Experiment-02: Potentiometer Data Acquisition and Pendulum Calibration

ME-330

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Contents

1 Learning objective

This experiment provides students the opportunity to:

- Learn to use Matlab's data acquisition toolbox.
- Create a simple program for data acquisition using Matlab and National Instrument's myDAQ.
- Become familiar with breadboards, digital power supply, wiring, digital multi-meters, and develop applied laboratory skills.
- Calibrate a potentiometer-based angle measurement system and create a calibration plot.
- Plot the time evolution (angle vs. time data) for a swinging motion of the pendulum system.

2 Introduction

In this experiment, you will connect a simple angle sensor (angular potentiometer) to the NI myDAQ data acquisition device and collect digital data using the Matlab data acquisition toolbox. First, you will collect data to create a calibration equation, then use the information from the calibration to convert the output voltage from the angular potentiometer to the pendulum angle.

It is important that you read this entire document before the experiment. If you have questions about the procedure, instruction provided, or the code, please visit office hours to talk to me or the TAs before Thursday.

3 Part-A: Creating Experiment Code

Preparing data acquisition program using Matlab data acquisition toolbox
The appendix of this document provides a Matlab program to use in this experiment. The main program sets the parameters for data acquisition. The "event listeners" lh1 and lh2 repeatedly call helper functions logData() and plotAndLogData(), which are responsible for capturing data to file and displaying it as it is acquired on a plot during experiments.

4 Part-B: Building the Potentiometer Circuit

Connect an angular potentiometer to the NI My-DAQ using a breadboard.

- Connect the potentiometer leads labeled "Power and Ground" to the 5 Volt reference signal and the reference ground from the power supply (Figure 1).
- Connect the NI MyDAQ to the angular potentiometer leads labeled "Signal and Ground". The red wire should connect to AI0+ and the black wire to AI0- as shown (Figure 1).

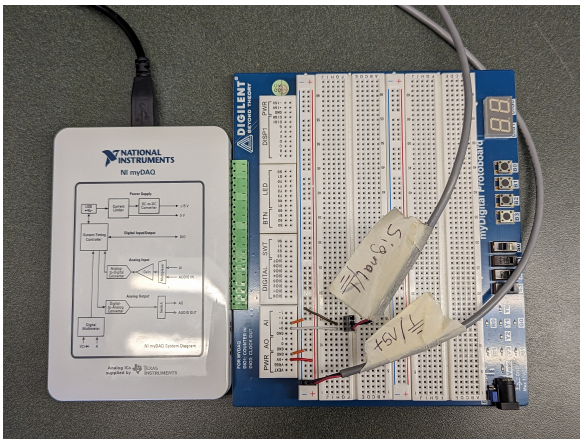

Figure 1: Connection to NI-DAQ system for experiment-2.

5 Part-C: Testing code and circuit

Run the acquisition program and test the circuit connections.

- Verify your circuit with the TAs
- Once your circuit is verified, run the tester acquisition program (see appendix **??**).
- Rotate the angular potentiometer and verify the results. The display should change with the movement of the pendulum.
- Keep in mind that DAQ system takes a while to initialize. There may be a slight delay before data acquisition starts.

6 Part-D: Perform Calibration

Create a calibration equation for the potentiometer to map output from volts to pendulum angle.

- Determine a repeatable method for measuring the pendulum's angular position using either the supplied protractor (or an application on your phone, e.g., bubble level).
- You will use the Matlab code in appendix **??** to perform the calibration.
- At each of 10 (or more) angles, ranging from ±90 degrees, collect the voltage at a sampling rate of 20 Hz for 5 seconds. Save each of these files with the following name Ang_(p/m)XXDeg.dat where xx represent angle and p/m represent plus or minus sign. For instance, the calibration file for -45^o will be saved as "Ang_m45Deg.dat" and the calibration file for $+60^o$ will be saved as "Ang_p60Deg.dat".
  - Make sure to document the pendulum angle for each recording **in degrees.**
  - **The zero degree angle is when the pendulum is straight down.**
- Create a table in log book similar to the table 1. You will use the values in the table for calibration.

