Department of Robotics and Mechatronics Engineering

University of Dhaka

Laboratory Report

Course: RME 3112 (Advanced Mechatronics Engineering Lab)

Experiment number: 02

Name of the experiment: Dynamic characteristics of PD controller

Group no.: 01

Group members:

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Submitted to:

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Experiment performed on: 22nd March 2022

Date of submission: 13th May 2022

Objective:

1) Understanding the working principle behind Proportional-Derivative(PD) control and its step response characteristics, as well as its analog circuit.
2) Understanding how a PID Control Circuit Trainer Kit can be utilised to demonstrate the functions and characteristics of PD, Proportional-Integral(PI) and Proportional-Integral-Derivative (PID) controls.
3) Demonstrating the dynamic characteristics of the PI control using the PI control circuit onboard a trainer kit via an oscilloscope.

Introduction:

Proportional-Derivative(PD) control is a control loop feedback mechanism (controller) widely used in industrial control systems due to its robust performance in a wide range of operating conditions & simplicity.[1] The PD controller produces an output, which is the combination of the outputs of proportional and derivative controllers. It is expressed by the equation[2]:

$$u(t) = K_P e(t) + K_D \frac{\mathrm{d}e(t)}{\mathrm{d}t}$$

Applying Laplace transformation to both sides gives us:

$$U(s) = (K_P + K_D s)E(s)$$

$$\frac{U(s)}{E(s)} = K_P + K_D s$$

Where the Right-Hand side is our transfer function.

The block diagram of a PD controller in a negative feedback closed loop is given below:

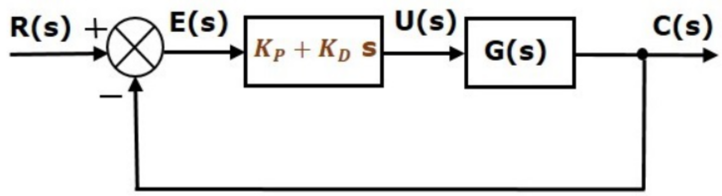

Fig 1: Block diagram for PD control in negative feedback closed loop.[3]

The PD controller is used to improve the output signal stability of the control system without affecting the steady-state error.

When a step function is applied to the loop as input, the expected output appears as the following (the trace for the PD controller is given by the solid green line:

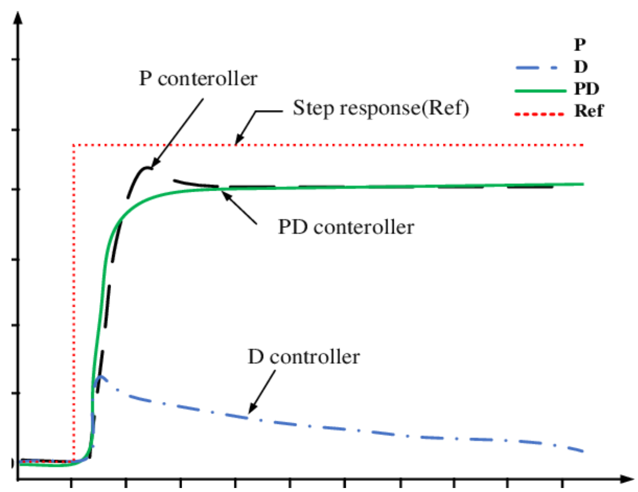

Fig 2: Voltage-time graph for P, D and PD controllers[4]

Apparatus used:

1. CL-PID: PID Control Circuit Trainer Kit
2. Dual-trace low-frequency slow-scanning oscilloscope

Fig 3: Dual-trace low-frequency slow-scanning oscilloscope[5]

3. Digital Multimeter

Fig 4: Digital Multimeter[6]

Procedure:

1. Connect the components of the trainer board with connecting leads according to the circuit in the diagram below to form the PD controller.
2. Simultaneously press the switches SW1 and SW2 switches of the power unit and let go.
3. Press down on switch SW5.
4. Adjust the potentiometer to give an output of +1V from the power supply's +12V to form a uniform step signal. (Check this using the digital multimeter.)
5. Connect the circuit with the PD controller according to the circuit in the diagram below.
6. Press down the switch of the operational unit and observe the output in the oscilloscope.

