QBALL-X4 QUICK START GUIDE

A STEP BY STEP GUIDE TO FLY THE QBALL-X4 UAV

This is a step by step guide to fly the Qball-X4 unmanned aerial vehicle. It is highly recommended to follow this guide particularly if this is the first time flying the Qball. Please read the Qball User Manual first before attempting to fly the Qball. There are many referrals to the Qball user manual in this manuscript so please keep it handy.

STEP 1: Except for connecting the batteries, the Qball should be shipped completely assembled and it does not require any assembly. However, before flying the Qball each time please make sure the motors are mounted firmly, the blades are not broken and securely fastened and all the wires are connected. If anything is broken or loose you need to fasten, repair or change the part before attempting to fly otherwise it will cause damage or harm to the equipment and/or the operator.

STEP 2: Make sure you have a properly licensed QUARC, a running Matlab/Simulink, and all the required files.

STEP 3: Connect the two fully charged Li-Po batteries to the Qball. Make sure they are securely fastened using the provided straps. Also, make sure they are placed roughly under the center of the frame. If not, this may cause imbalance and will affect the flight performance. For the instructions on how to charge the batteries and their maintenance consult the Qball user manual, section 7.

STEP 4: Make sure your wireless dongle (wireless card) is connected, installed and works properly. Set the right IP address for the wireless connection and make sure it is connected to the right network (GSAH). For detail instructions please refer to the Qball user manual, section 6.3 and 6.4.

STEP 5 (If you are using the OptiTrack positioning system): Before flying the Qball for the first time you need to setup and calibrate the OptiTrack positioning system. Please refer to the *"Quanser OptiTrack Quick Start Guide"* for more detail. Make sure that the OptiTrack calibration square (for setting the ground plane) is oriented with the Z axis facing the operator and X axis pointing to the left when setting the ground plane. This alignment is required for Qball autonomous flying using the provided models.

Remark: There are two main model files that will be used. One is the model file running on the host ground station to get the joystick (and OptiTrack positioning) data and send the information to the Qball. Second is the Qball control model running on the Qball which gathers all the information and does the flight control. Note that there are safety features in the Qball model that tries to land the Qball if the host model and Qball control model communication stops for 1 second (see *"Joystick from host\timeout safety"* subsystem). For a complete list of files used with the Qball refer to section 6.5 of the Qball user manual.

STEP 6: If this is the first time you are using the joystick you need to calibrate it in Windows using the Windows game controller properties. Next, open the model file *"Host_Joystick_TYPE_A[_B].mdl" that corresponds to the joystick type labeled on your joystick* (*"Host_Joystick_TYPE_A[_B]_Optitrack_v4.mdl"* If you are using the OptiTrack system). If you are unsure which joystick type you have contact support@quanser.com for assistance. Build and run this model. The Host_Joystick_xxx.mdl model creates a communication server using the Stream Server block. Other models connect to this server to receive a stream of joystick inputs that are used to fly the Qball.

To test that the joystick is properly configured build and run the Host_Joystick_Test.mdl model, which connects to the Host_Joystick_xxx.mdl model and displays a 3D visualization of the joystick controls. Verify that the joystick inputs are correct and that they are calibrated properly. You can also run the Qball simulator Qball_X4_Joystick_Simulation_3D.mdl to fly the Qball virtually with the joystick. Use this simulator to become familiar with the joystick controls that are used to fly the Qball. If the controls are not mapped correctly check that the joystick is calibrated. If after calibrating the joystick is still not functioning as expected, contact support@quanser.com for assistance.

Remark 1: The joystick/OptiTrack model should always be started BEFORE starting the Qball model. Failing to do so will cause a timeout in the Qball model and the Qball will not be enabled. Even in closed-loop (sonar/OptiTrack) control modes the joystick throttle is still used to enable the Qball (throttle >= 10% motors enabled, < 10% motors disabled).

Remark 2: The left stick controls the throttle and yaw (down->up is 0->100% throttle, left->right is rotate counter-clockwise -> clockwise about vertical axis) and the right stick controls pitch and roll (down->up is pitch backwards -> forwards, left-> right is roll left->right). The standard point-of-view is always with the Qball facing away from the operator, so he/she is viewing the Qball tail.

STEP 7: Open the setup_qball_x4.m script and make sure that the variable QBALL_MOTOR_TYPE is set to the value that corresponds to your Qball's motors. The motors are labeled, but if you cannot tell what type of Qball motor you have, please contact Quanser for assistance. Once you have set the value of QBALL_MOTOR_TYPE run the setup script in MATLAB.

STEP 8: The Qball control model should be configured to target the gumstix on the Qball (see section 6.4 of the Qball user manual for the instructions).

