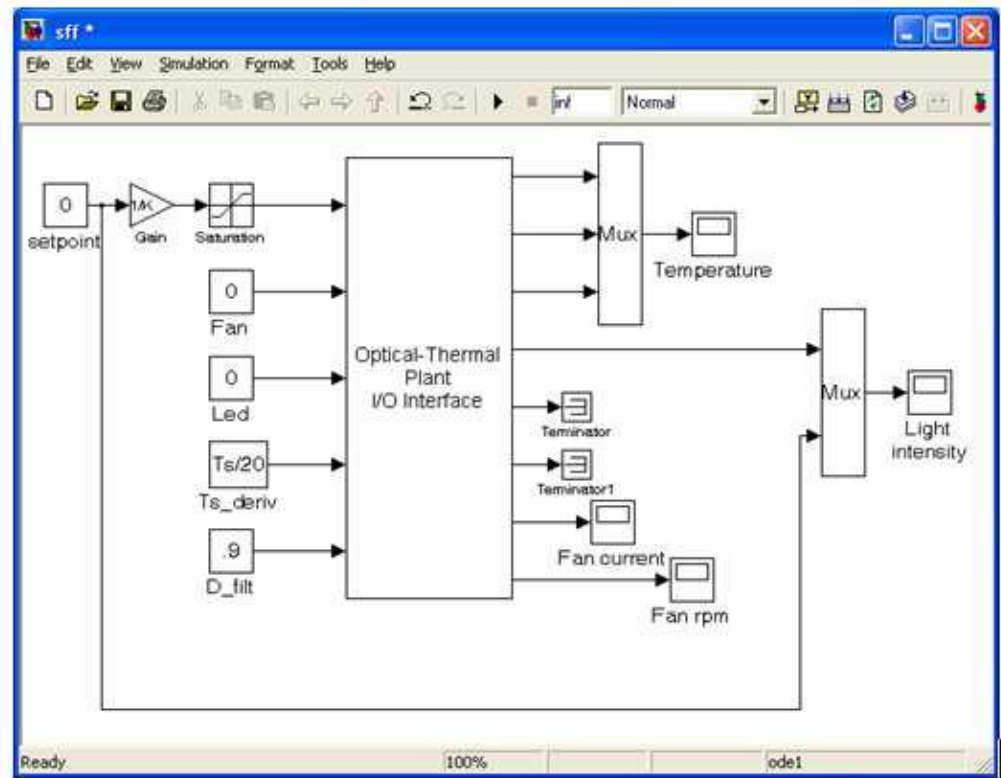
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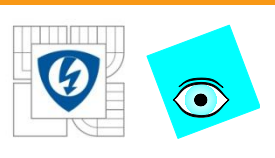




Static feed forward

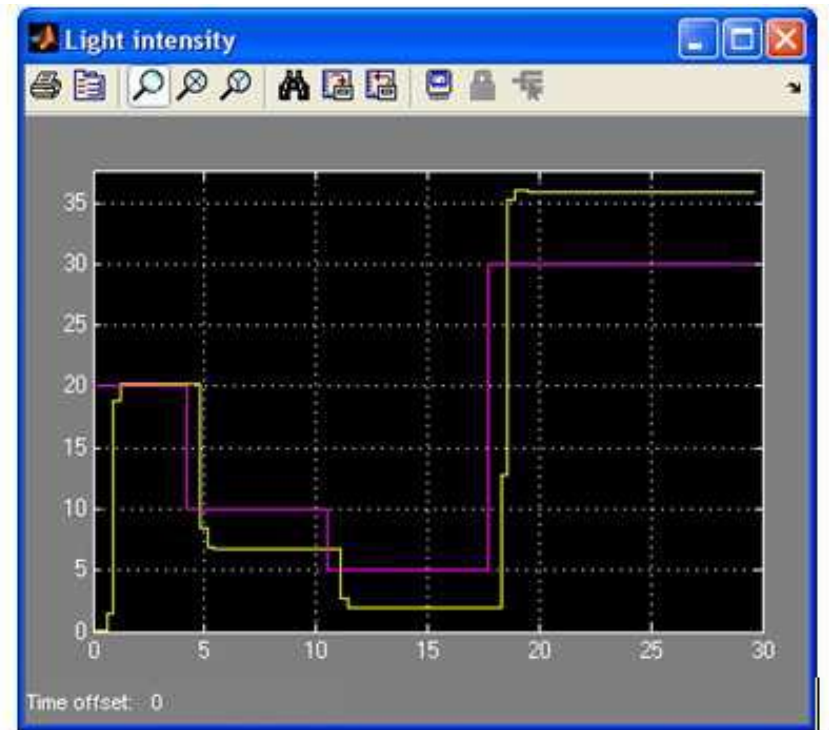
- Modify the Simulink model to use the inverse process gain to control the plant
- Do not forget to add the input saturation in the model, the bulb voltage is limited from 0V to 5V
- Add the setpoint signal to the light intensity scope.
- Set the simulation time to infinity.

