VRIJE UNIVERSITEIT BRUSSEL

SIEMENS
Ingenuity for life

Regeltechniek WPO 2– Control engineering exercises

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Rules

Any kind of cheating results in 0 points

No copy-paste, no sharing results, no reusing results,
no discussion with other groups

Three strikes

You can ask always questions, if it is something what you should already know, then you have three strikes, after that -0.1p/question.

You need to be able to explain and defend your results!

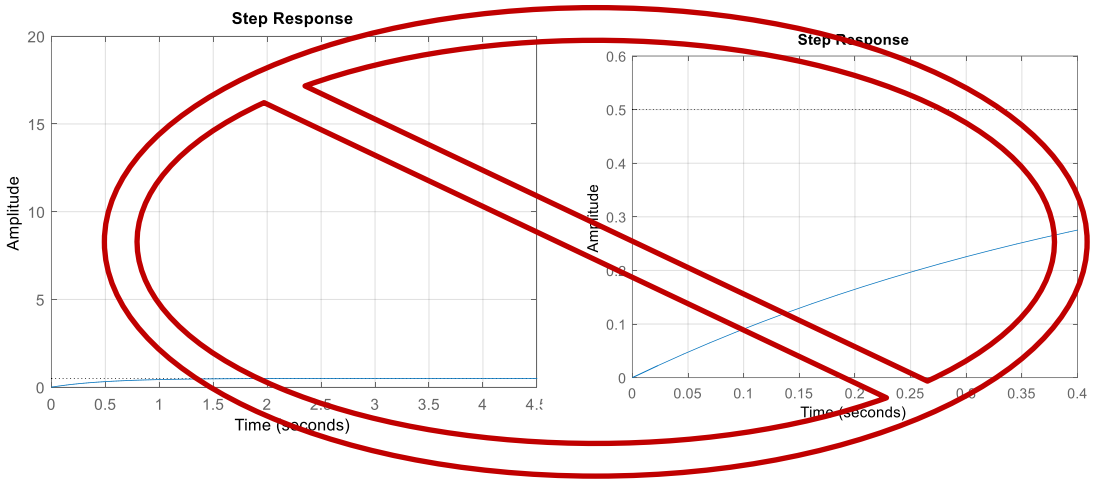
You cannot explain your results => 0 point
You wrongly explain your results and can correct => ½ points
You can explain your miscalculated results and can correct =>full points

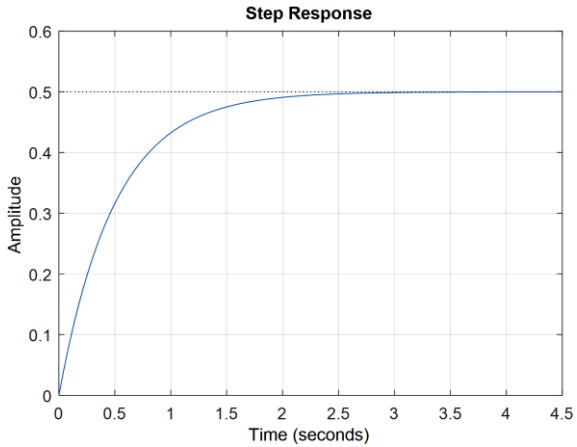
No social media, no messaging, music (not loud) ok

Exercise

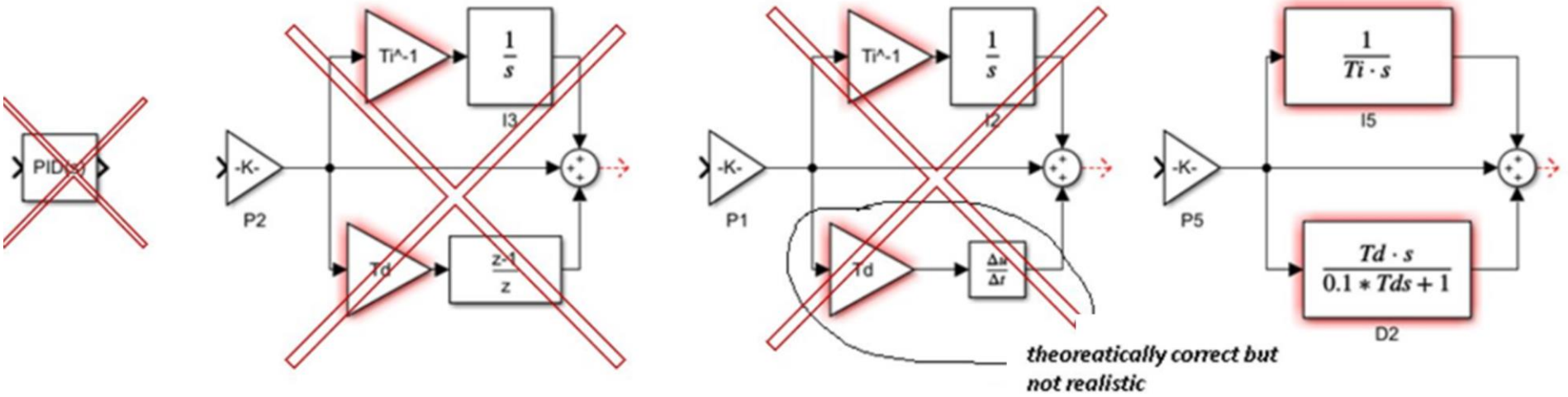
Some various materials from previous year:
http://homepages.vub.ac.be/~pcsurcsi/teaching.html

