

Homework #10

LabVIEW

Dr. Pogo

Assignment is due on Monday, December 18, 2023

Assigned November 30, 2023

Assignment #10: Data acquisition and analysis with circuits (Homework-only track)

Hardware: DAQ, one or two 12V+ Power Supplies, various electronics components.
3D printed plastic holding components

The intention is to characterize the properties of a DC gear motor (in this case, a Lego 43362 motor). The independent parameters are the voltage V applied to the motor, and the load τ (torque) being moved by the motor. To operate a motor, a voltage is supplied to it. Then the angular speed ω of the motor depends on this voltage and on the load (i.e., the torque, τ). If the load is higher, the speed is lower. It is possible for a load to be so high that the motor doesn't turn at all. Similarly, the current i provided to the motor depends on the torque. The expected dependencies are:

$$i = a_1 \cdot \tau \qquad \omega = a_2 \cdot \tau + b_2 \cdot V$$

To characterize the motor, we need to determine a_1 , a_2 , and b_2 . This is done by experimentation. The program you are creating will control and manage the experiments needed to compute these quantities.

For each experiment, the motor will be used to raise a small weight. The motor axle is held horizontally in a plastic holding block. A plastic disc with a diameter of about 3 inches is attached to the axle. A thin string is attached to the edge of this disc, and small weights are attached to this string, with the weights hanging over the edge of the table. The weights can be US nickels, which have a mass of 5.000 g each. Hold them in a very small bag or sling, perhaps attached to the string by a fragment of a small paper clip. For each run, weights should range from 0 to about 100 g. Note that the string provided already has an attached washer with a mass of 0.3 grams!

The user types in the total hanging mass, and specifies a voltage to apply (an **integer** from 3V to 8V). When the start button is pressed, the motor attempts to lift the weight. As the motor turns, small holes in the disc will pass between an LED and a photodiode. You will use a digital input on the DAQ to monitor the photodiode, and record the time(s) when each hole permits light to be seen by the photodiode. At first, the mass will be accelerating, so you must wait until the angular velocity reaches a steady speed. Your program will monitor these time(s), and actively decide whether the disc has reached a steady speed (perhaps based on the "recent" standard deviation of the acquired Δt values). Similarly, data should be rejected if V_M is too different from $V_{\text{requested}}$. Once it's reached, the program stops applying voltage to the motor, and records the final speed. The mass may never be permitted to crash into the disc! So, the program should continuously auto-compute the height of the mass using the total length of the string and the number of holes that have been detected. The cancel button can also be used to turn the voltage off early. Each time that an experiment is successfully concluded, the program should add a data point to a single, ever-growing csv file. The file should include enough data so that all analysis can be performed by a researcher without any other information. So, you should include the actual disc radius, the actual shunt resistance, and columns for mass, torque, requested voltage, actual resulting voltage, computed current, final speed, input power ($i \cdot V$), output power ($\omega \tau$), and efficiency ($P_{\text{out}}/P_{\text{in}}$). Also, each time an experiment is successfully concluded, new dots should be added to the xy plot for both the current and the angular velocity. There must be a legend for the 7 required series on the plot.

