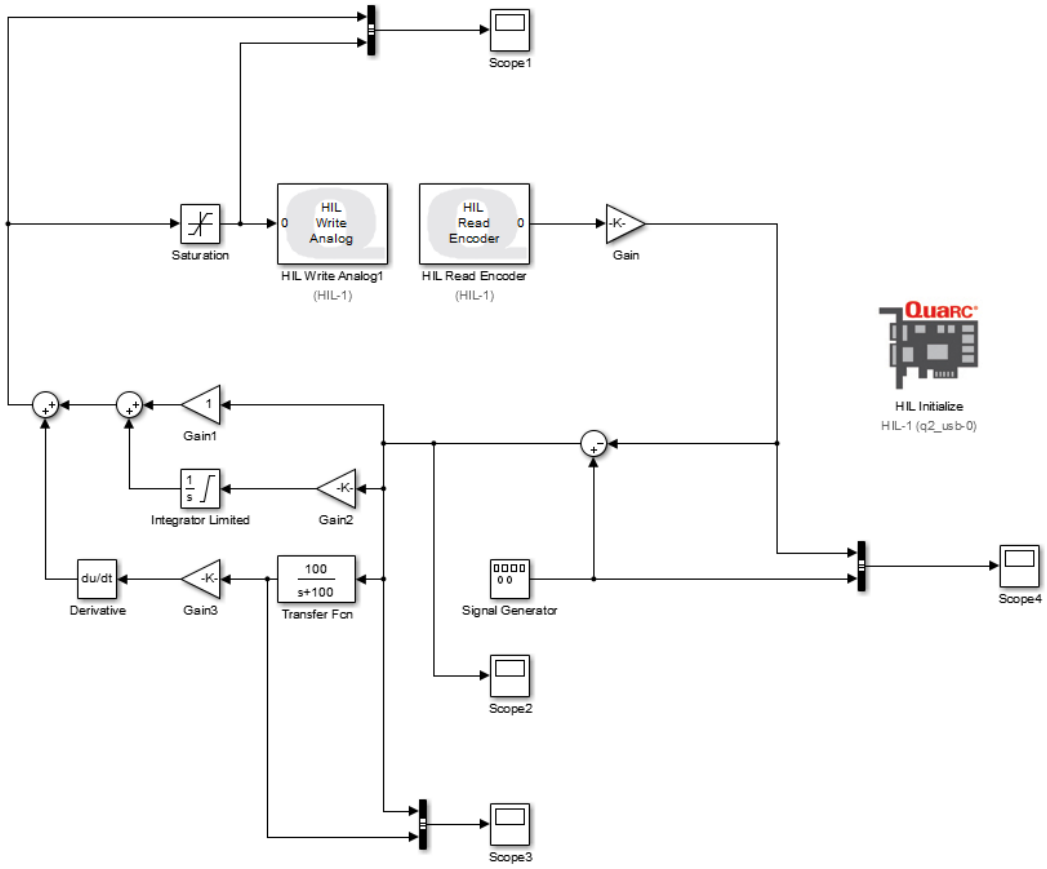
FL. 2018 ESE 447.02 Robotics Lab

Lab Journal 5

9/29/2018

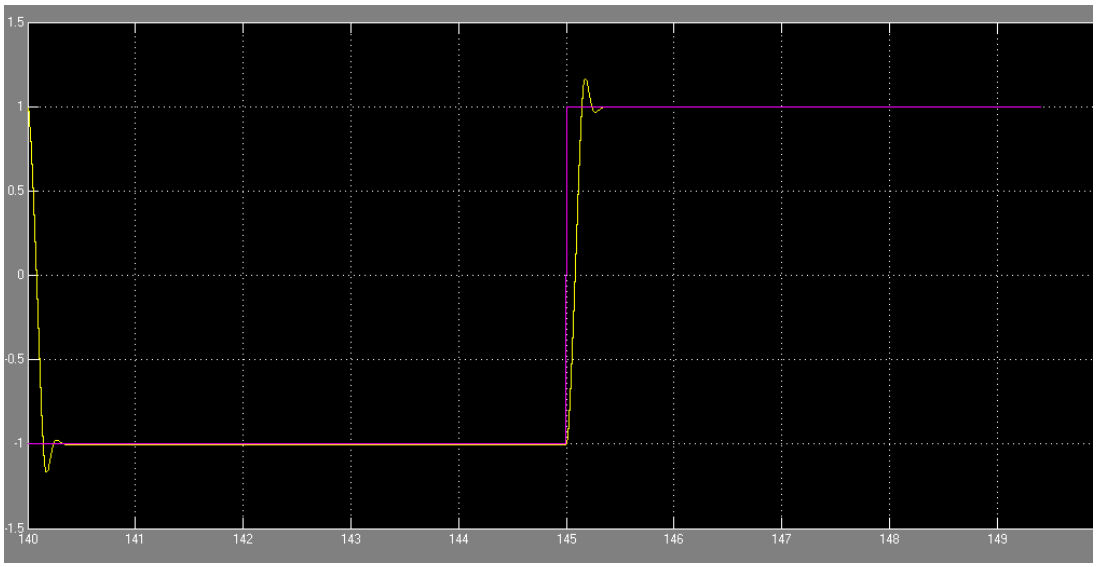
1. Continue building the model in Exercise 2.

   The Simulink model built is shown below.

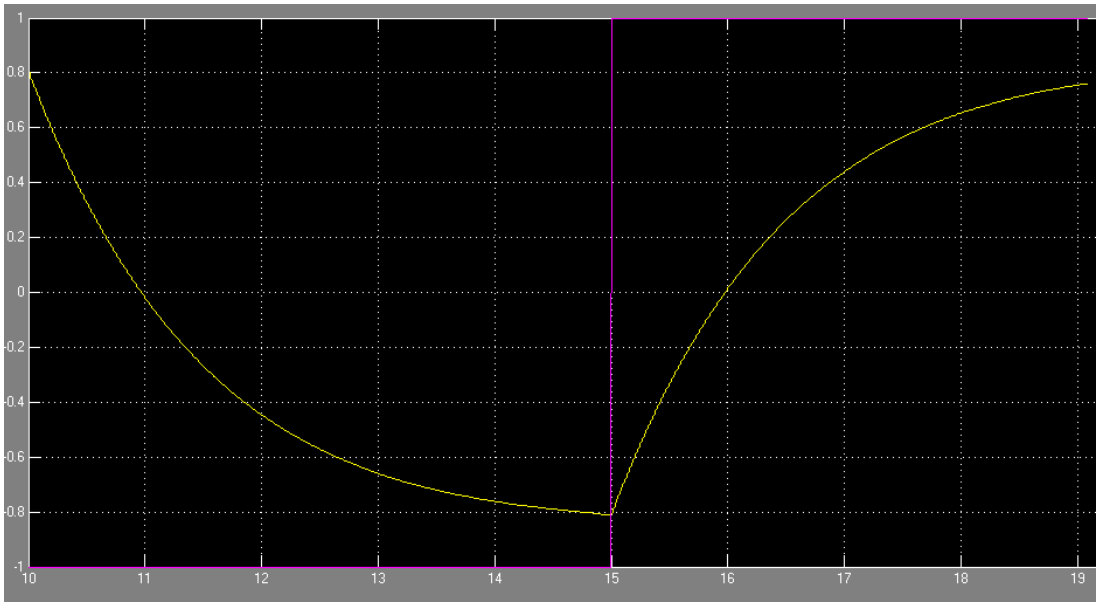


   Note that the gain attached to the Read Encoder is set to -2*pi/4096, which is different from previous exercises. This gain can provide a negative feedback. The signal generator is used again to generate the desired input. The Sum block will calculate the difference between the desired signal and the actual position.

