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M E M O R A N D U M

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Course: ME 422 – 07

Team: Group 10

Subject: Fluid Level Control (Two Tanks) Lab Part 2

Objective / Procedure

The objective of the Fluid Level Control Lab is to study regulation control and record system responses for a system of two identical water tanks connected to each other and a reservoir through shutoff valves. The bottom tank has an additional valve that acts as a disturbance. Using regulation control, the goal is to keep the water height in the bottom tank at its steady state value with external inputs, or disturbances, changing this value. Part 2 of this lab utilizes a closed-loop PI-controller to accomplish regulation control.

For the procedure, there is a pre-built Simulink model that is used to run the control system. By inputting the gain and bias values obtained from part 1 of the lab, the PI-controller can be tuned and operated. The model is then run as a closed-loop model and a disturbance is added to the system. As the open disturbance valve alters the flowrate of water out of the bottom tank, the system reacts and corrects for this. Eventually the system returns to steady state and operates with the desired tank water height values.

Results and Discussion

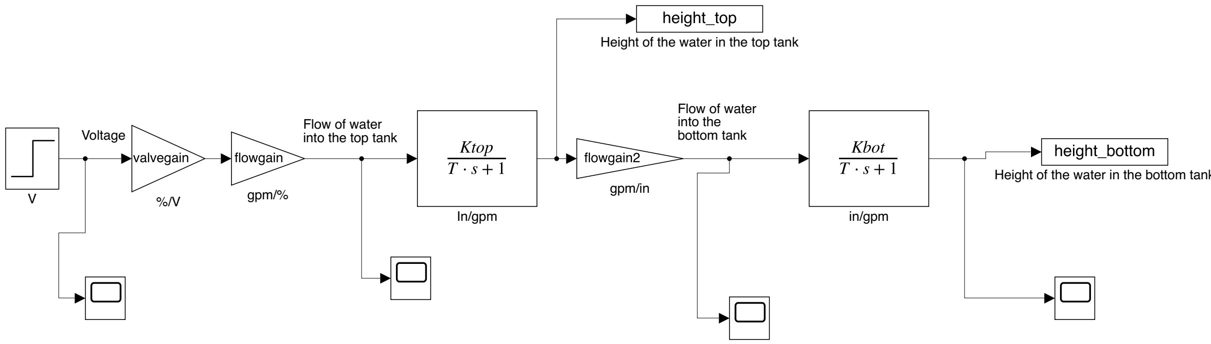

Figure 1: Open-loop Simulink block diagram for the two-tank system for Part 1.

Table 1: Parameters for the open-loop Simulink model.

Parameter	Value
Step Input Voltage [V]	0.2
Valve Gain [%/V]	8.9172
Flow Rate Gain into the Top Tank [gpm/%]	0.0676
Flow Rate Gain into the Bottom Tank [gpm/%]	0.057
Steady State Gain of the Top Tank, Ktop [in/gpm]	17.533
Steady State Gain of the Bottom Tank, Kbot [in/gpm]	14.844
Time Constant [sec]	100

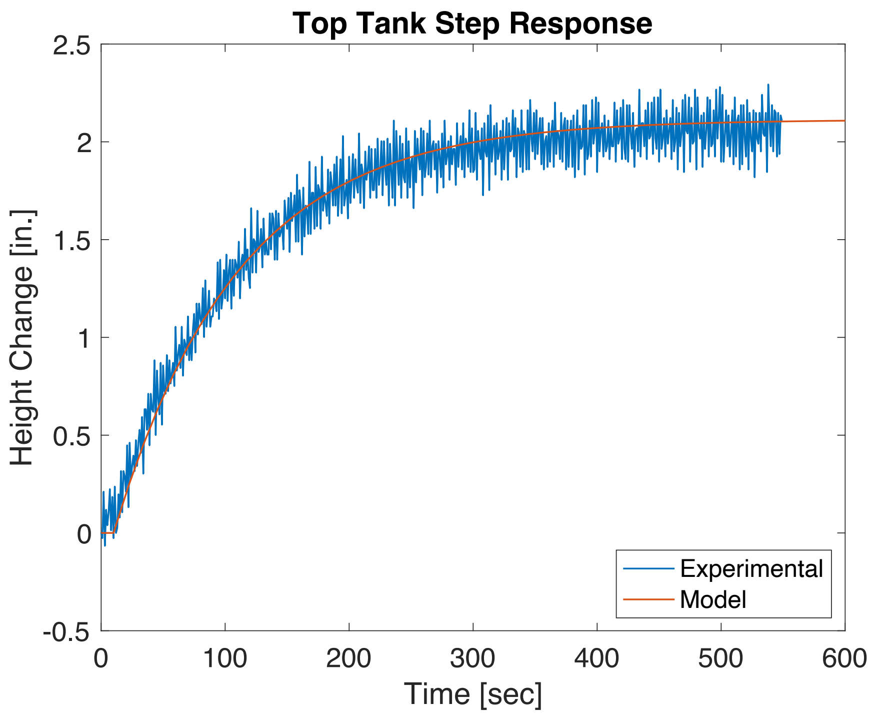

Figure 2: Top tank tuned simulation step response superimposed with experimental step response.

