



Lab Procedure

State Space Modeling Virtual

Introduction

Ensure the following:

- 1. You have reviewed the Application Guide State Space Modeling
- 2. Make sure you have Quanser Interactive Labs open in the Qube 3 DC Motor → Servo Workspace.
- 3. Launch MATLAB and browse to the working directory that includes the Simulink models for this lab.

The **Hardware Interfacing** and **Filtering** labs explained the basic blocks to read and write from the Qube-Servo 3. For simplicity, all labs forward will use a Qube-Servo 3 block that sets up the system beforehand and outputs the available information from the Qube.

Using the gains found to convert tachometer counts/s into rads/s from the instrumentation labs. Use the qs3_ss_model.slx.

In this lab, the goal is to create a state space representation of the DC motor equations of motion. The calculated representation will then be compared to the physical response of the Qube-Servo 3. The Simulink model shown in Figure 1 applies a 5V step to the Qube-Servo 3 and the state space model of the servo. The measured and modeled speed responses are plotted in the same scope for comparison.

Qube Servo 3 Modeling - State Space Modeling

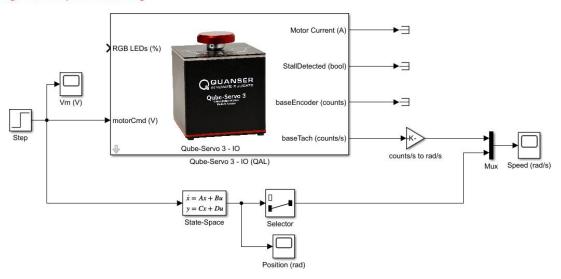


Figure 1: A 1V step input to a Qube-Servo 3 and its state space representation.

Creating the State Space Representation

1. Formulate the differential equation relating the motor position, θ_m , and its derivatives with the motor input voltage, $v_m(t)$.

Start with the motor electrical equation:

$$v_m(t) - R_m i_m(t) - k_m \dot{\theta}_m(t) = 0$$

The motor shaft equation:

$$J_{eq}\ddot{\theta}_m(t) = \tau_m(t)$$

And the torque equation based on current:

$$\tau_m(t) = k_t i_m(t)$$

2. Derive the state space representation of the DC motor from the differential equation you obtained above. Use the following state variables:

$$x_1=\theta_m(t)$$
, $x_2=\dot{\theta}_m(t)$, $y_1=\theta_m(t)$, and $y_2=\dot{\theta}_m(t)$ (measuring motor position and speed) and the input variable $u=v_m$.

- 3. Open qs3_ss_script.m which should be in the same folder as this file into your MATLAB workspace. The file does the following:
 - a. Loads in the Qube-Servo 3 parameters. If you have done previous labs to calculate any of these values based on your specific Qube, replace those values in qube3_param.m.
 - b. Creates the state space matrices, you should populate it with the real equations and values found in the previous step as the files only has placeholder values.
 - c. Simulates a step response applied to the state space model.
- 4. Save your script and a screen capture of the simulated step response plot.

State Space Validation in Simulink

- 1. Open qs3_ss_model.slx as shown in Figure 1 and modify the tachometer gain. The model should apply a 5V step to the Qube-Servo 3 and its state space model. Start from the model in the Filtering Lab if the model was not provided.
- 2. Run the MATLAB script from the above section to load your state space model parameters into the MATLAB workspace. Click on your model and click Ctrl+D. This will make sure that if the State-Space block was red, it now loads the variables from the workspace and now not show errors.
- 3. Run the QUARC controller using the Run button on the Simulation tab. The response should be similar to the scope in Figure 2.

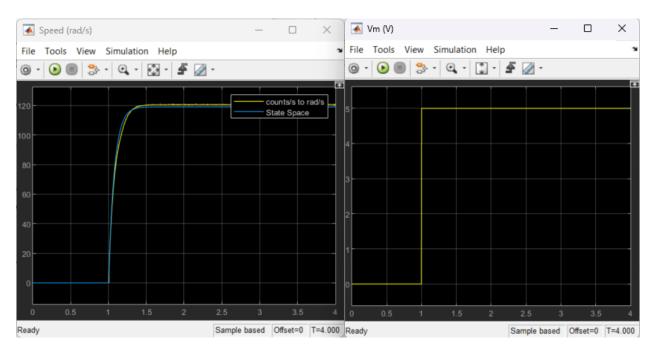


Figure 2: Comparison of the State Space Model with the physical response in the speed scope.

- 4. Take a screenshot of the speed (rad/s) scope.
- 5. Stop your model. Ensure you save a copy of the files for review later.
- 6. Close your model.
- 7. Close Quanser Interactive Labs.