- **Typical mistakes**
  - Simulation time is too short and/or wrong scaling



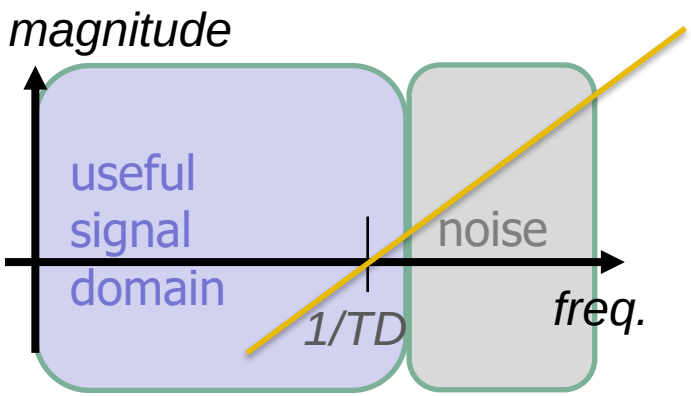


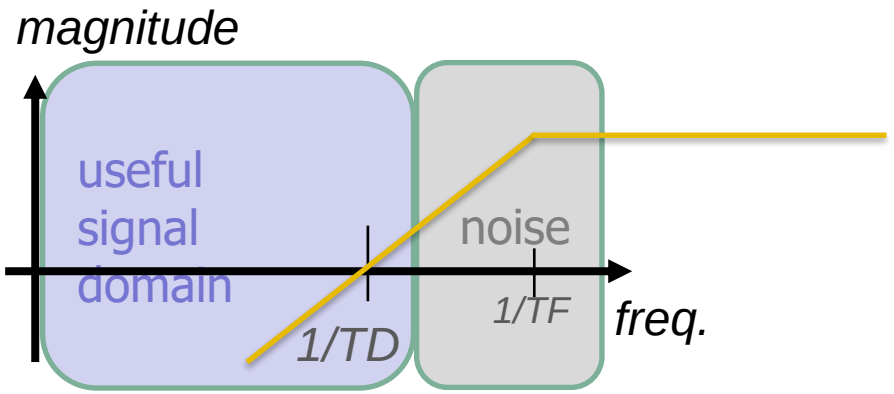
Exercise – accepted PID structure



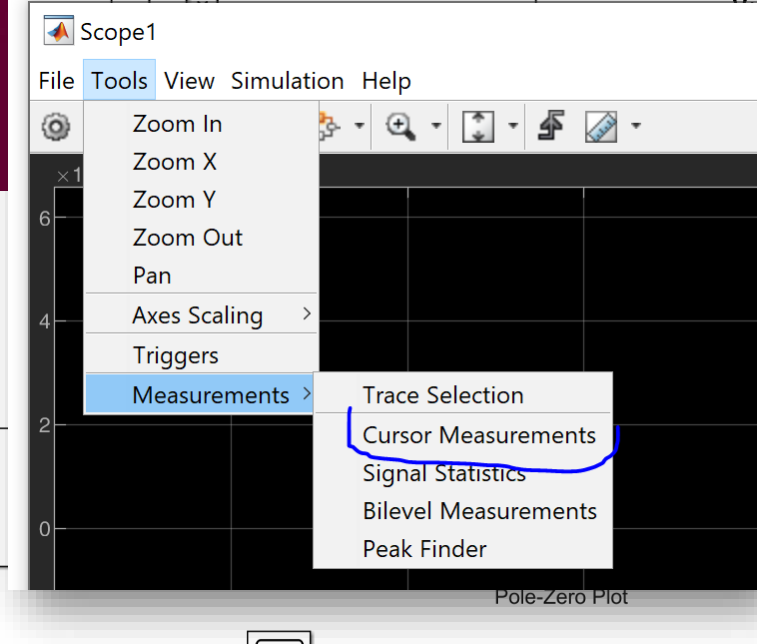
The third solution is theoretically correct but in practice it would result in a very 'jumpy' behavior because D term amplifies high frequency noise components.

So, in practice, D term is usually accompanied with a (1st order) low-pass filter.





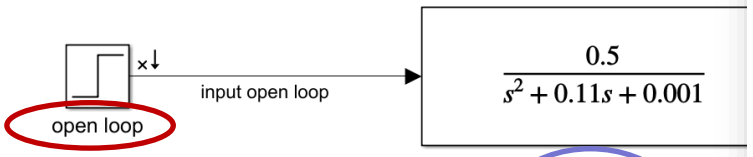
Exercise – advice

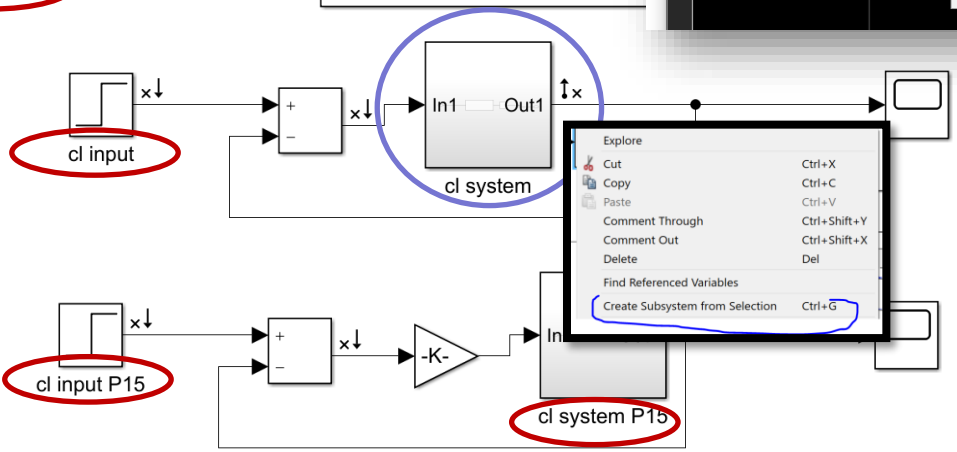


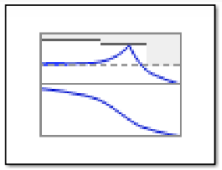
Tips:

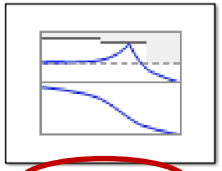
1 exercise 1 circuit

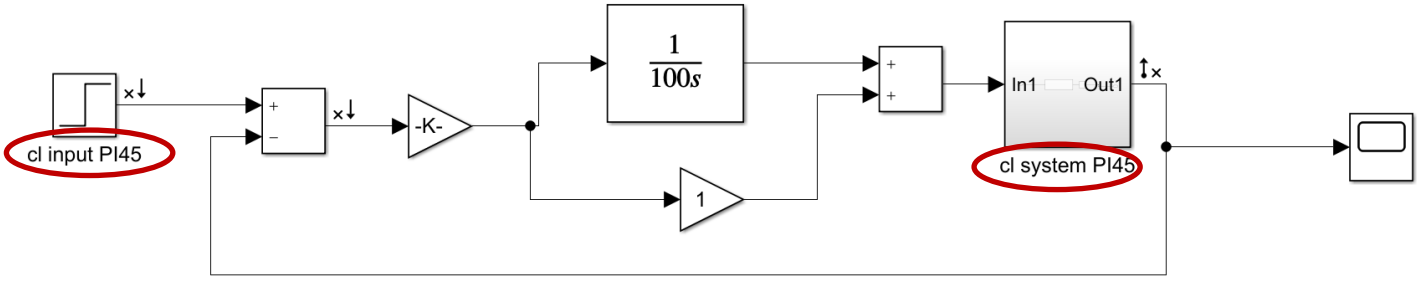
Use annotations

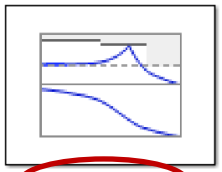




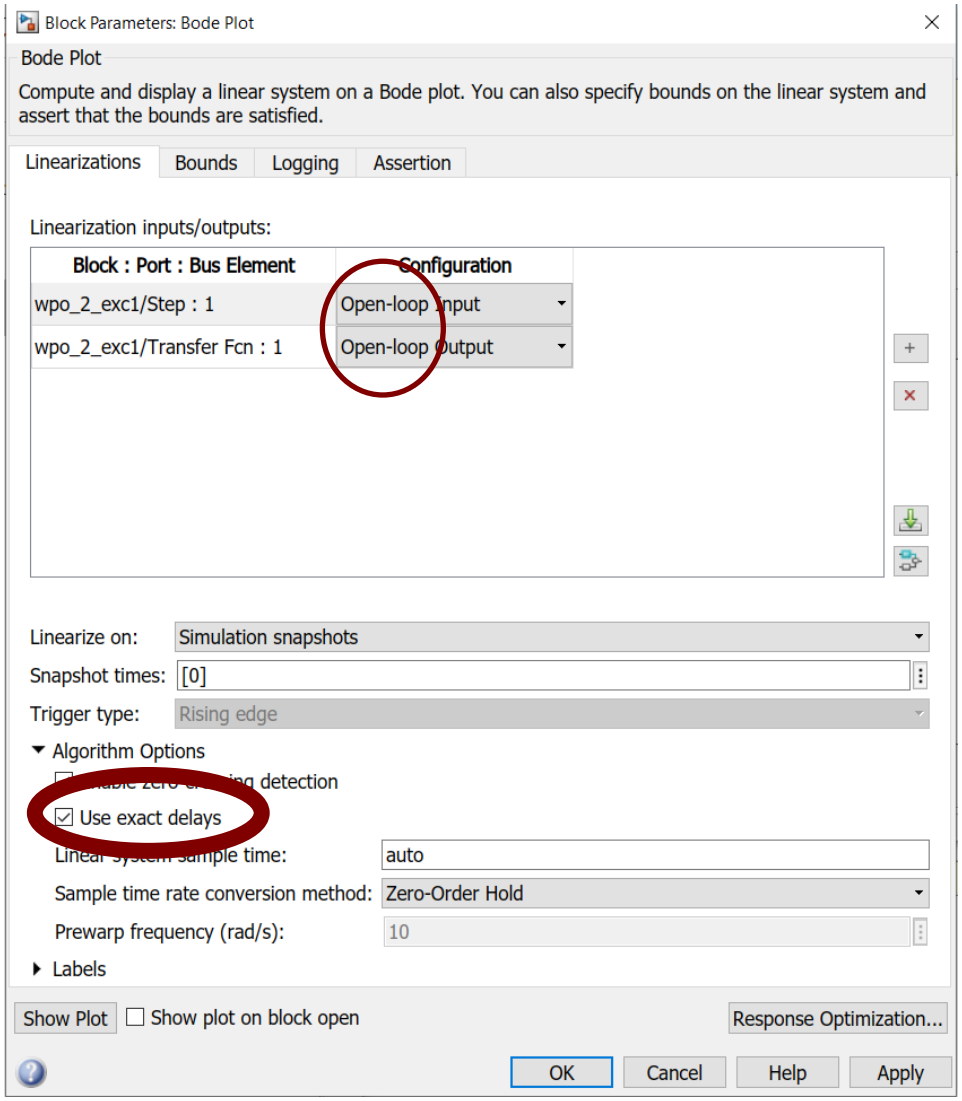

Bode Plot


Bode P15




Bode PI45

Bode diagram block



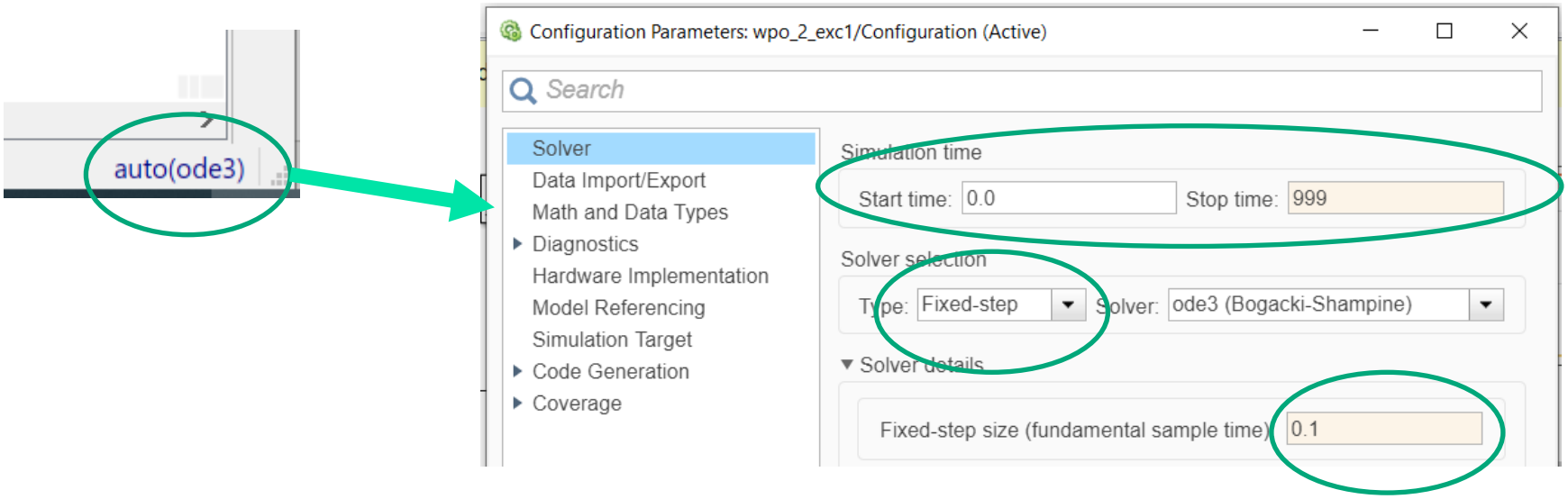
Make sure you use open-loop signals

Use exact delay should be ticked (otherwise your dead-time is not shown correctly)

