Simulink Onramp Project Thermostat

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Introduction

Engineering could be defined basically as the application of science and technology in solving human challenging problems. In nature, we experience weather seasons of winter, summer, fall, autumn and spring. Although, this varies with geographical location.

In seasons like this, it is important for the atmosphere to be conditioned to suit human habitation. For example, the environment could be extremely cold and this can be unfavorable for human habitation. The engineering of scientific and technological knowledge comes in here in the design and development of what is obtainable.

To develop a system in solving this problem, a control system is needed to condition and control the environment's temperature. This is what a thermostat does. As obtained from Wikipedia, a thermostat is a regulating device component which senses the temperature of a physical system and performs actions so that the system's temperature is maintained near a desired setpoint.

The thermostat could be regarded as a "closed loop" device as it seeks to reduce the error between the desired and measured temperatures of a physical system. The thermostat has a wide range of applications in various electronic devices which operate by heating and cooling mechanisms. Some devices that use thermostat include ovens, refrigerators, pressing iron, automobiles, HVAC systems, air conditioners, house heaters and so on. The thermostat works typically like a control system as it sends signals in the form of instructions to the appropriate electronic device or system based on set temperatures. The image in figure 1 shows a thermostat used for household heaters.

Figure 1: Thermostat

Project Description

In this project, I aimed at modeling a controller in Simulink having a set temperature and measuring the temperature of a house and sending a signal of that error. The controller is a representation of an equation which further represents the temperature dynamics of a house.

Here I modeled the discrete equations representing the proportional integral control. This simulink model contains a block representing the house, a set temperature and a controller which is the thermostat. In this project, the thermostat is the main area of concentration as I only modeled the thermostat as a control system.

The controller is modeled using a proportional integral method so as to obtain a more efficient temperature regulation. The controller now sends a signal when the measured temperature is within close range with the set temperature.

Methodology

The model was created based on the equation of a discrete PI controller with design variables K_p, K_i, and sample time T_s as shown in the equation below.

$$y[k] = y_p[k] + y_i[k] \tag{1}$$

$$y_p[k] = k_p e[k] \tag{2}$$

$$y_i[k] = k_i T_s e[k] + y_i[k-1] \tag{3}$$

The values of K_p, K_i, and sample time T_s are already defined in MATLAB workspace as 0.20, 0.05 and 0.15 respectively. The initial state of the model is shown below in figure 2.

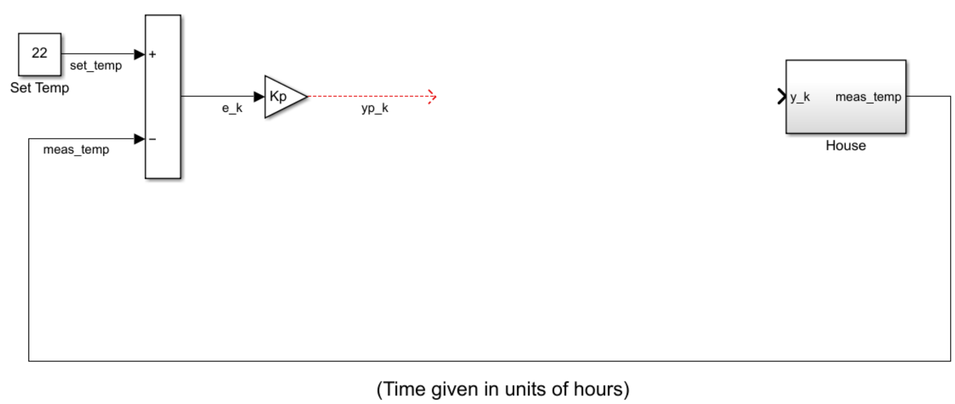

Figure 2: Initial Parameters

As shown in equation (3) above, the first step is to add a gain block to the model and set its value to K_i*T_s and connect e[k] to the gain block. This methodology achieves the first part of equation (3) as shown in figure 3 below.

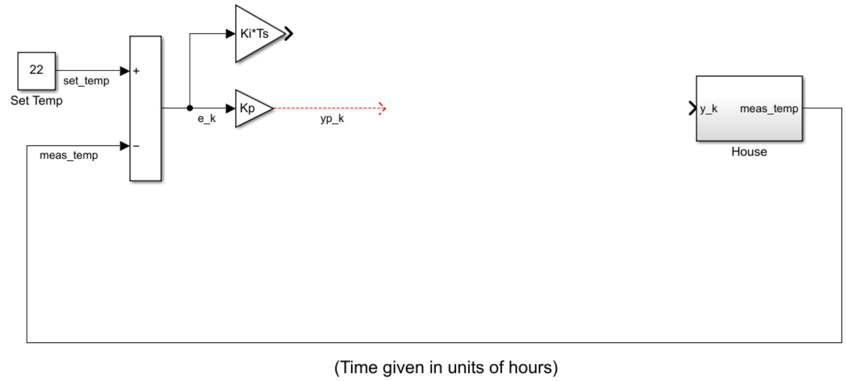

Figure 3: Gain added with predefined design variables

From equation (3) we can deduce that a single unit delay block is needed in the model to represent the integrator term $y_i[k-1]$. The reason for adding the unit delay block is to delay input by one iteration. Meaning, for every input, the system delivers an output. At this point, it is important to label the input and output parameters of the unit delay block. The unit delay block receives input $y_i[k]$ and outputs $y_i[k-1]$ as shown in figure 4 below.

