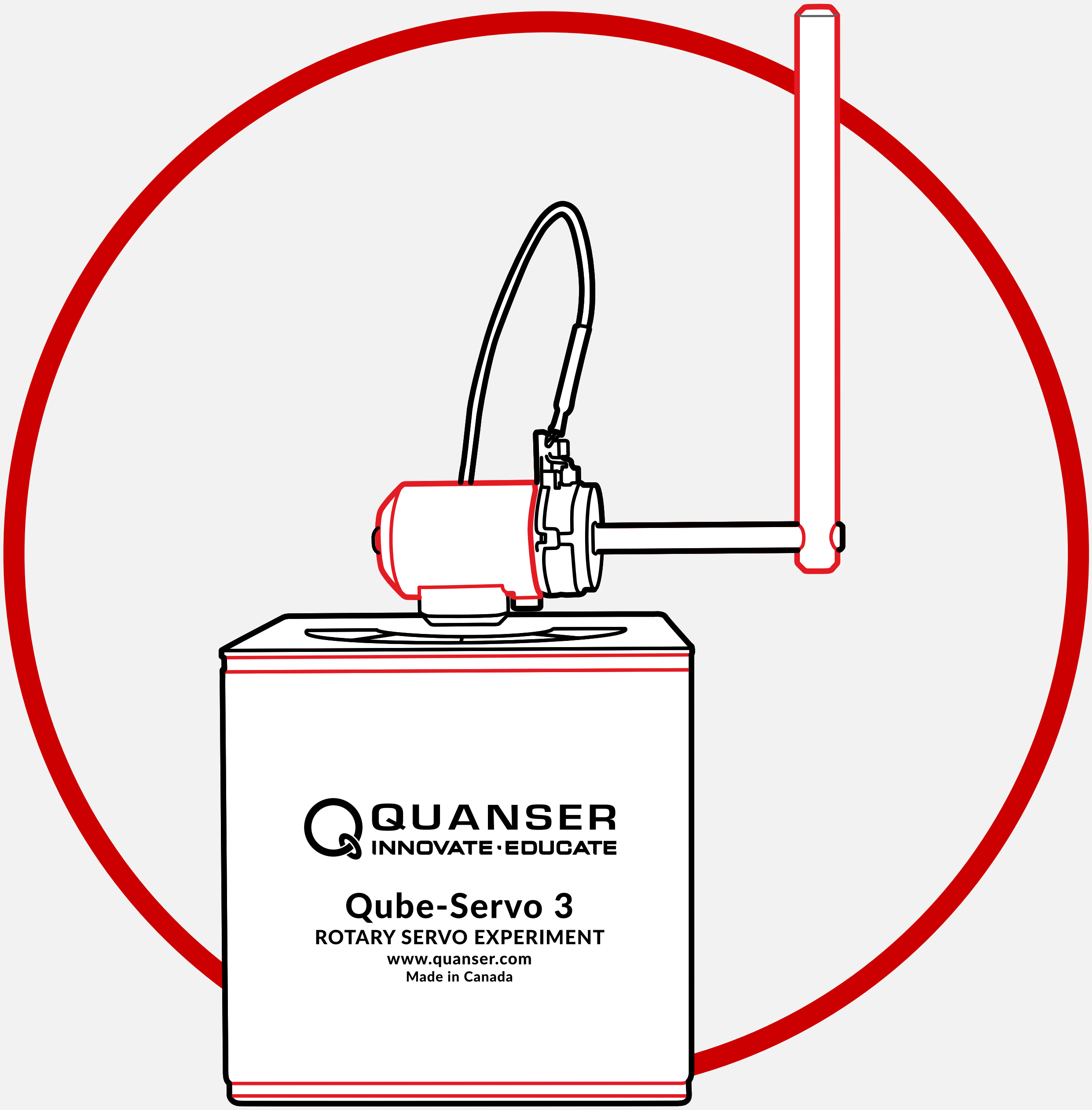

Qube-Servo 3

Proportional Control

V1.2 – 27th February 2025

For more information on the solutions Quanser offers, please visit the web site at: http://www.quanser.com

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Caution

This equipment is designed to be used for educational and research purposes and is not intended for use by the public. The user is responsible for ensuring that the equipment will be used by technically qualified personnel only. Users are responsible for certifying any modifications or additions they make to the default configuration.

FCC Notice This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.
Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

Industry Canada Notice This Class A digital apparatus complies with CAN ICES-3 (A). Cet appareil numérique de la classe A est conforme à la norme NMB-3 (A) du Canada.
Japan VCCI Notice This is a Class A product based on the standard of the Voluntary Control Council for Interference (VCCI). If this equipment is used in a domestic environment, radio interference may occur, in which case the user may be required to take corrective actions.