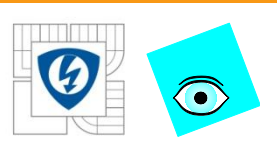




Static feed forward

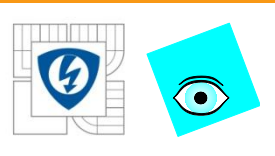
- Make multiple setpoint steps in a wide operational range.
- It can be done while the experiment is running.





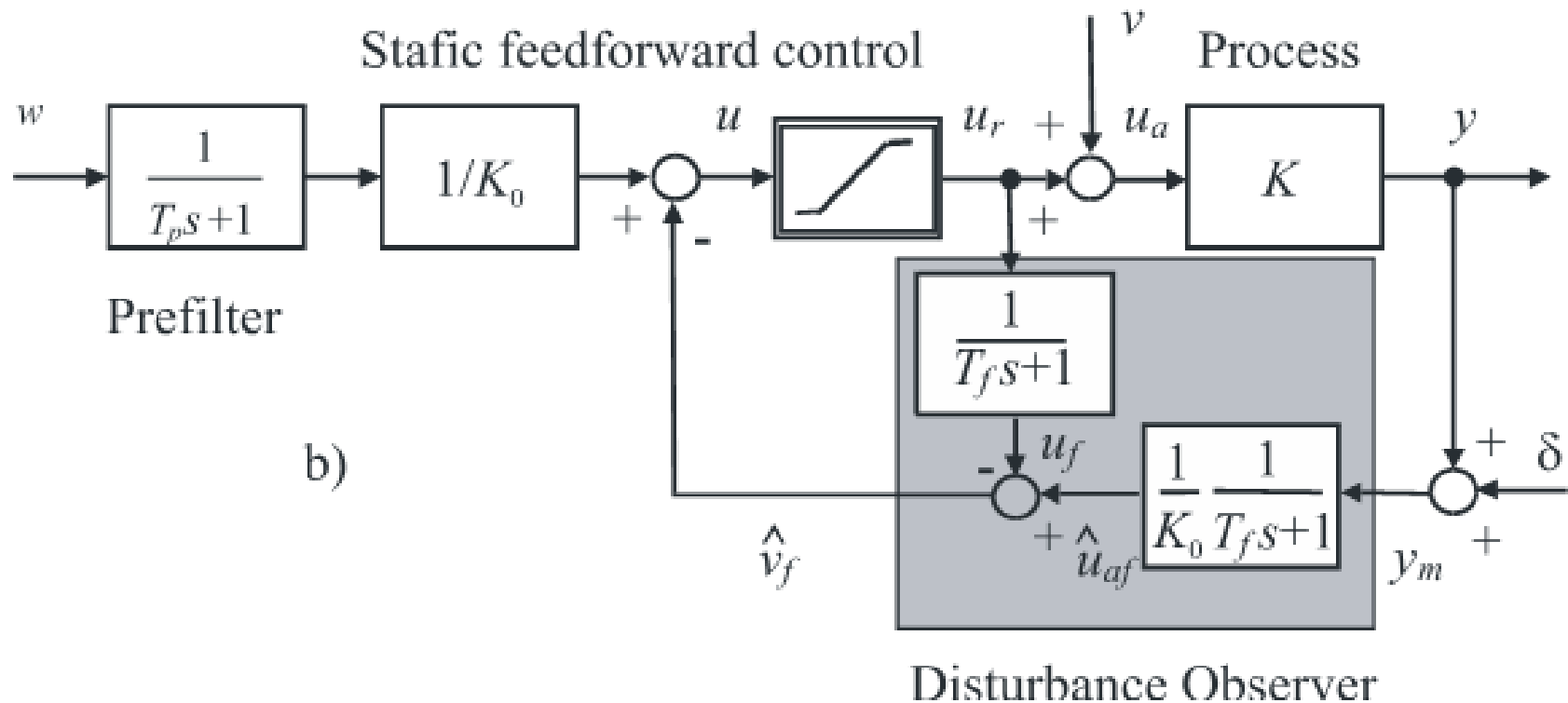
Static feed forward

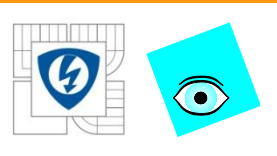
- You should observe a steady state error in several working points.
- The smallest steady state error can be seen around the point where the process gain was measured.
- It is not difficult to conclude that the process parameters vary through the operational range, in other words the I/O characteristics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



FI₀-controller

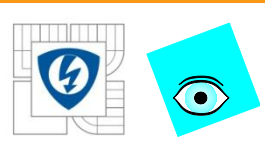