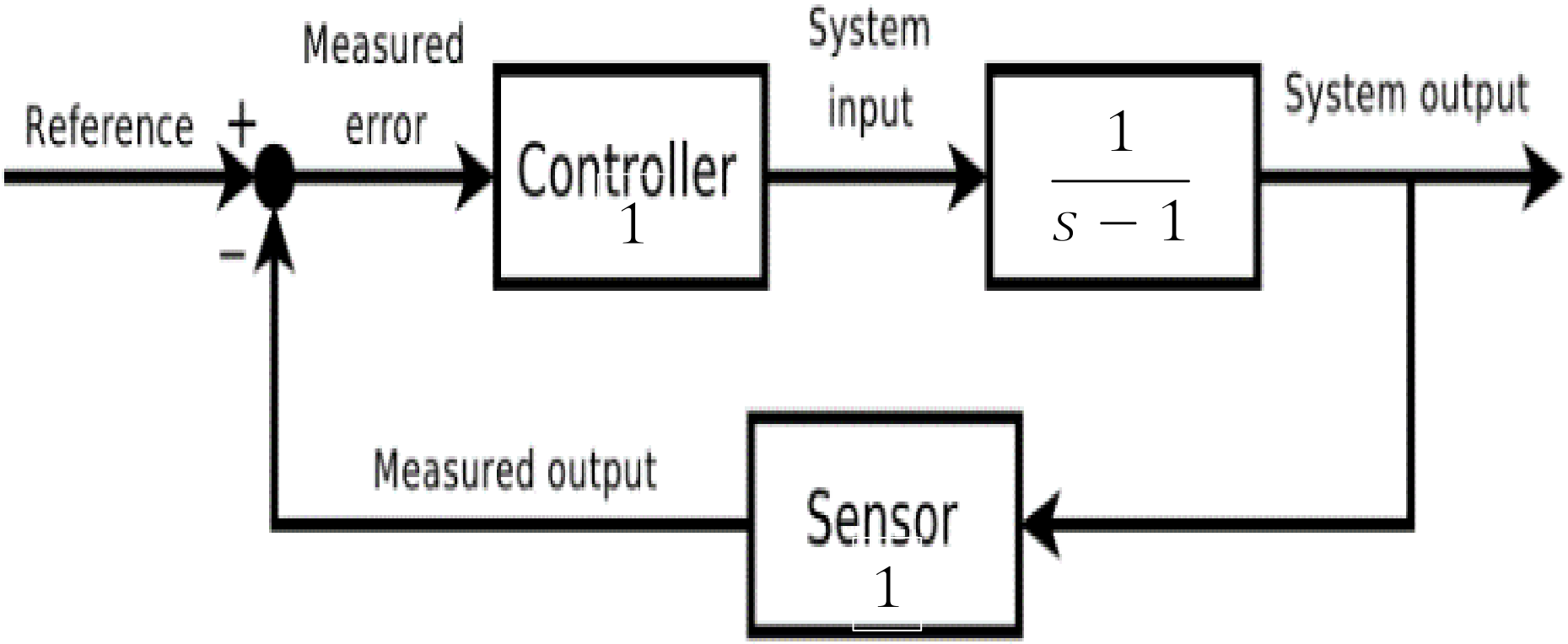
Add dead-time: use 'transport delay' block