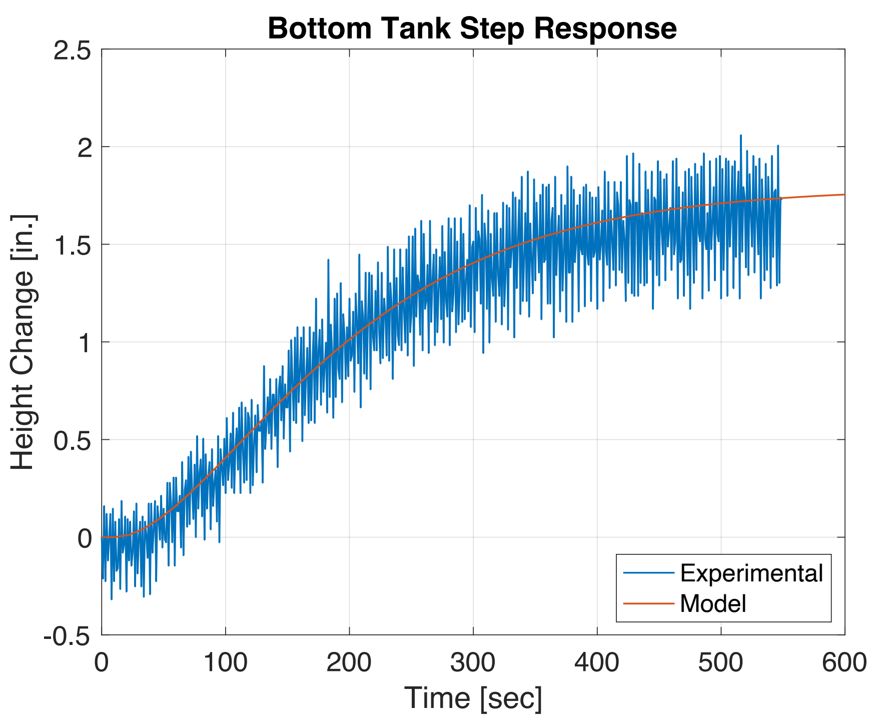

Figure 3: Bottom tank tuned simulation step response superimposed with experimental step response.

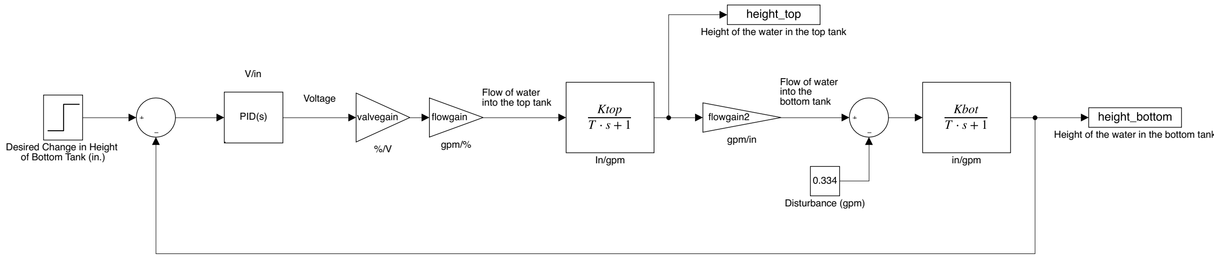

Figure 4: Closed-loop PI-controlled Simulink block diagram for the two-tank system for Part 2.

Table 2: Parameters for the closed-loop Simulink model.

Parameter	Value
Desired Change in Height [in.]	0
Valve Gain [%/V]	8.9172
Flow Rate Gain into the Top Tank [gpm/%]	0.0676
Flow Rate Gain into the Bottom Tank [gpm/%]	0.057
Steady State Gain of the Top Tank, Ktop [in/gpm]	17.533
Steady State Gain of the Bottom Tank, Kbot [in/gpm]	14.844
Time Constant T [sec]	100
Proportional Gain Kp [V/in]	0.6
Integral Gain Ki [V/in]	0.004
Disturbance Input [gpm]	0.334

