INTRODUCTION

A control feedback system conducts three essential actions: 1) sense, 2) decide, and 3) actuate. These actions are repeated over and over in a timely fashion. The control system must sense what it is trying to manipulate (such as the position of the turret). It must then decide how to actuate the system based on that sensed measurement (this is the job of the control algorithm from ES305). And finally, the control system must actuate the system (this is the job of the motor and motor driver).

Prior to implementing a control algorithm on an experimental test stand, we must FIRST ensure that we can: 1) sense what we are trying to control and 2) actuate the system. For our auto-turret, system we are going to make sure we can actuate the turret platform first. We will then work on sensing the position of the turret.

MOTOR FAMILIARIZATION

We need to first familiarize ourselves with the equipment of the turret sub-system. It consists of a DC motor and the corresponding motor driver. The following paragraphs consist of both questions and TODO items. The questions must be addressed in your write-up, however DO NOT just write Q1, Q2 etc. and the answer next to it in your report. Incorporate the answers to the questions using full sentences, for example: "A motor driver is needed because." Another example would be "The datasheet may be found in enclosure X or located on the TSD website [1]. For the TO DO items, these must also be addressed in your final report along with the associated data, plots, figures, etc. If you are asked to perform calculations, provide the equations and final answer (including units!).

(1) Why do we need a motor driver?

(2) What is the make and model number of the DC motor used to actuate the turret? (see Fig. 1)

(3) Locate the data sheet for this motor on the TSD website at http://intranet.usna.edu/WSELabs/index.htm.

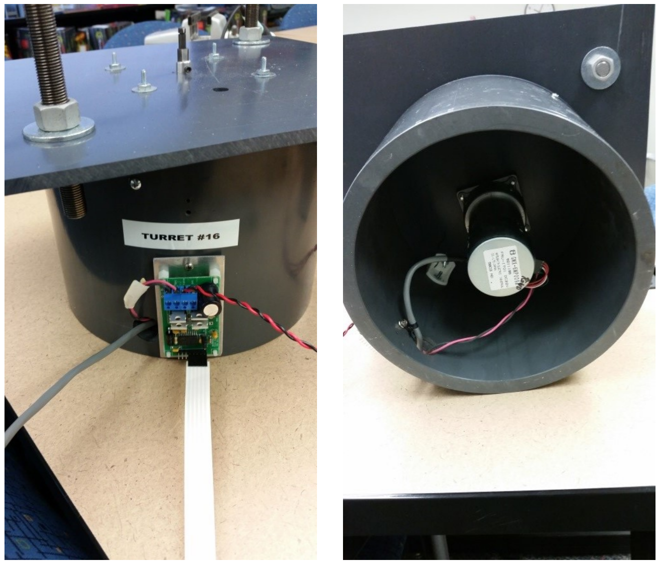
(4) What is the motors specified operating voltage?

(5) What is the no-load speed of this motor expressed in rad/sec? (If its not is rad/sec then you need to convert it to rad/sec)

TODO: Plot the torque-speed curve (torque vs. speed) for this motor using the lab test results from the datasheet. The torque units must be Nm and the speed in rad/sec. [Hint: curve fit the presented lab test results from the datasheet and make a plot similar to the one in Fig. 2 (but with different values).

TODO: Using your torque-speed curve results, estimate the stall torque for this motor (expressed in Nm).

TODO: Estimate the stall current for the motor. [Hint: use the lab test results from the data sheet to plot current vs torque and fit a line to this data. Then use your answer from your torque-speed curve to find the current at stall torque]. If you use the plotyy command, you can use two different y axes. TODO: Create a plot similar to Fig. 3 that overlays speed, current, and power vs torque. Use rad/sec for speed and Nm for torque.



(a) Turret subsystem showing Motor Driver

(b) Turret subsystem showing the make and model on the DC motor

Figure 1: (a) motor driver mounted on the size of the auto-turret; (b) make and model of the DC motor shown on the underside of the auto-turret.

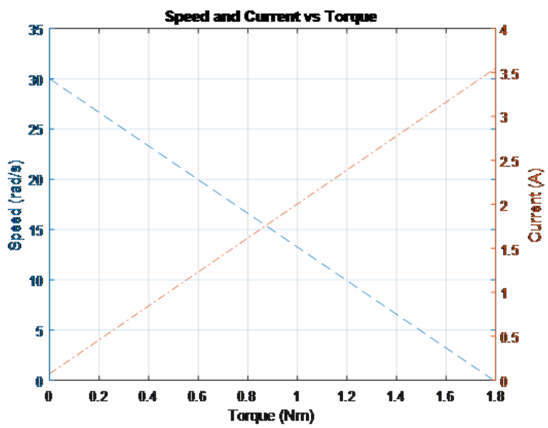


Figure 2: Speed vs torque and current vs torque curves for a generic DC motor. The no load speed is 30 rad/s and the stall torque is 1.8 Nm.