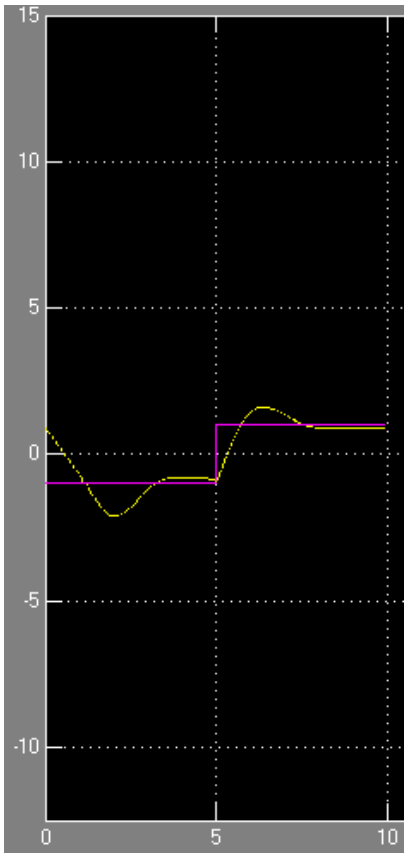
2. Explore the effects of each component of the controller “P”, “I” and “D”.
   (1) Signal plot with P=20, I=D=0.



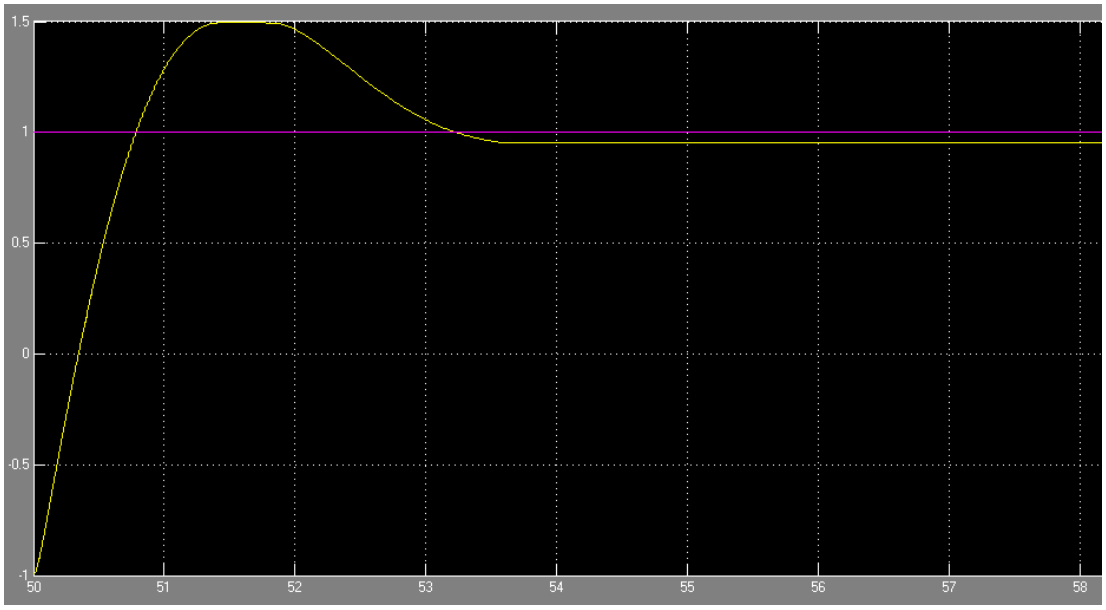
(2) Signal plot with P=1, D=1, I=0.



