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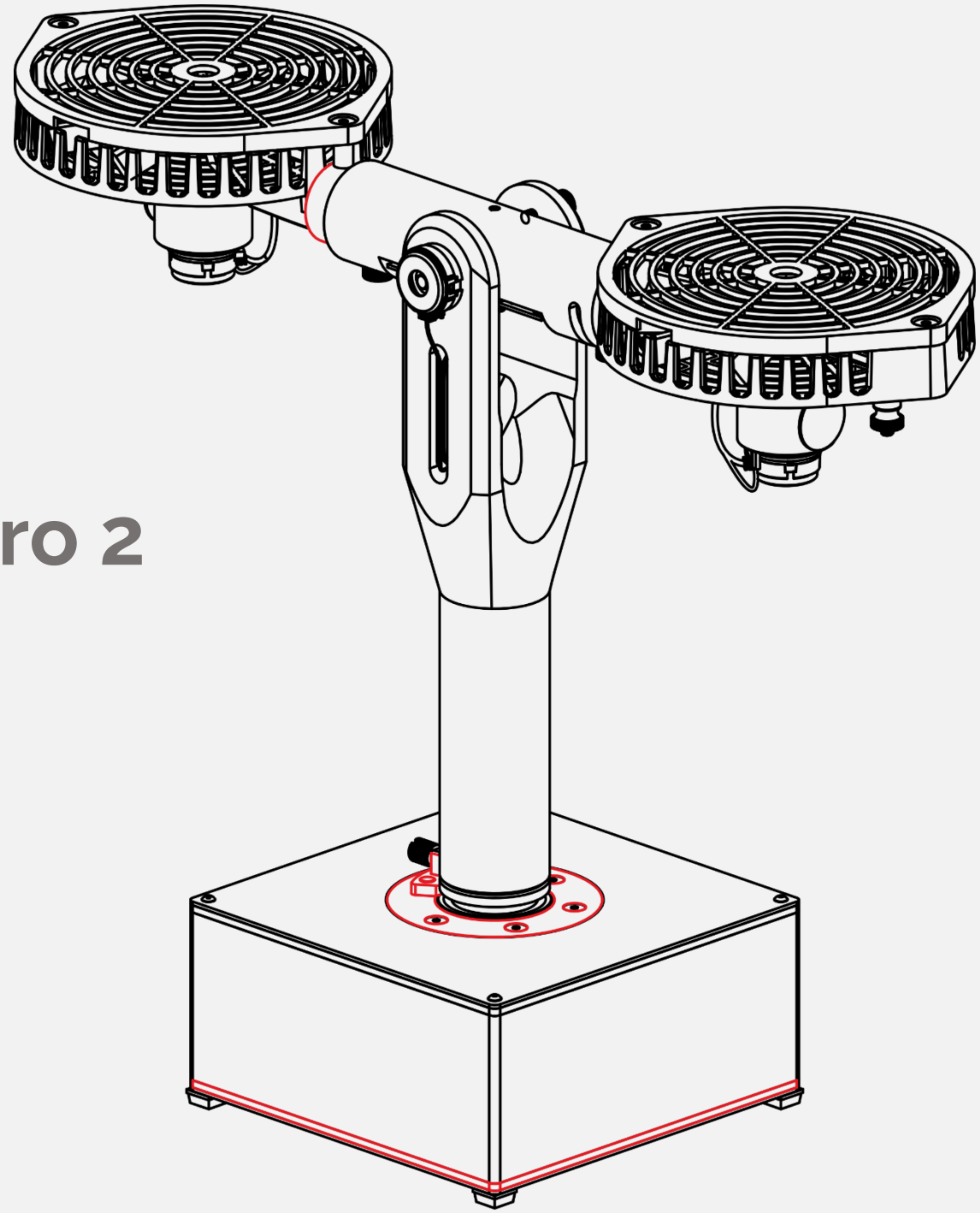

Aero 2

Half-Quadrotor Application Guide

for MATLAB/Simulink

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Aero 2 Application Guide

Half-Quadrotor System

Why Explore the Half-Quadrotor system?

Unmanned quadrotor vehicles have increased in popularity and been used in wide-variety of applications worldwith. Using a tethered half-quadrotor system allows students and researchers to focus on the modeling, control, and parameter estimation in yaw-axis motion of quadrotors, which can then be applied to full quadrotor system..

Topics

- Derive linear equations of motion for the half-quadorotor system
- Transfer function and state-space representation models
- Find the viscous damping and thrust force parameters about the yaw axes experimentally
- Design a PD control to control the position of the yaw axis.
- Simulate the PD control and run PD controller on the actual system
- Design state-feedback control using LQR to control the yaw position
- Simulate the state-feedback control and implement on the system

System Overview

The Aero 2 system can be configured as a half-quadrotor system, as shown in Figure 1. In this set up, both the front and back rotors are horizontal to the ground and only motions about the yaw axis are enabled, i.e., the pitch axis is locked. By changing the direction and speed of the rotors, users can change the yaw axis angle.

