ELCT 201 – EE LABORATORY [#3]

MOTOR CURRENT AND TORQUE

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ABSTRACT

The goal of this project is to measure the current and torque of a motor using dc power. The oscilloscope will be used to capture data from waveforms. Then a low pass filter will be created to eliminate brush noise and current ripple. Measurements will be used to show the relationship between torque and current for the motor. Then the relationship between electric and mechanical power will be observed.

INTRODUCTION

To start a series resistor is placed on a circuit board to measure the current using the voltage recorded across it. This was done using a 30 ohm resistor. When measuring the voltage it can be seen from the first 2 picture figures that a voltage of 120mV is recorded.

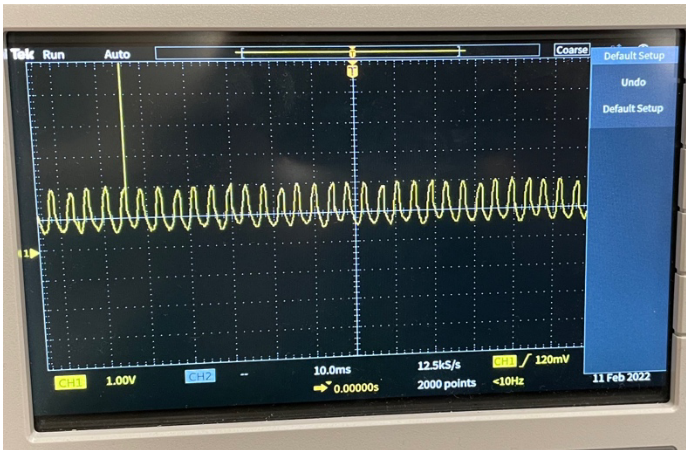

Figure 1 voltage across 30 ohm resistor

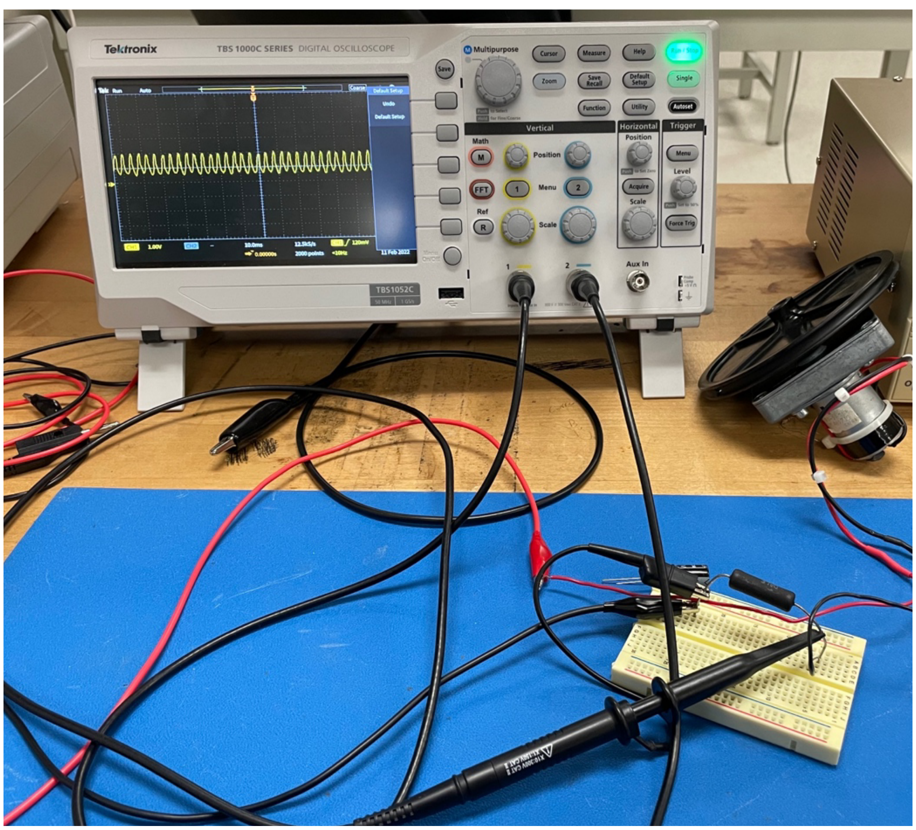

Figure 2 circuit for resistor in series with magnetic motor

The brushes of the motor cause the wave to appear this way on the oscilloscope because they open and close sequential rotor windings. A low pass filter is created using a resistor an capacitor to improve oscilloscope frequency supression.

