**EE3CL4 – Lab 3 Report**

**L04 - Group 06 - Tuesday**

**Yiming Chen, 400230266**

**Ruiyi Deng, 400240387**

[cheny466@mcmaster.ca](mailto:cheny466@mcmaster.ca)

[dengr6@mcmaster.ca](mailto:dengr6@mcmaster.ca)

Mar 12th, 2022

Contribution:

Ruiyi Deng takes charge of exp2 and discussion

Yiming Chen takes charge of exp1 and exp3

**Objective:**

To design a proportional controller and a proportional controller with velocity feedback for the DC motor servomechanism, and explore trade-offs involved in the selection of the controller parameters and their impact on transient and steady-state responses of the control system.

**Experiment I: Qualitative Trade-offs in Rise-time, Steady-State error, Overshoot, and Settling Time of a Proportional Controller**

The first task is to measure the overshoot. We measured the peak value and final value. Two important things should be noted. The runtime of the simulation should be at least 10 seconds for more accurate results. Also, the start point of this experiment is from the -45 degrees. And then calculate the difference of peak value and final value. This value is then divided by final value which is (final value measured + 45 degrees from the start point). The second task is to measure the rise time. It is determined by the junction of the DC motor simulation and the expected results which is the junction of the blue line and yellow line in the figure. Settling time is easy to see when the DC motor is steady. All the results are shown in the table below and the figures are attached in the Appendix I.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| kp value | peak value | final value | rise time | overshoot | settling time |
| kp = 0.5 | 60.47 | 50.98 | 0.248 | 9.887476558 | 0.68 |
| Kp = 1 | 77.7 | 42.36 | 0.128 | 40.4532967 | 0.476 |
| Kp = 2 | 101.6 | 49.92 | 0.096 | 54.44584914 | 0.691 |
| Kp = 3 | 110.7 | 49.57 | 0.077 | 64.63994924 | 0.703 |
| Kp = 4 | 116.4 | 46.93 | 0.068 | 75.56836724 | 0.858 |
| Kp = 5 | 121.8 | 46.76 | 0.058 | 81.77855275 | 1.174 |

When the proportional gain is increased, the percentage of overshoot is also increased as well as the settling time. Meanwhile, the rise time is decreasing with increment of the proportional gain.

The asked positions of the poles of the closed-loop transfer function are shown below:

图表

描述已自动生成

As can be seen from the figure, when kp is increasing, the angle of the pole positions on the left-plane is increasing. This implies the increasing percentage of overshoot and the settling time. And with ωn increasing, the rise time decreases.

The theoretical values of the steady-state error from the pre-lab are approximately 20, 10, 5, 3.33, 2.5 and 2 degrees respectively. And the measure results from the table is very closed to the theoretical value.

**Experiment II: Proportional Controller Design**

**Experiment III: Joint Design of Proportional Controller and Velocity Feedback**

In this experiment, two requirements should be met. The first one is to calculate the steady-state error from the given formula

According to the document, if the model was perfectly linear, then when kp =1, the disturbance would generate a steady-state error of 10 degrees. Thus to decrease the to 2 degrees, we would have to use kp > 5.

The second constraint is that the percentage maximum overshoot in the step response is less than 10%. This constraint is used to determine the value of kv according to the three formulas below.

The detailed calculation process is presented in the matlab file exp3.m. The result calculated from kp = 5,6 and 7 are kv = 0.1594, 0.1782 and 0.1954. The corresponding value is shown in the table below and the measurement method is the same as in experiment I.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| kp value | peak value | final value | ess | kv | P.O. | settling time |
| kp=5 | 52.73 | 47.29 | 2.29 | 0.1594 | 6.044444444 | 0.207 |
| kp=6 | 52.73 | 46.76 | 1.76 | 0.1782 | 6.633333333 | 0.169 |
| kp=7 | 52.91 | 46.23 | 1.23 | 0.1954 | 7.422222222 | 0.141 |
| kp=7 | 131.3 | 46.05 | 1.05 | 0 | 94.72222222 | 2.189 |

The measured result is very closed to the theoretical value from the pre-lab. Generally start from kp = 6, the steady-state error and P.O. are met.

The pole position is shown in the figures below

图表

描述已自动生成Apart from that, we also did when kv = 0. We can find that the oscillation is much larger and the ripples keep generating. It is obvious that at this time, the system is unstable.

**Comparison and Discussion:**

**How to improve accuracy of the estimation of model parameters:**

电脑的截图

描述已自动生成**Appendix I – kp from 0.5 to 5**

电脑的截图

描述已自动生成

电脑的截图

描述已自动生成

电脑的截图

描述已自动生成

电脑的屏幕截图

描述已自动生成

电脑的屏幕截图

描述已自动生成

**Appendix II –**

**Appendix III – kp = 5, 6, 7, kv = 0.1594, 0.1782, 0.1954 and kp = 7, kv = 0**

电脑的截图

描述已自动生成

电脑的截图

描述已自动生成

电脑的截图

描述已自动生成

电脑萤幕画面

描述已自动生成