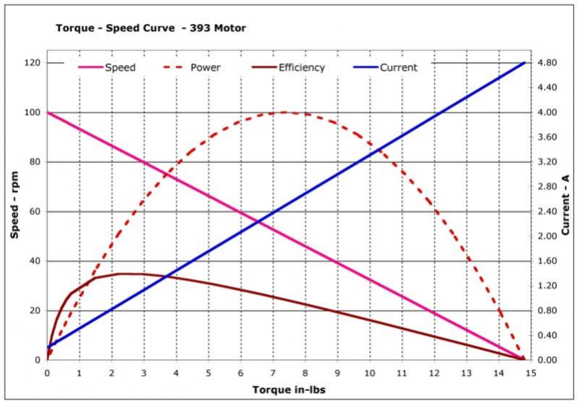


Figure 3: Speed and Current vs Motor Torque for the 393 DC Motor. Note that .....

(6) From the stall current and the operating voltage, estimate the motors armature resistance.

(7) What happens to the no-load speed for this motor (expressed in rad/sec) when the operating voltage is reduced to 12(V)?

TODO: Using a 12V supply, estimate the stall torque for this motor (expressed in Nm)? As above, curve fit lab test results down to zero speed for 12.0(V) operation.

TODO:Estimate the stall current and armature resistance for the motor operating at 12.0(V)? Did the value of the resistance change and should it?

FAMILIARIZATION WITH THE MOTOR DRIVER

As with the spinner/plunger motor, we need a drive circuit to actuate larger motors via the mBed. In our application, a custom motor driver board called the TD340 board is utilized. It was constructed by our Technical Services Division (TSD) and is shown below in Fig. 4.

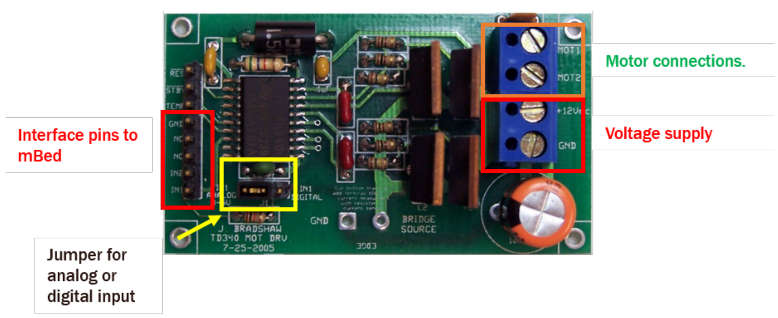


Figure 4: TD340 Motor driver board showing the interface pins to the micro controller, the motor connections, and the voltage supply and ground pins. Note the jumper pin for either analog or digital control

(1) Locate the data sheet for TD340 motor driver on the WSE technical support web site. What is the operating voltage range for the TD340 motor driver board? Are we within the acceptable range?

(2) What are the two types of protocols for interfacing (i.e., communication) from the mBed to the TD340?

(3) What is the analog output range for the mBed?

(4) Based on the analog output range of the mBed, which type of protocol (digital or analog) should we prefer to use for communication from the mBed to the TD340 board to maximize the resolution and why?

(5) If a digital protocol is selected between the mBed and the TD340, what needs to be done PHYSICALLY on the TD340 board to ensure that the selected protocol is being employed? Verify that this is done on your turret system.

(6) How many actual wires are needed to communicate between the mBed and the TD340 board utilizing a digital protocol?

TODO: List each wire and what will be transmitted on each wire (this will help with the development of the corresponding code).

CONNECTING THE MBED TO THE TD340

From your above investigation, you should determine that the digital interface protocol should have been selected (the why portion should be reasoned above). Therefore, you will need to connect three pins of the mBED to three pins on the TD340 board for implementation (IN1, IN2, GND). For cabling simplicity, we can accomplish this by utilizing a PRE-MADE 5 pin connector cable as show in Fig. 5.