- Plot the data collected calibration data using Matlab. The x-axis should be the recorded average voltages and the y-axis should be the angle in degrees. Be sure to properly annotate your plot. **Use the instruction from lab-01**
- Use Matlab's polyfit tool to determine a linear fit to the calibration data. This is your calibration equation. **Make sure to save your data in case you need to repeat any analysis**.
- Record the norm of the residuals from the linear regression provided by Matlab's polyfit function. Use this to calculate the standard error of the fit (s_{yx}).
- See the sample code in appendix to generate the calibration plot **??**.
- You need to modify 'x' and 'y' variables values in the code based on your calibration data.
- Make sure to save the calibration file with at least 600 dpi resolution.

Table 1: Sample calibration data for experiment 2.

Pendulum angle (degree)	Average output voltage (v)
-90°	1.21
-70°	1.43
-50°	1.65
-30°	2.00
-10°	2.31
0°	2.50
10°	2.55
30°	2.82
50°	3.20
70°	3.51
90°	3.74

7 Part-E: Acquire Pendulum Swing Data

Add the calibration equation to the acquisition program to display the pendulum angle in degrees during the data acquisition process.

- Update the slope and intercept values to reflect your calibration results in the provided Matlab program (Appendix **??**).
- Show your program and results to the TAs to verify your program.
- Change the acquisition time in the Matlab program to 15 seconds at a sampling rate of 200 Hz.
- You will need to save the data for this part. Change the output file name to "AngVs-Time.dat"
- Make sure your program is modified to acquire and store data to file.
- Run your Matlab program to store the time and angle data.

- Soon after you execute the program and acquisition initiates, release the pendulum from a horizontal position.
- If your program is implemented correctly, it should display the angle (in degrees from your calibration equation) vs. time.
- Confirm the file is stored correctly.
- Open the stored data file and determine the period, T_d, of the response oscillations and the corresponding frequency, ω_d.

8 Part-F: Lab space clean up

Return lab space to prior condition

- Remove all breadboard wires and place them back in the wire kit in an organized fashion.
- Remove the pendulum wires from the breadboard and set aside.
- Log off the computer.
- **Do this for every lab!**

9 General Instruction

- Make sure to name the files your FirstName_ LastName_ QuestionNumber, use the format provided in the sample Matlab code. Make sure the submitted figure is titled with your name. Include the apostrophe!
- Make sure to submit your post-lab assignment on the Canvas website.
- Here are some details to help.
  - Plot the experimental data using red circles with MarkerSize 8. Experimental data points should always be plotted using markers without lines connecting the points.
  - Plot curve from theory (or curve fit line) using a solid colored line with LineWidth 2.
  - Set the x and y-axis limits for each figure.
  - Make sure the major grid lines are visible.
  - All plot text should be in Times font. You will need to specify this for the title, labels, and legends. The axis labels and numbers should be in 10-point font.
  - The title should be in 10-point font.
  - Make sure to add the legend. Keep in mind that legend should not hide the plotted data.
  - For full credit, make sure that your submitted files look similar to the sample figures shown in the document.
  - If in doubt, make sure to request help from the TAs.

10 Post lab (50 points)

Postlabs are due Friday at 5 pm. For this experiment, submit the following items on Canvas for your post-laboratory assessment.

1. **Calibration plot**. Submit a calibration plot showing the raw data points as markers and the calibration curve as a line.
   - The plot should be 6.5" wide and 4.5" tall.
   - Properly annotate your plots: axis labels, titles, legend, etc. Make sure to include units.
   - Using the text command in Matlab, place the equations or numbers listed below on the plot. Use Greek symbols where appropriate. Make sure to include units.
     - The calibration equation on the plot with 4 decimals places for each number.
     - The norm of the residuals of your linear regression.
     - The standard error of the fit for your calibration equation.
2. **Pendulum Swing Plot.** Submit a time series plot showing the trajectory of your pendulum swinging from a horizontal starting position.
   - The plot should be 6.5" wide and 4.5" tall.
   - Make sure to properly annotate your plots: axis labels, titles, legend, etc.
   - Using the text command in Matlab, place the equations or numbers listed below on the plot. Use Greek symbols where appropriate.
     - The period of the oscillations, T_d.
     - The frequency of the oscillations, ω_d.
3. Answer all questions in the post-lab assessment on Canvas.