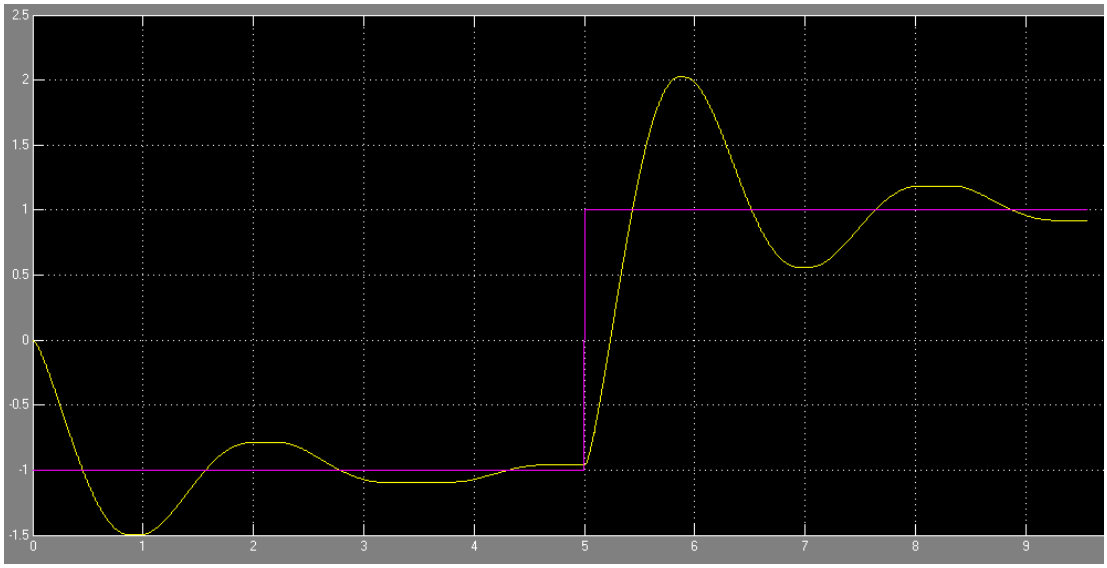
(3) Signal plot with P=1, I=2, D=0.



(4) Signal plot with P=I, I=1.5, D=0.



(5) Signal plot with P=1, I=5, D=0.



Note that the purple line is the input signal and the yellow line is the collected data.

By comparing the performance with different P, I, D values, we observed that a higher P value can result in a faster rotating speed of the arm, and higher speeds are more likely to cause overshoot and when the speed is too high, the motor can be possibly damaged due to overload.

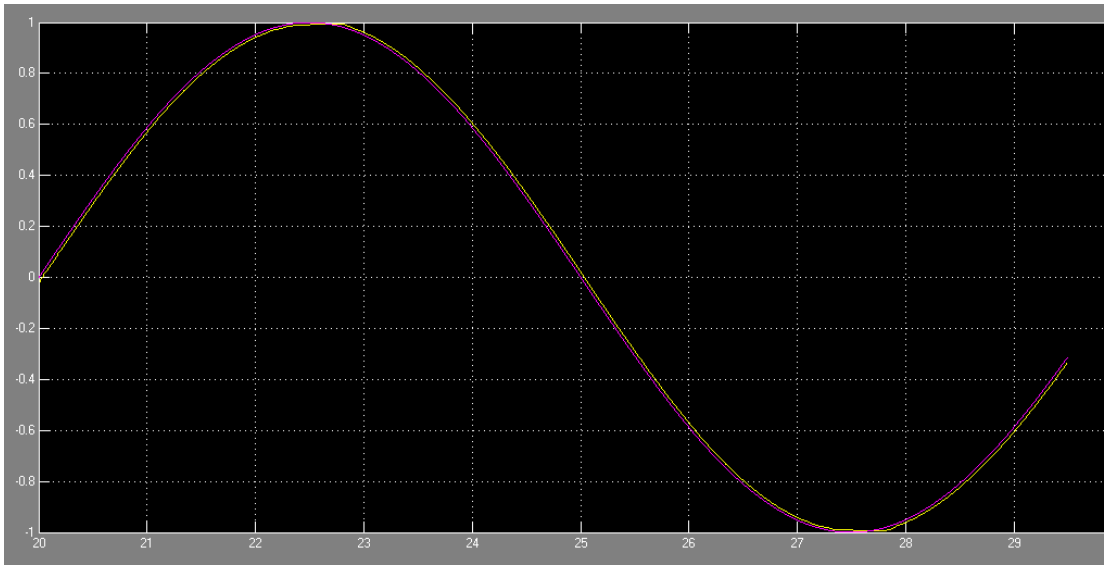
The I term increases action in relation to the time. A higher I value will cause a longer response time, because the integration of the error increases over time and the initial error is small. A pure I controller can bring the error to 0 but it will takes much longer than a pure P controller.

