

## Hands-on Lab 3

### System Identification with Experimentally Acquired Data

Recall that the course objective is to control the angle, rise time and overshoot of a suspended motor-prop. Towards this, the two previous labs provided the software and hardware foundations for writing LabVIEW programs and both generating and acquiring voltage signals. This lab fulfills our next step – to identify the system's underlying dynamics. The resulting data will be used in future labs to design a suitable control system. Three concepts will be covered: Reading optical encoders with a counter, writing acquired data to a file that can be displayed in Excel, and programming a derivative function.

#### Concept 1: Timers and Counters (Optical Encoders)

The USB-6211 features counters that can be used to read optical encoders interfaced to the NI-DAQ card. A counter will be configured to monitor the optical encoder mounted on the pendulum's shaft (see Figures A and B). The net result is the pendulum's angle can be displayed in real-time.

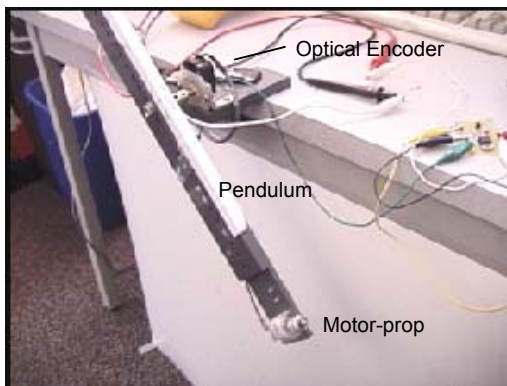


Figure A: Pendulum Setup

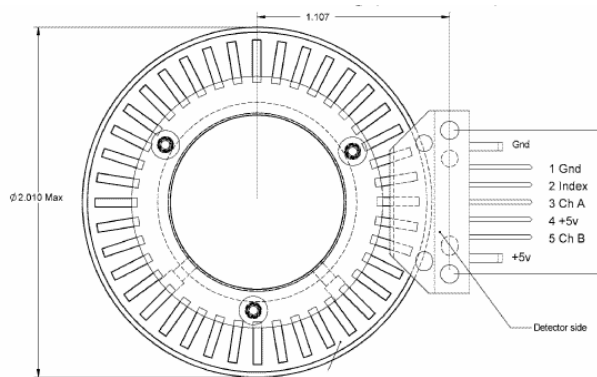


Figure B: US Digital Inc. Encoder (with pin out)

**Step 1:** Launch LabVIEW to create the following (very simple) front panel (Figure 1). **NB:** the text box should fit 8 digits

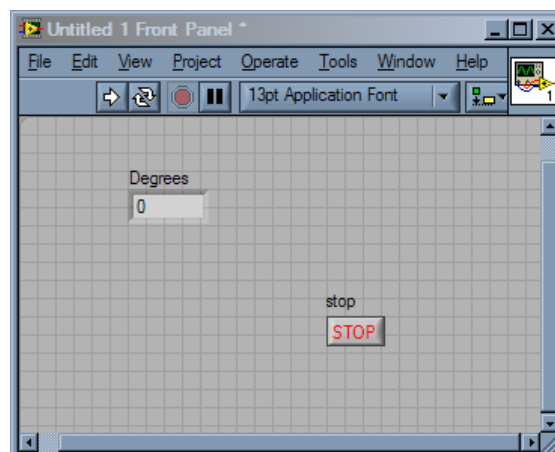
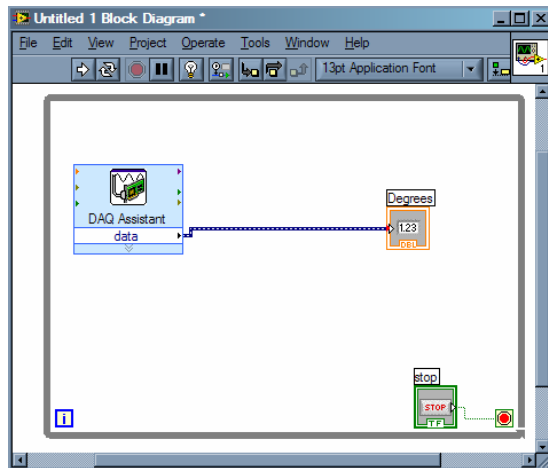