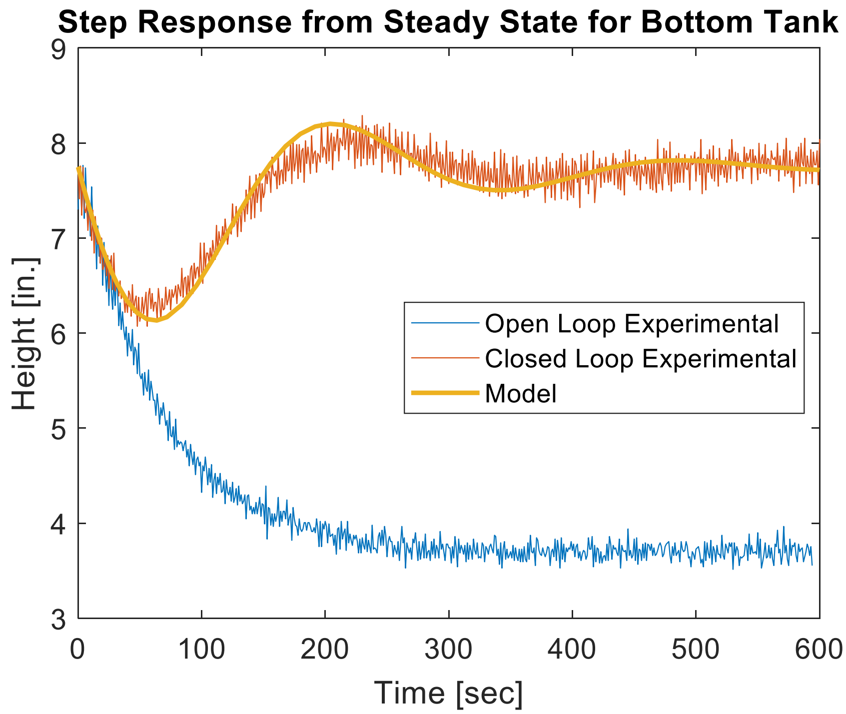

Figure 5: Bottom tank responses with disturbances for open loop experimental, closed loop experimental, and Simulink model.

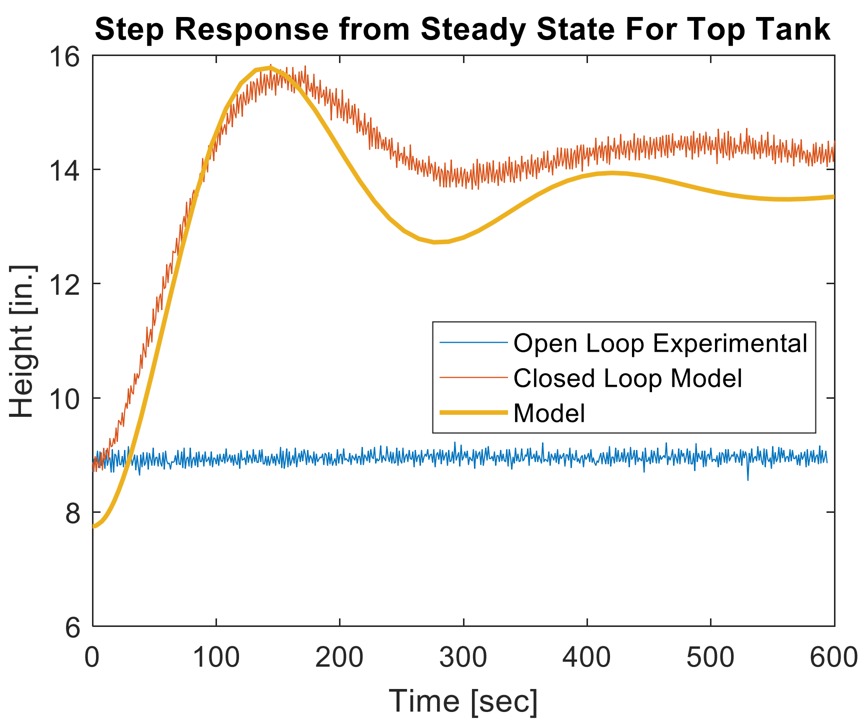

Figure 6: Top tank responses with disturbances for open loop experimental, closed loop experimental, and Simulink model.

Figure 5 and Figure 6 show the step responses in water level height of the two-tank system when we introduce a disturbance to the system by opening the disturbance valve connected to the bottom tank. When this valve is opened, the water in the bottom tank starts draining at a faster rate as the flow rate is increased. The open loop and closed loop iterations coincide for the first 30 or 40 seconds after the valve is opened. From this point onward, the data diverges. In the closed loop feedback-controlled system, the top tank responds to the decrease in water height of the bottom tank and increases the flowrate into the top tank. As the water height in the top tank increases, the flowrate out of the top tank increases and compensates for the increased flowrate from the bottom tank due to the disturbance valve. In the closed loop system, the system cannot respond to the disturbance so the water height in the top tank stays at the same level.

Conclusion

In the Fluid Level Control Lab, we successfully experimentally demonstrate a control system for two water tanks that regulates the height of water in the bottom tank with a disturbance input. Using closed-loop PI-control, the water pump is controlled to adjust for the water height change with feedback from pressure sensors in the top and bottom tank in order to track the tank height. The tank height is corrected, and the system returns to steady state with the bottom tank at the desired value. A Simulink model is created and run in order to optimize integral gain and compare to the experimental. Simulation and experimental results match well.