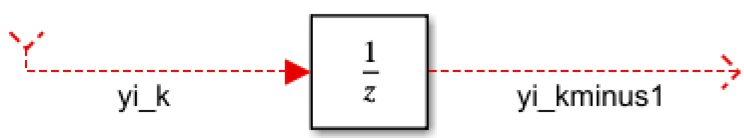

Figure 4: Unit delay block with labeled stubs

The model so far has defined equation 3. The figure 5 below gives a clearer representation.

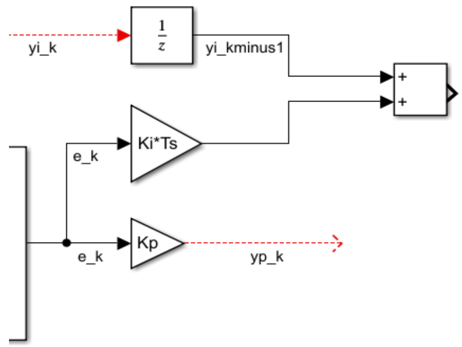

Figure 5: Adding the gain block and unit delay

Connecting $y_i[k]$ to the signal assessment block gives us the output of equation 3.

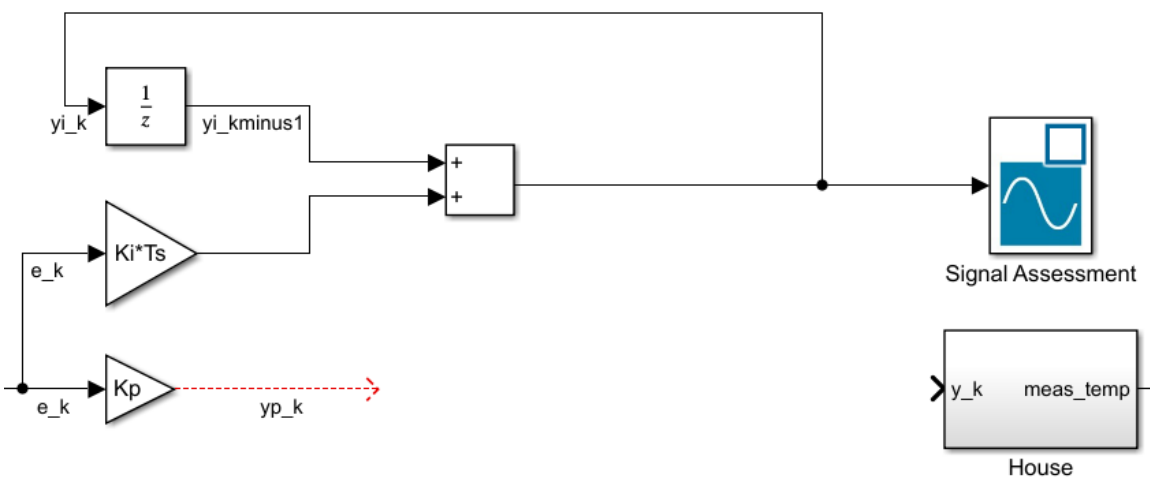

Figure 6: Proportional Term, $y_i[k]$

The graph below shows the result obtained from the model.

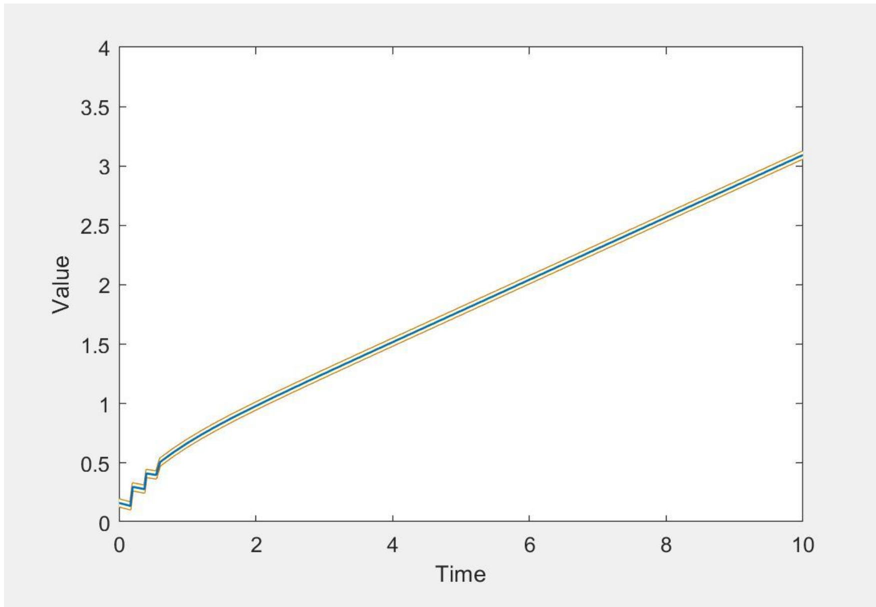

Figure 7: Proportional Term Result

To obtain the output of the controller y[k], we need to add the proportional and integral terms as shown in equation (1) above.

