

**Electrical & Electronics**

**Engineering Department**

**Control System Design**

**DC Motor Control PD Position Control Report**

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**PD CONTROL ACCORDING TO SPECIFICATIONS**

In this assignment, as a main goal, we are expected to analyse and learn how to control a DC Motor Control Proportional-Derivative process in control systems. Moreover, we are also expected to understand the fundamentals of Proportional-derivative compensator design according to specifications. We learned the input-output relation in the time-domain for a PD controller. We investigated how benefit from derivative action.

**In step 7**, as an experimental procedure, the response of position control is analysed.

**Speed Response**

Damping ratio affects the amplitude of vibrations in our designed system.

*ζ* =

**Natural Frequency**

Natural frequency causes to oscillation unless there is damping force, I observed the relationship between these terms to have stable system.

Ǉ0 = is the natural frequency of the system.

**Effect of Changing Naturel Frequency in step 9-10**

When *ζ* is zero the system oscillates. The sharpness of my system depends on the damping ratio, too.

* Simply, when I increase the natural frequency value gradually peak time is increasing.
* Natural frequency also effects the values of proportional and derivative blocks.
* Decrease in natural frequency increase peak time, too.

**Effect of Changing Damping Ratio in step 9-10**

The effect of changing damping ratio on my system leads to 3 cases; if it is greater than 0.75, it becomes ***overdamped*** whereas if it is between 0 and 1 it behaves as a stable which means ***underdamped***. However, in the system, when I decreased damping ratio, I realised that the system becomes ***undamped***.

Therefore, when I increase the value of zeta for 0 to 1 I decrease the damping in response. That is why system response speed up and system becomes stable.

* Increase in zeta results in increase on peak time which at the end becomes undefined, instability.
* Decrease in zeta results in decrease in peak time

**RESULTS**

![Chart, box and whisker chart

Description automatically 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Figure 1 Position Control Response from Step 7

