Lab 5 -DC Motor Step Response

Part 1: Motor Step Response

Objectives:

- Use the DRV8833 motor driver and obtain the motor step response
  - In External mode
  - Directly through the serial port
- Understand the logic needed to control the magnitude and direction of a motor
- Observe the different effects of different logic schemes to drive a motor

Background Information:

A motor driver chip converts a lower power signal (from the microcontroller: 5v, 40mA) to a high power signal (9v, 1.5A) to drive the motor. It can be thought of as a switch or relay to the driver supply voltage (9v or 5v in this case). Since the supply voltage is fixed this would result in a fixed motor speed. To regulate the speed a PWM signal is used to quickly switch the output on and off so that the average output voltage can be controlled.

The term motor "driver" is also commonly called "amplifier" or "chopper". The DRV8833 driver is capable of providing 2.7-10.8v at 1.5A RMS on each channel.

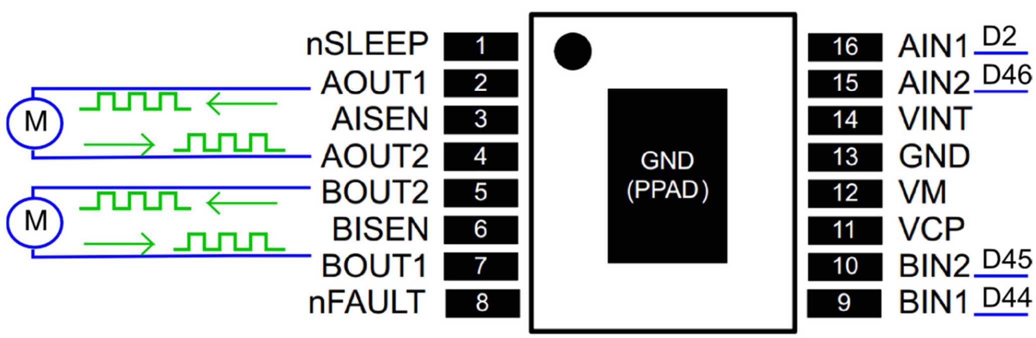


Figure 1: DRV8833 pinout/wiring diagram

". The SN754410 driver is capable of providing 3.5-36v at 1A on each channel.

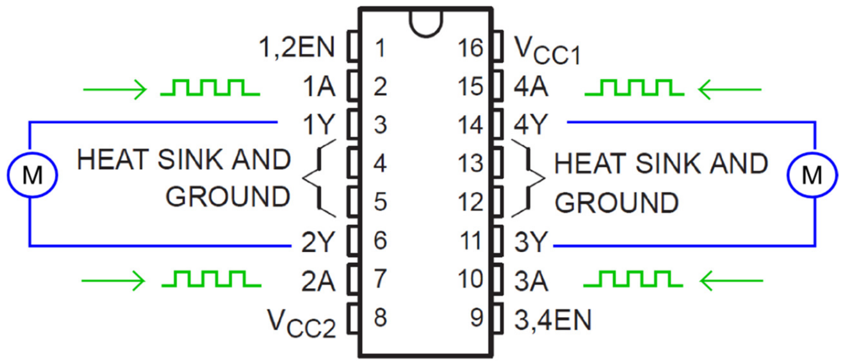
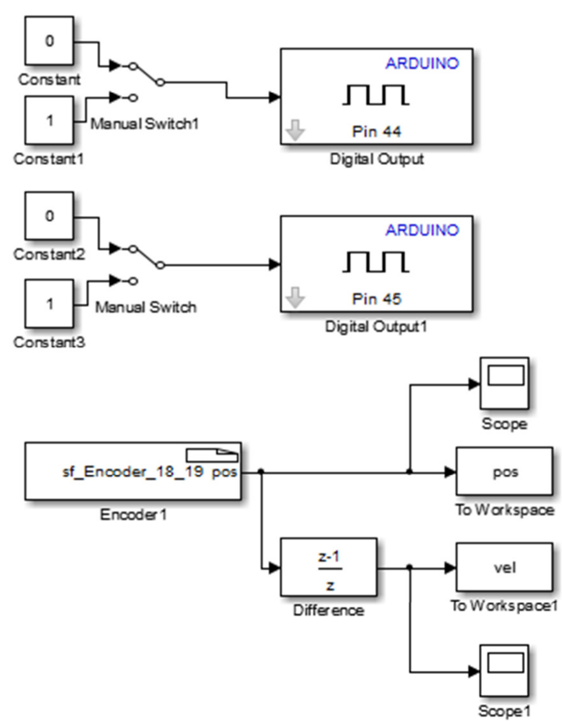


