EXPERIMENT 1: CIRCUITS

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LAB PERFORMED ON 1/17/2019

LAB SECTION: THURSDAY 2PM

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Worksheet

1. Oscilloscope
   (a) The measured amplitude of the scope's calibration signal was A = 5.00V.
   (b) Measured by eye, the risetime of the calibration signal was about 880 ns. Using the risetime measure function on the scope gave a risetime of 740 ns.
   (c) The uncertainty in the $\approx 0\ V$ signal was $\pm$8.00 mV. (Estimated by zooming in on the noise)
2. Potentiometer and myDAQ
   (a) Using Figure 1.1a in the 4BL lab manual, I can derive an expression for V_{out} in terms of V_{in}, R_1, and R_2. Since the circuit is in series,
   $$V_{in} = IR_1 + IR_2 = I(R_1 + R_2) \tag{1}$$
   And
   $$V_{out} = IR_2 \tag{2}$$
   Solving Equation 1 for I produces
   $$I = \frac{V_{in}}{R_1 + R_2} \tag{3}$$
   And plugging Equation 3 into Equation 2 produces
   $$V_{out} = \frac{V_{in} \cdot R_2}{R_1 + R_2} \tag{4}$$
   (b) The measured Voltage applied across the potentiometer was about 5.00V
   (c) The potentiometer's Output Voltage is an apparent linear function of the turning angle θ. Output Voltage increases at a constant rate as the turning angle θ increases.
   (d) The potentiometer follows Ohm's Law; therefore, it is Ohmic. Since the potentiometer's output voltage always increases linearly, it must follow Ohm's Law.
3. Magnetic Levitator
   (a) The equilibrium position of the bolt assembly *without* the magnetic coil on was about 1.30 $\pm$ 0.05 cm below the magnetic coil. The equilibrium position of the bolt assembly *with* the magnetic coil on was about 1.85 $\pm$ 0.05 cm below the magnetic coil.
   (b) The equilibrium before the magnetic coil is turned on is unstable; once the bolt is let go, it is immediately brought upwards to the magnet. The equilibrium while the magnetic coil is on is stable; once the bolt is let go at its equilibrium position, it levitates and its position is stabilized (it does not drop to the table nor is it brought upwards to the magnet.
   (c) The iPhone 7 and iPhone 8 cameras are not sensitive to the IR light, but the Samsung Galaxy S4 camera is sensitive to IR light.

