QUANSER INNOVATE·EDUCATE

Lab Procedure

Filtering Virtual

Introduction

1. Make sure you have Quanser Interactive Labs open in the Qube 3 - DC Motor → Servo Workspace.

2. Launch MATLAB and browse to the working directory that includes the Simulink models for this lab.

Based on the model developed in the Hardware Interfacing lab, the goal is to design a model that measures the servo velocity using the encoder as shown in Figure 1. Use qs3_filtering.slx as a starting point.

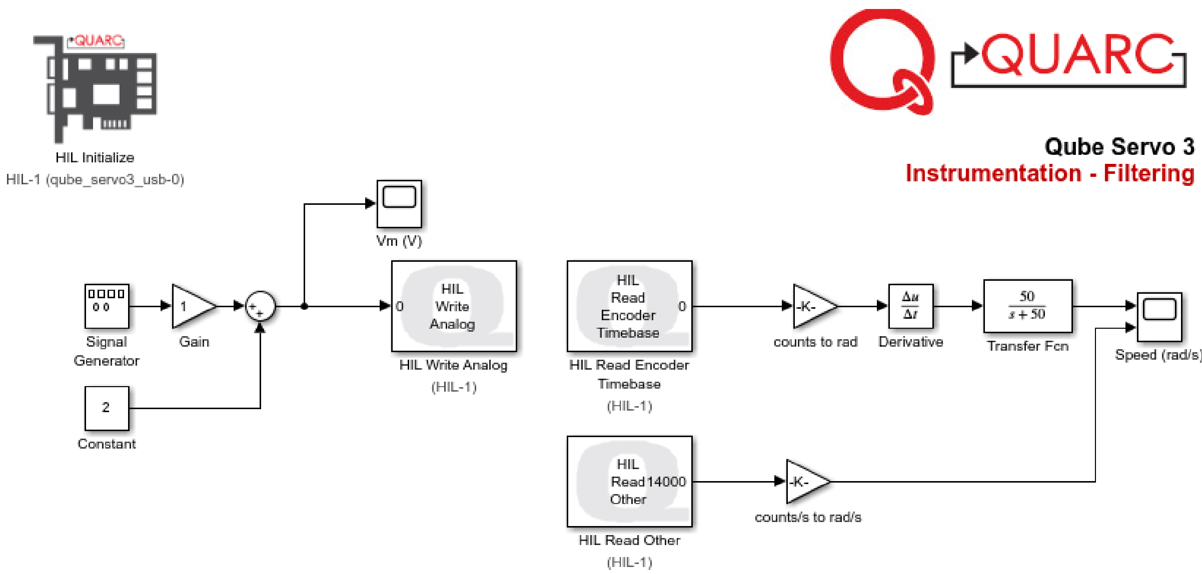


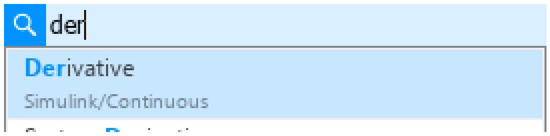
Figure 1. Measuring speed using the encoder

Configuration

1. Take the model you developed in the Hardware Interfacing lab or qs3_filtering.slx. Change the encoder calibration gain to measure the gear position in radians (instead of degrees). What is the value of your gain?

2. Build the Simulink diagram shown in Figure 1 but, for now, do not include the `Transfer Fcn`.

   a. Derivative – add a `Derivative` block to the encoder calibration gain output to measure the gear speed using the encoder (in rad/s). For all blocks, you could search in the Library Browser, however, you could also double click in an empty part of the model and type the block you are looking for to place it.

