Chapter 1

Lab #6: Frequency Domain Compensator Design

Objective

The purpose of this lab is to expose you to frequency domain design techniques. In particular, you will use Bode plots and Nyquist plots to determine the stability and robustness of a design. Because you are now all largely familiar with LabVIEW, the description of this lab will be kept rather brief. However, keep in mind that this is nevertheless a reasonably long lab—don’t put off the work until the second week!

Note that this lab will be at least a two-week lab.

Warning:

As usual, please always run the ECP unit with someone holding the power button, in case something happens to go wrong.
CHAPTER 1. LAB #6: FREQUENCY DOMAIN COMPENSATOR DESIGN

1.1 Pre-Lab Tasks

Read this entire document before starting the lab. A significant part of this lab can be completed without hardware, so I recommend you complete as much of it as you can before coming to lab.

1.2 Tasks

1.2.1 Task #1–Lead Controller for Disk 1

Task: Design a Lead controller for Disk 1 as the output and plot its root locus and its Bode plot.
Task: What is the associated gain margin (GM) and phase margin (PM)?
Task: How could you change your Lead controller to improve your margins? Can you do so while simultaneously increasing your overall system gain?

1.2.2 Task #2–Controller Design for Disk 3

Task: What is difficult about using Disk 3 as the output instead of Disk 1? What happens in the root locus if you try and use a Lead compensator in this case?
Task: Plot the Bode plot for the open loop system with the third disk as the output. Is it stable? How much gain $K$ will destabilize it, if $K$ comes from a proportional feedback controller with unitary feedback?
Task: Plot the Nyquist plot for the open loop system. What does this tell you about the system stability?
Task: Print the Nyquist plot and Bode plot and draw the gain margin and the phase margin into both plots for a particular value of $K$ (a value close to what you used when you first stabilized this system with a proportional controller).
Task: Design a higher performance controller that allows you to push the overall system gain up higher while not destabilizing. You may find the notion of a notch filter to be useful here. (This is described in FPE, and the entire description there you may find useful.) Can you improve upon your PID controller performance? In particular, make sure that you maintain your gain and phase margin at the “reasonable level” you just determined. Test your design in simulation. What do you think are limits on the performance that this system can achieve?
Task: At this stage, the SISO tool in MATLAB (command: sisotool) will probably be very handy—you will probably want to take MathScript code and copy it to MATLAB. Use the SISO Tool in MATLAB to improve your controller design from the previous section. When moving poles and zeros around, only move the poles and zeros of your controller, not the plant itself!
1.2. TASKS

**Task:** What is the gain margin and phase margin for your final controller design?

**Task:** Test your design in experiment. If there are differences between the experiment and the simulation, explain them.

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