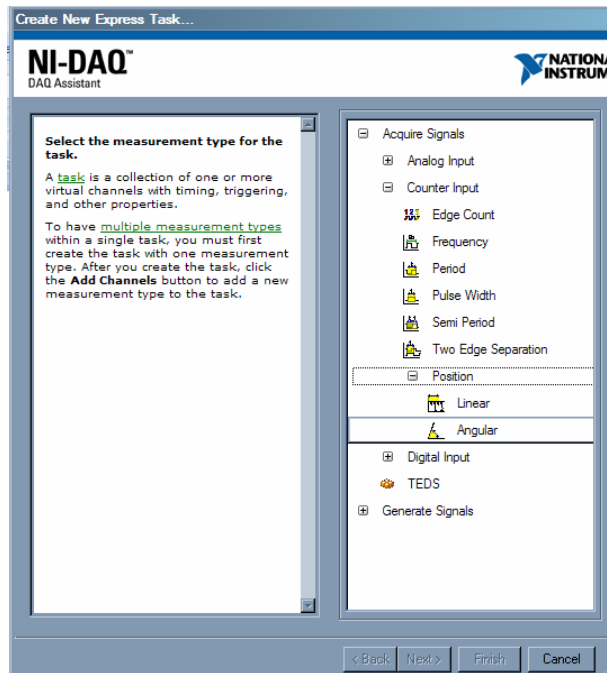
Figure 1: Front panel to display real-time optical encoder degrees

**Step 2:** Start the following block diagram with a while loop.



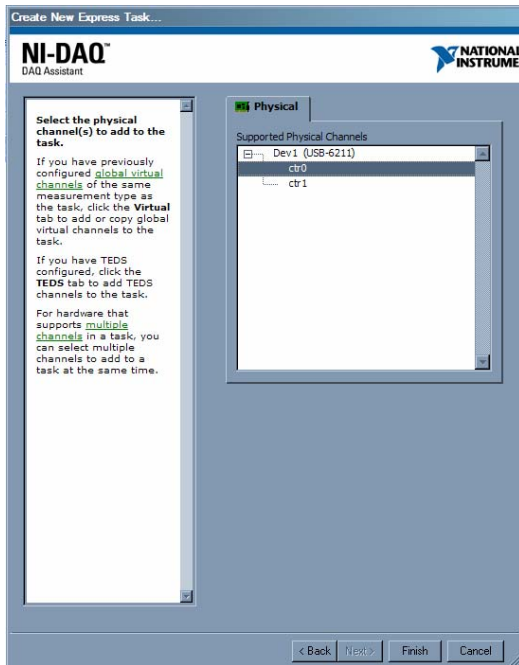
**Figure 2:** Block diagram for displaying encoder angle.

**Step 3:** Complete the block diagram by adding the DAQ Assistant control. Right Click – Measurement I/O – NI-DAQmx – DAQ Assist will bring up the screen (**Figure 3A**). Choose Acquire Signals and then select Counter Input – Position – Angular.

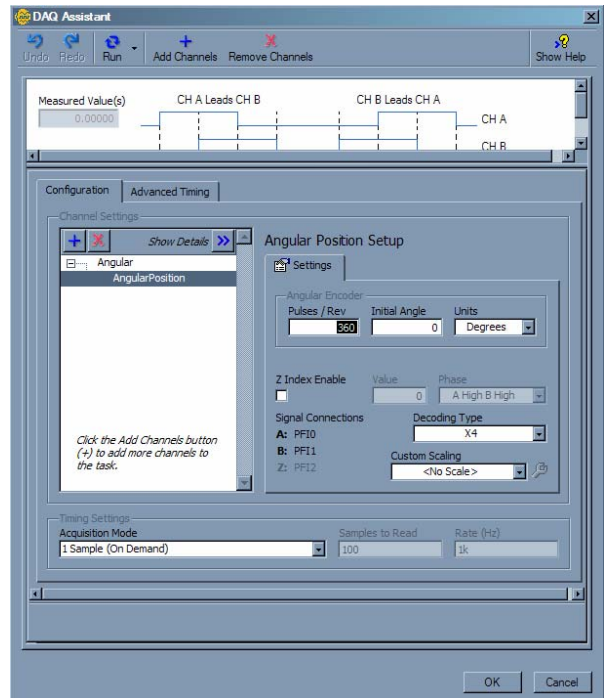


**Figure 3A:** Choose Position - Angular

Choose `ctr0` (counter 0) as shown in **Figure 3B**. This will invoke the screen shown in **Figure 3C**. Set the Angular Encoder - Pulses/Rev to 360 and Decoding Type to  $\times 4$ .