この装置は、クラス A 情報技術装置です。この装置を家庭環境で使用すると電波妨害を引き起こすことがあります。この場合には使用者が適切な対策を講ずるよう要求されることがあります。 VCCI–A

Waste Electrical and Electronic Equipment (WEEE)
This symbol indicates that waste products must be disposed of separately from municipal household waste, according to Directive 2012/19/EU of the European Parliament and the Council on waste electrical and electronic equipment (WEEE). All products at the end of their life cycle must be sent to a WEEE collection and recycling center. Proper WEEE disposal reduces the environmental impact and the risk to human health due to potentially hazardous substances used in such equipment. Your cooperation in proper WEEE disposal will contribute to the effective usage of natural resources.

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CE Compliance CE

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.

Proportional Control

What is Proportional Control?

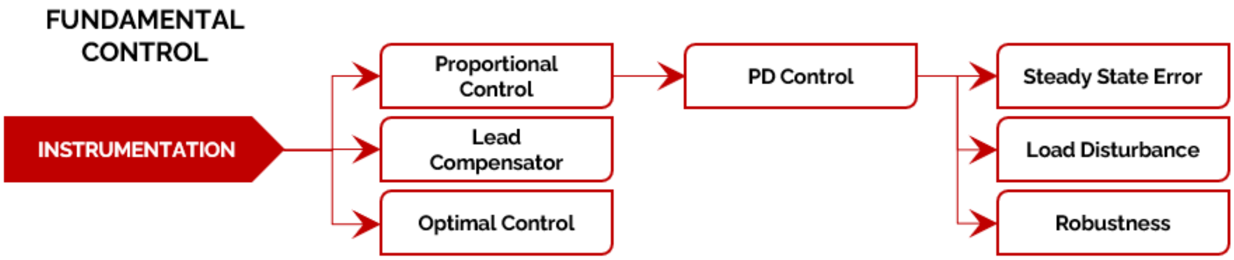
Proportional control is a control algorithm that adjusts the control variable in proportion to the error between the desired value and the measured current value. The goal of proportional control is to minimize the steady-state error between the system's output and the desired reference input.

The key benefit is its simplicity. By directly applying a control proportional to the error, the system can quickly react to changes and maintain the current value near the setpoint. This makes proportional control good for applications that require fast response times, such as temperature regulation or motor speed control. However, one limitation of proportional control is that it cannot completely eliminate steady-state error.

Background

This lab is part of the Fundamental Control skills progression of the Qube-Servo 3. This will give you hands-on experience in applying fundamental control techniques to a DC motor system. It will help you understand how different control strategies can be used to regulate the motor's speed and position, while also understanding the impact of load disturbances and the importance of system robustness.

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 (Step Response/Second Order Step Response section).
- Concept Review – Controls → PID Control (PID Control, Proportional Control and For Qube-Servo/Proportional Control sections). s

Second Order Systems

Second order systems in DC motor analysis characterize the dynamic behavior of the motor using second-order differential equations. These systems are defined by their natural frequency and damping ratio, which together determine important characteristics like settling time, overshoot, and rise time. Understanding these parameters is crucial for predicting how the motor will respond to various inputs and designing effective control systems.

This will help you describe how quickly your motor speeds up or slows down, and how it might oscillate before settling to its final speed. Useful information can be derived about the DC motor behaviour even before performing any physical experiment.

Final Value Theorem

The Final Value Theorem (FVT) can be used to determine the steady-state or final value of the system output $y(t)$ given its Laplace transform $Y(s)$, For a system with an unstable pole (i.e. a pole in the right half of the s-plane), the final value is unbounded.

If the system is marginally stable with a complex conjugate pole pair on the imaginary axis, the output of the system will be oscillatory, and the final value is not defined. For a stable system response (i.e. all poles of the systems are strictly located in the left half of the s-plane), the following equation is:

$$\lim_{s \to 0} sY(s) = \lim_{t \to \infty} y(t)$$

Steady – State Error

Steady-state error is the difference between the reference input and output signals after the system response has settled. Therefore, for a time t when the system is in steady-state, the steady-state error equals:

$$e_{ss} = r_{ss}(t) - y_{ss}(t)$$

Where $r_{ss}(t)$ is the value of the steady state input and $y_{ss}(t)$ is the steady state value of the output.

We can find the error transfer function in terms of reference $R(s)$, the plant $P(s)$, and the controller $C(s)$. The Laplace Transform of the error is:

$$E(s) = R(s) - Y(s)$$

Getting started

In this lab you will analyze the response of second order systems as well as learn how to create a proportional controller for speed and position of a DC motor. You will experiment with what the proportional gain does the output of the system.

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.