The disturbance observer can be added to the static feedforward control to compensate the steady state error. To obtain a structure equivalent to I-controller, the pre-filter with time constant equal to the observer time constant has to be added as well.





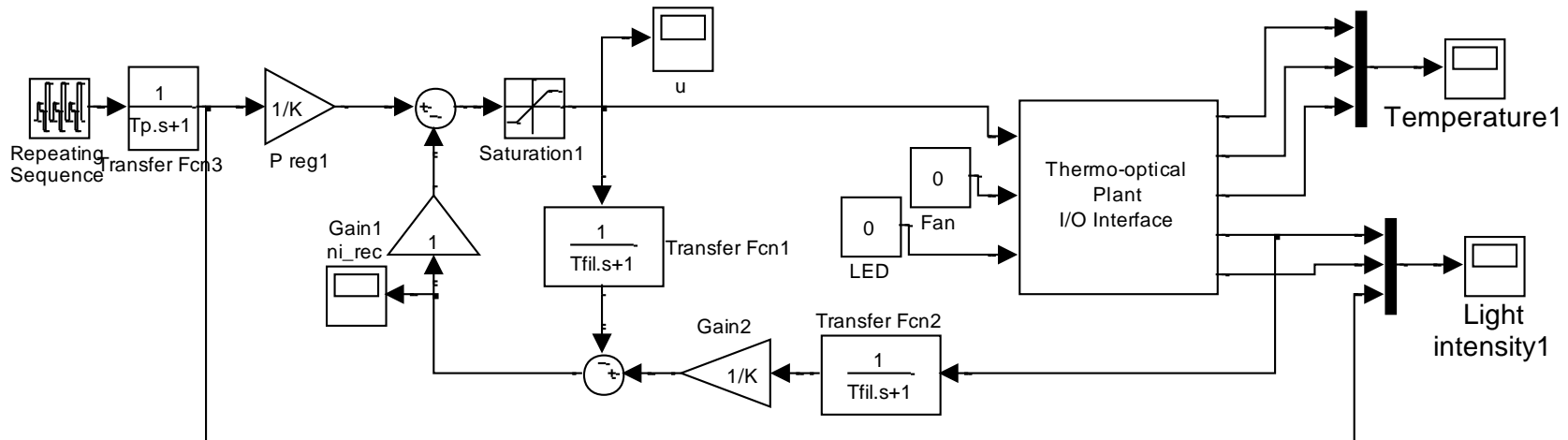
FI_0 -controller

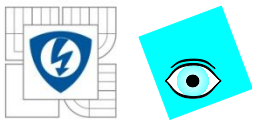
- Use exnum: 3 to start experiment with FI_0 -controller
- Tuning of the controller requires information on a process gain and approximation of the non-modelled dynamics - usually by the dead time.
- Feel free to modify the model to make your own setpoint steps sequence.
- The goal is to achieve quick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



