Turntable Parameter Identification and Characterization

UCSD MAE156a

Parameters you will need: Inertia of turntable: **0.000884 Kgm2** Inertia of Motor Armature: **4.97e-007 Kgm2**
Motor stall torque: **.010 Nm** Motor no load (max) speed: **370 rad/s**

Assignment Overview:
In this assignment you will measure the open-loop performance of the turntable, and identify parameters such as friction of the system and slip between the motor drive wheel and the turntable. Start with a low spring preload in the friction drive, so you will able to observe some slip. Steps 1 & 2 should be completed in the week 2 motor driver lab, or have it checked off by a TA within 2 days of the lab. The rest of the steps should be turned in to a TA in week 3 on your lab day before the end of evening office hours.

1) **Data Collection Program:** Here you will operate the turntable in open-loop and record the time it takes to reach 540 degrees You will use the data collected in this step to begin your optimization log and for the rest of the steps in this assignment.
    a. Provided is a short Arduino ino file which prints the current time and position of your motor to the serial monitor at regular intervals. Modify this code as indicated in the comments to also print the position of your turntable by reading the potentiometer.
    b. Wiring instructions for the motor and encoder are on the next page.
    c. Gather data for both clockwise and counterclockwise rotation of the turntable.

2) **Oscilloscope Screen Shot**: Take a screen shot of the oscilloscope showing:
    a. The motor encoder before and after the Schmidt trigger
    b. The potentiometer and motor encoder, showing possible slip

3) **Test and Calibrate the Potentiometer:** Note, that there is a dead zone where the potentiometer switches from zero resistance to maximum resistance. Accordingly, the operating range of the pot is not a full 360 degrees. Accordingly, you will need to calibrate the pot to convert between measured voltages and degrees of rotation:
    a. Spin the turntable by hand while observing the pot voltage or counts measured by the Arduino.
    b. Identify the size of the dead zone
    c. Calculate the counts per radian.

4) **Process Data:** In the open-loop test all data analysis can be done after the test (note, this will not be the case for closed-loop control). Copy your serial output data to excel and add columns for the following:
    a. Velocity of turntable. Subtract one measurement by the prior measurement and divide by time step.
    b. Smoothed velocity. Use a moving window to average 5 adjacent measurements. Since, the smoothing uses both future and past data to estimate a value, you will not be able to use this method next week when doing closed-loop control; instead you will use filtering.
    c. Velocity of motor using encoder counts (use same method as above).
    d. Smoothed velocity of motor (use same method as above).
    e. For the first rotation of the turntable from rest (before the dead zone is reached):
        i. Turn in plot of smoothed and unsmoothed turntable velocity in units of milliseconds and radians/s.
        ii. Turn in plot of smoothed and unsmoothed motor velocity in units of milliseconds and radians/s.

5) **Quantify Slip:** Using the data from the prior steps show the time during which slip between the motor shaft and the turntable are occurring. Illustrate this on a plot. Make sure to use appropriate scale and notes on the plot to clearly illustrate your data interpretation.

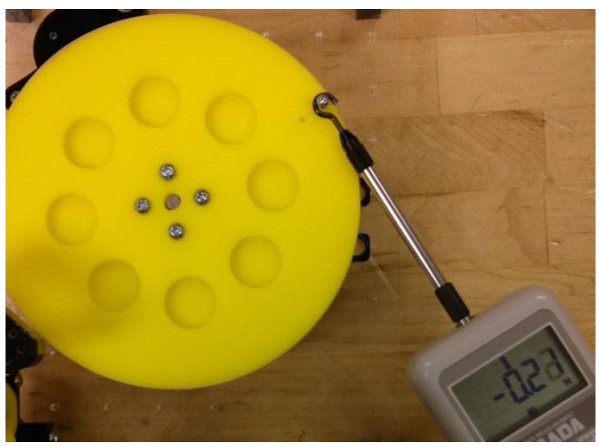
Quantifying Friction

Reducing friction is important for speeding up your turntable. You will need to quantify friction for an accurate computer model of your turntable and to track what changes reduce your friction. You will use 3 methods to estimate friction and to avoid errors.

6) **Terminal Velocity Method:** The terminal velocity of the motor will differ from its no-load speed due to friction. Calculate the motor torque required to over come friction using the motor-torque vs. speed curve. Show work.

