

Qube-Servo 3

State Space Modeling

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- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)

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Qube-Servo 3 – Application Guide

State Space Modeling

What is state space modeling?

State space modeling describes DC motor dynamics using a set of first-order differential equations. This approach uses state variables (such as current, speed, and position) to capture the motor's behavior at any moment.

The model is typically expressed using two main equations: the state equation describing how variables change over time, and the output equation describing the values we can measure or observe. The advantages of this approach is that can easily handle multiple inputs and outputs while helping analyze into system stability and performance. The state space representation is useful for determining important characteristics of a system when doing control.

Background

This is one of multiple labs describing how to model a servomotor. Any of these labs can be done in any order. These modeling labs include modeling through frequency response, step response, parameter estimation, block diagrams and state space.

Prior to starting this lab, please review the following concept reviews (should be located in Documents/Quanser/4_concept_reviews/),

- Concept Review – Modeling & IO → Modeling (Fundamental DC Motor Concepts section). You will need the motor's mechanical torque equations and the electrical equation of a motor.

State Space Representation

The standard statespace representation of a multi-input multioutput (MIMO) continuous lineartime invariant (LTI) system with n state variables, r input variables, and m output variables is:

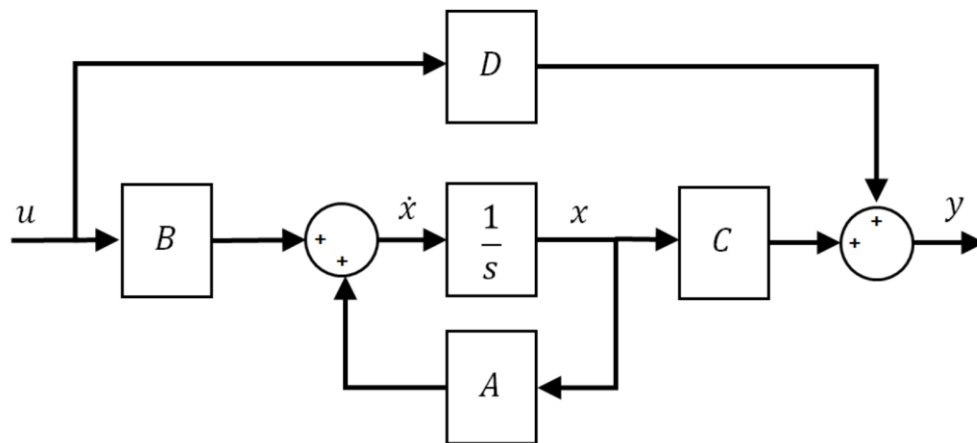
$$\dot{x}(t) = Ax + Bu$$

$$y(t) = Cx(t) + Du(t)$$

Where:

- x is the vector of state variables ($n \times 1$),
- u is the control input vector ($r \times 1$)
- y is the output vector ($m \times 1$)
- A is the system matrix ($n \times n$)
- B is the input matrix ($n \times r$)
- C is the output matrix ($m \times n$), and
- D is the feedforward matrix ($m \times r$).

The block diagram representation of statespace of the equations above is shown below:



State-Space Block Diagram

Getting started

The goal of this lab is to create the state space representation for the DC motor equations of motion. A Simulink model will be used to compare the created state space model with the real life response of the Qube-Servo 3.

Ensure you have completed the following labs

- **Hardware Interfacing Lab**
- **Filtering Lab**

Before you begin this lab, ensure that the following criteria are met.

- If using a physical Qube-Servo 3, make sure it has been setup and tested. See the Qube-Servo 3 Quick Start Guide for details on this step. Make sure the inertia disc load is attached to the Qube-Servo 3.
- If using the virtual Qube-Servo 3, make sure you have Quanser Interactive Labs open in the Qube 3 - DC Motor → Servo Workspace.
- You are familiar with the basics of Simulink. See the [Simulink Onramp](#) for more help with getting started with Simulink.