ENCODERS

Goals: The goals of this laboratory are to implement a variety of angular measurement systems and investigate the behavior and limitations of several types of rotary encoders.

Learning Objectives: After completing this laboratory, you should be able to:
1. Explain the operating principles, advantages, and disadvantages of the rotary encoders examined.
2. Determine the critical issues for encoder choice and circuit implementation through laboratory investigation of several encoder applications.

Laboratory Preparation: In preparation for this laboratory, you should:

a) Attend the lecture session on encoders, read over this laboratory activity, and examine the data sheets provided on the course website for the encoders and IC. The optical encoder is a 1250 count per rotation encoder from Dynamics Research Corp. (DRC) that is supplied with 5V. (Red: +5V, Black: GND) The model number is M21AASODB03-1250.

PQ1: Using only a D Flip-Flop, design a circuit that can be used to output an UP/DOWN bit from the DRC encoder. (UP/DOWN = 1 for CW rotation and UP/DOWN = 0 for CCW rotation). Relevant parts of the encoder datasheet are available on the course website as Appendix A.

2. List two kinds of applications that would call for use of a rotary encoder. For each application, answer the following questions (PQ2-PQ4):
   PQ2: What kind of accuracy is necessary?
   PQ3: What encoder parameters might affect repeatability in measurements?
   PQ4: How does angular speed correspond to the encoder output?

Laboratory Tasks and Questions:

BNC-2120 Encoder:

In this section of the lab, you will examine the properties of the BNC-2120 encoder. This encoder can be found as a knob attached your lab bench's DAQ board.

1. Download the BNC 2120 VI from the course website. Connect the CLK port (PULSES on the newer DAQ boards) to port PFI8 on the DAQ board. Connect the UP/DOWN port to port DIO6 (PO6 on the newer DAQ boards). On the front panel of your VI, make sure DEV#/CTR0 is selected. Run the VI and view the output of the quadrature encoder knob on the front panel.

   Q1: What is the output of the encoder?
   Q2: How many pulses are there per encoder increment?
   Q3: What is the mapping between the UP/DOWN output of the encoder and the CW/CCW direction of rotation?

ENCODERS

Optical Encoder Investigation
In this section of the lab, you will examine the properties of the DRC optical encoder. This encoder has an attached metal arm that corresponds to the angle displayed on the provided VI's front panel.

2. Using the protoboard and datasheets provided, connect the DRC encoder to a +5V DC source. Verify with the TA that your circuit to collect the signal from the encoder is appropriate and use the oscilloscope to view its output.

   Q4: What is the phase relationship between the two output channels of the encoder? Sketch the waveform and include it with your lab report.

MINI-EXPERIMENT 1: Construct the D flip-flop circuit designed in the prelab activities and replace the inputs to the BNC-2120 counter used in part 1 (CLK: PF13, DIR: DIO7) with the CLK and DIR outputs from your circuit.

*****Make sure to connect your protoboard circuit's ground to the DAQ board ground!*****

Modify the example VI to use the proper count per revolution for the DRC encoder. While running your VI, move the arm of the encoder slowly off the bench and back down. Note the initial and final outputs of the encoder. Experiment with parameters such as rotation speed, direction of rotation, and number of sequential rotations.

Mini-Experiment Purpose
Mini-Experiment Equipment and Setup
Mini-Experiment Hypotheses
Mini-Experiment Results
Mini-Experiment Conclusions

To help lead your Mini-Experiment write-up, consider the following questions…

- Explain how a D flip-flop and the encoder outputs can be used to generate a direction bit.
- Does the encoder maintain its positional accuracy for each of the three variations above? If not, provide possible explanations for the encoder's behavior.

ENCODERS

Servo Potentiometer Investigation

In this section of the lab, you will examine the properties of the servo potentiometer. This device can be found attached to your lab bench and is often used to determine rotational velocity of the bench's attached DC motor.

3. Connect the bench's digital multimeter to the middle and upper banana jacks of the potentiometer. Change the multimeter to read resistance.

   Q5: What is the maximum resistance across the connected terminals?
   Q6: What is the minimum resistance across the connected terminals?
   Q7: Does the resistor have any "dead" zones? If so, how does this affect the type of applications for which this encoder can be used?

4. Construct a voltage divider circuit with the servo potentiometer and resistors provided in lab. Construct a LabVIEW VI that measures the voltage across the potentiometer.
   a) Add an analog input or reconfigure an previously-used channel in LabVIEW using the following settings:
      - Units: V
      - Range: 0V to 5V
      - No Scaling
      - Referenced Single Ended
   b) Show the input waveform captured from your circuit. Implement a rotary gauge on your VI's front panel that shows the measured angle in degrees. Include offset value and degrees per volt conversion factors as modifiable control inputs on your VI's front panel.

5. Print the VI block diagram and front panel capturing the ramping of the voltage as you move the potentiometer as well as the "dead zone" readings in the waveform window. Scale Y and X axes for readability.

   Q8: Do you observe any variation in the output of the potentiometer when it is held stationary (not rotating)? Will this affect its usefulness in certain applications? Explain.

6. Return all materials and sensors to their storage positions.

ENCODERS

Student Post-Lab Questions and Conclusions

1. Explain the operation of the BNC-2120's quadrature encoder.
2. Explain the operation of the DRC encoder.
3. Explain the operation of the servo potentiometer.
4. List one application where a servo potentiometer would be preferred over an optical encoder. Consider issues such as cost, reliability, accuracy, mechanical wear, etc. in your analysis of the specific application.
5. How does the speed of your data acquisition hardware affect the use of each of these encoders?
6. Which encoder is prone to the most capture speed related errors? Why?
7. What are two important lessons that you learned from this lab that deal with the selection and implementation of encoders?

Plots, Figures, and Tables:

- Prelab circuit schematic (PQ1)

- Waveform sketch (Q4)

- Potentiometer Voltage Divider Circuit (Part 4)
- Potentiometer VI Front Panel (Part 4)
- Potentiometer VI Block Diagram (Part 4)