Solver options

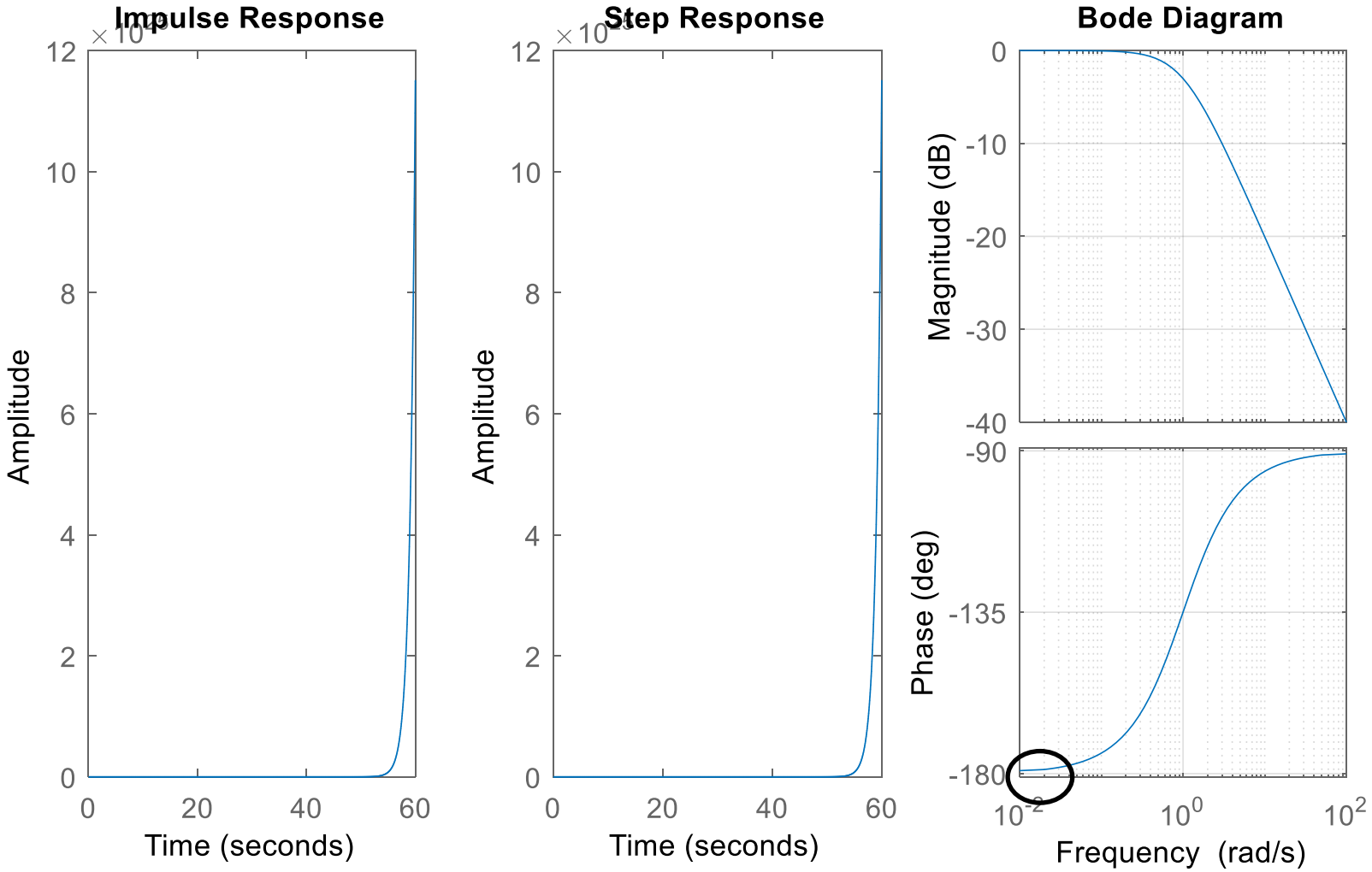
The sampling frequency (sampling time) can be set by modifying the solver parameters (fixed step size, see the icon on the bottom right corner of the Simulink window).



Control example



Control example



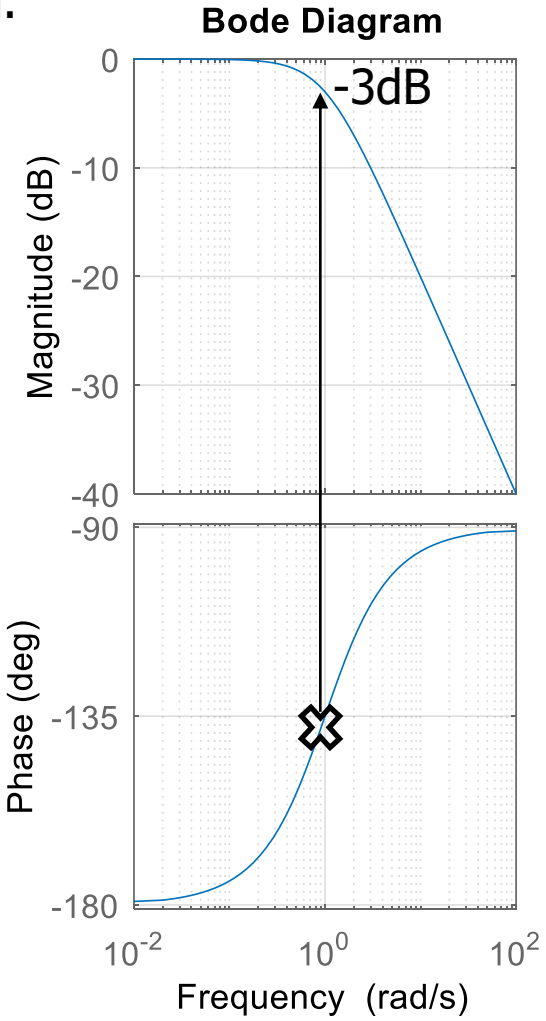
Control example

Design of a P controller with 45 degrees of phase margin.