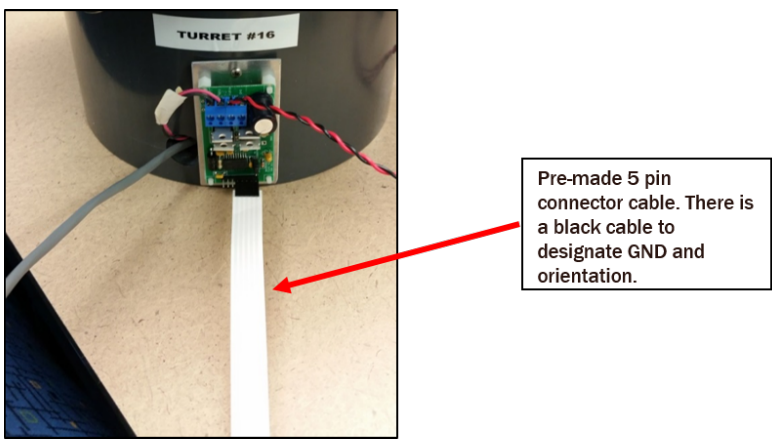


Figure 5: Pre-made connector cable connecting the micro-controller to the TD340 Motor Driver board. Note the black cable that designates the ground and its orientation.

Since we only need three wires, two wires in the pre-made cable will be no-connects (NC). On your breadboard, select the appropriate pins from the mBed and wire those pins in the correct order to a male header pin on the breadboard as show in Fig. 6.

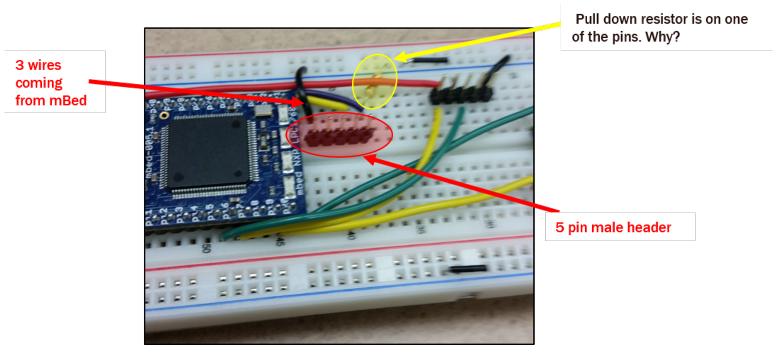


Figure 6: Three pins designated from the mBed attached to a 5 pin male header. Two of the pins are no-connects. A 10K resistor remains on one of the pins.

(1) Why is a 10K resistor needed on one of the connector pins to the TD340? Hint: try it without it, but make sure nothing is near the turret (especially yourself). Be ready to disconnect power.

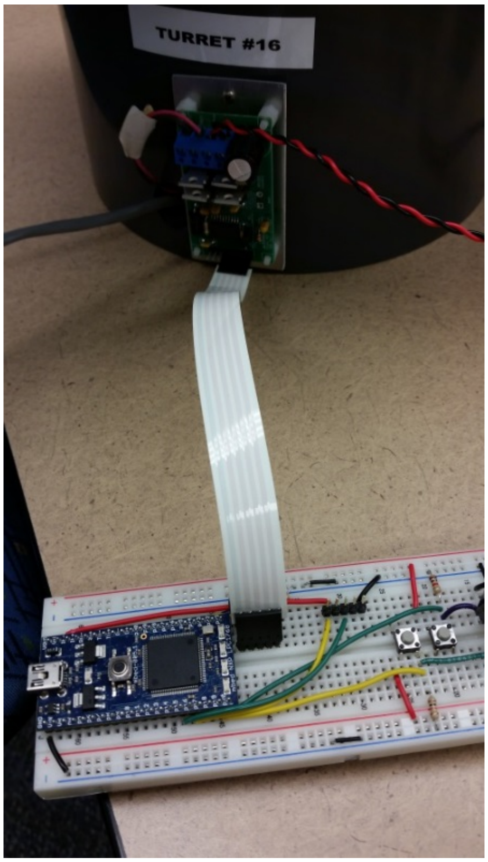


Figure 7: Firing circuit with microcontroller pins properly attached to the T340 motor driver. The red and black wire pair connects to the raw battery output.

When your system is connected, it will appear as shown in Fig. 7.

WRITE CODE TO MOVE TURRET MOTOR

Once the wiring connection is established, you need to create a program that will:

1. Accept a duty cycle command from the user
2. Accept a direction command from the user
3. Ensure that the duty cycle (DC) is within appropriate bounds ($-100\% \leq DC \leq 100\%$)

   IMPORTANT: When starting out (i.e., the first time you get ready to run the motor), saturate the DC to a LOW value (say 20 %). That way, you do not get surprised by a fast spinning turret system.

4. Apply the direction and duty cycle command correctly to the motor.

   Note: There exist several classes that you may use for this exercise (Motor, PwmOut, and MotCon)

DELIVERABLES

Please submit/demonstrate the following:
1.) Submit answers to all the above questions. 2.) Demonstrate the actuation of the turret motor system via Terra Term to your instructor.