STEP 9: In the Qball control model under the *"joystick from host"* subsystem you will see a *"Stream Client"* block. Change the URI to match the IP of the host ground station PC (this is the IP address configured for the wireless adapter in STEP 4). This block receives the packets from the host joystick/OptiTrack model and passes the joystick commands (and OptiTrack data) to the various Qball control subsystems.

STEP 10: Familiarize yourself with the Qball model. The main subsystems from the top level are broken down into the following:

- **a.** *"Calculate Roll Pitch Heading Height"*: This subsystem computes the Qball pose or states by using the information provided by the HiQ sensors.
- **b.** *"Control signal mixing"*: Combines the throttle, roll, pitch and yaw control signals to calculate the output for each of the 4 motors. This subsystem also contains some safety for enabling the motors.
- **c.** *"HiQ"*: This is where you will find the HiQ DAQ blocks. Motor values (4 PWM output channels) are output and various sensor values are read in. There is a large gain block just before the *"HIL Read Write"* block that is primarily used to disable the motor outputs for testing. Change this gain to [1 1 1 1]*0 to disable the motors or [1 1 1 1]*1 to enable the motor outputs.
- **d.** *"Joystick from host"*: As mentioned before this subsystem receives packets from the host model containing joystick (and optitrack) information. It also includes timeout safety and will land the Qball if a timeout is detected.
- **e.** *"Mode control"*: This subsystem controls the operating mode of the Qball, which can be either joystick control or OptiTrack (or sonar depending on the selected source of height) control.
- **f.** *"Pitch controller"*: This subsystem includes the controller for stabilizing the pitch of the vehicle and to make it follow the commanded pitch. Pitch reference commands are either coming from the joystick or from a position controller.
- **g.** *"Position Commands"* (If you are using the OptiTrack system): In this subsystem the operator can set the height, heading and position commands on the fly.
- **h.** *"Roll Controller":* Similar to the pitch controller.

i. *"SAVE DATA (black box):"* Saves various signals to a *".mat"* file on the host computer.
j. *"Yaw controller"*: This subsystem generates a yaw control signal from either the joystick or measured heading depending on the mode setting.

STEP 11: It is important to know that the Qball control model has two operating modes for the height, position, and heading control. In the *"Mode control"* subsystem, make sure all of the switches are set to JOYSTICK ON if you want to use the joystick to control the flight. You can then switch the mode to use autonomous control for height, position, and heading of the Qball. (Joystick mode is always recommended if this is the first time flying the Qball)

STEP 12: Disable the Qball motors by setting the gain to [1 1 1 1]*0 in the *"HiQ"* subsystem.

STEP 13: Compile and run the Qball control model. Make sure that the joystick packets arriving at the Qball are correct when you move the joystick. Check the sensor outputs and pose measurements (roll, pitch, and heading). Note that the heading offset may need to be adjusted (you can find this setting in *"Calculate Roll Pitch Heading Height \ Calculate Heading"* subsystem).

STEP 14: Make sure the Qball model is stopped. Enable the motors through the gain block to [1 1 1 1]*1 in the *"HiQ"* subsystem.

STEP 15: Make sure the host joystick (OptiTrack) model is already running and the throttle is at zero when starting the Qball control model.

STEP 16: To help the operator become familiar with the controls used to fly the Qball, a flying simulator is provided on the CD under the Controllers\Qball_X4_Simulation folder called Qball_X4_Joystick_Simulation_3D.mdl. This model connects to the Host_Joystick_xxx model and uses the joystick controls to fly the Qball. Get familiar with the joystick controls and how they are used to control the roll, pitch, yaw, and throttle of the Qball simulator. Use the joystick trimming to make adjustments if necessary.

When you are comfortable with the controls and are ready to try flying, start the Qball control model. Keep the throttle at zero for 3 seconds (the motors are always disabled for the first 3 seconds to ensure the communication to the host model is working). Slowly increase the throttle to get the motors to start spinning. If you wish, you can double-check the motor rotations are correct (see the Qball user manual section 5.3.4). Slowly increase the throttle until the Qball begins to take off. Try hovering at a height of 10-30 cm to become comfortable with the system.

Remark 1: In the event you want to stop the system you can always bring the throttle to zero to stop the motors or you can stop the model.

Remark 2: It is always recommended to have a second operator to monitor the models while you are flying.

Here are some important points you need to pay attention to:

a. Some safety is built into the Qball model and in the event of a timeout you will get a message popup on the screen. In case you are using the OptiTrack positioning system you will also get an OptiTrack timeout message if the system cannot track the marker anymore.

b. There is a low battery warning message that comes up when the batteries reach 10.6V or less. Change the batteries before they get very low or it may damage the batteries such that they can no longer be recharged.

c. ***ALWAYS FULLY STOP THE MODEL AND PUT THE JOYSTICK THROTTLE TO ZERO BEFORE APPROACHING THE QBALL***