Presentation Report

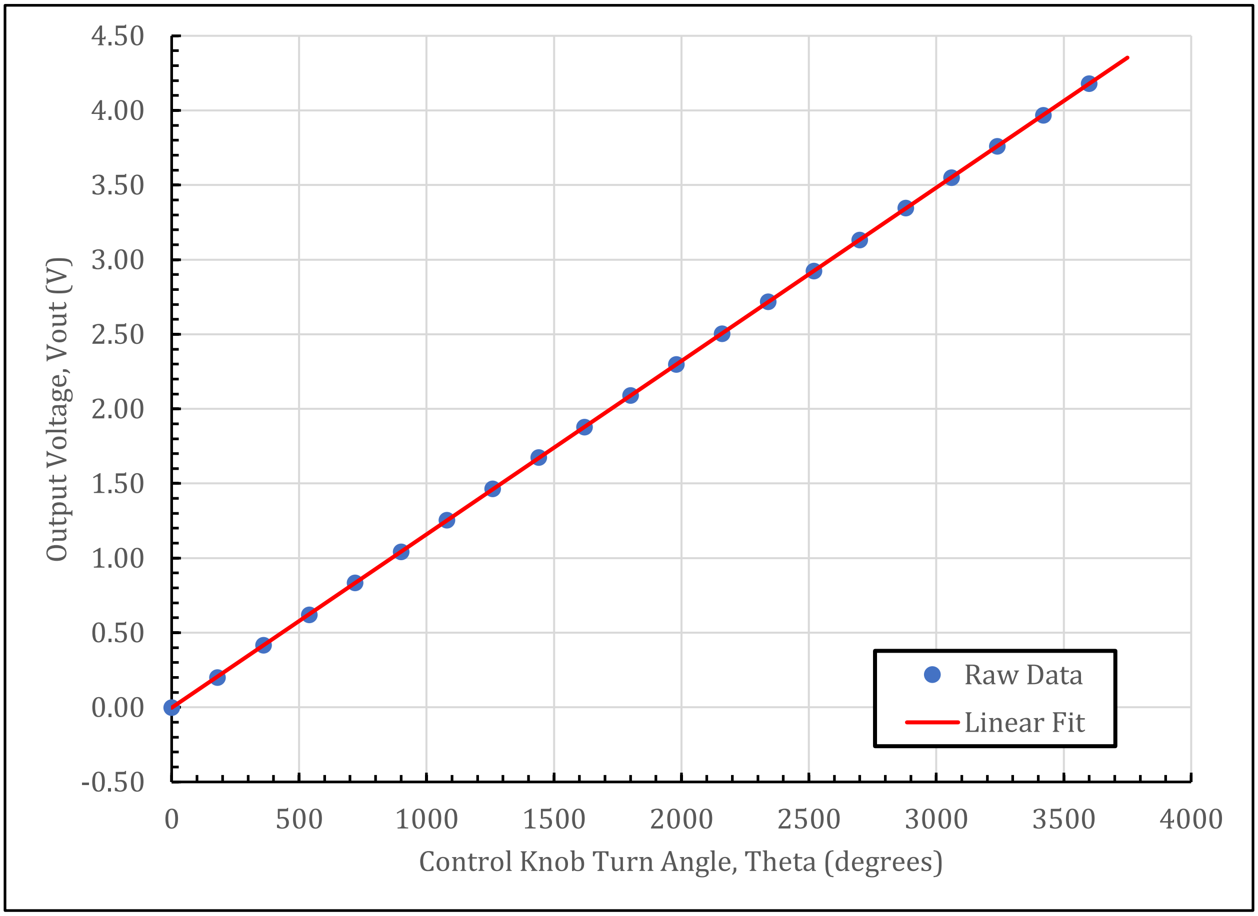

Figure 1: Potentiometer Output Voltage's Linear Dependence on Knob Angle θ. A potentiometer was delivered about 5.00V (Input Voltage V_{in}) and connected to MyDAQ to record its Output Voltage V_{out}. Beginning with the Control Knob Turn Angle $\theta = 0°$ on the Potentiometer, Output Voltage was recorded after every rotation of the knob by 180° until the knob reached its maximum angle. The blue points are the raw data Output Voltages and the red line is the linear fit to the data. The linear fit's equation takes the form $V_{out} = m\theta + b$ where $m = 0.0011617 \pm 0.0000006$ V/degrees and $b = -0.003 \pm 0.001$ V.

The intercept of the best fit line, $b = -0.003 \pm 0.001\ V$ has an important characteristic. When $\theta = 0°$, The Output Voltage should be 0V, because the knob angle is directly related to the Resistance of the Potentiometer. Because the uncertainty in b (δb) is not greater than the absolute value of b, the intercept of this best-fit line is *not* consistent with zero. This may be due to error in the equipment or in the data acquisition. As for the slope of the best-fit line m, this value provides an accurate value for the Output Voltage increase for every 1 degree increase in the control knob angle.

