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

1. **Calibration**
* Execute the calibration procedure provided in the manual. Provide the numbers that you have obtained.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Platform's length | Camera FPS | Neutral angle | Minimum angle | Maximum angle | *Manipulator***\*** |
|  |   |   |  |   |   | linear/ derivative / integrate |

**\*** At the controller output, which manipulator did you use to feed the servo motor with control signal? Why?

1. **Manual Tuning Points: /1.5**
* Provide the best settings found while tuning P and PID controller.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | K | Ti | Td | Tf | Deadband error | Deadband motor | Min/Max angle | Dead-time  |
| P |  |  |  |  |  |  |  |  |
| PID |  |  |  |  |  |  |  |  |

* Have you used these branches of the PID controller and why (YES/NO, WHY)?
1. Low-pass filter (Tf):
2. Integrator wind-up:
* Perform multiple step response experiments between step sizes ±0.1 and ± 10 cm. Which one is the best step size to perform experiments and why?
* Using the best P and PID controller settings, record 2-2 *step response* experiments settings. Post analyze the experiments using any data processing software of your choice (e.g. Excel, Matlab/Python [example script provided on the homepage]). For each experiment prepare a graph and indicate the measured quantities. Advise: make one longer recording containing multiple experiments.

|  |  |  |
| --- | --- | --- |
|  | P controller experiments | PID controller experiments |
|   | 1 | 2 | 1 | 2 |
| Max overshoot/undershoot |   |   |   |   |
| Settling Time |   |   |   |   |
| Static error |   |   |   |   |

* Describe your experience with different branches of the PID controller in details (you may continue on the back side of this page):
1. **ZIEGLER-NICHOLS TUNING Points: /0.5**

**In this exercise you can choose either the closed loop or open loop technique.**

* Perform multiple tuning experiments of your choice. Make sure that you deactivate the dead-bands for the tuning experiment (you can turn them back afterward). Advise: make one longer recording containing multiple experiments and analyze the ‘best looking’ data segments.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Closed **|** Open loop | Experiment 1 | Experiment 2 | Experiment 3 | Used values**\*** |
| Kcr **|** Kp |   |   |   |   |
| Pcr **|** T |   |   |   |   |
| --- **|** L |  |  |  |  |

\* In case of deviation between experiments, what tunning values did you choose and why?

* Provide the PID parameters obtained via formulas, and if it is needed fine-tuned PID parameters.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | K | Ti | Td | Tf | Deadband error\* | Deadband motor\* | Min/Max angle\* | Dead-time\*  |
| PID |  |  |  |  |  |  |  |  |

**\*** If you changed these values with respect to the manually tunned parameters, explain why:

* Using the best step size, perform 2 experiments with the best performing PID controller settings. Using the data recording function of the software, post analyze the experiments.

|  |  |  |
| --- | --- | --- |
|   | Experiment 1 | Experiment 2 |
| Max overshoot/Undershoot |   |   |
| Settling time |   |   |
| Static error |   |   |

* Considering 1) the time needed for the previous, fully manual tunning and tunning method of Ziegler-Nichols, 2) the measurement quality (from the tables), draw your conclusions in detail: