ELECTROMECHANICAL ANALYSIS LAB
EMET 3424_70
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8:00 – 9:50AM, SET 363

LAB#4

ANGULAR DISPLACEMENT MEASURMENTS

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LAB OBJECTIVE

The objective of this laboratory experiment is to gain experience and practice working with electrical devices. We will see how we can find rotational measurements. We will use both a shaft encoder and a rotational potentiometer. In doing so, we will understand both devices and their limitation.

The equipment used in this lab is listed but limited to this list.

- Shaft Encoder
- Rotational potentiometer
- Vernier Dial
- Hewlett Packard 34401A Multimeter, S/N 3146A29090
- Multiple Outlet Strip, Sockets Plus, Perma Power, Serial: 265-8533 (Mov Surge Protected)

ANGULAR DISPLACEMENT MEASURMENTS

THEORY

Just about every maniacal system has some sort of rotating part(s). Many of these systems rely on the rotation distances that a shaft has traveled. There are many fancy calculations to find the rotational distances traveled, but these are based on a few constants, radius, velocity, and/or acceleration. When in lab, shop, test centers, or on the runway, we may not have all the information need so we have to have a way of finding the rotation distances. For both the shaft encoder and the rotational potentiometer, we have a shaft, free to rotate. The sensors could be used for a verity of application. An example would be used to find the movement of a cutter of a CNC machine. The shaft encoder, though a pre-assembled circuit encodes the data, then outputs it to a panel of LED's in the form of a binary number.

FIGURE 1: BLOCK DIAGRAM FOR SHAFT ENCODER

The rotational potentiometer converts the change in rotation in to a change in resistance, and then outputs that resistance in the form of volts on a digital multimeter.

FIGURE 2: BLOCK DIAGRAM FOR ROTATIONAL POTENTIOMETER

To find the scale factor for each sensor we use the slope equation. This equitation is a rise over run or calibrated result over raw data.

FIGURE 3: SLOPE EQUATION

$$\mathrm{ScaleFactor} := \frac{\mathrm{CalibratedResult}}{\mathrm{RawData}}$$

Using a general equation, scale factor times raw data we can derive the equations to find calibrated result for each sensor.

FIGURE 4: CALIBRATED RESULT EQUATION

$$\mathrm{SCalibratedResult} := \mathrm{ScaleFactor} \cdot \mathrm{RawData}$$

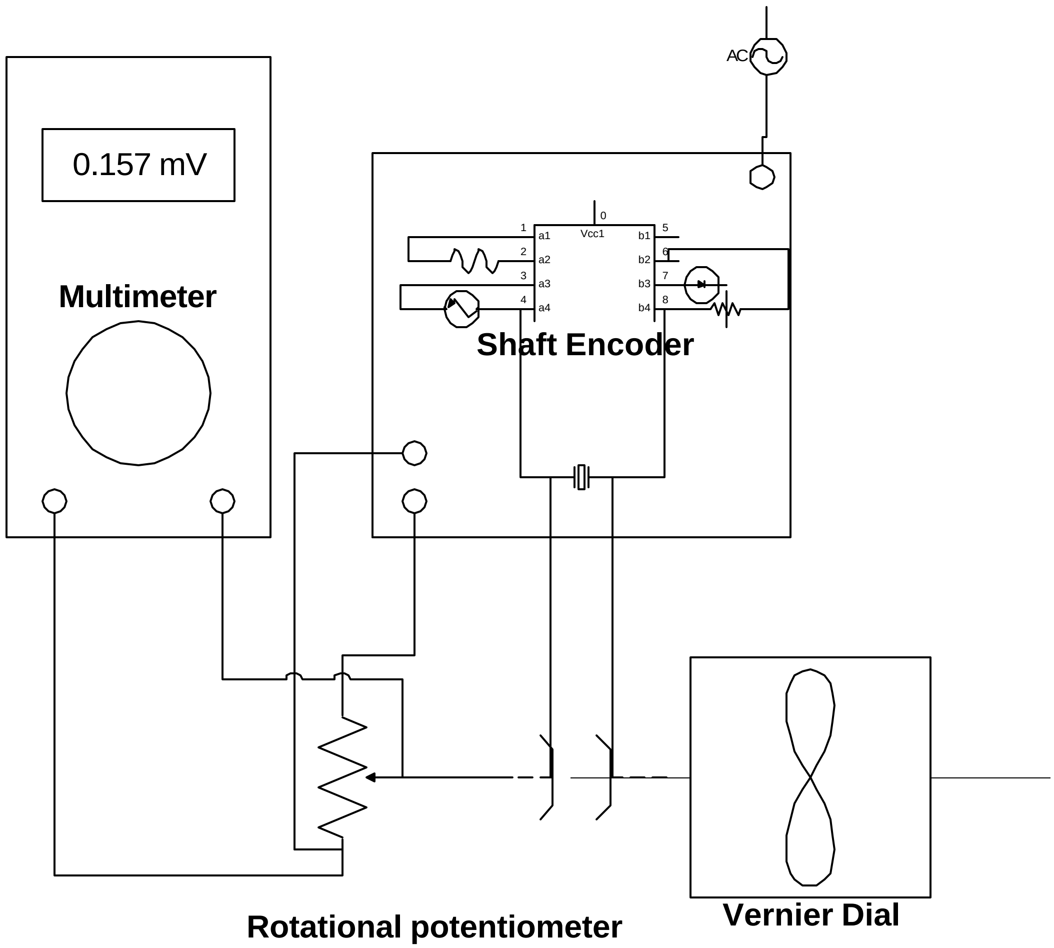
We find the percent error by finding the difference of calibrated result and true value divided by full-scale value.

FIGURE 5: PERCENT ERROR EQUATION

$$\%Error := \frac{CalibratedResult - TrueValue}{FullScaleValue} \cdot 100$$

SCHEMATIC

FIGURE 6: MECHANICAL SETUP



PROCEDURE / DATA COLLECTION

The vernier dial is set such that the output voltage is at or as close to zero volts. We then note the angular offset and rest the binary bits. We then calculate the scale factor each sensor as seen below. We then take reads of ever 10 degrees. All data is entered in to our table and analyzed.

CALCULATIONS

Rotational Potentiometer

$$CalibratedResult := 20$$

$$RawData := 2.96$$

$$ScaleFactor := \frac{CalibratedResult}{RawData}$$

$$ScaleFactor = 6.757$$

$$CalibratedResult2 := ScaleFactor \cdot RawData$$

$$CalibratedResult2 = 20$$

$$TrueValue := 20$$

$$FullScaleValue := 200$$

$$\%Error := \frac{CalibratedResult - TrueValue}{FullScaleValue} \cdot 100$$

$$\%Error = 0$$

Shaft Encoder

$$CalibratedResult := 200$$

$$RawData := 157$$

$$ScaleFactor := \frac{CalibratedResult}{RawData}$$

$$ScaleFactor = 1.274$$

$$CalibratedResult2 := ScaleFactor \cdot RawData$$

$$CalibratedResult2 = 200$$

$$TrueValue := 200$$

$$FullScaleValue := 200$$

$$\%Error := \frac{CalibratedResult - TrueValue}{FullScaleValue} \cdot 100$$

$$\%Error = 0$$

RESULTS SUMMARY

TABLE 1: ANGULAR DISPLACEMENT MEASURMENTS

True Value Angle (deg)	Original Raw Data			Calibrated Results		Percent Error	
	R_D Pot (Volts)	R_D Encoder (Binary)	R_D Encoder (Decimal)	C_R Pot (Deg)	C_R Encoder (Deg)	Pot	Encoder
0	0.001	0000000000	0	0.03	0.00	0.02%	0.00%
10	0.065	0000001111	15	4.21	10.51	2.90%	0.25%
20	0.190	0000011100	28	12.35	19.62	3.82%	0.19%
30	0.344	0000101010	42	22.40	29.43	3.80%	0.29%
40	0.482	0000111000	56	31.39	39.24	4.30%	0.38%
50	0.627	0001000111	71	40.83	49.75	4.58%	0.13%
60	0.781	0001010101	85	50.86	59.56	4.57%	0.22%
70	0.932	0001100011	99	60.70	69.36	4.65%	0.32%
80	1.077	0001110001	113	70.14	79.17	4.93%	0.41%
90	1.237	0001111111	127	80.56	88.98	4.72%	0.51%
100	1.388	0010001110	142	90.40	99.49	4.80%	0.25%
110	1.547	0010011101	157	100.75	110.00	4.62%	0.00%
120	1.703	0010101011	171	110.91	119.81	4.54%	0.09%
130	1.860	0010111001	185	121.14	129.62	4.43%	0.19%
140	2.011	0011000111	199	130.97	139.43	4.51%	0.29%
150	2.163	0011010101	213	140.87	149.24	4.56%	0.38%
160	2.333	0011100011	227	151.94	159.05	4.03%	0.48%
170	2.482	0011110011	243	161.65	170.26	4.18%	0.13%
180	2.642	0100000000	256	172.07	179.37	3.97%	0.32%
190	2.804	0100001111	271	182.62	189.88	3.69%	0.06%
200	2.960	0100011101	285	192.78	199.69	3.61%	0.16%