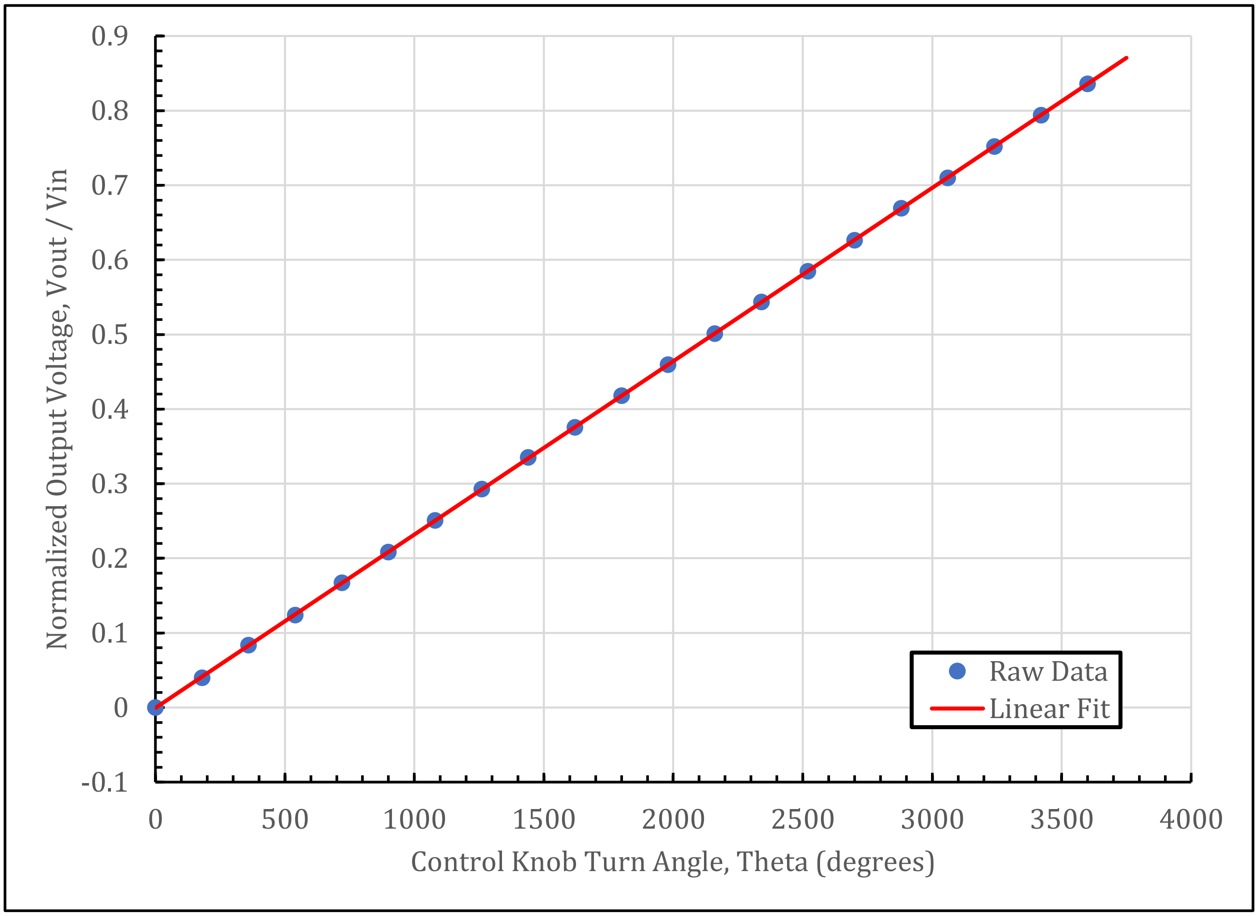

Figure 2: Potentiometer Normalized Output Voltage's Linear Dependence on Knob Angle θ. The input Voltage was recorded as $V_{in} = 5.00V$, and the Output Voltages are the same values collected from the previous procedure. The blue points on this figure are the raw data for the *Normalized* Output Voltages (V_{out}/V_{in}) measured every 180 degrees and the red line is the linear fit to the data. This line takes the form $V_{out}/V_{in} = m\theta + b$ where $m = 0.0002323 \pm 0.0000001$ 1/degrees and $b = -0.0005 \pm 0.0002$.

The Residuals of the data presented in Figure 2 were calculated by subtracting the predicted Normalized Output Voltages from the actual values for these voltages for each turn angle measured. The magnitudes of the minimum and maximum residuals respectively are $r_{min} = 0.0000870$ V and $r_{max} = 0.00144$ V. From these residuals, the Minimum and Maximum Percent Deviation from the fit line can be calculated using:

$$\%Deviation = \frac{r_{min/max}}{V_{in}} * 100\%$$

This equation yields a maximum deviation of $\pm 0.029\%$ and a minimum deviation of $\pm 0.0018\%$. The manufacturing company is said to claim a maximum tolerable independent linearity of $\pm 0.25\%$, which is much higher than the maximum deviation calculated. Therefore, I can say that the potentiometer that I used was very accurate and produced an extremely linear relationship between the Knob Turn angle and Normalized Output Voltage, hence verifying Ohm's Law.