**Figure 3B:** Select Counter 0 (ctr0)



**Figure 3C:** Pulses / Rev is 360

**Step 4:** Wire up the optical encoder to the NI-DAQ screw terminals as follows

Encoder	Wire Color	Screw Terminal
DGND	BLACK	Pin 11
IND		NOT CONNECTED
CH. B	BROWN	Pin 1
5 V	RED	Pin 10
CH. A	WHITE	Pin 0

With the pendulum motionless, execute the VI and the numeric indicator should read 0. Slowly rotate the pendulum counter clockwise and degrees should increment (i.e. positive angle). Rotate clockwise and degrees should decrement. The angle becomes negative if rotated past 0. NB: This is a 360-counts/revolution encoder. As such, each count represents 1 degree.

**Exercise 1:** In LabVIEW create programs for the following:

- 2-4. Increase or decrease the counter when rotating clockwise or counter clockwise respectively
- 2-5. Let the pendulum's vertical position (i.e. resting angle or 6 o'clock position) represent 90-degrees. Increase and decrease the counter when rotating the pendulum clockwise and counter clockwise respectively. In other words, the indicator should read 0 at the 3 o'clock position and 180 at the 9 o'clock position.

**Concept 2:** Write angle data to file and identify parameters

Recall that a virtual data recorder was created in Lab 2 Concept 3. The VI recorded and wrote data acquired from analog channel 0.

**Step 1:** Create a VI to record the pendulum's angle data (0, +90 and -90 degrees at the 6, 3 and 9 o'clock positions respectively). Block diagrams given below. The DAQ Assistant should be the same as Concept 1.

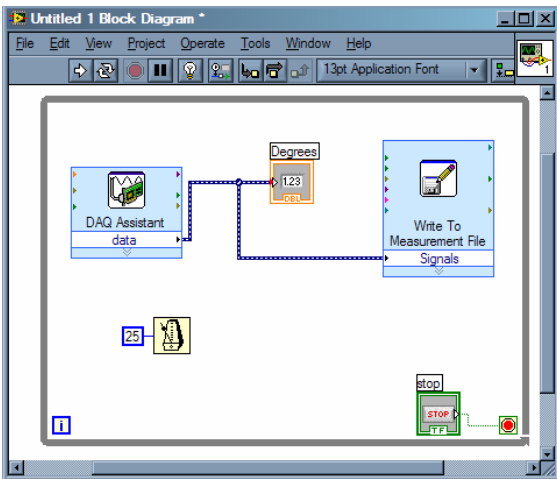


Figure 4A: Block diagram for recording angle data

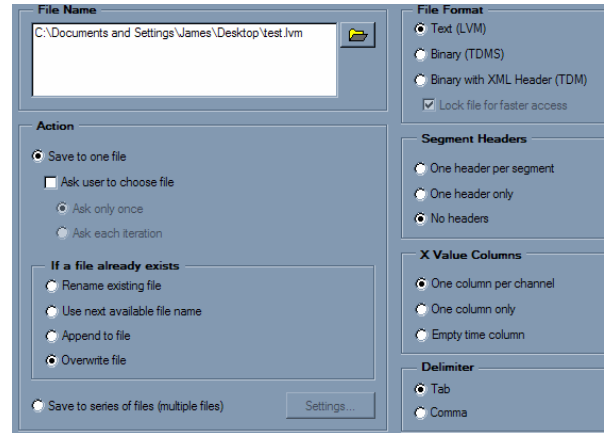


Figure 4B: Write to File Settings

**Step 2:** From the pendulum's rest position (6 o'clock) execute the VI. Rotate the pendulum counter clockwise to approximately +60-degrees and then release. Let the VI run for about 10 seconds and then terminate the VI. Plot the data in Excel, which should look like Figure 5.