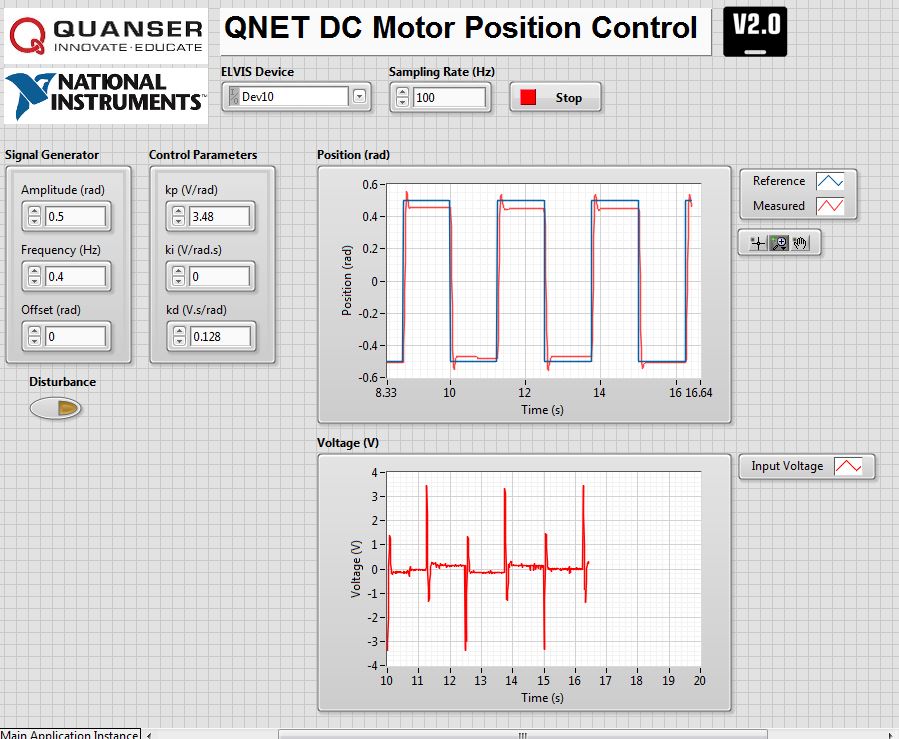


Figure 2 PD Response Plot with calculated Kp, Kd terms

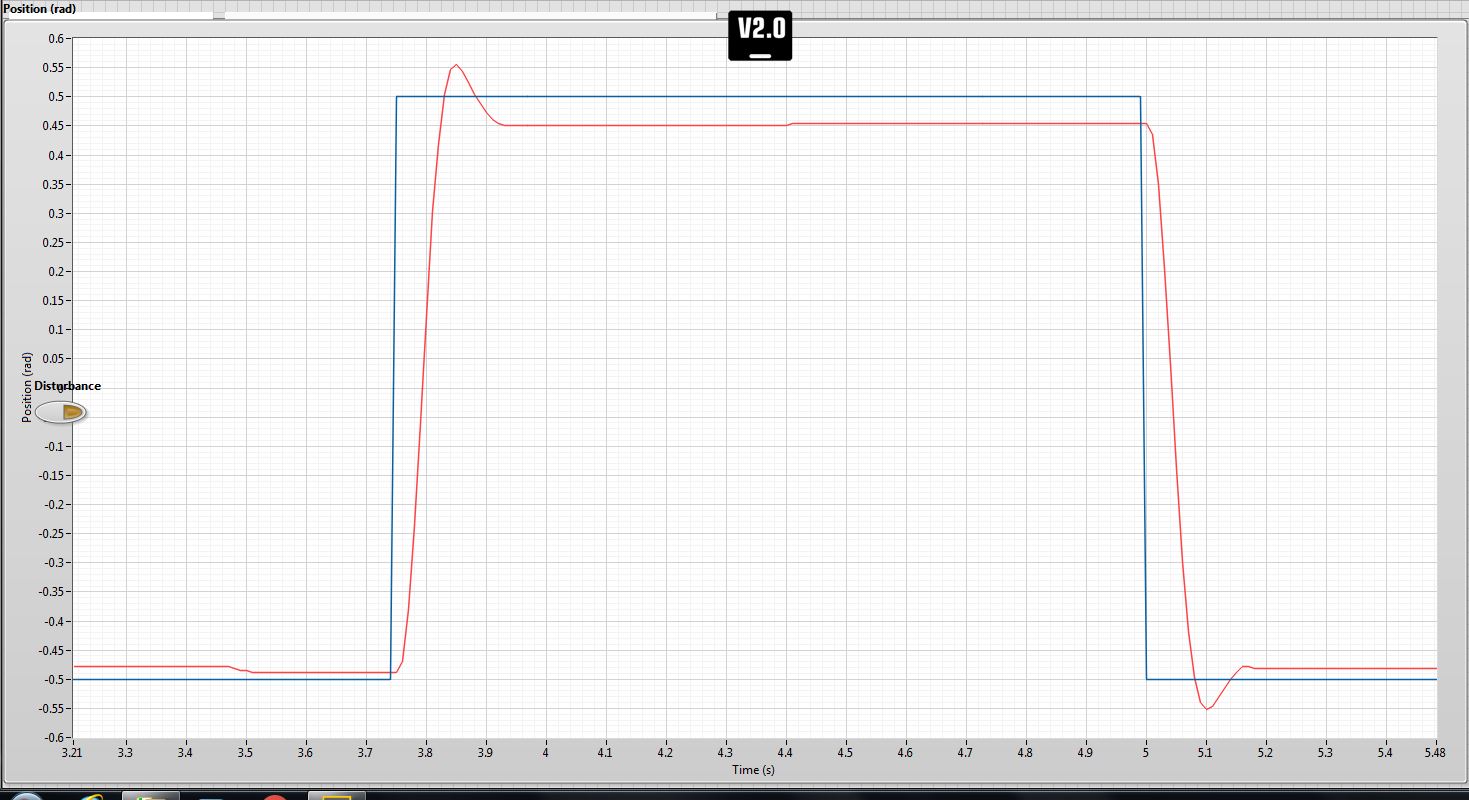


Figure 3 Peak time & Percent Overshoot of speed control Disturbance Response

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | **Symbol** | **Value** | **Unit** |
| **Section 2.1 PD Control Design** |  |  |  |
| Model gain used | K | 26 | rad/s |
| Model time constant used | τ | 0.145 | s |
| Proportional gain | Kp | 3.48 | V(rad/s) |
| Derivative gain | Kd | 0.128 | V/rad |
| Measured peak time | tp | 0.157 | s |
| Measured Percent Overshoot | MP | 9.48 | % |

Table 1: DC Motor Position Control Results

## ANALYSIS

**Calculations for analysis in Step 8**

**Percent Overshoot**

I have used the formula (0.9) from DC MOTOR PD Control System.

**PO** = 100\* = 9.48.

I found the values of Kd and Kp according to the formulas shown in the booklet (1.5, 1.6) Kd = 0.1283, Kp = 3.48

**Peak Time**

From the initial step time t0, the time it takes for the response to reach its maximum value is tp = tmax − t0.

tp = = 0.157s, tp = 0.157s, measured tp = 0.3s

**Effect of changing Proportional and Derivative gains**

In this experiment, PD controller produces an output that is the combination of the outputs of PD controllers which is shown below.

u(t)=Kp\*e(t)+KD\*de(t)/dt

The proportional derivative controller is used to improve the stability of the control system without affecting the steady state error.

**Peak time and Percent Overshoot of Position Control Response**

There is not a big difference between my own calculations and simulation results. So, specifications are mainly satisfied. Therefore, it can be concluded that since there is not an excessive exceeding the maximum value of the step response in step 9. Moreover, since we have a derivative control, it reduces the overshoot in our system.

## CONCLUSION

It can be concluded that the desired simulation output and actual motor speed graphs are similar. Steady-state error is simply defined as the difference between input and output of system for unity feedback systems.

* My calculations met the specifications on PD position controller. In my system, steady-state error is calculated using the final value theorem.
* I obtained PO value 9.48, peak time 0.157s.
* Measured Steady State error is small when using PD Controller with unit function as an input.
* Disturbance affects this closed loop control system. It should be close to zero to have a high stability criterion.
* PD controller is beneficial to improve the transient performance, however PI controller improves the steady-state performance that is why there is a trade-off.