FI₀-controller

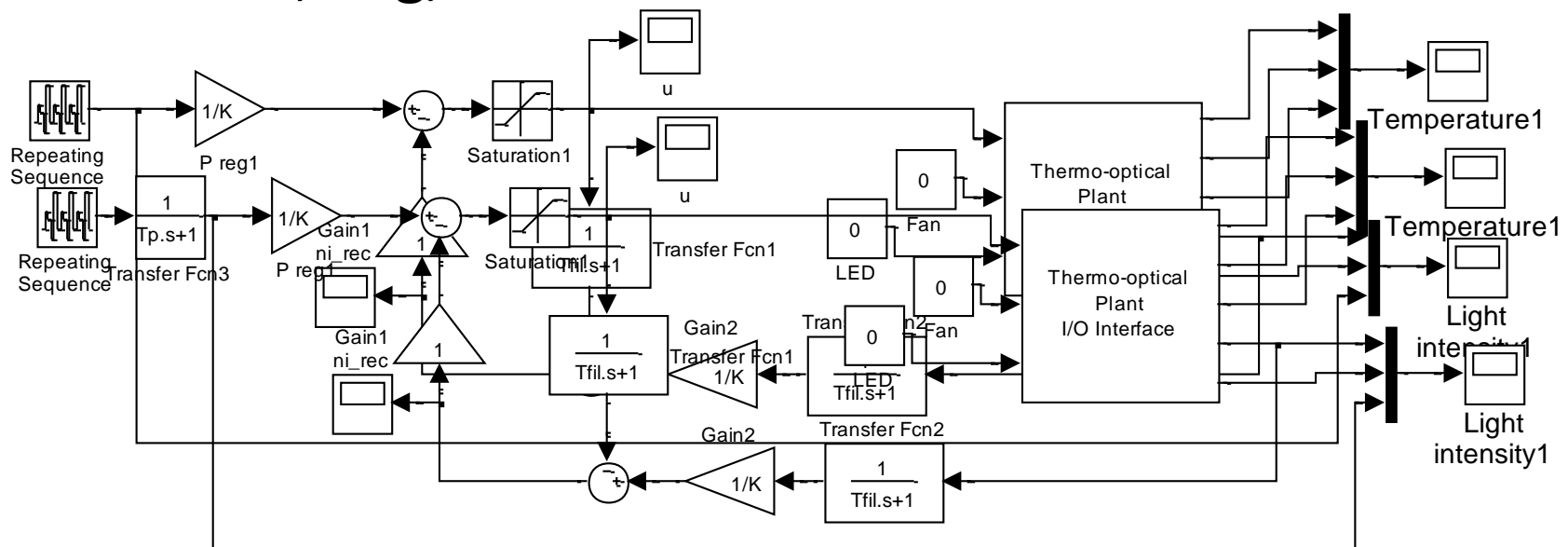
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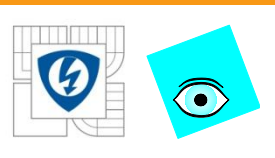




