Lab Week 10: Liquid Level Physical System Testing

0. Objectives

- Experimental testing of the physical liquid level system
- Comparing testing data to simulation data

1. Overview

This multi-week lab consists of using MATLAB Simulink and Arduino microprocessors to control a liquid level system. The system operates by manipulating the outlet valve to maintain a desired water height regardless of inlet flowrate.

2. System Description

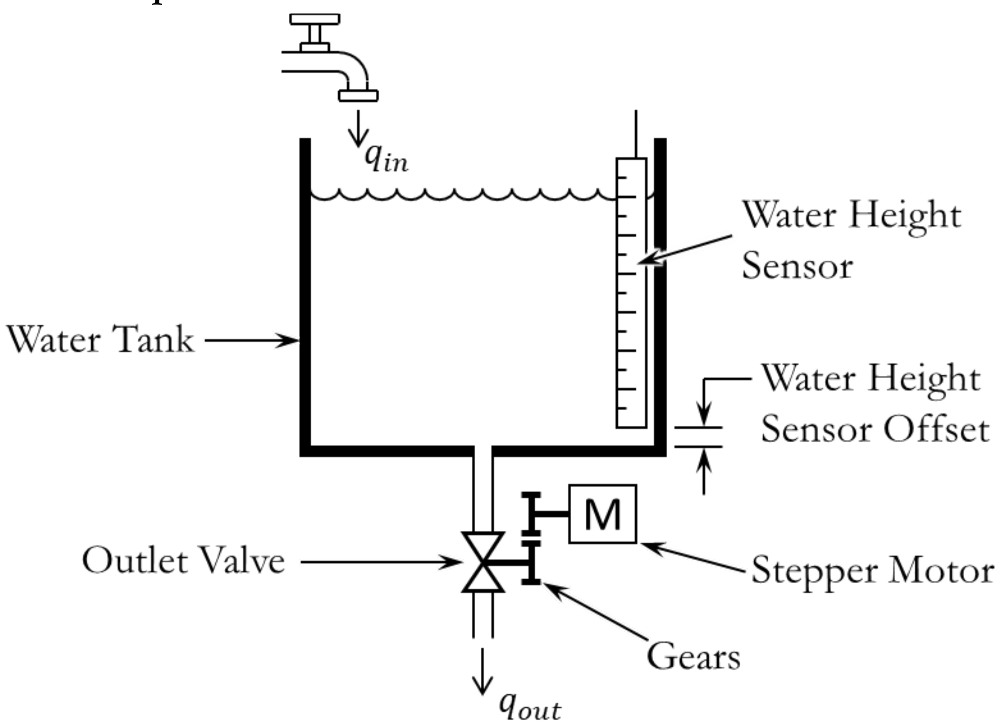

Figure 1: Mixing tank schematic

2.1 Main System Components:

- Outlet valve: controls outlet flowrate to maintain desired water height
- Stepper Motor
  - Opens and closes outlet valve via gears
  - When outlet valve is fully closed, the stepper motor position is 'steps = 0'
  - When outlet valve is fully open, the stepper motor position is 'steps = 1020'
- Water height sensor
  - Detects water height
  - Also referred to as an eTape sensor
- Water tank

2.2 Main system variables:

- Inlet flowrate (q_{in})
  - Inlet flowrate of water
  - Value of flowrate is unknown, uncontrollable, and can vary
  - Units: cm^3/s
- Outlet flowrate (q_{out})
  - Outlet flowrate of water
  - Flowrate will vary depending on outlet valve position **and** actual water height
  - Initial outlet flow rate is 0 cm^3/s
  - Units: cm^3/s
- Outlet valve position (X_{valve})
  - Fully closed position = 0 steps
  - Fully open position = 1020 steps
  - The valve position can be anywhere between 0 steps and 1020 steps
  - Initial valve position is 0 steps
  - Units: steps
- Water tank cross-sectional area (A_{tank})
  - Assume constant
  - 643 cm^2
  - Units: cm^2
- Setpoint water height ($h_{setpoint}$)
  - The desired water height
  - Units: cm
- Actual water height (h_{actual})
  - This is the output variable; the variable we want to control
  - The setpoint water height will be specified. By adjusting the outlet valve, the actual water height will change until it matches the setpoint water height
  - The initial actual water height is 0 cm
  - Units: cm
- Sensor water height (h_{sensor})
  - This is the output/reading of the water height sensor
  - Units: cm
- Water height sensor offset (h_{offset})
  - 3.5 cm
  - Units: cm

3. Objectives

Using MATLAB Simulink and Arduino microprocessors, a liquid level system will be controlled by manipulating the outlet valve to maintain a desired water level regardless of inlet flowrate. The basic steps for completing the multi-week lab are as follows:

1. Create a block diagram of the full system simulation model (Lab Week 4)
2. Characterize and model system components (Lab Week 5)
3. Build simulation model of full system using Simulink (Lab Week 5)
4. Run simulation model to optimize controller and predict behavior (Lab Week 6)
5. Build physical system control model (Lab Week 9)
    - Create new block diagram that will be used for the physical control model
6. Compare simulated results and experimental results

4. Background: comparing simulated results and experimental results

The goal is that the system behavior from your simulation model resembles the behavior of the physical system. The simulation model was used to design a controller that effectively controls water height. Each team will use their determined PID controller gains and demonstrate the capability of their control system. Data will be collected of your physical system tests and compared to your simulated model data.

5. Assignment

5.1 Experimental Testing

Using the PID gains found in previous labs, gather response data of the liquid level test stand.

5.2 Compare Simulation Data to Experimental Data

Analyze and comment on the differences between the simulation data and the experimental data

6. Deliverables

- Problem 5.1
    - Plot of experimental system response. Your plot will have two traces: setpoint height and actual experimental height
        - In the title of the plot, be sure to include what test stand was used and what PID gains were used
    - Answer the following questions
        - What is the inlet flow rate?
        - What is the 5% settling time?
        - Why do you think there is so much valve chatter during the experiment?
- Problem 5.2
    - Plot comparing experimental and simulation response. Your plot will have three traces: setpoint height, actual experimental height, and actual simulation height
        - Be sure your simulation model is using the same PID gains
        - Be sure your simulation model is using the correct inlet flow rate
    - Answer the following questions:
        - How well does the simulation match the experiment?
        - Why do you think there are differences?
- You do not need an executive summary
- Don't forget a cover sheet