EE 301P: Control Systems Laboratory
Lab Exercise 4

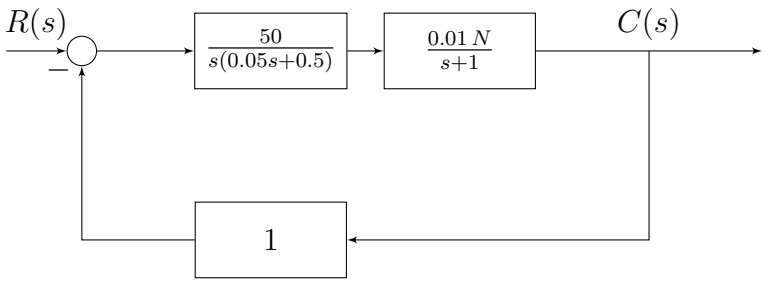
Lab session : September 08, 2023 *Report due*: September 15, 2023

1 Objective

To find an analytically tractable approximation of a higher-order system and evaluate the accuracy of the approximation.

2 Pre-lab exercise

The block diagram of a liquid-level control system is shown below. The liquid level is represented by $c(t)$, and N denotes the number of inlets.



a) Find the transfer function $C(s)/R(s)$. What is the order of the resultant system?

b) Plot the poles and zeros of the system.

c) Find an approximation of the system that is amenable to transient response analysis. Find the peak overshoot and peak time of the approximated system.

3 Lab exercise

a) From Pre-lab exercise (c), you may have noticed that the peak overshoot and peak time depend on the number of inlets N. Vary the value of N in the range $1 : 10$ and plot the peak overshoot and peak time as functions of N. Draw inferences from the plots: how do the two transient response specifications change as the number of inlets in increased?

b) Obtain the unit step response of (i) the original system (without the approximation), and (ii) the approximated system, for the smallest and largest value of N considered. Compare the response of the two systems for both values of N. Comment on the accuracy of the approximation as a function of N.

c) Let $c_o(t)$ be the step response of the original system (without the approximation) and $c_a(t)$ be that of the approximated system. Define the approximation error as $e_a(t) = |c_o(t) - c_a(t)|$. Note that this error can be used as a metric to evaluate the accuracy of the approximation. Plot this error as a function of N (use the same range as above, $N \in [1, 10]$). Verify the comment made in part (b) above using this plot.

4 Deliverables

1. Lab report, necessarily containing
   (a) Transfer function of the original system and the approximated system.
   (b) Expressions for peak overshoot and peak time of the approximated system.
   (c) Plots showing peak overshoot vs. N and peak time vs. N.
   (d) Plots showing step responses of the original and the approximated system for smallest and largest value of N.
   (e) Plot showing $e_a(t) vs N$.
   (f) Detailed inferences for all parts of the Lab exercises.
2. MATLAB code/Simulink model.