PRELAB

To find the resistor to use in the circuit it is stated that the motor will use approximately 100mA of current when 10 volts are applied with no additional mechanical load. The current can possibly be 2 times larger when load is applied to the motor. The theoretical current is doubled to 200mA to calculate the required resistor for this application. Using V=IR the resistance can be found by rearranging the formula to V/I = R this will effectively mean 10/.2 = a 50 ohm resistor. During the actual lab a 30 ohm resistor is the closest thing available, because there were no 50 ohm resistors in the lab. The power dissipated can be found by using the formula Pe = IV. This would mean after the calculation of 10*.2 the power dissipated would be 2 watts. The power rating is found for this by using the formula P = V^2/R which will also produce 2 watts.

It is stated that the frequency of the motor current will be 500 Hz in order to suppress the frequency to 20db a lowpass filter is using a resistor and capacitor. Zc = 1/jwc and H(w) = Zc/(R+Zc) knowing this H(w) is substituted for 20db. Knowing w = 2pi50 this is substituted into the equation 1/wrc = .1. the closest rc values would be .1 ohms and .1 farads.

The motor is now drawing 150 mA with a 100g mass causing load resistance. To find the torque coefficient of a 10cm diameter wheel k = rmg/I and the tau is = rmg 10*100*9.8/150 which is approximately 65 nm of torque.

MEASUREMENT OF MOTOR CURRENT

The characteristics of the first figure are observed with an increased time resolution in the third figure. The peak amplitude of the voltage is 1.25 volts. Using v=ir v/r = the peak current which would be 1.25/30=0.0417amps.

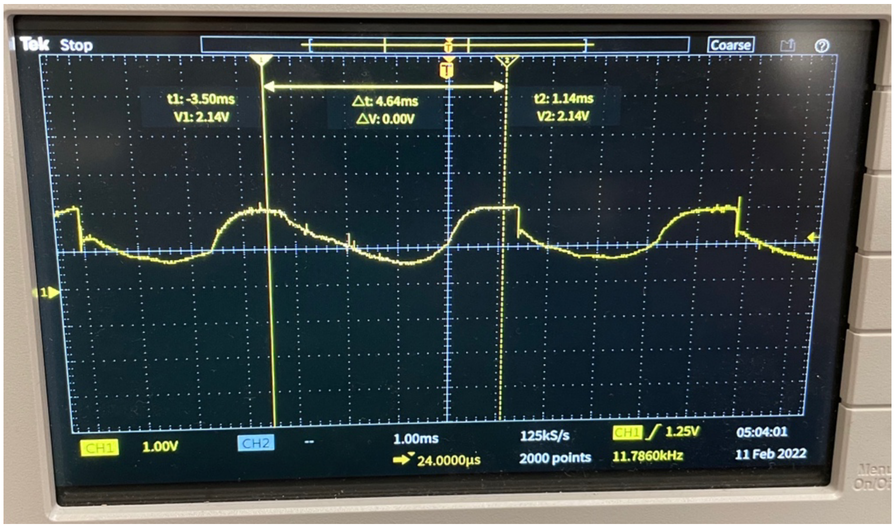

Figure 3 for the increased time resolution

When physically adding load to the motor the current increases. This increase grows proportionally to the amount of load applied to the motor until it can be unmeasurable on the oscilloscope based on the resolution.

LOW PASS FILTER THE MOTOR CURRENT

A low pass r c filter is created in figure 4 to suppress the fundamental frequency of the brush current.

