EE3302 Lab Report:
E1: Advanced Control Systems

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October 28, 2009

1 Objectives

Consolidate understanding of the cencepts of feedforward and cascade control systems via practice first on a simulated system, and then on a desktop thermal chamber.

2 Results - Graphs

2.1 Feedforward Controller

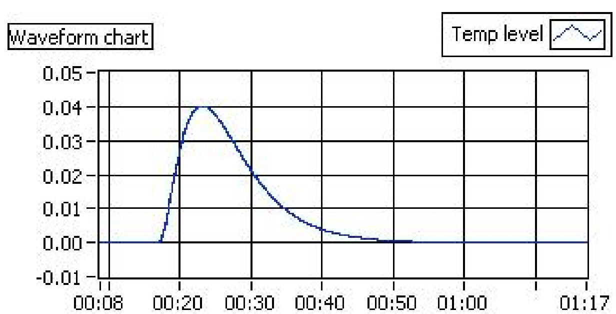

Figure 1: Output y of the system after the load was introduced

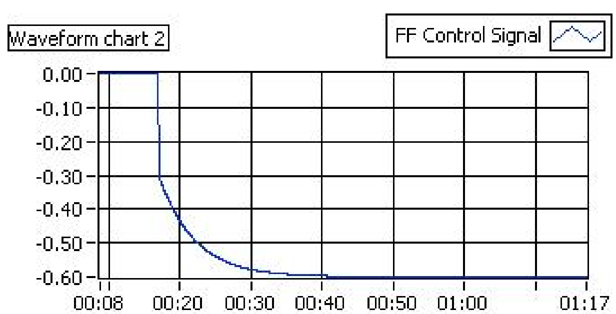

Figure 2: Control signal u of the system after the load was introduced

2.2 PI Control with Feedforward Controller

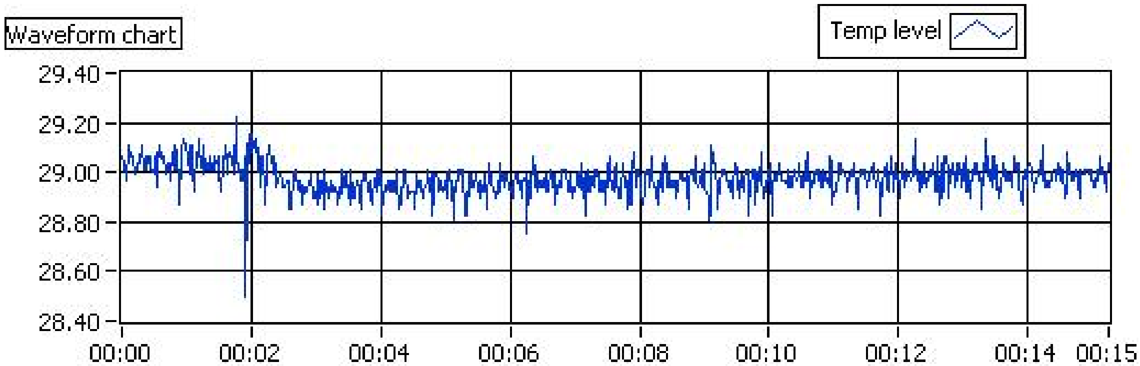

Figure 3: Output of the system using PI Controller

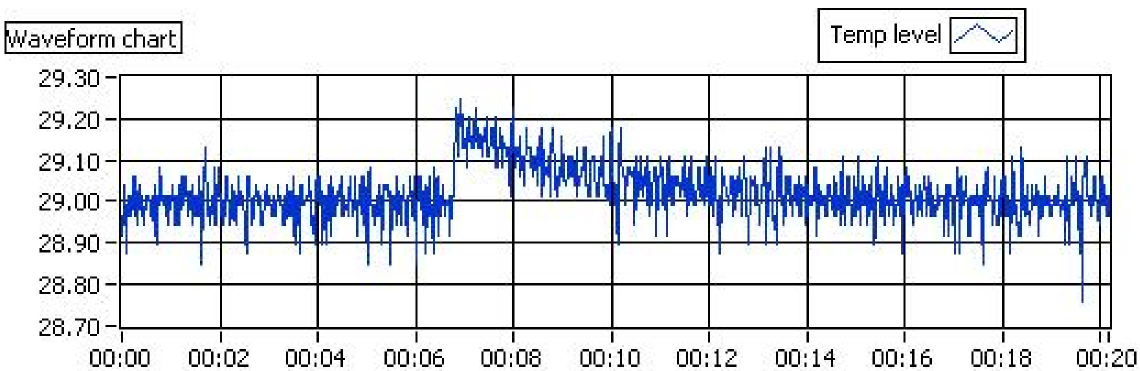

Figure 4: Output of the system using PI Control with Feedforward Controller Before Tuning