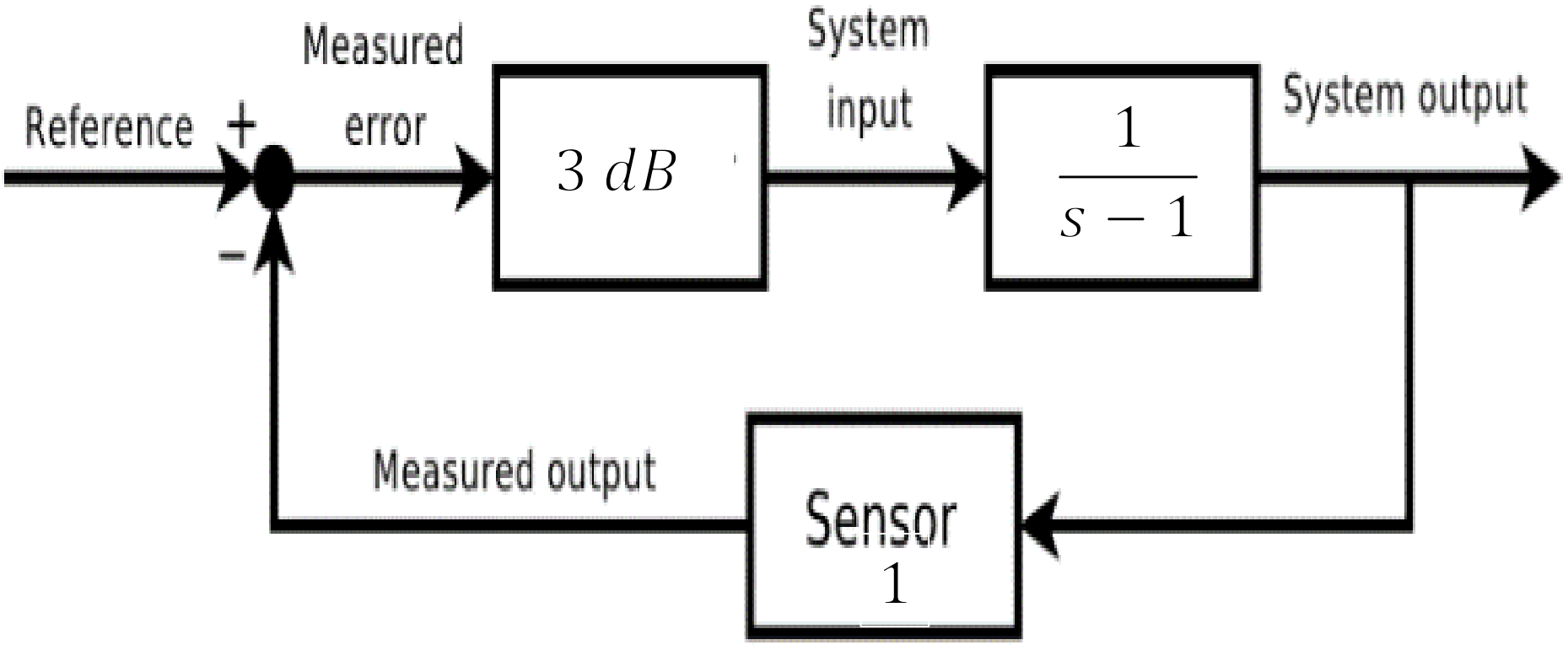
1. Look for the phase where 45 degrees PM would be
2. Check the magnification at this level
3. Move the diagram with the gain needed to be that point the new cross-over

Additional advise:

