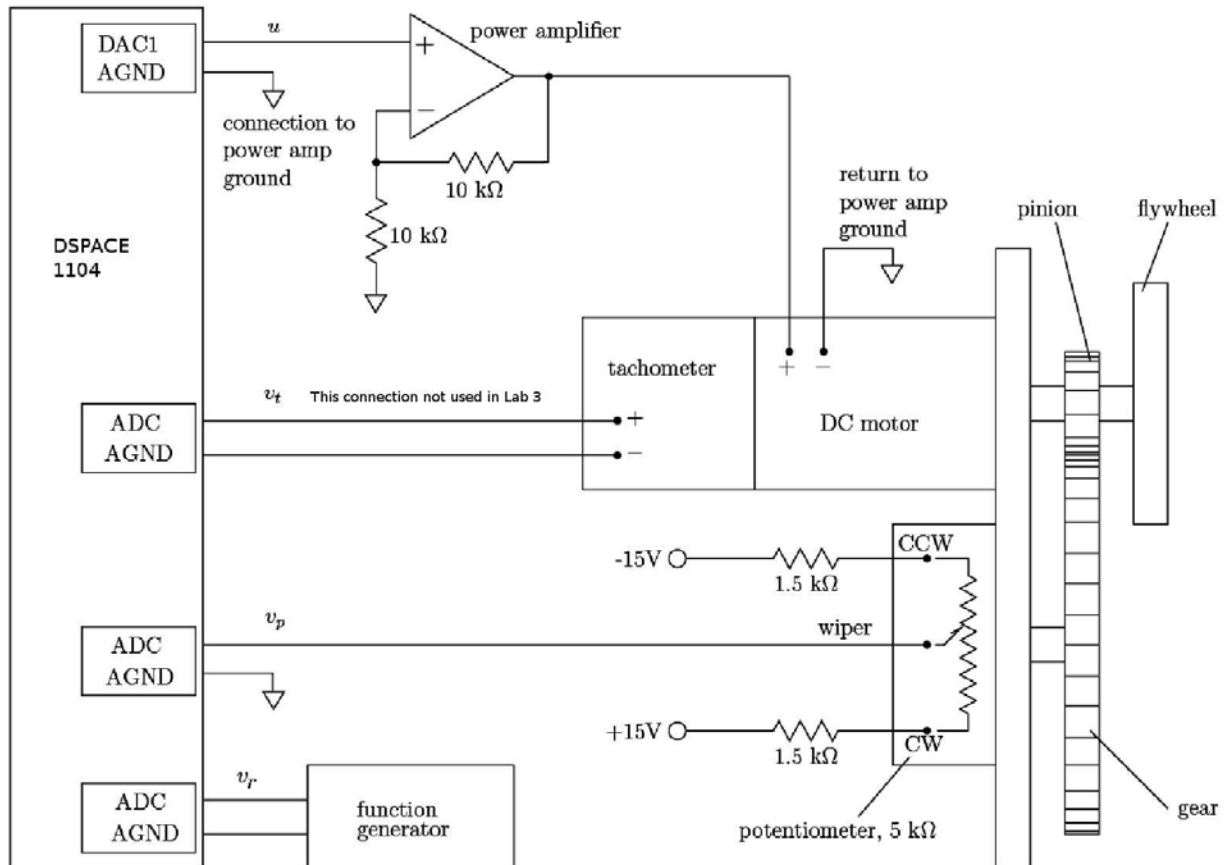


2.140: Week of 4/2

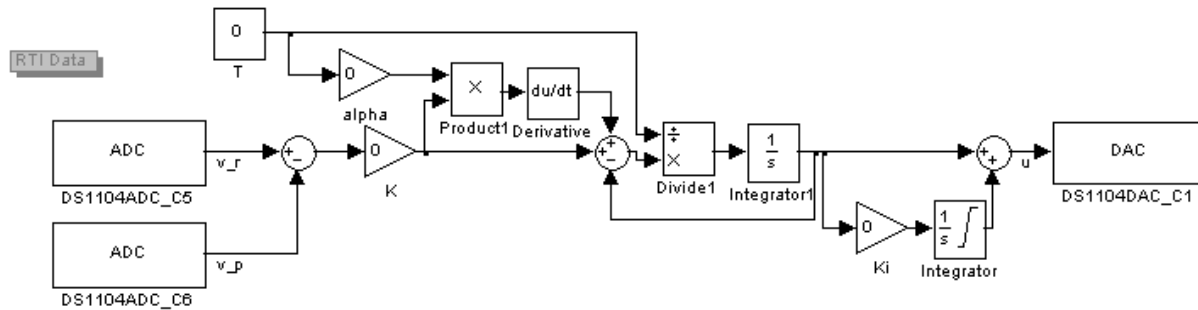
2.14: Week of 4/9



In this lab, we implement a position controller for the same DC motor system we studied in Lab 2. The potentiometer connected to the geared payload provides the feedback signal v_p proportional to the rotation angle, and the function generator provides the “reference” voltage v_r . A schematic of the system is shown above, including the power op-amp that drives the motor. The motor parameters are as in Lab 2 (and repeated below), with the exception that we will use the potentiometer rather than the tachometer.

R	7.5	Ω	armature resistance
L	5.55	mH	armature inductance
K_T	0.024	N·m/A	torque constant
J	1.5×10^{-5}	kg·m ²	total inertia of motor and payload
K_{pot}	0.5	V/rad	potentiometer voltage per angle of rotation of the <i>motor</i>

The controller is implemented in dSpace as illustrated in the block diagram on the following page. This controller and a GUI that allows you to vary system parameters will be provided in lab.



The difference between the reference voltage v_r and the potentiometer signal v_p is an error signal, on which the controller acts to produce the motor command u .

1. Verify that the controller shown in the diagram above has the transfer function

$$G_c = K_p \left(\frac{s + K_i}{s} \right) \left(\frac{\alpha T s + 1}{T s + 1} \right) \quad (1)$$

2. As in Lab 2, we can neglect the motor inductance. Under this assumption, show that the transfer function from amplifier input u to potentiometer output v_p is

$$\frac{v_p}{u} = \frac{2K_{pot}}{K_T s(\tau_m s + 1)} \quad (2)$$

where K_{pot} and K_T are as given above and $\tau_m = JR/K_T^2 \approx 200$ ms is the mechanical time constant. (Assume that the power op-amp behaves ideally.) Sketch the Bode plot of v_p/u .

3. Based on your hand sketches, design a compensator to obtain a crossover frequency of 50 rad/sec and a phase margin of 45° . You should set the lag parameter K_i to give as much gain at low frequencies as possible without compromising the phase margin significantly.
4. Based on the controller you design, use Matlab to make Bode plots of the return ratio (i.e., -1 times the loop transmission) and the closed-loop transfer function from v_p/v_r .
5. Use Matlab to plot the step response of the closed-loop system.