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| **Names:** |  | **Date:** | **Total points:** |  |
|  |  |

1. **Tuning according to specifications Points: /2**

* Realize an open loop system with the following model . Is the open-loop system stable? Show a theoretical and an empirical (practical) proof. (0.1)
* Use in closed loop mode with unity feedback. Apply 20 (Celsius) as step reference signal.**\*** (0.2)
* Design a P controllers that has a 15⸰ of phase margin. Apply 20 (Celsius) as step reference signal.**\*** (0.3)
* Vary the gain of the P controller. What do you observe? (0.2)
* Design a PI controller that has 45⸰ phase margin. Apply 20 (Celsius) as step reference signal.\* (0.5)
* Design a PID controller with 60⸰ phase margin. Apply 20 (Celsius) as step reference signal.\* (0.5)

*\*For each experiment prepare a graph and indicate the measured quantities, be prepared to explain all your findings. Fill out the table below and draw conclusions.*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Case | Controller | | | Bode diagram | | | Step response | | | |
| K | Ti | Td | Static gain | Phase-margin | Gain-margin | Static gain | Max overshoot/ undershoot | Settling  Time | Static  error |
| closed  loop |  |  |  |  |  |  |  |  |  |  |
| P15⸰ |  |  |  |  |  |  |  |  |  |  |
| PI45⸰ |  |  |  |  |  |  |  |  |  |  |
| PID60⸰ |  |  |  |  |  |  |  |  |  |  |

* Analyze the above obtained results

*Proposed questions to be answered: Compare the step responses/steady-state errors/what is the influence of phase-margin/ P,PI,PID terms? What conclusions can you draw?* (0.2)

1. **ZIEGLER-NICHOLS TUNING 1. Points: /0.5**

* Realize the following system: . Perform the Ziegler-Nichols open loop method. What parameters did you estimate from the process variable? (0.25)
* Design a closed-loop PID controller based on the recommendations of Ziegler-Nichols. What parameters did you estimate? (0.25)

1. **ZIEGLER-NICHOLS TUNING 2. Points: /0.5**

* Realize the following system: Perform the Ziegler-Nichols closed loop method. What parameters did you estimate from the process variable? (0.25)
* Design a closed-loop PID controller based on the recommendations of Ziegler-Nichols. What parameters did you estimate? (0.25)