ME581 Lab1 Report

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Abstract

This report presents a simulation of an output signal using feedforward and derivative control to reduce overshoot in the system's response. The system is simulated using an Op-Amp and a microcontroller, which can be commanded via Python scripts. The tests are performed on a second-order analog plant, comprising a polyfuse, two resistors, and two capacitors. Three sets of values are tested to compare their performance, including tests with and without derivative control, as well as a test with derivative control and an additional disturbance. The simulation results demonstrate that derivative control effectively dampens the output signal, even in the presence of disturbance input. Overall, this report highlights the effectiveness of derivative control in mitigating overshoot in a simulated system.

1 Discussion

The setup for this lab is illustrated in Figure 1, which is based on the electrical schematic shown in Figure 2. In the schematic, resistor 1 has a value of $160k\Omega$, resistor 2 is $200k\Omega$, capacitor 1 is $10\mu F$, and capacitor 2 is $0.082\mu F$.

The step response of the output signal y with only feedforward control $k_{ff} = 1$ is presented in Figure 3. As observed in the figure, the output signal exhibits overshoot and eventually converges to the input signal u at steady state. However, the goal is to reduce overshoot and ensure y converges to u as smoothly and quickly as possible. Therefore, the derivative control is implemented.

Figure 4 shows the response with a derivative control $k_d = 0.2631$. Unlike Figure 3, the signal y converges to the signal u much more steadily without overshooting. However, the signal u appears to have a wiggling response and drops, likely due to lag.

Next, a step disturbance input is applied to the reference input. Figure 5 illustrates that the magnitude of the response doubles due to the additional disturbance input. Additionally, the disturbance causes the signal u to drop more dramatically compared to Figure 4.

It is worth noting that all the Figures show a drop in signal magnitude at the beginning. This is because the microcontroller captures noise during startup. To address this, a 2-second wait time is implemented to initialize the noise using feedforward control to eliminate the noise. Once the signal returns to 0, the reference input is applied.

Overall, the results demonstrate that the derivative and feedforward controls can effectively reduce overshoot in the output signal.

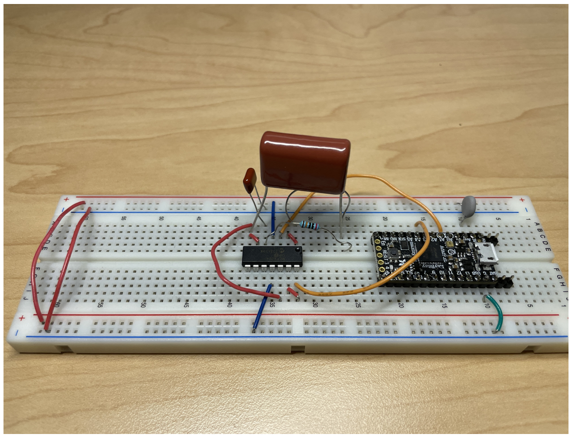

Figure 1: Hardware setup

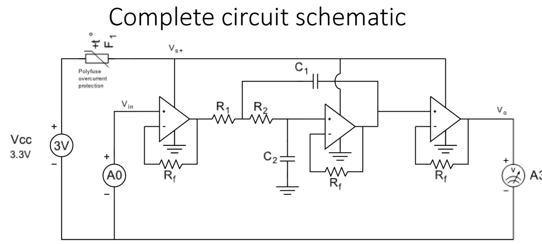

Figure 2: Electrical schematic

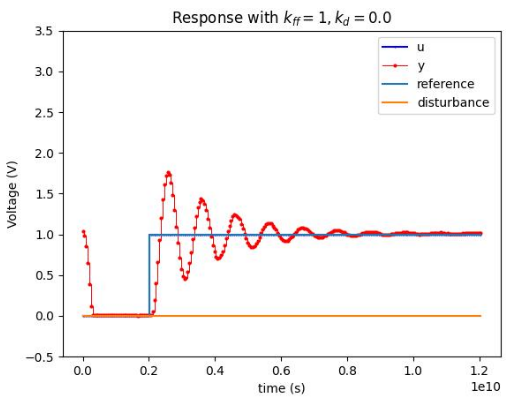

Figure 3: Step response with $k_{ff} = 1, k_d = 0$

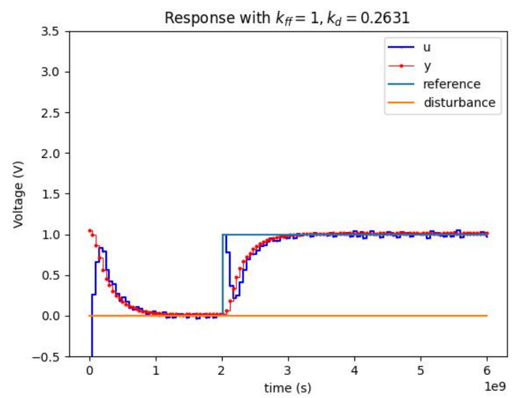

Figure 4: Step response with $k_{ff} = 1, k_d = 0.2631$

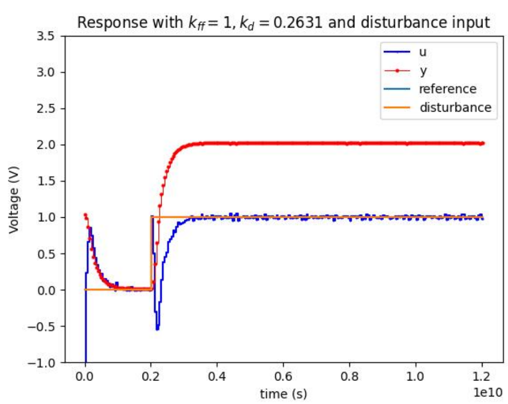

Figure 5: Derivative control response with step disturbance input