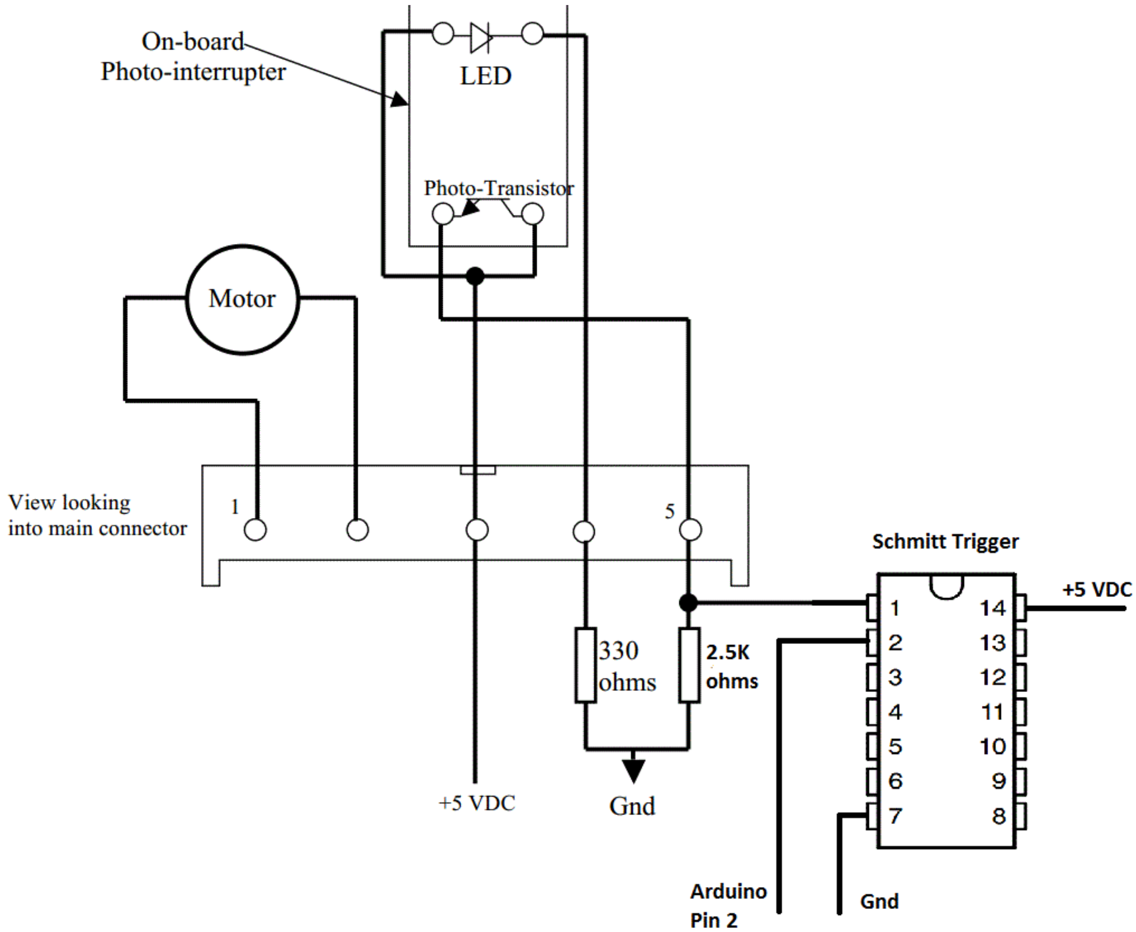
7) **Spin Down Test:** When the power to the motor is stopped, the turntable will decelerate and the rate of deceleration corresponds to the amount of friction in the system. Use the spin down test protocol to estimate the system friction in Nm.

8) **Static Pull Test:** Confirm that your coefficient of friction under dynamic conditions is correct by using the digital force gauge to turn the turntable and calculate the equivalent toque. See picture below for setup.



9) **Compare Friction Estimates:** Convert all 3 friction estimates to the coordinate system for the turntable. Compare the results. Discuss which you believe is more accurate for turntable performance objectives, and the reasons for the differences between the results.

10) Is this close to your findings from the dynamic methods above? Which is a more accurate test? **Clockwise vs. Counterclockwise rotation:** Does the system behave differently when accelerating in different directions? Explain why how this can happen using a Free Body Diagram and clear but concise explanation.


On-board
Photo-interrupter
LED
Photo-Transistor
Motor
View looking
into main connector
1
5
330
ohms
2.5K
ohms
+5 VDC
Gnd
Schmitt Trigger
1
2
3
4
5
6
7
14
13
12
11
10
9
8
+5 VDC
Arduino
Pin 2
Gnd