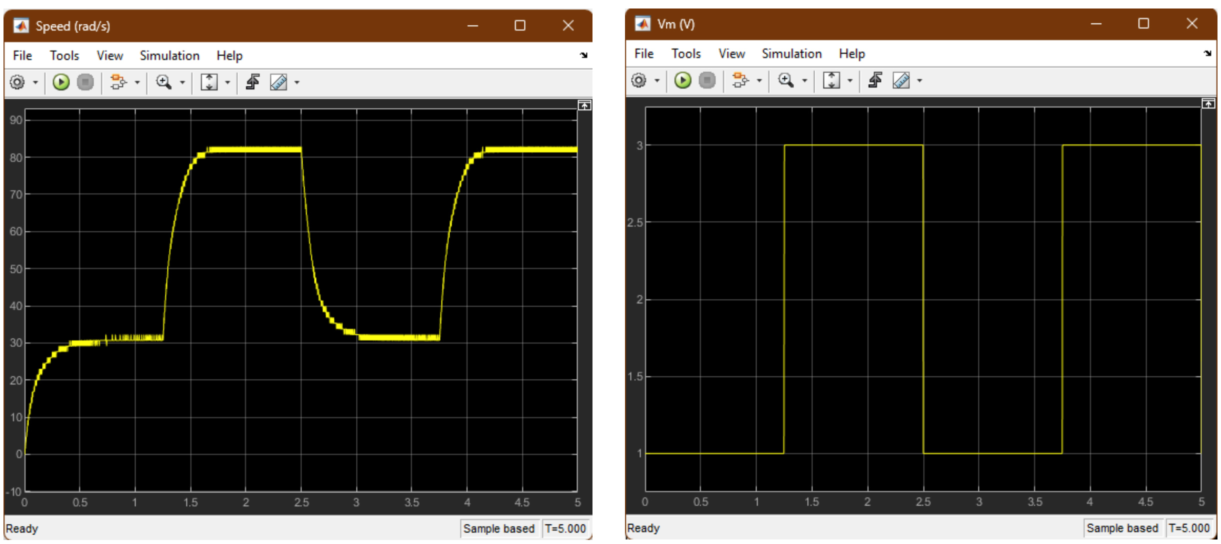


b. Scope – connect the output of the `Derivative` to a `Scope`.

3. Using the `Signal Generator` block, set it up to output a square wave with an amplitude of 1V at 0.4Hz. Use a Sum block as shown in Figure 1, to convert the output from -1V to 1 V to a square wave between 1 and 3 V.

4. On the `Simulation` tab, set the Stop Time of the model to 5 seconds. This will make sure your model stops exactly at the 5 second mark instead of having to manually stop it. If you want it to run indefinitely, set the time as inf.

5. Run the QUARC controller using the `Run` button on the `Simulation` tab. For more information on this, refer to the Hardware Interfacing lab. Examine the encoder speed response and motor voltage plots, and take screenshots. They should look like Figure 2.



a. Encoder speed

b. Motor voltage

Figure 2. Measured servo speed using encoder

6. One way to remove some of the high-frequency components is adding a low-pass filter (LPF) to the derivative output. Add a `Transfer Fcn` block, this could be by double clicking on an empty part of your model and typing it out or from the `Simulink | Continuous Simulink library`. Place this block after the `Derivative` output and connect the output of the `Transfer Fcn` to the `Scope`. Set the `Transfer Fcn` block to a cutoff frequency of 50rad/s so that your block shows $50/(s + 50)$, as illustrated in Figure 1.

7. Run the QUARC controller using the `Run` button on the `Simulation` tab. Take screenshots of the filtered encoder-based speed response and the motor voltage. Has it improved with respect to step 5?

8. Vary the cutoff frequency ω_f between 10 and 200 rad/s. What effect does it have on the filtered response?

9. The Qube-Servo also has a built-in digital tachometer which allows us to read the speed of the servo in couts/s. Use the `HIL Read Other` block in the model.

10. Double click on that block, and on the pop-up menu, click on the three dots next to Channels. Select Tachometer 0 on channels available and use the arrows >> to move it into channels selected. This will make sure you are reading the tachometer from the servo. This should look like figure 3. Click OK on both dialogs to close them.

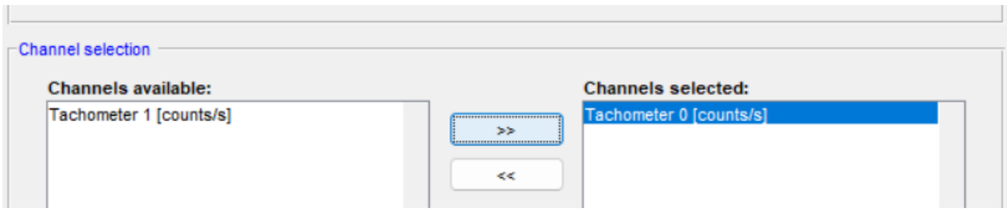
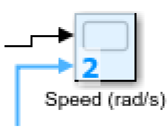


Figure 3. Reading servo tachometer

11. Create a copy of your gain that converted counts to rad and paste it after your `HIL Read Other`. This will now convert your counts/s to rads/s.

12. Drag the output from that block into your speed scope. It will create a second input port once you bring it closer with your mouse.



13. Run the QUARC controller using the `Run` button on the `Simulation` tab. Take screenshots of the new response comparing the filtered encoder-based speed response and the speed response using the tachometer.

14. Has it improved with respect to step 14 or what are the differences? Your second input into your speed scope is the blue line. Note the differences between using the tachometer against using the derivative and a filter.

15. Close your model.

16. Close Quanser Interactive Labs.