FIGURE 7: ANGULAR DISPLACEMENT MEASURMENTS GRAPH

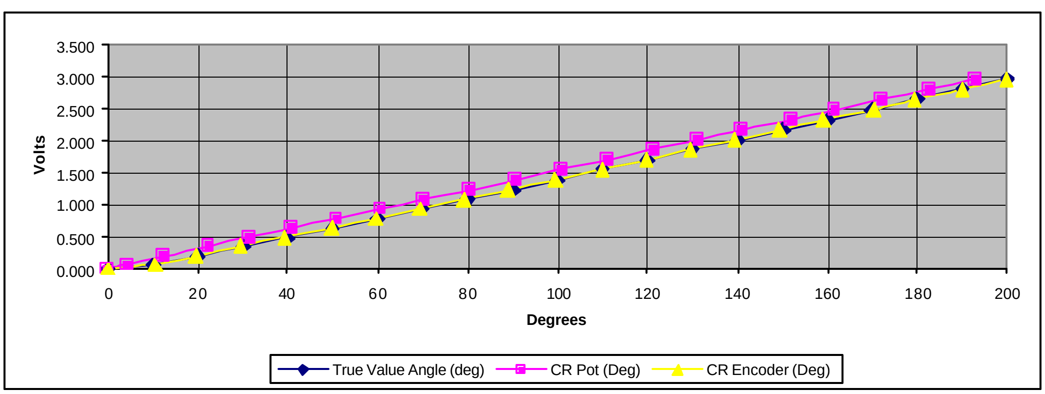
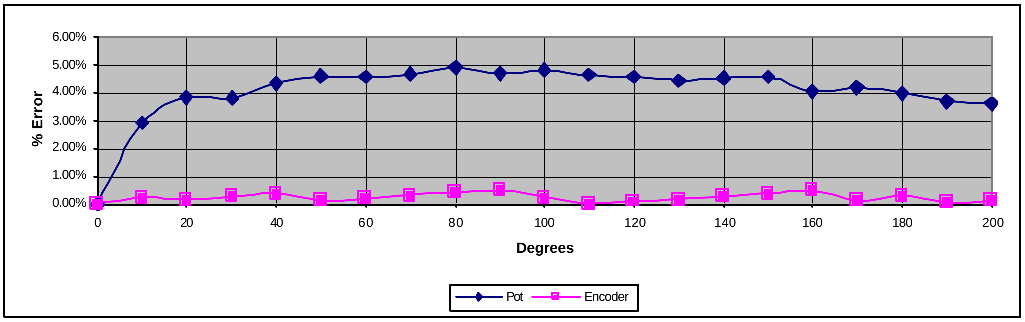


FIGURE 8: % ERROR GRAPH



DISCUSSION

We can visual see that the shaft encoder has a much greater sensitivity then the rotational potentiometer. The slightest change in the vernier dial will change the output of our encoder. We can as see from our percent error graph; the shaft encoder is more accurate then the rotational potentiometer. The rotational potentiometer has a percent error 5% where the shaft encoder's percent error is less the 1% error. The advantages of the shaft encoder are that is it very accurate and sensitive. Although it disadvantage is that it contain complicated circuitry and may not always be available. It also has an output that must be converted to interpret. The advantage of the rotational potentiometer is that it very potable and has an output that can directly be interpreted. Although its disadvantage is that, its accuracy and sensitivity are less superior to the shaft encoder.