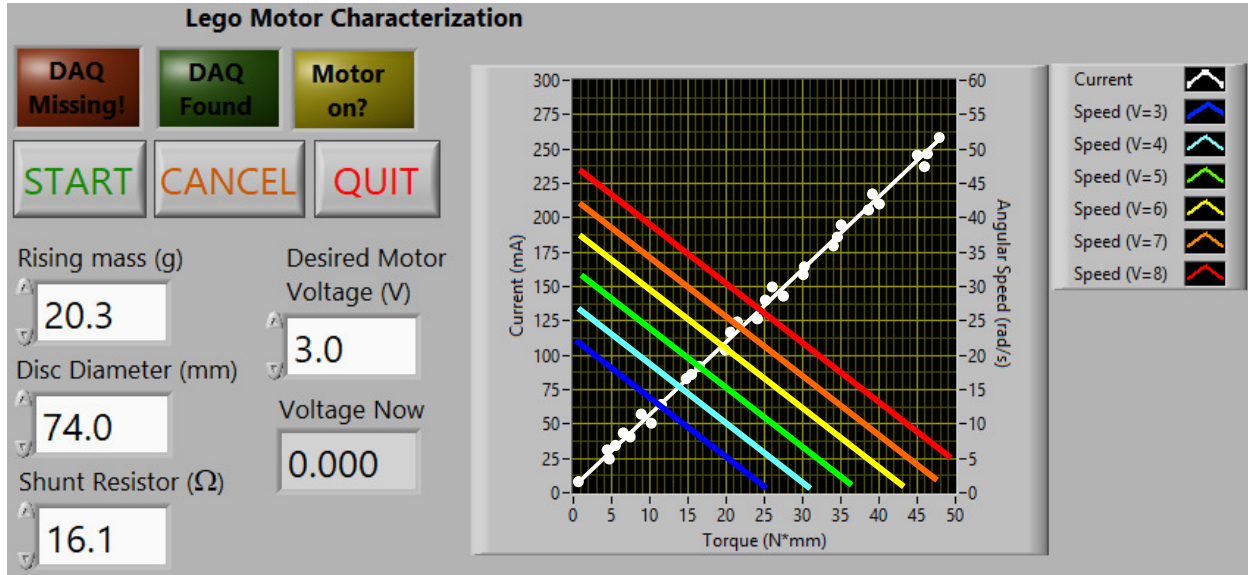
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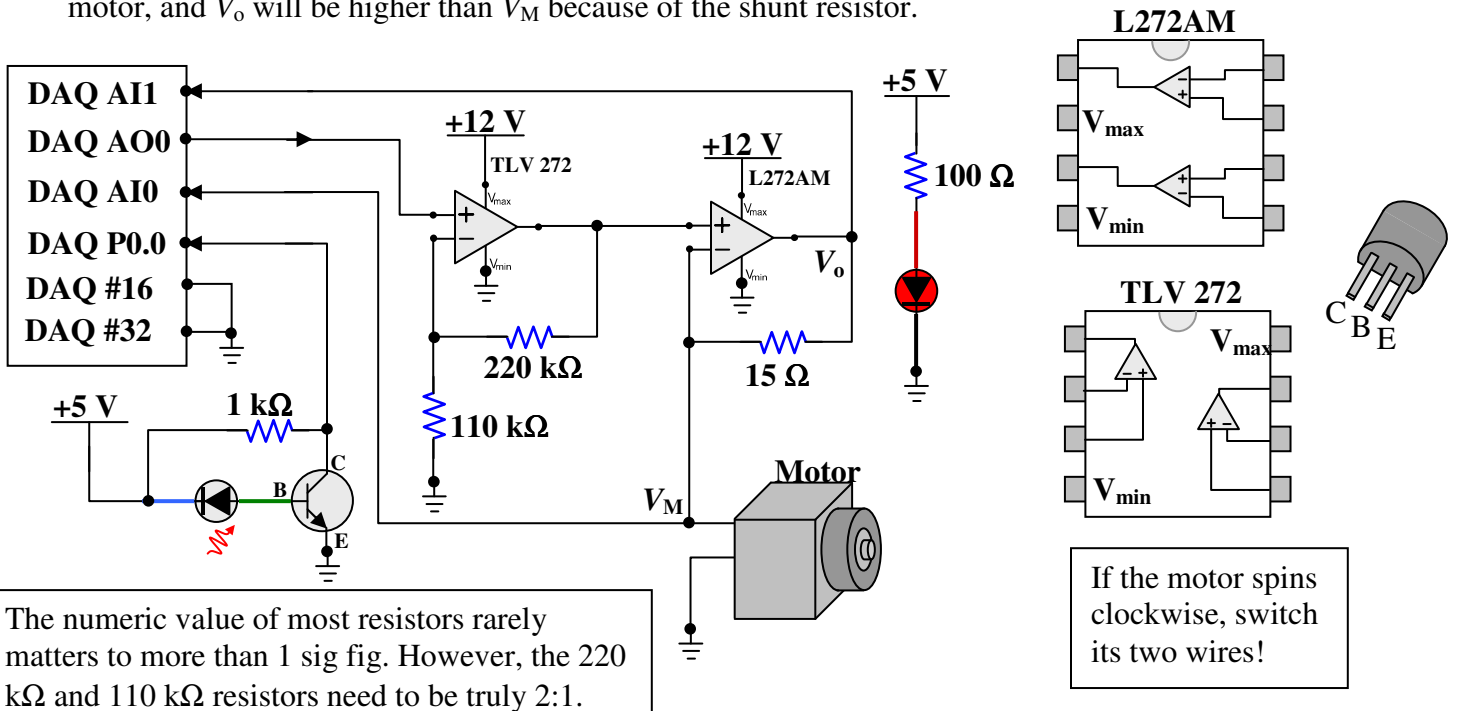
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You'll have to build the circuit shown below to test your program. This circuit has some very clever properties. Please note the wire colors (green/blue) on the diagram to prevent burning out the photodiode! Since the DAQ can't output voltages higher than 5 V, the output of AO0 will be one third of the desired value. Then, the TLV 272 op-amp will boost this to the actual motor voltage V_M , and your program will then record the actual applied voltage V_M using AI0. Since current is hard to measure (the DAQ has no current inputs!), you will compute the current using the voltage difference across the 15 Ω "shunt" resistor. The second op-amp provides the actual power to the motor, and V_o will be higher than V_M because of the shunt resistor.



The numeric value of most resistors rarely matters to more than 1 sig fig. However, the 220 k Ω and 110 k Ω resistors need to be truly 2:1.

If I could, I would prohibit you from even touching the diodes, because you're so careless. So, even though you *may* touch them, you may **NOT EVEN SLIGHTLY** bend these two wires that come out of either diode holder. Any bends must be at least 6 inches away from the holders!!