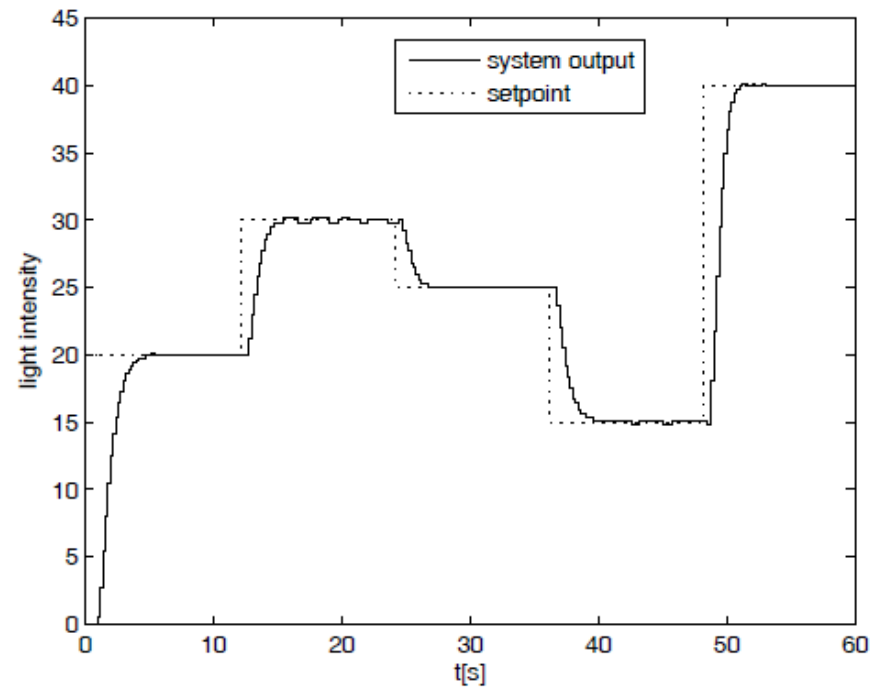
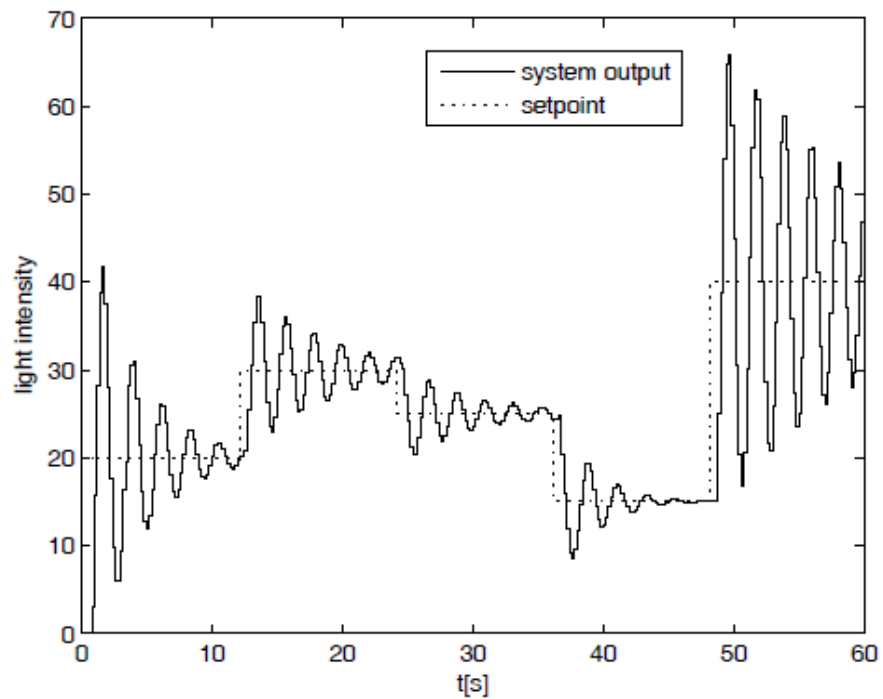
$I_0, F I_0$ -controller