The D term does not consider the error and a pure D controller cannot bring the error to 0. It considers the rate of change of the error, which means it aims at the error trajectory into a horizontal line, damping the force applied and so reduces the overshoot.

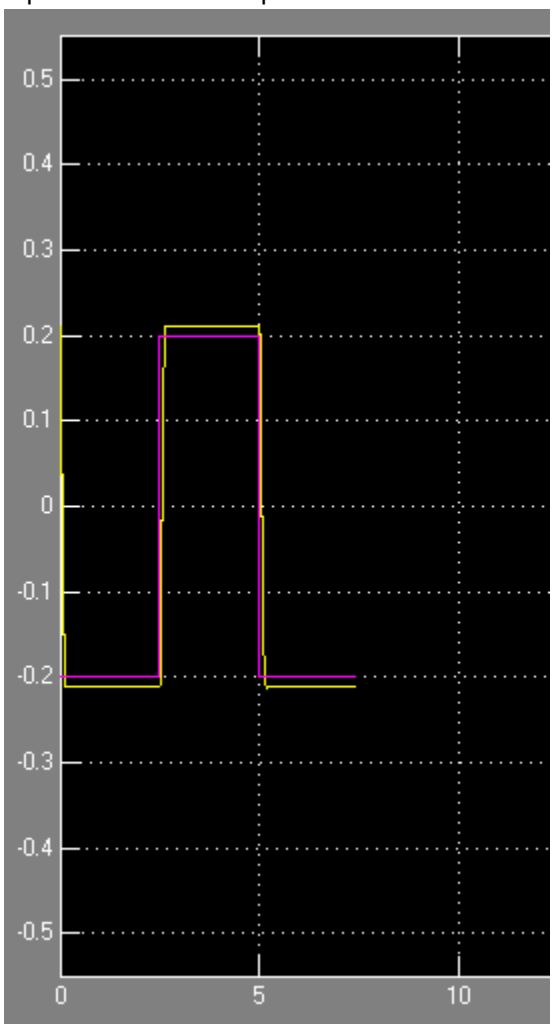
A good combination of P, I and D values will help get a good system response performance.