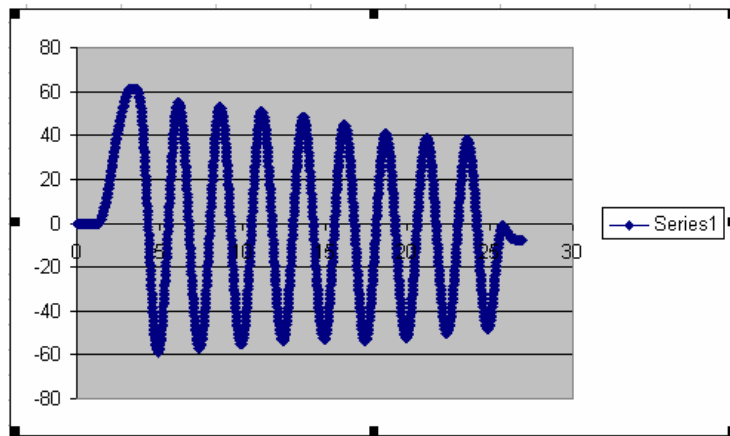


Figure 5: Excel plot of the acquired comma-delimited data

**Exercise 2:**

- 2-1. Save your recorded data (you will need this for your lab report)
- 2-2. From your data, calculate  $\xi$  and  $\omega_n$ .
- 2-3. Using your calculated  $\xi$  and  $\omega_n$ , solve for  $c$  and  $J$ . (Save the work and results)

**Concept 3:** Measure angular velocity by programming in a derivative function

In this concept we calculate the numerical derivative of the angle position to obtain the angular velocity.

**Step 1:** Create a VI to calculate and record the angular velocity of the pendulum. Block diagrams are given below. Your “DAQ Assistant” and “Write to Measurement Files” should be set up similarly to Concept 1 and 2.

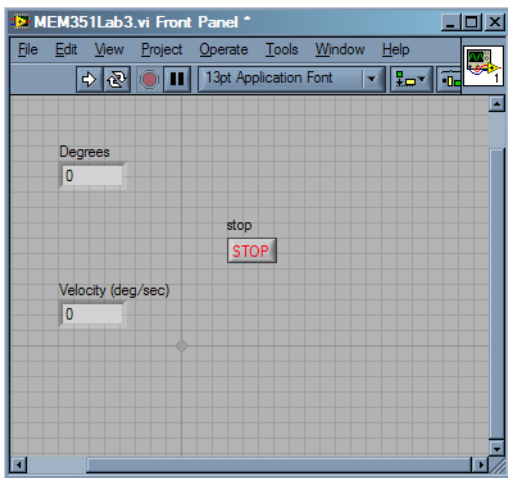


Figure 6A: Front Panel

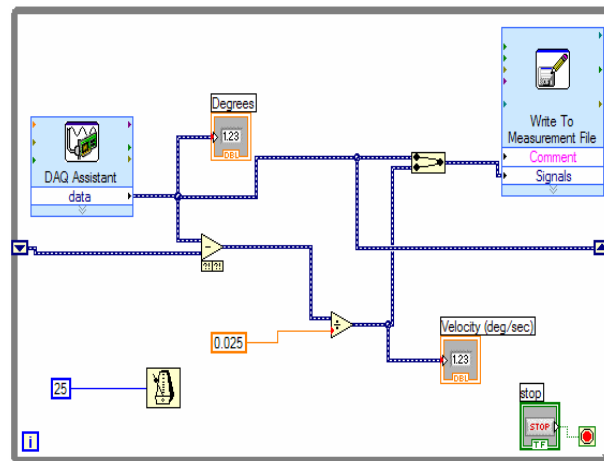


Figure 6B: Back Panel

**Step 2:** Run your program. Raise the pendulum to 60 degrees and release. Let the pendulum oscillate 5 to 10 times. Plot the recorded angle and velocity data. You should get a plot similar (not exact) to **Figure 7**.

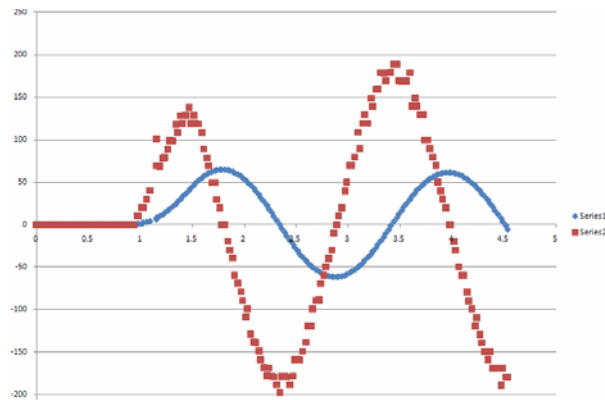


Figure 7: Excel plot of the acquired angle (blue) and velocity data (red)