Lab #1: Introduction to Digital Simulation in LabVIEW

Objective

The purpose of this lab is to become familiar with using the graphical programming language provided by LabVIEW (or other similar languages such as SIMULINK) for simulation and implementation of digital control systems. The main steps in this lab will be the following. First, you will simulate a linear model of the torsional disk system with only one disk and that is using a proportional controller. You will then include the effects of saturation and time delays in your model. Lastly, you will implement a proportional controller on your simulated system. Before doing any of this, you will need to be comfortable with the LabVIEW programming environment, so you may wish to look at the tutorial that will be available on http://moodle.cs.colorado.edu. You may alternatively wish to go to www.ni.com and look at one of their interactive tutorials. Lastly, a PDF of a user’s guide for LabVIEW should be on the lab computers at Start>>Programs>>National Instruments>>LabVIEW 8.2>>Search the LabVIEW Bookshelf.pdf.

0.1 Tasks

In this lab we will be considering a second-order mechanical system. For now, assume the system is linear and can be represented as a feedback loop (seen in Fig.??). Assume that $C(s) = K_p$ and $P(s) = \frac{K}{s^2 + 2\zeta\omega s + \omega^2}$. This will be the idealized plant for the torsional disk system with only one disk. For this lab, use the parameter values $K = 1$, $\zeta = 1.25$, and $\omega = 2$. 
0.1.1 Task #1–Step Response

Examine the response of the system to a step response of 10 for 30 seconds. (You may shorten this length of time if it will be helpful.) Find the maximum value of $K_p$ that results in 0% and 50% overshoot. Record how long it takes to get within 2% of the desired state (the 2% settling time) and how long it takes to get within the steady state error for both cases. Lastly, what are the units in this block diagram? Label each wire of the block diagram with its physical units. What does a step response of “10” mean physically?

For each case, turn in a plot that includes the output, the step input, and the controller input. (These can typically be copied directly from LabVIEW to MS Word. Plot control can be obtained by right clicking on the plot and choosing options.)

0.1.2 Task #2–Actuator Saturation

Although we model many systems as being linear, most are actually nonlinear. One of the most common nonlinearities that one can encounter is a saturation. All actuators have saturations because they cannot actually provide infinite force or torque. Use the LabVIEW saturation block to insert a saturation on the control in your simulation. Start with an step reference of size 1, and create a saturation of $-200$ to $200$ on the output of your control block, and then decrement it until you start to see the effects in your simulation.

Using the same gains determined in Task #1, record the 2% settling time and the steady state error for a step size of 1. Then do so again for a step size of 10. How does this change your results? Obtain the same plots as requested in Task #1.
0.1.3 Task #3–Time Delay

Time delays are another problem in many control systems. Insert a time delay in the feedback loop to represent processing time for the sensors. At what time delay do you start seeing what you would deem “significant” difficulties?

0.1.4 Task #4–”Best” $K_p$

What do you think is the “best” $K_p$ for this system if there are saturations and/or time delays? Defend your answer using the plots and data you have accumulated during the rest of the exercise.

0.1.5 Task #5–Dependence on $\omega$

What happens if you change $\omega$? In particular, what happens if you change it to 0 or to 10? How does this affect your performance/stability/etc?

0.2 Things You May Want To Know

All of the vi’s that you need to complete this lab are part of LabVIEW’s Simulation Module. Hopefully, the LabVIEW tutorial from class has been sufficient. However, a copy of the Simulation Module manual is available online at www.ni.com. Searching “Simulation Module” within this site will bring you to the pdf manual. Alternatively, you may wish to view Finn Haugen’s website at http://www.techteach.no/publications/labview/.

Remember, if you get stuck on some part of the lab, ask your classmates, the TA, or myself.