Figure 2: SN754410 pinout/wiring diagram

Simulink Model

Build and run the following Simulink diagram. Use the corresponding encoder/dual encoder block for your system, and the digital pins that do to your motor driver

- M1V4: motor on 4&5 or 9&11, encoder on 2&3 or 18&19
- M2V3: motor on 2&5 or 6&8, encoder on 18&19, or 15&A8
- MinSegMega: motor on 2&46 or 44&45, encoder on 18&19 or INT6&int7

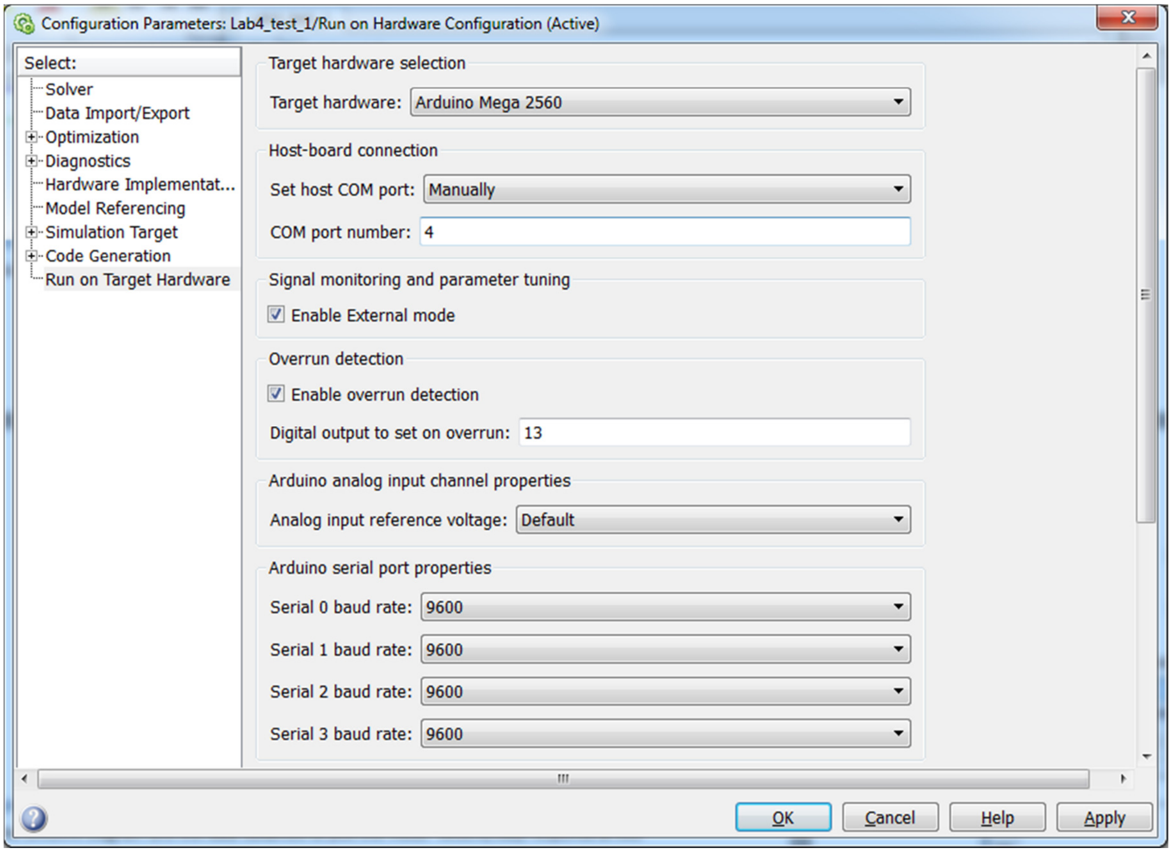


- Run the model in external mode to log the data

    - Sampling rate of .03 seconds
- Observe the response of the system
    - toggle the manual switches
    - toggle the On/Off switch on your board – this will determine the voltage source of the driver chip (VM):
        - OFF - USB voltage (~4.5 volts)
        - ON – Battery voltage (~9v fully charged)
- Stop/disconnect from the system, save the data then plot the results
    - The commented line below stores the variables 'pos' and 'vel' into the data file ext_dat.

```
%save ext_dat pos vel    % save the data
load ext_dat             % load the data
figure, plot(pos)
figure, plot(vel)
```