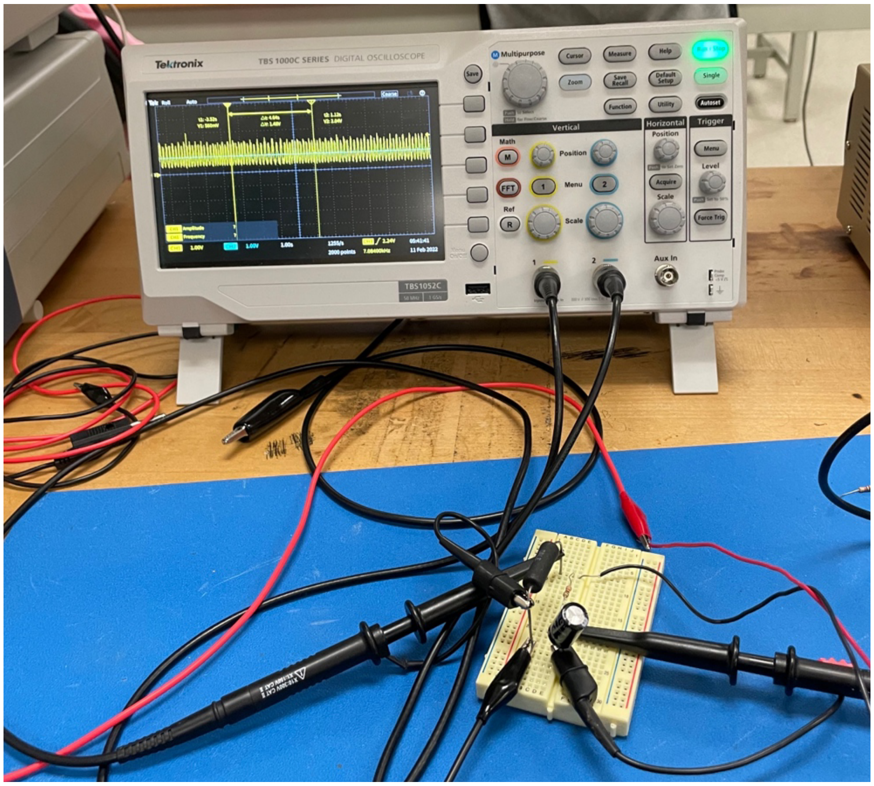

Figure 4 the rc filter

The first channel records the voltage of 2.24v across the resistor, and the rc filter voltage output is recorded across the second channel in blue. Figure 5 below shows how when load is added to this motor the current increases for both channels.

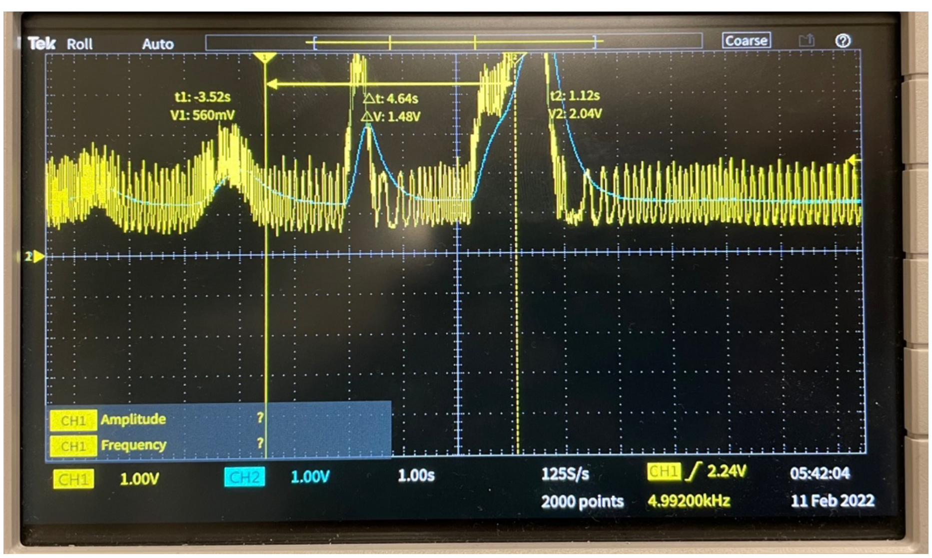

Figure 5 adding torque to the motor in the rc low pass filter

MEASURE MOTOR TORQUE

To measure the torque a string is attached to the motor with a bottle of water attached to the end of it. The initial motor included a hole to tie the string onto it. A 500ml bottle of water needed 3.6 volts to move the motor. to convert this to a current 3.6/30 = 0.12A. The bottle is reduced to 250ml and the steps are repeated to find a current at 1.6 volts. 1.6/30 = 0.0533A. To record the current at 125ml a new motor is used because the initial motor gets damaged from use. This caused the voltage to have an inconsistent increase to move the water. It takes 2 volts to move the next motor. the calculations for the current are 2/30 = 0.0667A.