Figure 1 – Aero 2 – Half-Quadrotor configuration.

Lab Modules

A summary of the Half-Quadrotor labs supplied is given in Table 1. Each of the lab modules has a MATLAB Live Script. The Live Script include the following:

- Concept review of the modelling or control techniques
- Loads the MATLAB workspace with all the needed parameters.
- Opens the Simulink model for simulation or for QUARC implementation on the hardware.
- Code to analyze the results.

Lab Module/Application	MATLAB Live Script	Description
Modelling/Parameter Estimation	aero2_half_quad_parameter_id.mlx virtual_aero2_half_quad_parameter_id.mlx	Overview of the linear model used in the Aero 2 Half-Quadrotor. Includes the transfer function and state-space model derivations. Measure the thrust force gain and damping of the yaw axis. Model validation.
PD Control	aero2_half_quad_pd_control slx virtual_aero2_half_quad_pd_control mlx	Design a PD controler to control the position of the yaw axes through both rotors.
LQR Control	aero2_half_quad_lqr_control.mlx aero2_half_quad_lqr_control.mlx	Design a state-feedback control using LQR to control the position of the yaw through both rotors.

Table 1 - Aero 2 Half-Quadrotor Lab Modules Provided

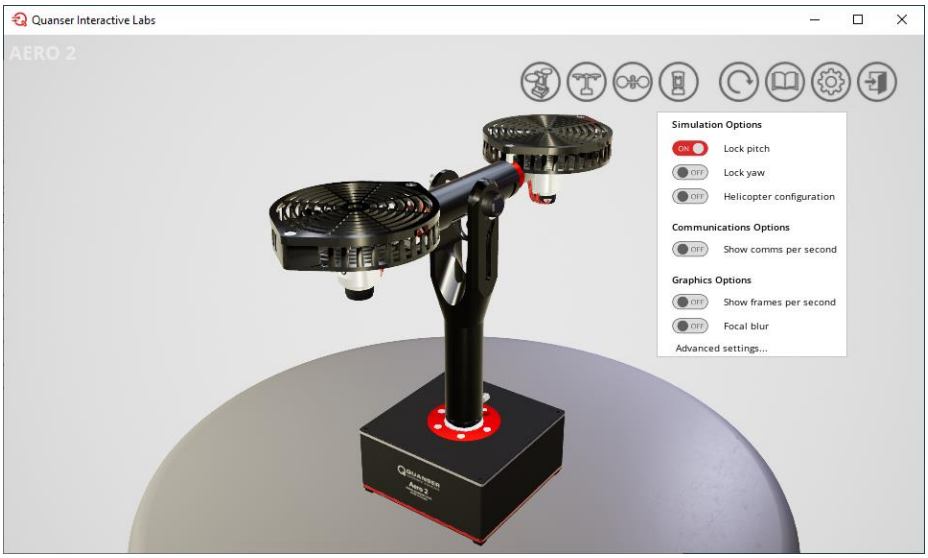
Aero 2 Setup

1. Make sure the Aero 2 has been tested as instructed in the Quick Start Guide.
2. Setup the Aero 2 in the Half-Quadrotor configuration, as shown in Figure 1:
    a. Lock the pitch axis and unlock the yaw axis.
    b. Both rotors are horizontal (i.e., rotor shields are parallel with the ground).
    c. Mount weight on each rotor.
3. Connect the USB cable to your PC/laptop.
4. Connect the power and turn the power switch ON. The Aero base LED should be red

Virtual Aero 2 Setup

1. Launch MATLAB and browse to the working directory that includes the Simulink models for this lab.
2. Run the Quanser Interactive Labs (QLabs) software and login using your account.
3. From the product list select *Aero 2*, then select *Aero 2 Workspace*.
4. Configure the Virtual Aero 2 in the Half-Quadrotor configuration. To do this, click the *Options* button and ensure the following settings are selected
    a. Lock pitch ON
    b. Lock yaw OFF
    c. Helicopter configuration OFF

    The Virtual Aero 2 should look as shown below.



How to Run the Labs

1. Launch MATLAB.
2. Browse to the working directory that includes the Simulink models for the lab.
3. Open the Live Script for the lab, e.g., aero2_half_quad_pd_control.mlx.
4. Go through each section by clicking on the *Run Section* button.
5. Run the Simulink model for simulations and the Virtual Aero 2. Use QUARC to run the model on the Aero 2 hardware.