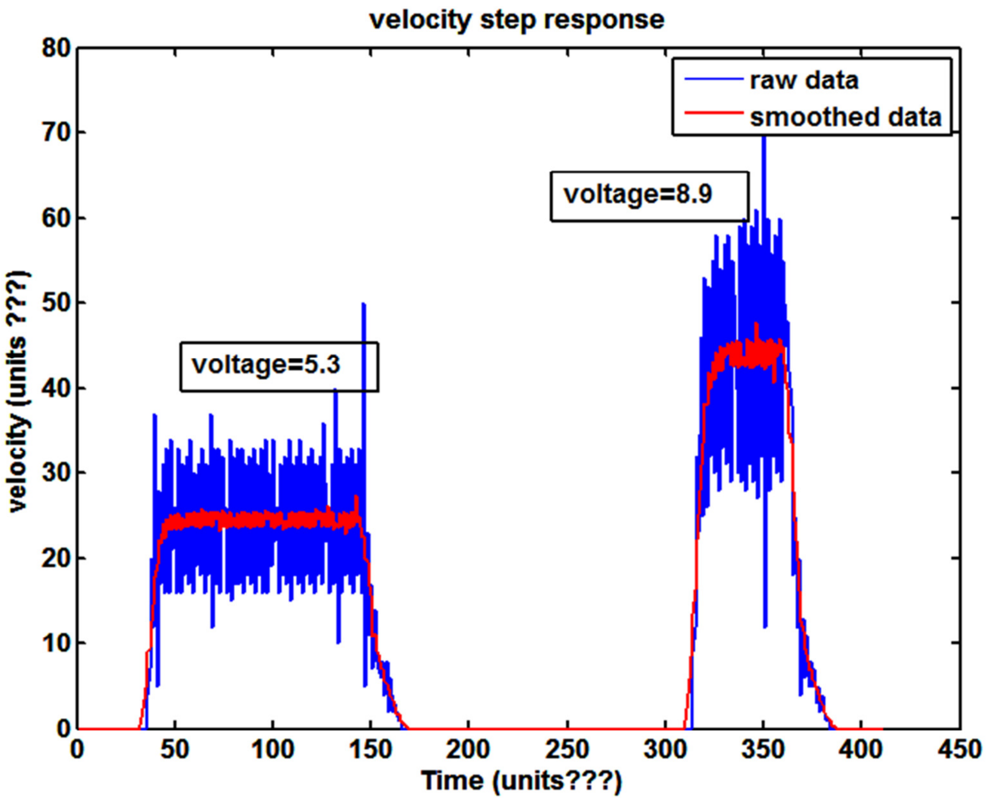
The velocity data obtained in external mode will be noisy. The primary reason seems to be that the time between samples is not actually fixed/constant. In the configuration parameters if you check the box "Enable overrun detection" then the digital pin you specify will be set high if the controller cannot execute your code in the sample time you specify. Check this box, select pin 13, and connect to the device. You will notice that the LED on pin 13 is always on. This indicates that in external mode the microprocessor has trouble meeting the sample time. This implies the time between each sample is not exactly 30 milliseconds. Any calculation assuming a fixed sample time, such as velocity, will then contain some error (noise) due to the sample time not being constant. Note that this noise is from the measurement system - not actual noise present in the signal or system.



- The actual motor velocity will not be fluctuating like the "noisy" data indicates. To make the data more useful use the "`smooth`" command in Matlab. Type "`help smooth`" to obtain details on the smoothing method
    - `vel_smooth=smooth(double(Vel), 10)`
        - This function will use a moving average over 10 samples to smooth the velocity data
        - double – this converts the int16 values in Vel to doubles. If this is not done the function will complain

Questions:

- Provide a plot that contains the velocity step response. Provide the raw data and a smoothed response. Plot the velocity in RPM and time in seconds. An example plot (for two different voltage steps) is shown below for an unknown motor with unknown units:



Data for Parameter Identification (Optional)

The DC motor parameters can be determined from steady-state voltage and current measurements.

- From the pinout diagram for your system find the jumper that connects the driver to one of the motor terminals
  - Leave the jumper in so the motor is spinning at a constant velocity – use a multimeter to measure from the ground on the batter terminal block to the pins for the motor jumper. NOTE: the voltage will only be a meaningful value when the motor is spinning in one direction, in the other direction it will be closer to zero. If your voltage is not near the expected value reverse the direction of the motor. This is because the jumper is connect to only one of the motor leads.

