SSY156 Homework 4
Problem

Introduction

Assume that you would like to control the amount of a fluid in a hydrofor (tank). The linear part of the fluid dynamics can be written as:

$$M\ddot{q} + B\dot{q} = u$$

where q is chosen as the amount of water in the tank (in cubic meters) and the nonlinearities of the system have been ignored. The variable M represents the inertia of the water body (in kg/m^4), B corresponds to viscous friction (in $kg/(m^4 s)$) and u is the controlled pressure input.

Part (a)

Assume that measurements of the flow rate (in m^3/s) and the amount of water are available, $M = 10$ and $B = 0.5$. Using transfer functions, design a controller consisting of two loops: an inner loop for controlling the flow rate with a PI controller and an outer loop for controlling the position with a P controller. One of the controller gains should be chosen such that the time constant (i.e. the dynamics) of the water tank does not affect the closed-loop dynamics. The other gains should be chosen such that a desired behaviour (chosen by you) of the closed-loop system is achieved.

In the report, provide transfer functions of the plant and the controller. Also, explain how you chose the controller gains. Finally, show a plot of the step response of the closed-loop system.

Part (b)

While holding the gain of the PI controller constant, try changing the gain of the P controller. Then, try the opposite. Is there a difference in the system's behaviour for the two cases? Can you achieve arbitrary desired dynamics? If not, try to explain the limitations. You can also provide plots to support your answer.