CONTROL LABORATORY ENG5022
SERVO-MOTOR CONTROL AND SYSTEM SIMULATION – CONTINUOUS AND DIGITAL
PART 2

This is **Part 2** of the lab handout. This part covers the procedures for the **online lab**.
You must have completed Part 1 before continuing with this part.

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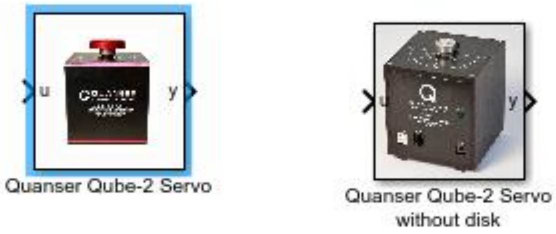
2 PART 2: EVALUATION WITH REALISTIC MODEL

2.1 OPEN-LOOP SYSTEM

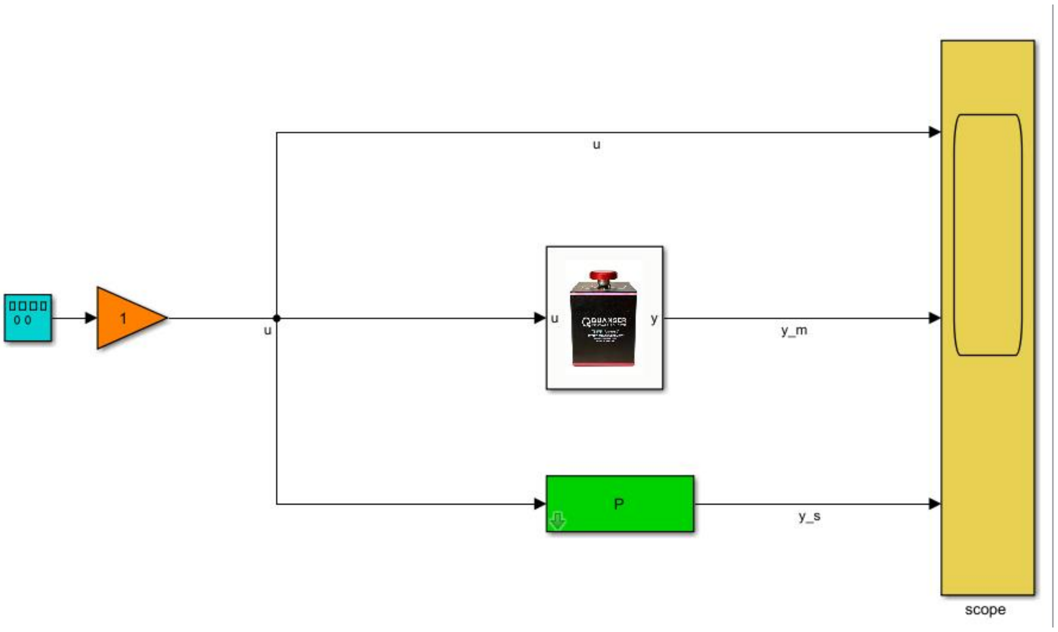
You will now evaluate how well the linear model corresponds with a realistic model which approximates the true servo system.

2.1.1 COMPARISON OF SIMULATION MODEL AND REAL SYSTEM

Create an open-loop model, such as the one made before, but this time the `sys` transfer function block is replaced with a realistic simulation of the system. Download the Simulink library *qube2servo.slx* from the lab section on the Moodle page and open it. You will find two blocks in this model:



Copy the block named *Quanser Qube-2 Servo* (which provides a realistic simulation of the servo system) to your Simulink model. You could also run, in parallel and simultaneously, the model of the plant developed before, to compare the results, such as in Model 1 below. **Save this model under meaningful name (e.g. as `model_5`)**



Model 1. Open-loop system comparing the simulated plant and the actual servo-motor.

Make sure you set up the Scope block as explained on page 9!

Note that we have used, as a signal source, a *Signal Generator* block, which allows to generate various types of signals, and not only a sinusoid. For now, we are interested in sinusoidal inputs, so make sure that the "wave form" is set to "sine" with unit amplitude.

You will now record data from the model and the system for a sinusoidal input with a frequency of 1 rad/s.

Make sure that the value of the Gain block is set to `1`, and check that the frequency in the *Sine Wave* (or *Signal Generator*) block is 1 rad/s.

Run the simulationfor 60 seconds.

Change the sine wave frequency to 5 rad/s and repeat the experiment!

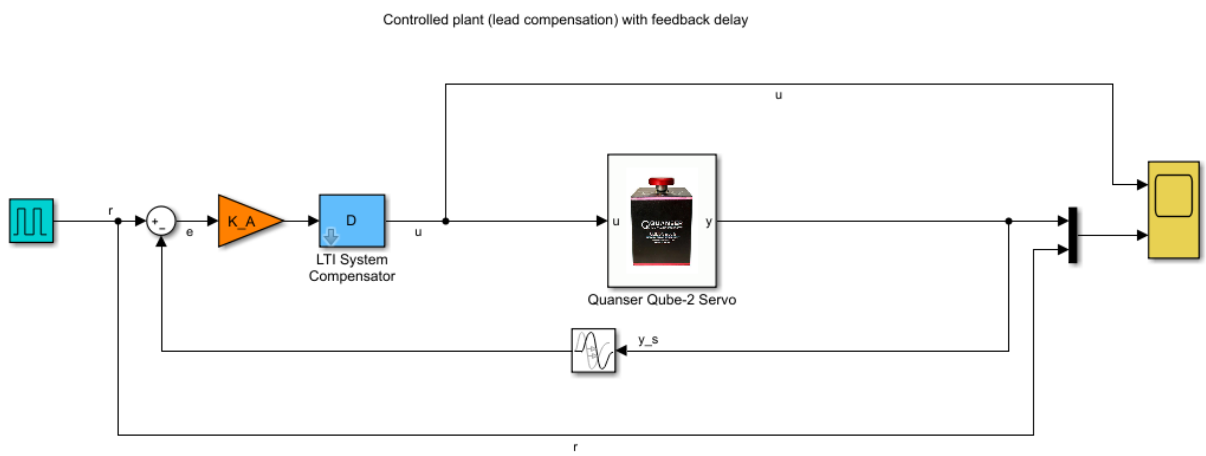
Q2.1: Plot the output of the model simulation and the measured output for an input frequency of 1rad/s and 5 rad/s and include them in your report. Note down possible reasons for the differences between them:

2.2 Continuous Feedback Control of the Real Servo System

Based on the simulation analysis, you will now evaluate the feedback controller with the real servo system.

You should choose the controller gain **`K_B = 2.23`** from the simulation in the previous section which should result in a controller with good properties to regulate the position of the servo system.

Starting from your Error! Reference source not found. **from the first part of the lab, replace the linear plant model with the realistic simulation block which you used in Model 5, to obtain a system similar to Model 6 shown below**.



Model 2. Feedback system with proportional gain and hardware-in-the-loop

Enter the feedback gain you have chosen (`K_B=2.23`) into the gain block in the model. The time-delay in the *Transport Delay* block should be set to 0.

Execute the real time simulation and compare the behaviour with that of the closed loop system model which you have evaluated in the previous section.

Q2.2: Plot the output `y_s` and the reference and include these in your report. Give reasons why the behaviour of the real system is different from that of the simulation with the mathematical model.

Now try using `K_B = 0.2` and repeat the experiment. Observe how the behaviour of the closed loop system changes. Relate this to the system analysis you have done in the previous section.

Add a delay time in the feedback path and increase its value. You should start with a delay which is much smaller than the delay margin which you have calculated for this feedback gain earlier. Evaluate the result.

Q2.3: Describe the behaviour of the real servo system for different delays. Include relevant plots in your report. Does it become unstable, like the mathematical model? Try to explain the difference in behaviour between the real servo system and the mathematical model.

2.2.1 Modified System Characteristics

In this part of the experiment, we will evaluate how the feedback control system changes when the physical properties of the servo plant change. We will remove an additional load from the output of the servo.

Replace the model of the servo with the block *Quanser Qube-2 Servo without disk* from the Simulink library *qube2servo.slx* and run the simulation.

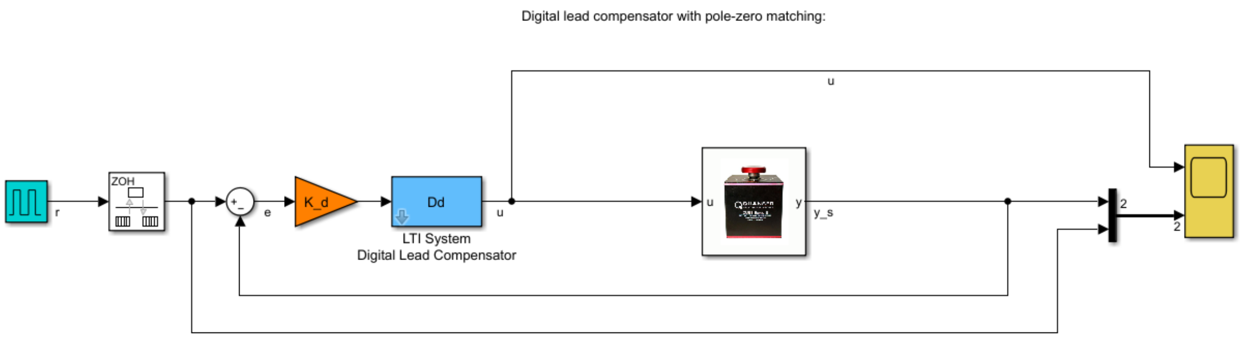
Q2.4: Which physical values of the system have changed? Has this affected the behaviour of the closed loop system?

2.3 REAL-TIME DIGITAL IMPLEMENTATION

We will now test the digital controller.

Create a feedback loop with the digital compensator and the gain calculated, as shown in Model 3 below. You need to **insert a "Rate Transition" block** after the "Pulse Generator" to ensure that the sample rates are set correctly.

Set `T` to the same value for which you have designed `Dd` (i.e. `T = 0.01`).



Model 3. Digital feedback system with lead compensator and simulated hardware-in-the-loop

Run the simulation. Open the *Scope* (double click on the block if it is not visible).

Q2.5: Use the report to plot and compare the time histories of the continuous (Model 2) and the digital (Model 3) versions of this controller. How does the performance compare in terms of overshooting and settle time?

2.3.1 *EFFECT OF THE SAMPLE TIME*

We will now increase the sample time, and re-assess the performance of the controller.

Set the sample time to `T = 0.04` in the MATLAB workspace. Use the parameters of the re-computed discrete compensator `Dd` and its gain `K_d` for the new sample time.

You can now run the feedback system with `T = 0.04`.

Q2.6: Use the report to plot the time history of the output and discuss how the real plant is affecting the stability. Is it still stable?