- exnum: 3
- $T_d = \max(T_d)$
- $K = \min, \text{avg}, \max$



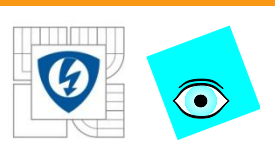


Results

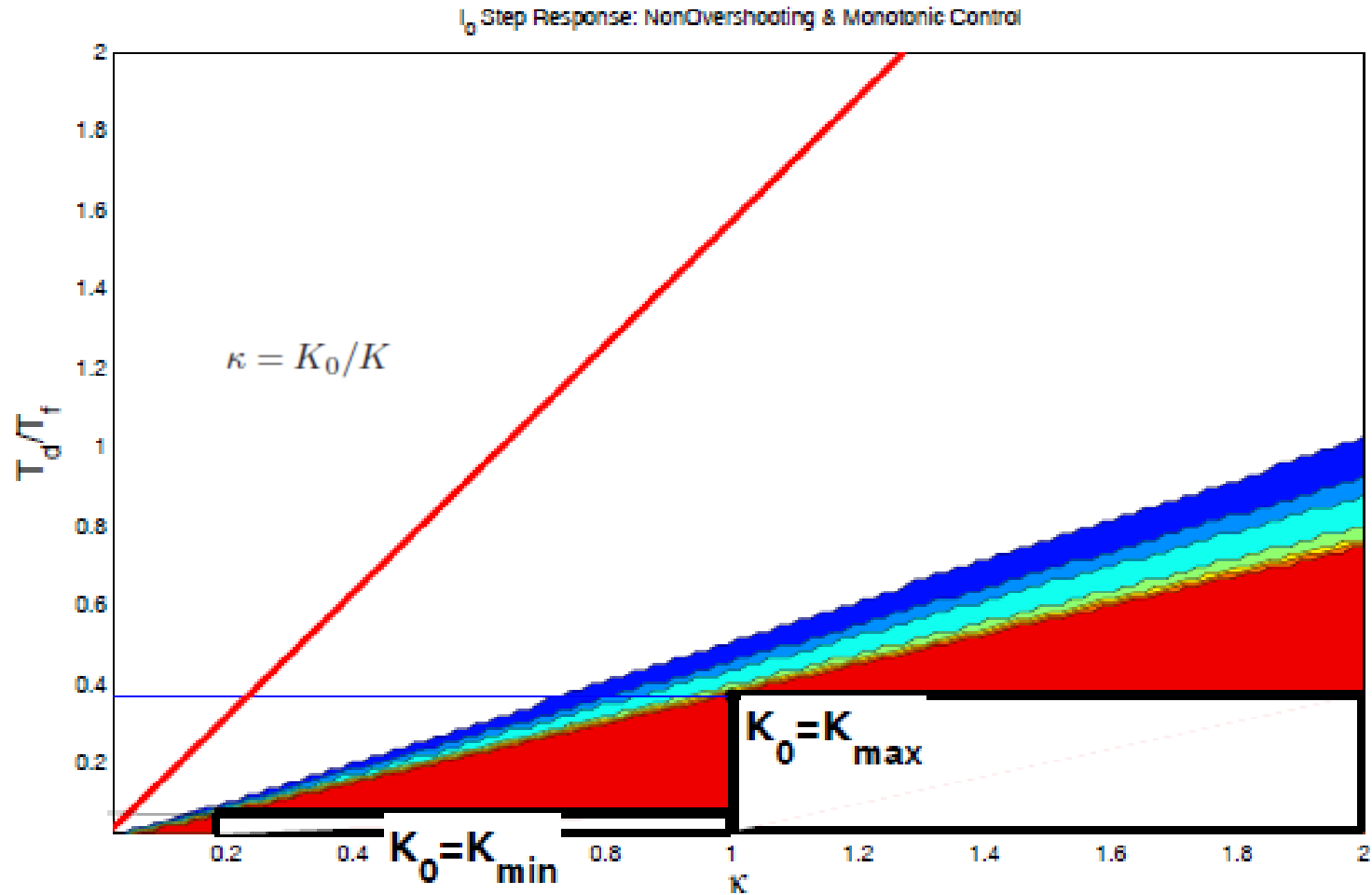


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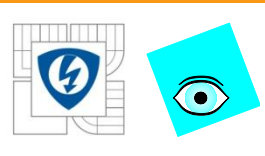
Robust tuning



