EE 301P: Control Systems Laboratory
Lab Exercise 1

Lab session: August 18, 2023. *Report due*: August 25, 2023.

1 Objective

To understand the impact of following forms of feedback on a simple system:

1. proportional control
2. proportional-integral control
3. proportional-derivative control
4. proportional-integral-derivative control

2 Pre-lab exercise

Consider the following setup:

Input signal: a continuous-time sinusoidal signal with a positive DC shift
System: a single first-order integrator.

Answer the following questions:

1. Given that the system at hand is an integrator, what output do you expect to see? What is your intuition behind the expectation?
2. What happens to the output when the DC shift is removed?
3. How does the output change upon increasing or decreasing (a) the DC shift, (b) the frequency?
4. Is this an open-loop system or a closed-loop system? Justify.

Optional: You may rig up a simple Simulink model to verify your answers to the above questions.

3 Lab exercises

Consider a simple model for automatic cruise control (ACC) of a car. The purpose of such a controller is to ensure that the car moves at a required velocity despite any external disturbances such as road inclination, wind resistance etc. A simple first-order ordinary differential equation model for dynamics of a moving car is given by

$$m\dot{v} + bv = u, \tag{1}$$

where m is the mass of the car, b is the damping coefficient, v is the velocity of the car and u is the external input applied to move the car forward. As output is the velocity of the car, we may write the output equation as

$$y = v. \tag{2}$$

Writing equations (1) and (2) in the input-output form and finding the transfer function of the system, we obtain

$$G(s) = \frac{V(s)}{U(s)} = \frac{1}{ms + b}. \tag{3}$$

We now need to explore the impact of P, PI, PID controller on the above system.

One way of doing this is by building simulation models on Simulink. Build the model based on the below block diagram. Once the model is built, you may vary

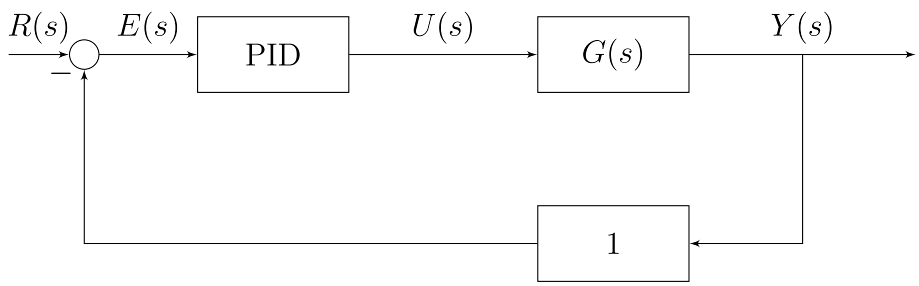

Figure 1: Closed-loop system representing automatic cruise control of car.

the parameters of the controller to understand the impact of each component on the system output, *i.e.*, velocity of the car. For the simulation model, use parameters $m = 1000$ kg, $b = 50$ Ns/m. Set a reference speed of your choice, and tune control parameters k_p, k_i and k_d to understand the impact of various forms of feedback on speed regulation. For example, to understand how a proportional control would perform, set k_p to a certain value and set $k_i = k_d = 0$. Likewise, to understand the how a proportional integral controller would perform, set k_p and k_i to certain values and set $k_d = 0$. Record your observations in the form of tables and graphs for various combinations of parameter settings. Draw inferences and conclusions and state them clearly.