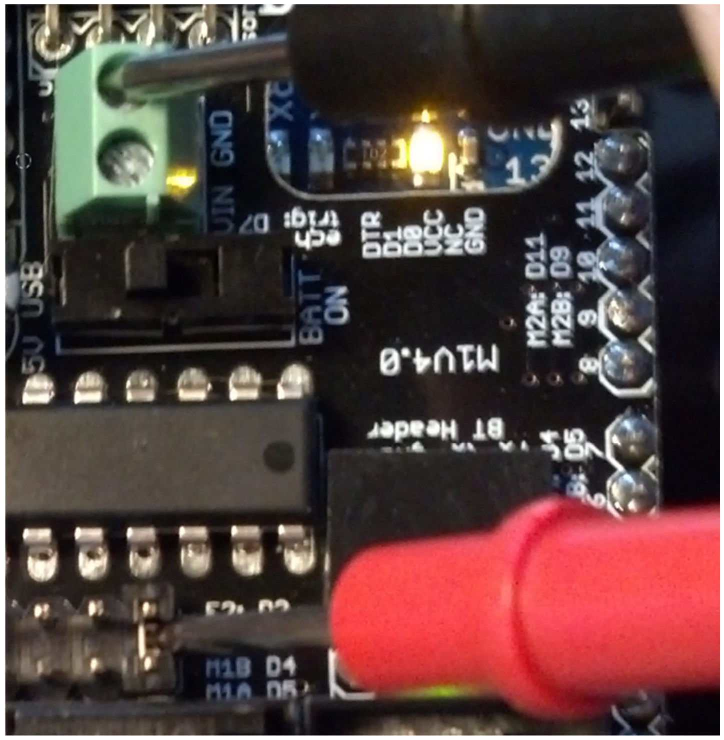


Figure 2: M1V4 Voltage measurement jumper

  - Before you can measure the current determine the maximum current your multimeter can read. At steady-state most small DC motors will be less than 200ma.
  - Remove the jumper and use a multimeter in current mode to complete the circuit and allow the motor to spin at a steady state speed and measure the current. Be careful not to short the multimeter probes.
- When the motor is running at a steady-state constant velocity record the steady state:
  - velocity average (with correct units)
  - voltage with a multimeter
  - current with a multimeter

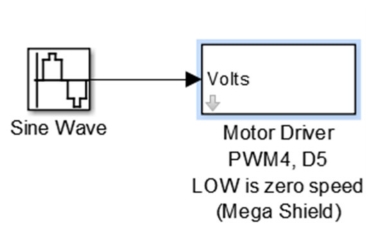
Questions:

- What is the maximum current your multimeter can read?
- When powered from USB what is the steady state speed, current, and voltage (include units)?

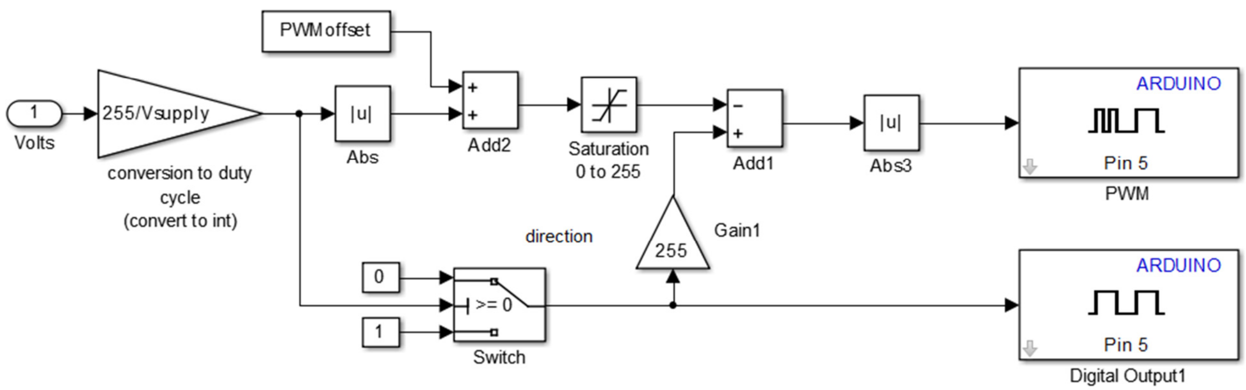
Part 2: Motor Logic: Direction and Magnitude

To regulate the speed a PWM signal is used to quickly switch the output on and off so that the average output voltage can be controlled. In addition the correct switching logic needs to be implemented so that the motor can change direction based on the sign of the input.

