ELE427 - Lab 1

Potentiometers and Optical Encoders

Goal:

To examine the operation and performance of two techniques for measuring angular displacement.

Introduction:

Details on the operation of the optical encoder and the potentiometer are given in the lab lecture. In the laboratory setup the optical encoder is physically connected to a DC motor and tachometer, and is electronically connected to a digital counter. In part I of the lab you will consider only this portion of the equipment, verifying the optical encoder's operating characteristics. In part II of the lab the potentiometer will be connected to the optical encoder and the known characteristics of the encoder will be employed to study the operation of the potentiometer.

Part I: Optical Encoder

The optical encoder is connected to a digital counter. Turn on the counter circuitry's power supply and select single decoding. Manually rotate the encoder's shaft noting the change in count. For an encoder with 1,000 slits, the counter should change by 1000 for every cycle. Notice also that the count increases or decreases depending upon the direction of rotation.

- Looking at the motor with the shaft toward you, does a clockwise rotation increase or decrease the count?
- Can you turn the shaft so that the count only changes by ±1?

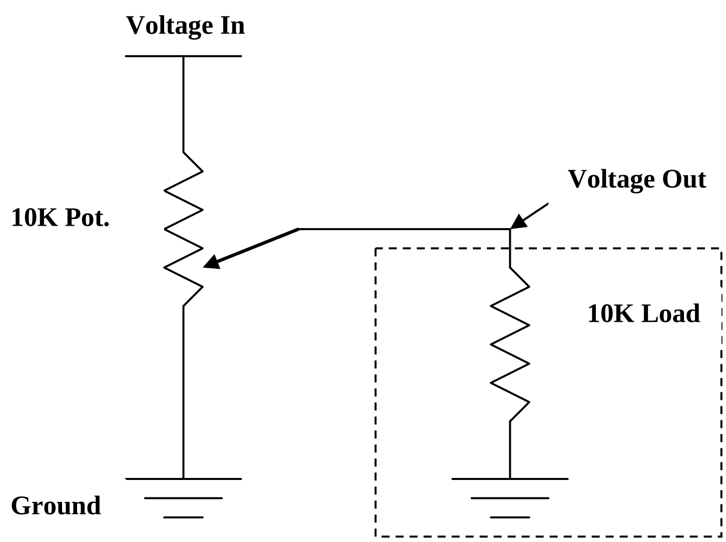
For the next section of this experiment connect an oscilloscope to the two outputs of the optical encoder (one to Channel 1, the other to Channel 2). Also, connect a voltmeter to the tachometer output. The idea is to apply power to the DC motor to run the tachometer-motor-optical encoder at a constant speed and observe the outputs. Be sure that you are applying power to the motor not the tachometer. The motor has much thicker leads.

- If the potentiometer is connected to your motor, disconnect it. **Running the potentiometer at motor speeds will damage the wiper.**
- Connect the motor power supply to the DC motor and apply current until the shaft rotates at a slow speed. Observe the tachometer output. A tachometer produces a voltage (volts) that is proportional to motor velocity (Krpm), $v = K_T \omega$, where K_T is called the tachometer constant with units of Krpm/volt. The tachometer constant is usually printed on the nameplate of the motor. For the motors used in the lab, a number is printed, but it is not accurate. Thus, as part of the experiment, you will determine the value of K_T from experimental data, using the output of the optical encoder to measure speed (see the following bulleted item). Set the direction of rotation so that the tachometer voltage is positive.

- With the motor running at a constant speed, observe the optical encoder outputs on the oscilloscope. The output should be a periodic rectangular waveform. From the screen, measure the period. Knowing that there should be 1000 pulses per revolution, compute the motor speed. Measure the corresponding tachometer voltage to a tenth of a volt. Use data at five different speeds to compute the tachometer constant.
- Notice that one of the encoder waveforms leads/lags the other. This should indicate the direction of rotation. Reverse the direction of the motor's rotation to demonstrate this.
- Finally, notice the effect of rotation direction on the digital counter.

Part II: Potentiometer Operation

As described in the lab lecture the potentiometer is a three terminal device; two ends and one wiper (slider). Between the two ends the resistance is nominally 10K. Since this varies from potentiometer to potentiometer we will set up a voltage divider, as shown below, and take the ratio of voltage output versus voltage supplied.



Disconnect the power from the motor. Running the motor with the potentiometer attached will damage the wiper contact. Connect the potentiometer shaft to the optical encoder shaft using the apparatus supplied. As you rotate the connected shafts, the optical encoder will supply precise data for the angle while the voltage divider output will supply potentiometer data. Notice that if you turn the shaft more than one rotation the optical encoder counter remembers the number of total turns while the potentiometer output repeats. Hence, if the total turn (greater than 2π radians) is desired, the potentiometer output by itself does not supply enough information. Often, however, we are only concerned about the angle within $(0; 2\pi)$ and the potentiometer is an inexpensive sensor for this information.

- Chose an input voltage for the voltage divider. The power rating of the potentiometer is 1 Watt. Select an input voltage so that P_{diss} is significantly less than 1 watt. Measure this voltage and record it. This must be held constant throughout the experiment.

- Turn the potentiometer shaft until you read a small output voltage, and then turn a little more until the voltage reaches zero. Initialize the optical encoder with a count of zero. Take 10 readings increasing the encoder count over the angles from zero to 2π. That is, measure the potentiometer voltage (to the nearest millivolt) at encoder readings of 0, 100, 200, …, 900. Take the same 10 readings as the angle is decreased from 2π back to zero. Repeat this cycle three times so that you can calculate linearity, repeatability, and hysteresis.
- Consider the voltage outputs where the wiper jumps from one end of the resistor to the other. Is this region linear? How will this affect the possible uses of this device?
- Calculate the repeatability and hysteresis of your potentiometer. Using the linear regression method calculate the linearity
- Choose a range of angles for which the potentiometer is almost perfectly linear. Comment on your choice.
- If you turn the shaft by a very small angle the optical encoder counter will not change but the voltage divider output will. What is the resolution of the voltmeter-voltage divider-potentiometer combination. How could this resolution be improved?
- Add a 10K resistor between the wiper (output voltage) and ground. This simulates a load on the sensor. Take another three cycles of data using the same method. Calculate the percent linearity (worst case) for this set of data. How does it differ from the unloaded case? At what angle does the largest non-linearity occur? Why?
- If you were using this potentiometer in a real application that required the output voltage to drive a 10K load, how could you correct the non-linearity?

Lab Writeup

Be sure to follow the guidelines distributed in class for your lab report. We expect these reports to be the sort of professional document that you would present to your employer in the workplace. Describe your experiment with enough detail that it could be repeated using only your lab report as a guide. Be specific about the devices that you tested (make, model, serial number) and how you set up the equipment (connections, input voltage, etc.) Include answers to all the questions.

Part I: Show your work on computing the tachometer constant using the optical encoder. Sketch the oscilloscope waveforms. Comment on the resolution of the optical encoder.

Part II: Include the original data and a plot of voltage versus angle for your potentiometer. Compute the percent linearity, repeatability, and hysteresis. Comment on your choice of a linear range. Comment on the potentiometer resolution.

Last update:
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