ECE411 Lab 5/Design Project

1. Objective

To have students complete a full control design including all phases:

- Modeling
- Analysis
- Controller Design
- Simulation
- Implementation
- Testing

Of course this process usually also involves iteration between the various stages.

Note:

Maximum team size is limited to 4.
This Lab counts for double points.

2. Methodology

The methodology used in this lab is:

- Select an ECP system.
- Perform analysis and identify system properties.
- Design a controller.
- Model the controller in Matlab®.
- Implement and test controller on the ECP station.
- Analyze the results.
- Write a report.

3. Select an ECP System

Servo Trainer (Gear with Encoder 2 Feedback) - Model 220 _____
Torsional Dynamic System - Model 205 _____

Note: Everyone should initially carry out this process for the Servo Trainer (220). You MUST select Encoder 2 Feedback, which will change the transfer function from that used in earlier labs.

For (optional) extra credit you can also try the Torsional System (205) which is significantly harder.

4. Perform Analysis and Identify System Properties

Typical methods of identifying plants are step responses and sine-sweeps, as well as measuring physical parameters (e.g., mass, velocity). You might want to start with a physics-based model (e.g., free body diagrams) and then model your initial findings in Matlab® and test your open loop model versus the real item. The model and real system won't match exactly but should be similar, say responses within 10% accuracy would be reasonable.

Note that your work on identifying the plant should appear as part of your report. Indeed for many problems in practice it can be a large part of the control system development effort.

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5. Design a Controller and Test in Simulation

You've learned about a number of control designs in class. Feel free to experiment with different approaches. You may want to use Root-Locus, Bode-plots, Nyquist etc., when designing your controller. Utilize the Matlab® model you have developed. Test your designs in simulation, and adjust as necessary until you're satisfied.

6. Implement Controller on the ECP Station and Test

Implement and test your controller design(s) on the ECP station. Consider running the same tests that you ran on your simulation model(s) in Matlab®. How do they compare? *In practice, problems are a lot more expensive to fix in the field*, so it is always important to test your control system adequately.

You may well find things did not go as expected, and you have to return to an earlier step in the process – potentially all the way back to step 4. This also happens in practice and it is important to resolve the differences between your design and your model, so that you have confidence in the final finished design.

7. Analyze Results

In fact you have already been doing this as part of the design process but now it is time to sum up all the data, run any additional desired tests/analysis, and make sure the system is performing as well as desired. You also should have an adequate explanation of all observed phenomena. For instance, maybe the steady state accuracy was not exactly as initially expected but there is an explanation due to nonlinear friction effects (and the design is still acceptable). Ideally, try to model these issues in Matlab® so that you have a rigorous explanation for them, and can predict their effects.

8. Writing the Report.

Your report should look professional.

This means it should be comprehensive, but concise. Engineering managers don't have that much time to read.

It should include support analysis on the models and design, such as:

- Calculations
- Models
- Plots:
  - Root Locus
  - Bode
  - Nyquist
  - Time Response

It should deliver the performance capabilities of your design in an easy-to-read fashion. Use tables to summarize results/data where appropriate. Items of interest could include:

- Appropriate Plots
- Gain Margins
- Phase Margins
- Bandwidth
- Frequency Sweeps
- Step Responses

Point out the advantages and drawbacks to your design. Include desired specifications (e.g., overshoot, settling time), and then what was actually achieved in analysis/simulation and also on the ECP system.