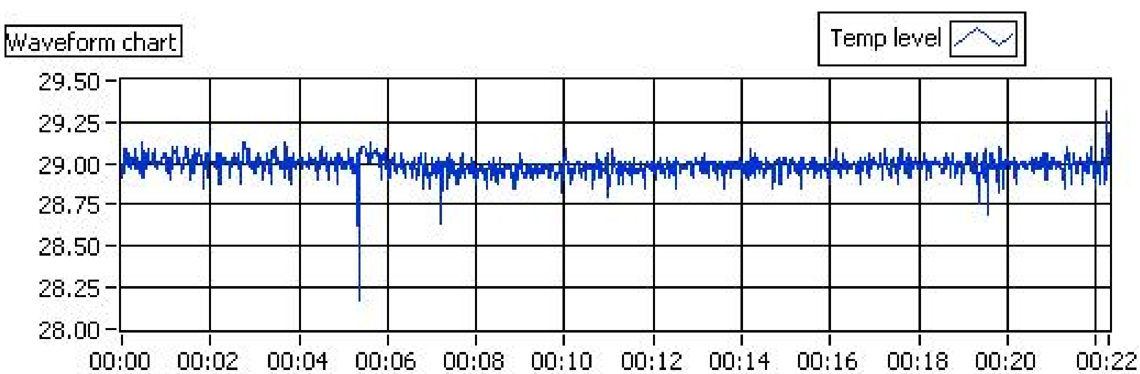

Figure 5: Output of the system using PI Control with Feedforward Controller After Tuning

3 Discussions

1. In majority of the industrial control system, overshoots are not preferable. By tuning the controllers to reach a quarter-decay, it ensures that the system's oscillation will attenuate fast enough to achieve a reasonable performance.

2. Based on the four cases above, cascaded control is most effective in eliminating load 2 disturbance, which is the load change in the inner loop of the cascaded control system. In theory, when the inner loop (secondary controller) works faster than the outer loop (primary controller), any disturbance arising in the inner loop can be adequately quenched by the secondary controller before it affects the outer loop. Hence a good cascaded control system will completely reject disturbance on inner loop of the control system. It is further proven in this simulation as we can observe that the steady state of secondary loop output, u, does not change after the injection of disturbance on inner loop.

3. From the observation, the response to the positive step is not symmetrical to the response to the negative step. The negative step shows a faster response than a positive step, in other words, it is slower to heat up the environment than to cool down the system in this experiment. This phenomenon is mainly cause by the room temperature during the experiment. When the system is being heated up, there are losses of heat to the environment which has a lower temperature. However, during the cooling down of the system, the transfer of heat to the environment contributed to a faster cooling down response. In order to make the response more symmetrical, one may set the lowest temperature to be lower than room temperature, and highest temperature to be higher than room temperature. By then, both heating and cooling process will undergo heat losses and heat gains during the process when the temperature goes from lower than ambient to higher than ambient and vice versa.

4. In real time, perfect disturbance rejection cannot be achieved, unlike what it is shown in simulation. It is due to a few reasons:

   (a) **External Disturbance** occurs during the experiment. We can not ensure that there are no other undesired disturbance acting on a real system. In this particular experiment, potential disturbance could be from the ambient temperature, the heat generated by students nearby, etc.

   (b) **Inaccuracy in Modelling** is one of the factors that causes undesired error in system's output. In a real application, ideal system model is hard to obtain due to the wear and tear of the machines.

5. We can observe the output when the portion of FF and FB control action is varied. It is observed that by having a higher FF portion, the output signal actually over corrected the error and hence the overshooting of the output in different direction of disturbance signal in the initial response. However, higher FB control action will result in a system response that is similar to normal single Feedback system, where the output signal will change due to the disturbance at the initial stage. However, in this experiment, it is shown that FF controller and FB controller can be optimised to have an almost ideal performance in terms of disturbance rejection. Since the FF controller of the experiment over corrected the signal too much, to have a large portion of the disturbance rejection being enforced by the FB controller actually improve the performance of the system.

4 Conclusions

1. Cascaded controller will work well to reject disturbances acting on inner loop (secondary controller) but it has no effect to reject disturbances acting on the outer loop (primary controller).

2. In real applications, any control system does not effectively reject disturbances as shown in simulations due to the external disturbances and the error in modelling the system.

3. Feedforward controller combine with feedback controller will improve the performance of the system compare to using either one of the controller alone. It can be fine tuned to get an almost ideally disturbance rejection system.