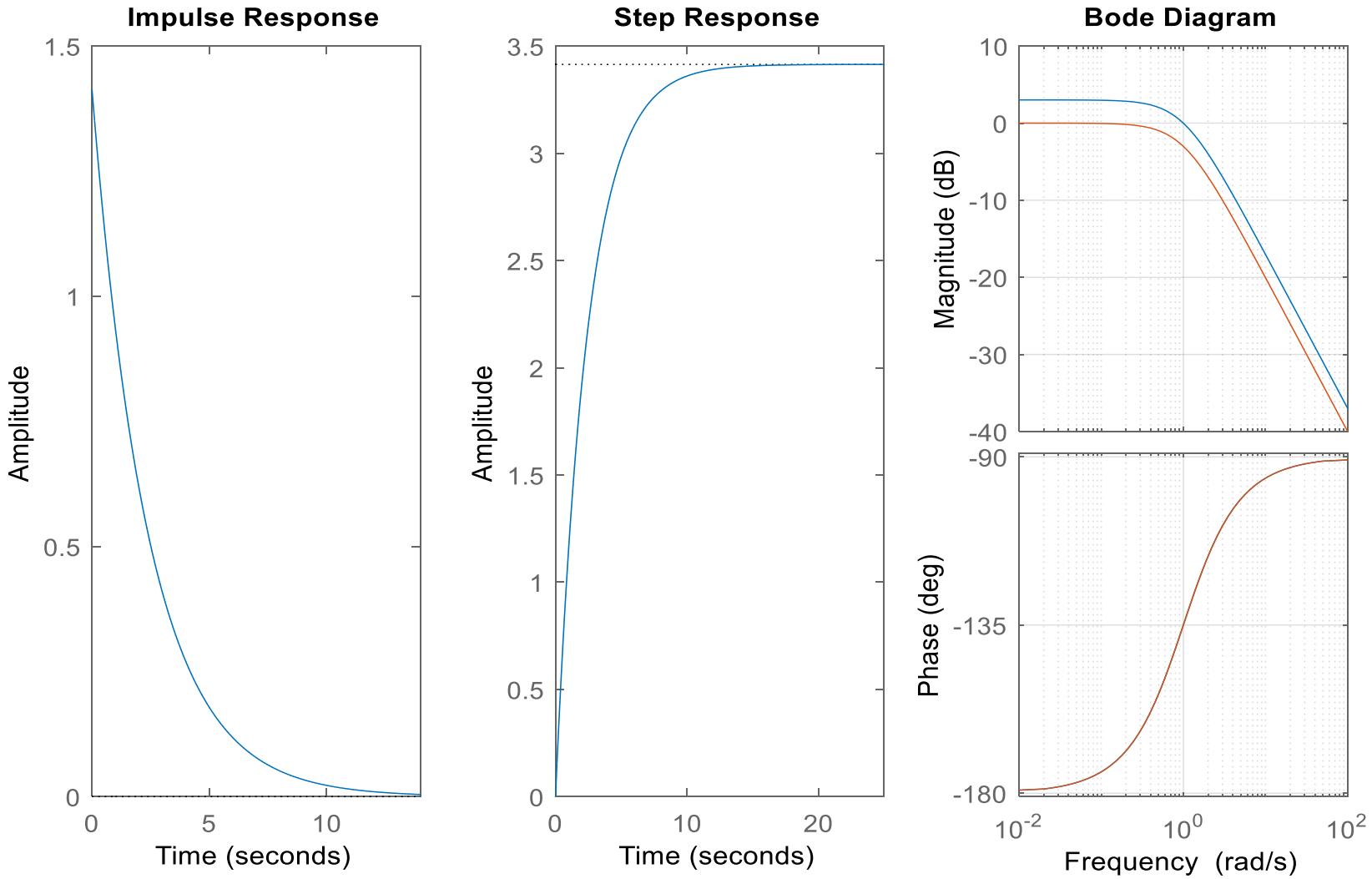
1. Choose dominant time constant as integration time
2. Second dominant constant as diff time
3. Check after adding I and D the PM (and GM)



Control example



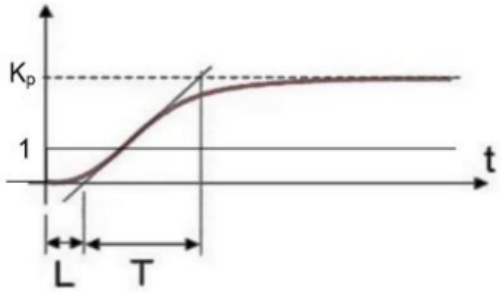
Control example



Ziegler-Nichols open loop method

Works for low order systems which can be approximated as $K_p e^{-Ls}(1 + sT)$.

1) Turn off any integrator and differentiator in the controller. Set K (gain) to 1.
2) Measure the unit step response of the underlying open loop system (plant model identification, feedback term involved).
3) Estimate the gain K_p, time delay L and the dominant time constant T, see figure.
4) Apply the following controller parameters:

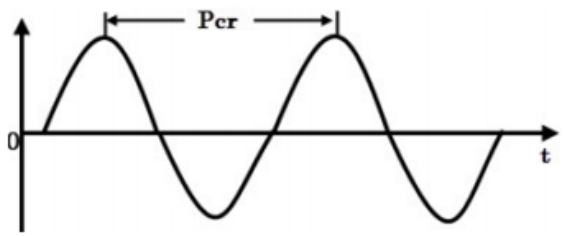


	K	τ_I	τ_D
P	$T/L/K_p$	Inf (off)	0 (off)
PI	$0.9T/L/K_p$	L/0.3	0 (off)
PID	$1.2T/L/K_p$	2L	0.5L

Ziegler-Nichols closed loop method

Works for closed loop systems which oscillates at certain gain level.

1) Turn off any integrator and differentiator in the controller. Set K (gain) to a low value.
2) Measure the unit step response of the closed loop system.
3) Gradually increase K until the system just starts to oscillate, this value is the Kcr – critical gain.
4) Estimate the period time of the oscillation, see figure.
5) Apply the following controller parameters:



	K	τ_i	τ_D
P	0.5Kcr	-	-
PI	0.45Kcr	Pcr/1.2	-
PID	0.6Kcr	Pcr/2	Pcr/8

Extra materials

Simulink overview:
https://youtu.be/Nef17ProSGk

My videos for PID design:
From previous year, using codes instead of Simulink.
What is important here: how to read graphs to design PID controller.
You do not have to write any codes, just understand the context.
https://youtu.be/QejsribaIBo
https://youtu.be/LkQWgbSTAdQ
https://youtu.be/LkQWgbSTAdQ