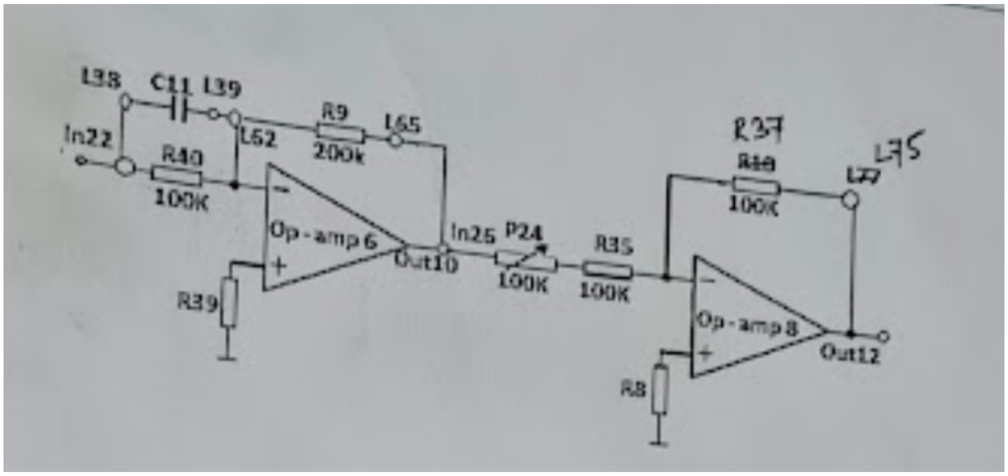

Fig 5: Circuit to be designed for the PD controller

Result:

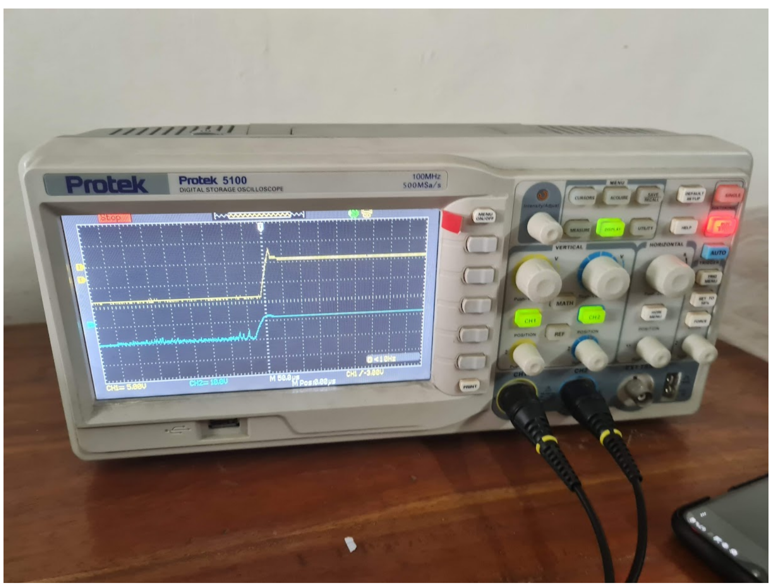

Fig 6: The oscilloscope giving the desired output

Discussion:

The analog circuit behaved as we expected it to upon applying power, as can be seen in Fig 5, The components of the trainer kit behaved per expectation and all adjustments could be made swiftly and easily.

Conclusion:

The output displayed on the oscilloscopes roughly resembles the expected voltage-time characteristics shown in Fig 2, indicating that the experiment yielded the expected outcome. The noise that can be seen on both the step-function as well as the output signal could possibly have been created due to the presence of resistance on the board and connecting leads. The time delays observed for the step function could also be due to the presence of inductive loads at some parts of the load.

References:

1. https://vivekbose.com/introduction-to-pid-controller-with-detailed-ppipd-pd-control
2. https://www.tutorialspoint.com/control_systems/control_systems_controllers.htm
3. https://www.tutorialspoint.com/control_systems/control_systems_controllers.htm
4. https://www.researchgate.net/figure/Figure-7-The-P-D-PD-Vs-Step-response_fig2_341979581
5. https://www.tek.com/en/products/oscilloscopes/tbs1000
6. https://www.daraz.com.bd/products/digital-multimeter-dt830d-i100266333.html

Rough sheet:

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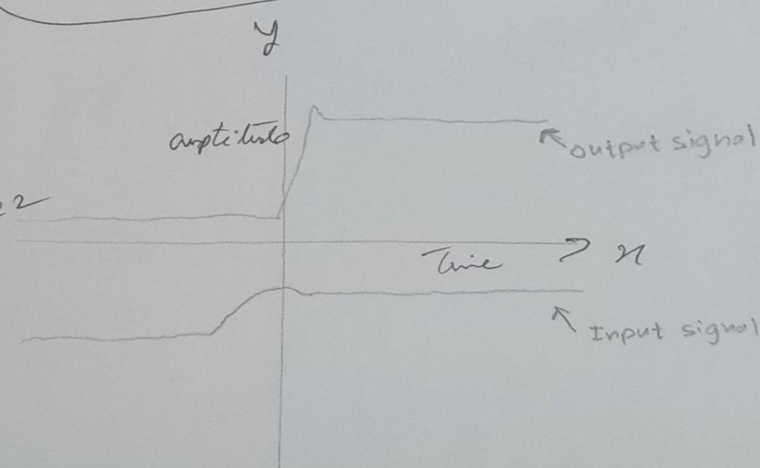
Graph:



22.03.2022