To find the torque coefficient the radius of the wheel is recorded, and it takes 4 seconds to rotate the wheel at 125ml. This time is used to calculate the omega of 2pi/4seconds. The calculation for the torque constant of 125ml is as follows (.05715*.125*9.8)/.0667 =1.04961 n.m/a. to calculate the torque constant for 500ml and 250ml a similar calculation is used. (.05715*.5*9.8)/.12 = 2.33363 n.m/a (.05715*.250*9.8)/.0533 = 2.62697 n.m/a. The torque for the wheel with no load is 1.04961*.0667 = 0.07001 n.m. When comparing the values of the mechanical power to the electrical power there is a noticeable difference. To calculate the mechanical power 0.07001*(2*pi)/4 = 0.109971450838911 W and to calculate the electrical power 7.999*.0667=0.5335 W. The voltage across the motor at this instance is 10-.0667*30 = 7.999 V. The efficiency of this motor is calculated as 0.109971450838911/0.5335 = 0.206132054056066*100 = 20.6132054056066%

ADJUST THE MOTOR SPEED USING VOLTAGE MODE OF DC POWER SUPPLY

The time for a complete revolution at various voltages is recorded for this portion of the experiment. This is done unloaded. It takes 3.79s at 10V, 8.51s at 5V, and 5.10 at 7.5V. The measurements were made using a stopwatch, so there is a margin of error of at most .3 seconds. To calculate the speed the formula S=d/t is used. The radius of the wheel is 5cm and the circumference is equal to 2pi*radius which would mean .314 meters. Using an example of the speed formula .314/3.79= .08m/s at 10 volts. The voltage speed relationship is demonstrated in figure 6 below.

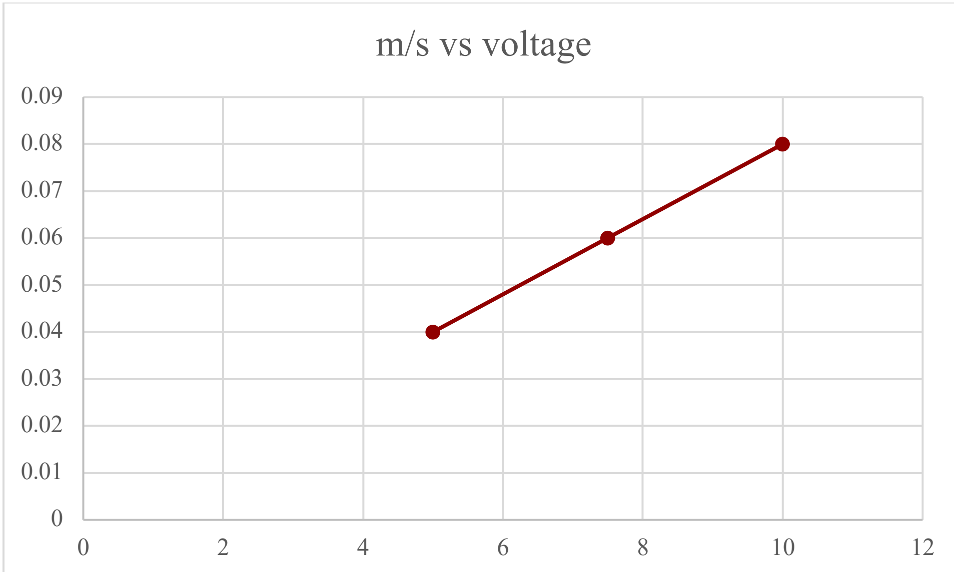

Figure 6 voltage and speed relationship.