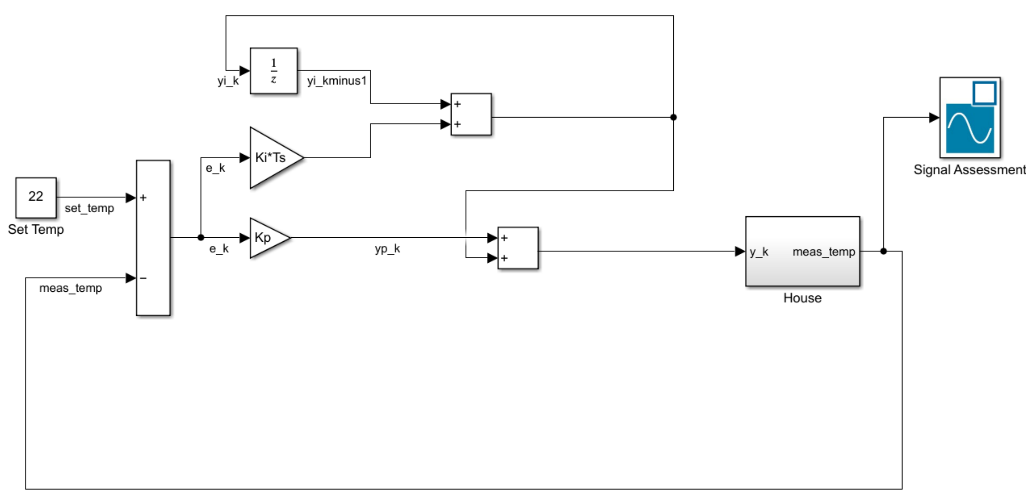

Figure 8: Controller Output Model

Result

The image below displays the output of the controller (thermostat). On the y-axis is the temperature reading against time on the x-axis. We can deduce from the result that the temperature is consistent and never quite reaches the set temperature. The heater receives a signal from the controller to regulate the temperature whenever the temperature of the room is approaching the set temperature.

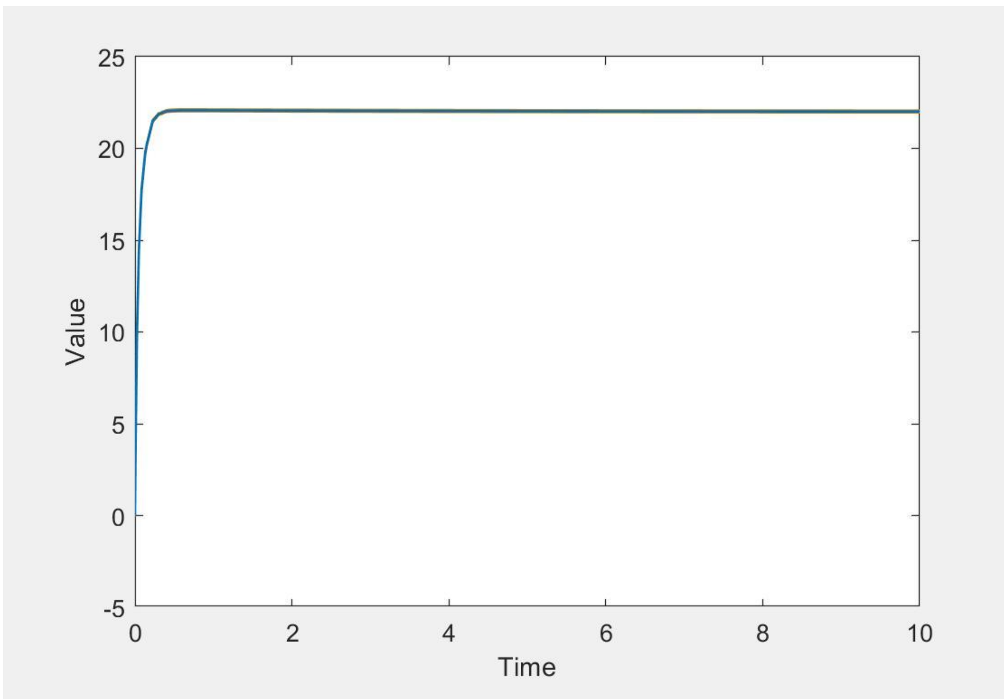

Figure 9: Controller Behavior

Conclusion

From this project, we understand that thermostats are very crucial devices for thermal management in any engineering system. With devices like this we can regulate the temperature distribution in any engineering system and prevent overheating.

This project has availed me the opportunity to learn about modeling controllers in simulink, the concepts of unit delay blocks, arithmetic and gain blocks. Furthermore, on how to predefined parameters in MATLAB workspace and re-use these parameters for modeling in Simulink.