System Dynamics (22.554 & 24.509)

Homework Assignment #7 -- Spring 2014

Introduction to Simulink

This HW considers the heated tank problem that we have been discussing during the class lectures. In particular, in the **heated_tank4** demo, we added a PI controller to the open loop plant model to automatically vary the heat source, Q, to maintain a nearly constant fluid temperature as determined by the setpoint temperature, Tset. In addition, in **heated_tank2** and **heated_tank3**, two different Simulink models of the open loop plant -- a linear model written in transfer function form and a nonlinear model contained within an S-function -- were developed and shown to give the same results as their Matlab counterparts.

Part A

Part A of this HW wants you to build Simulink linear and nonlinear closed loop models to do the same full system simulations as done in **heated_tank4** using the PI controller (with $k_p = 50$ kW/^{o}F and $k_i = 0.1$ kW/^{o}F-s). Note that only the final full system simulation from the **heated_tank4.m** file is to be reproduced here within Simulink with the same inputs, namely

Case a: 10% increase in inlet flow rate

Case b: 2 ^{o}F decrease in inlet temperature

Case c: 0.5 ^{o}F increase in the setpoint temperature

Also, as done in **heated_tank4**, be sure to plot h(t), T(t) and Q(t) (all deviation variables) for all three cases (see output plots from **heated_tank4.m**).

In setting up the linear closed loop Simulink model, you can start with the **heated_tank2_sl.mdl** file and add a PID controller block, as needed, to do the desired simulations. For the nonlinear model, you should start with **heated_tank3_sl2.mdl** and again add a PID controller to form the closed loop nonlinear model (note that the nonlinear model will use the **heated_tank3_sfunc.m** S-function file to formally model the nonlinear equations for this system -- you should not have to change this…).

In getting and displaying the results of your models, be sure to remember that the linear model works exclusively with the deviation variables, and that the nonlinear system model requires the actual states and inputs -- thus, you should be careful here. Also, for consistency and for ease of comparison, plot all the results for both the linear and nonlinear cases as ***changes from reference***.

Part B

The linear results from Part A should exactly match our results from the **heated_tank4** simulations and the nonlinear simulations should be quite similar (recall that we have already shown that the linear model gives a good representation of the nonlinear system). Now, within your validated Simulink models, add a ***saturation block*** to the model to limit the heat input to its practical range given by $0 \le Q \le Q_{max}$. Re-do the simulations from Part A -- are there any differences? Explain…

Now, run a second sequence of simulations where all the inputs are increased by a factor of two -- that is

Case a: 20% increase in inlet flow rate

Case b: 4 ^{o}F decrease in inlet temperature

Case c: 1.0 ^{o}F increase in the setpoint temperature

What about this sequence of simulations? Do these results make sense? Be sure that you can indeed explain the observations seen here…

Good luck – this exercise should re-enforce a lot of the material discussed in class over the last few weeks and it should give you good exposure to a few of the many excellent features of the Simulink package…

Documentation

Documentation for this assignment should include a picture of both the linear and nonlinear Simulink models, the output plots for each simulation, and a brief discussion of your results and comparisons -- and a clear discussion of how saturation affects these simulations. Note that there will be a lot of plots generated here -- linear vs. nonlinear and reference inputs vs. the inputs with increased magnitude -- so be sure to properly organize, combine, and label the plots for ease of discussion. Finally, you should also comment on the general Simulink capability demonstrated here. Is this something you find useful, etc. etc.

As usual, an overall professional job is expected!