**EE 160: Introduction to Control Project**

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# Introduction

The EE160 Project is about the modeling, analysis, design and simulation of a control system of your choice . You should complete a final report (at least 4 pages) and a presentation on your own. The content should at least include theoretical analysis, modeling analysis, and the final demonstration section. In actual display, in addition to clarifying the content of the PowerPoint, it should also include video demonstrations of simulation results. The goal of this project is to practice how to analyze your system using root locus methods, Bode diagrams, and other methods, and design feedback controllers for practical applications. In addition, you will also learn from this project how to analyze the performance of closed-loop systems and demonstrate their effectiveness and stability.

# Main requirements on the final report

1. Clarify the control problem you choose and model the system in both Time and Frequency domain
2. Analyze the performance of the open-loop system.
3. Design a feedback controller and analyze the performance of the closed-loop system.
4. Analyze the stability of the system and show the performance with simulation. Verify the robustness,sensitivity,relative stablity and other performance of the system.

# Some specifications for the report

Write a short report (preferably in Latex) containing the following sections:

1. Title and Authors (find a good title + name of the author)
2. Introduction (describe the problem that you want to solve)
3. Problem Formulation (introduce a suitable mathematical notation to define the problem that you are trying to solve)
4. Open-loop performance analysis (use the method in class to describe the performance)
5. Controller Design and closed-loop performance analysis (explain how you design your controller and why the controller is able to achieve your control objective.)
6. Numerical Results and Experimental Results (plot/visualize and explain your results)
7. Conclusion (analyze and summarize the highlights of your results)

## Requirements on the final presentation

1. Your presentation will take approximately 15-20 minutes and should include the following content:physical demonstration,software simulation,theoretical analysis,and summary of thinking.
2. In terms of physical demonstration, you should be able to correctly connect the circuit and conduct simulation to ensure good response curve tracking performance.
3. In the theoretical analysis section, you should elaborate on the process of selecting the controlled object and determining parameters. Compare the experimental results with the simulation results and analyze the reasons for the differences.
4. At the end of the demonstration, you should present your own thoughts, such as comparing the similarities and differences between the pid controller and the lead lag corrector, and what impact the different model selection of the controlled object will have on the experiment. The direction of thinking is completely open.

Other requirements:

1. The length should be at least 4 single-column pages with 10pt font. Be brief.
2. No plagiarism or self-plagiarism. The student is never allowed to reuse his/her own published papers as the final project.

## Wind arm and wind tunnel ball experiment

goal:

1. The wind arm adjusts the speed through PID to suspend the arm at the target angle under the action of wind.
2. The wind tunnel ball adjusts the wind speed through PID to suspend the ball at the target position inside the acrylic cylinder.
3. Compared with the target curve, the tracking curve should have as little steady-state error as possible and a faster response speed, minimizing the number of oscillations as much as possible. Save your simulation results.

Note:

1. The angle signal of the wind arm is from the potentiometer, so no special processing is required. It can be output directly.
2. The feedback signal of the wind tunnel ball comes from ultrasonic ranging. The feedback circuit converts the duty cycle pulse signal of ultrasonic ranging into DC and adjusts the polarity of the signal. Added the required bias voltage. Convenient access to analog PID units for control.

The actual model is as follows,you should choose one of these:

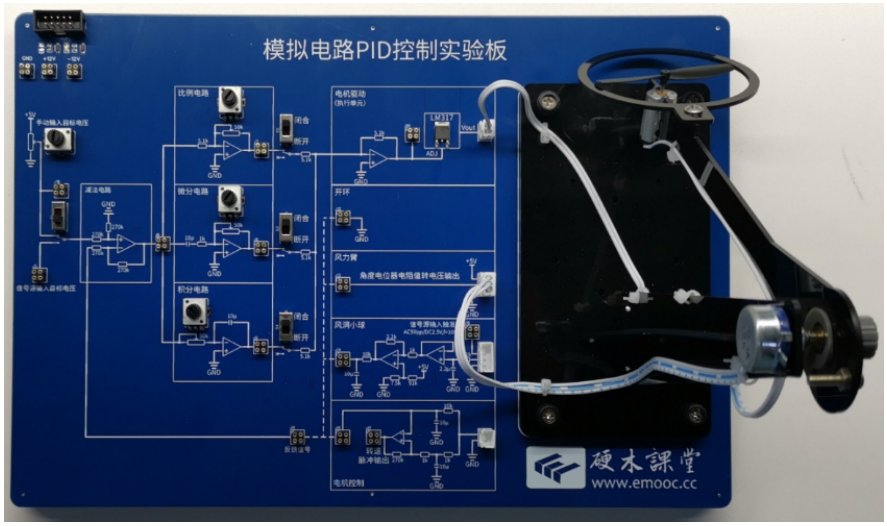


Figure 1: wind arm

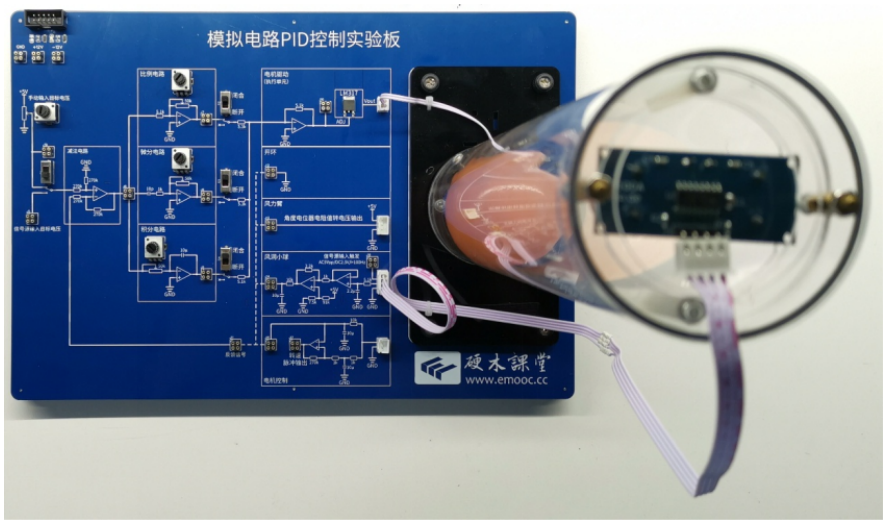


Figure 2: wind tunnel ball

## Requirements

1. Connect the circuit to form an open-loop system, given a series of step-input signal, observe the output of the system.

2. Based on the behavior of the system, determine an approximate first or second order transfer function to model the system. Identify the parameters of the open loop system. Connect the circuit as a closed-loop system and compare the behavior of the unit negative feedback system with real and simulated systems.

3. Using one of the techniques taught in the lecture (Root locus or Bode diagram) to design a PI/PD/PID controller for the system to achieve better performance. Specify at least three index to improve, for instance, steady state error, percentage overshoot, setting time and phase margin. Give the detailed design procedure, and verify your design in your simulink.

4. To bring the results simulated on simulink into the actual system, you need to calculate the resistance value corresponding to the actual circuit under the set coefficient. And compare the experimental results with the simulink results of different reference inputs. Identify differences and explain the reasons.

5. You need to think more about the similarities and differences between pid controllers and lead lag controller. You can design a lead lag controller to control your model, in order to achieve a control effect similar to that of a pid controller. You need to think about how your model was determined. Finally, summarize what you have learned from this project and propose improvement suggestions for the design program.