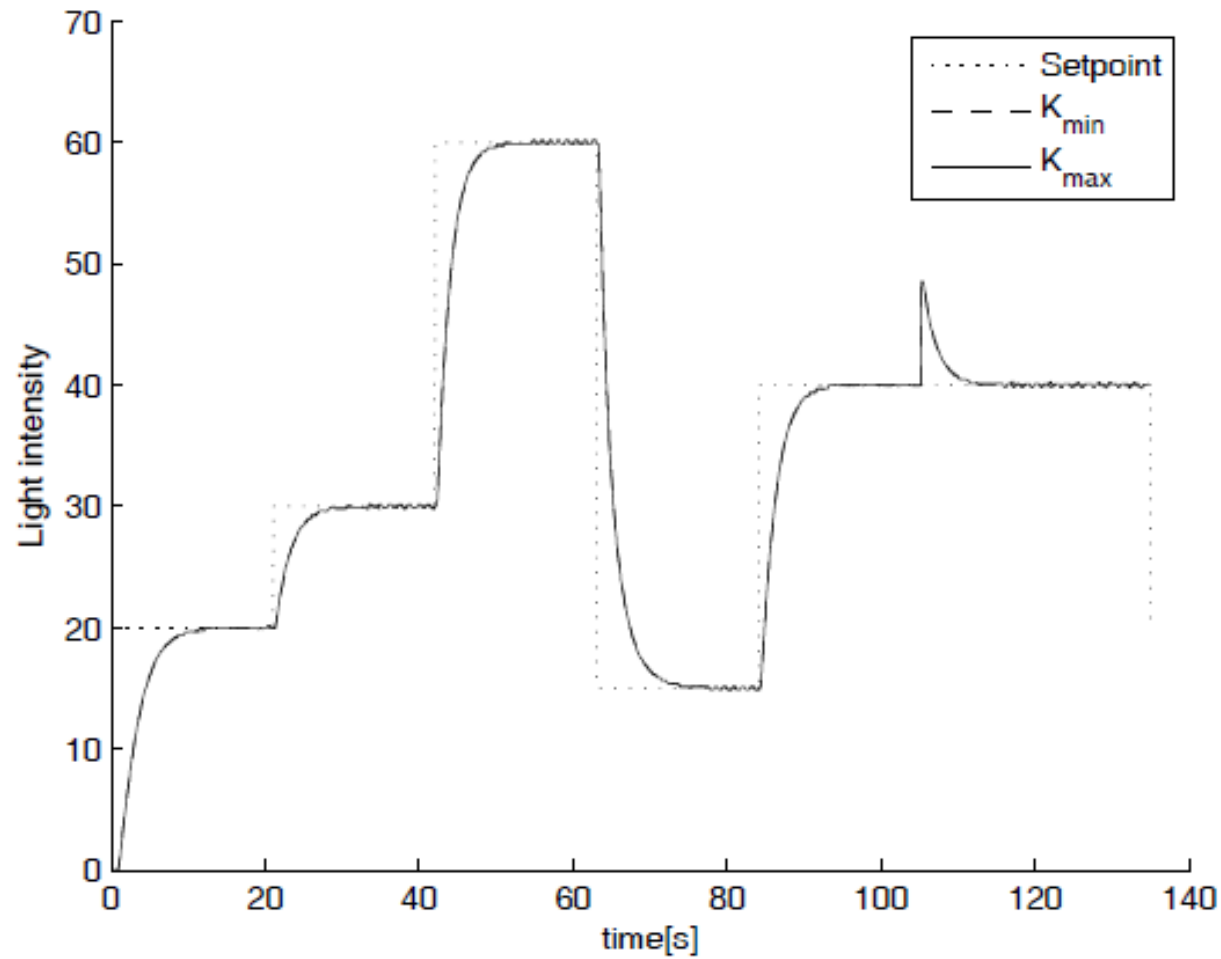
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Experiments results



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