



Qube-Servo 3

Stability Analysis

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中国客户 Quanser Consulting Inc. 关于关于限制在电子电气设备中使用某些有害成分的指令 (RoHS)。

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This product meets the essential requirements of applicable European Directives as follows:

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

Warning: This is a Class A product. In a domestic environment this product may cause radio interference, in which case the user may be required to take adequate measures.

Qube-Servo 3 – Application Guide

Stability Analysis

What is Stability?

Stability analysis determines whether a control system will produce bounded outputs for bounded inputs, making it a fundamental aspect of control system design. Stability in control systems describes a system's ability to reach and maintain a steady, controlled state after experiencing a disturbance. A stable system goes back to equilibrium or follows its intended reference signal when disturbed, while an unstable system's output grows or oscillates uncontrollably. An unstable system can cause many problems, from damaged equipment, to catastrophic failures, such as an aircraft losing control, or industrial robots making dangerous movements. Stability is quantified through mathematical analysis of the system's characteristic equation and its poles.

Background

This lab is part of the Analysis skills progression of the Qube-Servo 3. This will help you understand how to analyze the motor response and its stability using different methods.

The lab progression is as follows:



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 > Basic Motor Equations > Transfer Functions section).

Transfer Functions of a Qube-Servo

The voltage $V_m(s)$ to speed $\Omega_m(s)$ transfer function of a DC motor is:

$$\frac{\Omega_m(s)}{V_m(s)} = \frac{K}{\tau s + 1}$$

The voltage $V_m(s)$ to position $\Theta_m(s)$ transfer function is

$$\frac{\Theta_m(s)}{V_m(s)} = \frac{K}{s(\tau s + 1)}$$

Where:

- K is the model steady-state gain
- τ is the model time constant
- $\Omega_m(s) = L[\omega_m(t)]$ is the Laplace transform of the motor/disc speed
- $\Theta_m(s) = L[\theta_m(t)]$ is the Laplace transform of the motor/disc position, and
- $V_m(s) = L[v_m(t)]$ is the Laplace transform of the applied motor voltage.

Note how the voltage to position transfer function is the same as the first equation with an integrator in series. It multiplied by $1/s$ to integrate it in time to find the position of the motor.

If no modeling lab has been done, for Qube-Servo 3, $K = 24$ and $\tau = 0.1$ are good defaults, however, the Step-Response lab in the modeling skills progression will walk you through an easy experiment to figure those variables specifically for your servo.

Stability

Definition for Bounded-Input Bounded-Output (BIBO) stability is:

1. A system is stable if every bounded input yields a bounded output.
2. A system is unstable if any bounded input yields an unbounded output.

The stability of a system can be determined from its poles:

- Stable systems have poles only in the lefthand plane.
- Unstable systems have at least one pole in the righthand plane and/or poles of multiplicity greater than 1 on the imaginary axis.
- Marginally stable systems have one pole on the imaginary axis and the other poles in the lefthand plane.

Getting started

In this lab you will analyze the stability of the system based on poles and the definition of Bounded-Input Bounded-Output (BIBO) stability.

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.