3. Oscillate the system with various input waveforms.

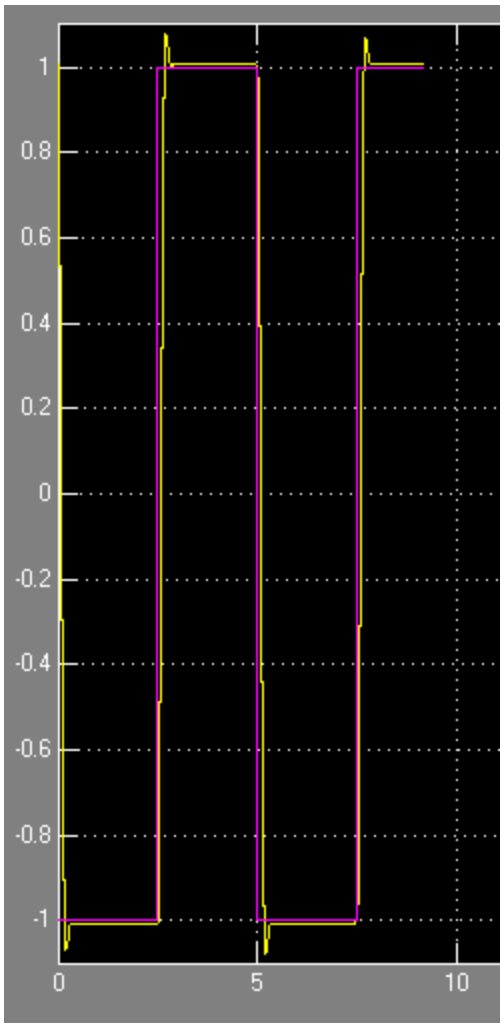
(1) Sine wave input



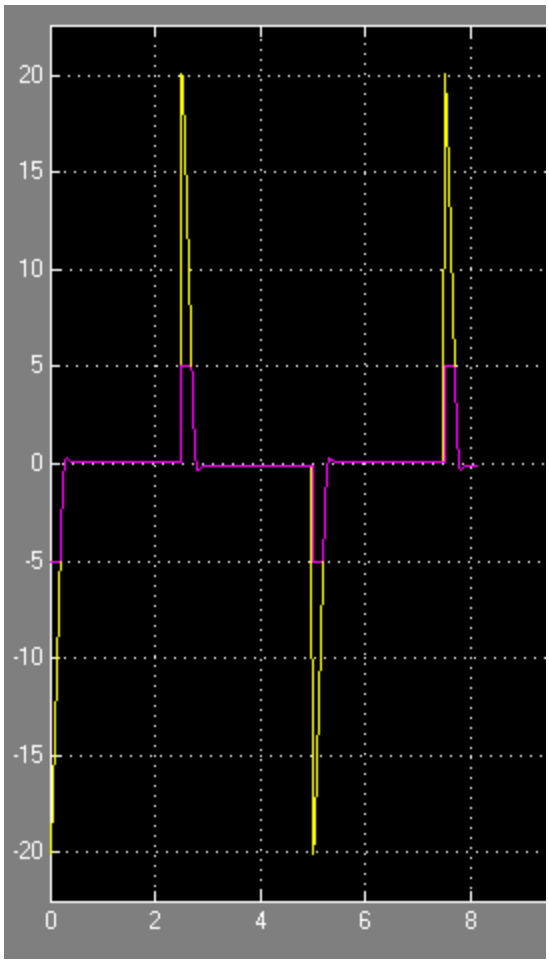
(2) Square wave with amp=0.2



(3) Square wave with amp=1



(4) Triangle wave with saturation bound lower than the input signal.



Note that this also shows how the saturator block works.

4. Task 3. Move the link to any given θ and hold the position.
   This can be achieved by giving the system an input of a constant. The only difficulty to do this is to adjust the PID parameters to appropriate values so that the link can rotate to the desired position in a considerably small amount of time and the accuracy can also be controlled.
5. Questions and answers
   (1) Could you use this device as a position control device?
   Yes. This device has more advantages over the previous exercise since it can stop at a specified position.
   (2) What is the shape of the motion when looking at the position using the scope?
   The shape is observed is similar to the shape of the input signal, but it is deformed to different extends based on the PID parameters. There could be damping, shifting and overshooting in the shapes.
   (3) Can you control the shape of the motion while oscillating?
   Yes. The shape can be controlled by using different parameters. The D parameter is especially related to damping.
   (4) What can you say about the speed of the link throughout the entire oscillating region?
   The speed is not uniform.
   (5) Can you predict the shape of the motion if the SRV-02 would be tipped on its side?

The frequency of the shape will be smaller, meaning the shape will be stretched out.

(6) Does this controller have any predictive nature?
The performance of the controller can be optimized according to the mass and other properties of the system.

(7) What is the primary effect of “P” in the transient region when the system is subjected to a step input?
The proportional controller will have the effect of reducing the rise time and will reduce but never eliminate the steady-state error.

(8) What is the primary effect of “P” in the steady state region when the system is subjected to a step input?
In the steady state region, the P will affect the accuracy of the system since it will enlarge the error.

(9) What is the primary effect of “I” in the transient region when the system is subjected to a step input?
The integral control will have the effect of eliminating the steady-state error, but it may make the transient response worse.

(10) What is the primary effect of “I” in the steady state region when the system is subjected to a step input?
In the steady state region, the integration part will keep adjusting the system as long as there is a slight difference between the input and the output.

(11) What is the primary effect of “D” in the transient region when the system is subjected to a step input?
The derivative control will have the effect of increasing the stability of the system, reducing the overshoot, and improving the transient response.

(12) What is the primary effect of “D” in the steady state region when the system is subjected to a step input?
The D controller does not have much effect on the steady region.