The subsystem block below is used to correctly output the correct magnitude and logic of the PWM if the only input is a scalar input voltage (which could be negative)

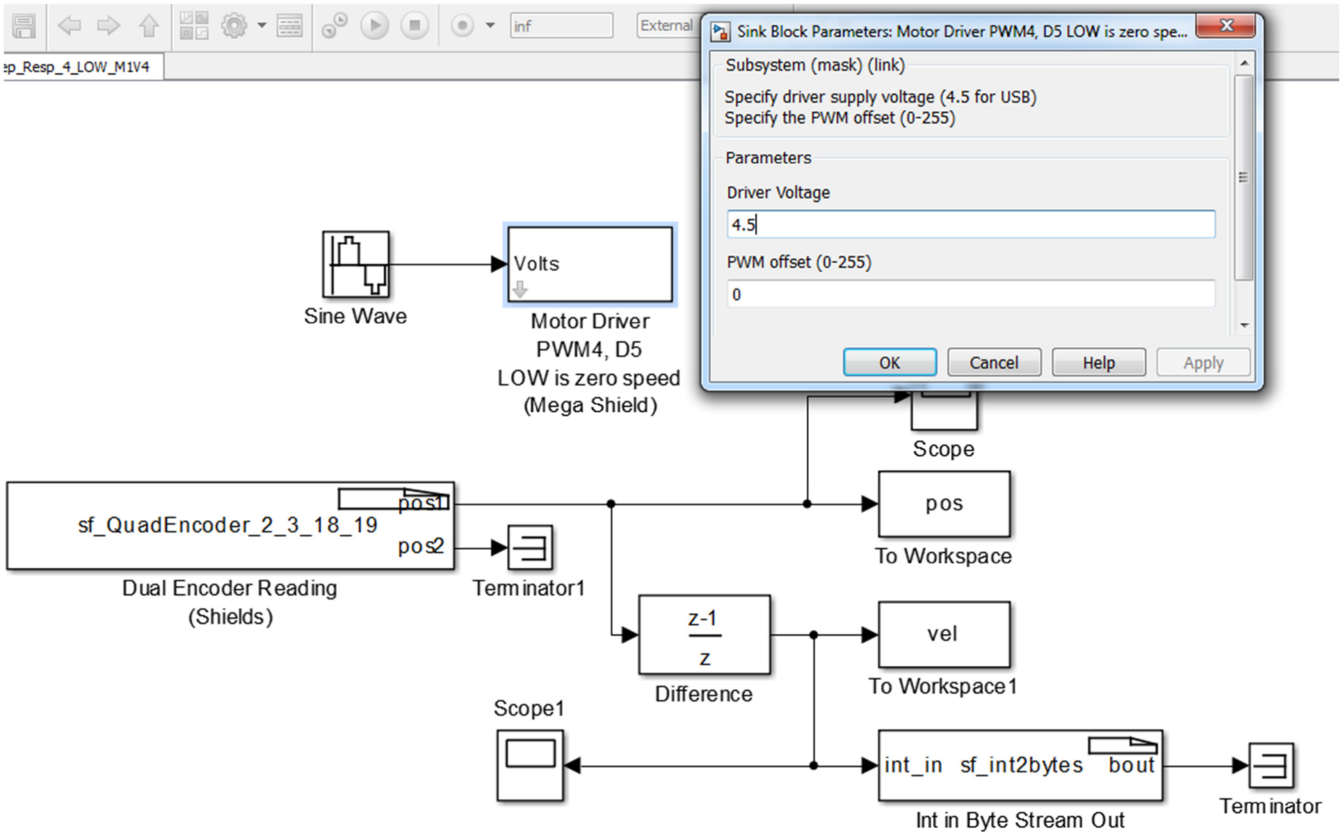


The contents of this subsystem are shown below:



- Use this subsystem block to generate a sinusoidal motor response:

cc



- Edit the Subsystem parameters to correctly specify the driver supply voltage (4.5 if power is from a USB) and a PWM offset – normally zero.

Questions:

- Provide a plot of the sinusoidal velocity in external mode.