# EE443L Lab 4: Open Versus Closed Loop Motor Speed Control Continued

<u>Closed Loop Motor Speed Control</u>

1. Download the VI lab4.vi and its associated sub VI PWM_Clock_Source.vi located at N:/EE443L/LAB4/. Run it with a supply voltage between 14V and 18V noting that the selected duty cycle values of –127, …, 0, … 127 correspond to PWM duty cycles of –100%, …, 0%, … 100% which are implemented via an Altera PLD. Three major changes to the VI structure have been made to increase and control loop efficiency.
   a) An Altera PLD is now generating the PWM signal. The VI sends out an 8-bit signed number and Altera generates the corresponding duty cycle.
   b) The main loop is now hardware timed via the analog input scan rate that can be adjusted on the front panel. If the loop needs to be slowed down, the light will come on indicating the processes in the loop can't be run at that speed.
   c) Signal plots are performed outside of the loop to further reduce the computational overhead in the loop.

2. Modify the LabVIEW VI lab4.vi to implement open loop control with gain K and the desired speed switching from 0rad/sec to 25rad/sec after 500 loops. The frequency-to-voltage converters voltage to speed conversion in software should checked. It is initially set to 57.1, but several of you have computed a value of 51.7 indicating a digit transpose on my part. Find the gain K for which the output equals the input and measure the step response peak time $T_p$, percent overshoot P.O., settling time $T_s$, rise time $T_r$, and steady state error $e_{ss}$. Note using Altera for PWM generation we can achieve much faster loop times and more accurate measurements.

3. Modify the open loop controller so that it becomes proportional closed loop control with closed loop controller gain K as shown in Figure 1.

   Important note: One important closed loop characteristic to remember is that the maximum effective voltage we can apply to the motor via PWM is the supply voltage $V_{SUPPLY}$; therefore, the largest error e(t) we can accommodate without requiring larger voltages that we can supply is $e_{max} = V_{SUPPLY,max} / K$. This limitation is most often encountered when step responses are required since the initial (and most often maximum) error is the value of the desired speed. One way of providing control when required voltages exceed available voltages is to limit (saturate) the motor voltage to the maximum in software.

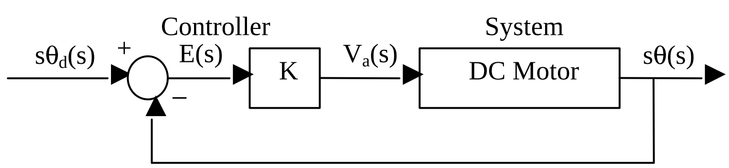


**Figure 1:** Proportional Closed Loop Motor Speed Control Diagram

4. Using the closed loop controller, vary the closed loop gain K such that overdamped and underdamped DC motor speed step responses are achieved. Plot the motor step responses for a desired motor speed of 25rad/sec and note the corresponding gains.

5. Measure the step response peak time $T_p$, percent overshoot P.O., settling time $T_s$, rise time $T_r$, and steady state error $e_{ss}$ for both the overdamped and underdamped step responses.

6. Create a table of performance metrics including those from the open loop response as well as both closed loop responses. Compare these and comment on the various apparent advantages and disadvantages of each approach/response.

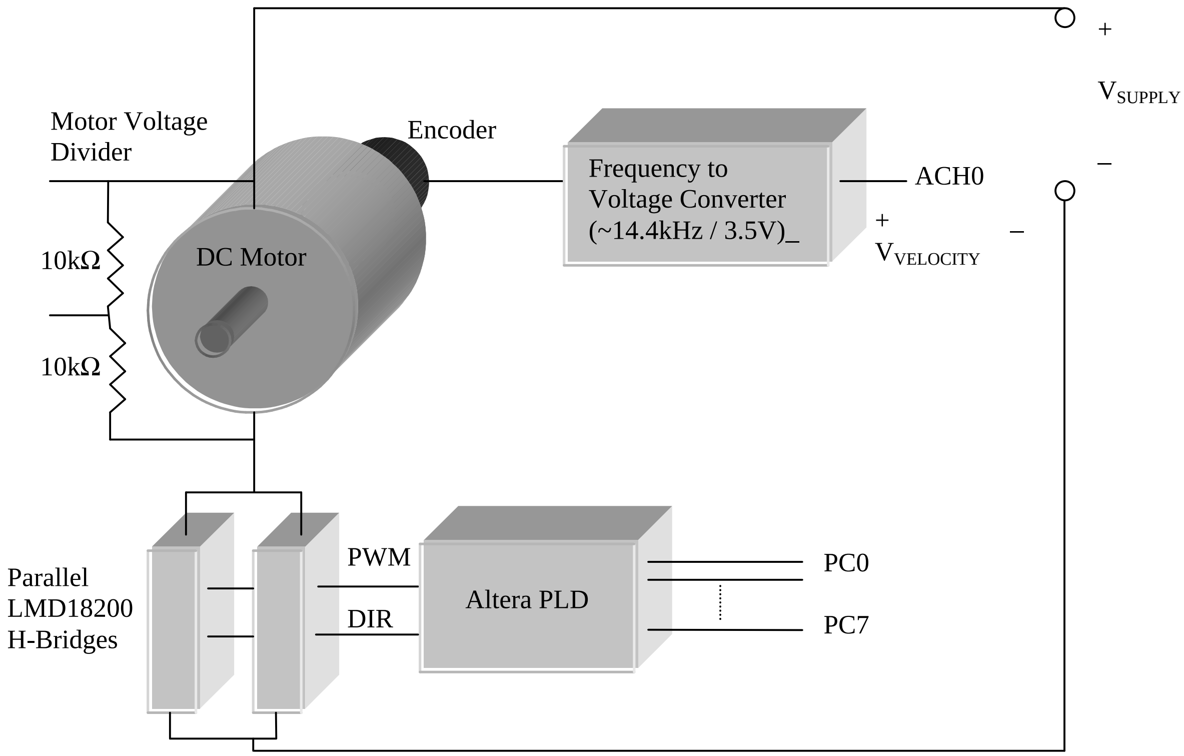


**Figure 2:** DC Motor Experiment Setup