FEEG2001: Getting Started with SP Racing F3

Table of Contents

Introduction 1
Configuration Menu 3
Connecting the Receiver 4
Setting up the Arm Switch & Horizon Mode 5
Calibration Menu 6
Failsafe Menu 6
PID Tuning Menu 7
Receiver Menu 7
Power & Battery Menu 7
Adjustments Menu 7
Sensors Menu 7
Servos Menu 8
Motors Menu 9

Introduction

The following document walks through the setup of the SP Racing F3 flight controller (FC) and some of the features pertinent to this project. This controller has been provided to manage the complex interactions between the four motors of the aircraft to enable steady-level flight and hover without you having to develop these yourself.

As described below and in the provided FC manual, the controller contains its own gyroscope, accelerometer and barometric pressure sensor. These sensors enable the controller to control the orientation of the aircraft and its altitude (although a barometric pressure sensor is not accurate enough for the given task). In addition to this the board comes with its own memory module which can be used to record the sensor readings. While useful for tuning the aircraft's PID and comparing to the Arduino sensor data it cannot be easily accessed by the Arduino system when in flight. It is still necessary, therefore, to record additional data using the Arduino system. You are free, however, to compare and contrast the data in your final report.

Installing "Betaflight – Configurator"

The FC board is running the open-source Betaflight flight control software. To configure and setup the autopilot, you need to install the Betaflight – Configurator, which is a configuration tool for Betaflight. It is available for a number of operating systems (Windows, Mac, Linux etc.) and allows you to configure your FC via a GUI.

1. Download Betaflight version 10.2 from the project's github (LINK). Note that newer versions of Betaflight will not support the SPRacingF3 or will provide only partial support.

2. Install Betaflight on your computer
3. If installed correctly you should be able to run Betaflight and be presented with a screen similar to that in Figure 1. Ignore any warnings about the version being out of date.

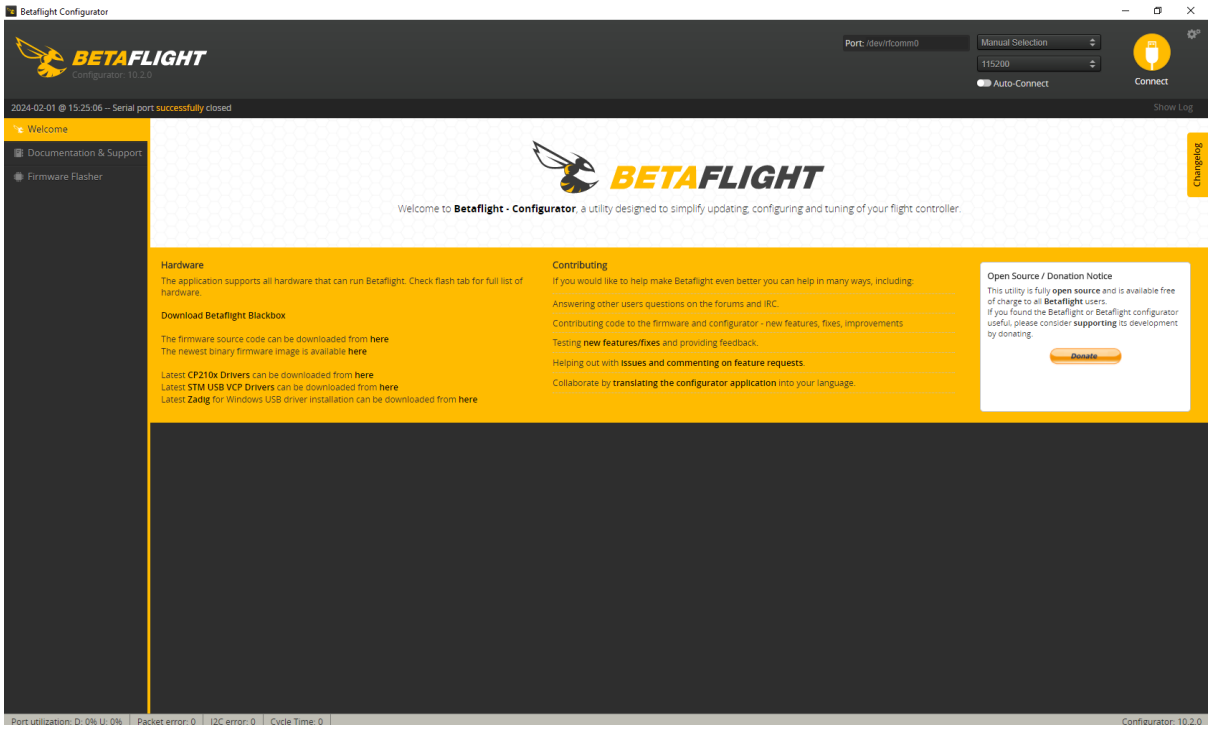

Figure 1 Betaflight main screen

4. Please note that you will need to install the CP210x drivers and instructions for this can be found on the Betaflight splash screen
5. Once you have installed the USB drivers you can plug your flight controller into your computer using the provided USB cable. If all works correctly Betaflight will recognise the controller has been connected and the top right of Betaflight will change to something like Figure 2

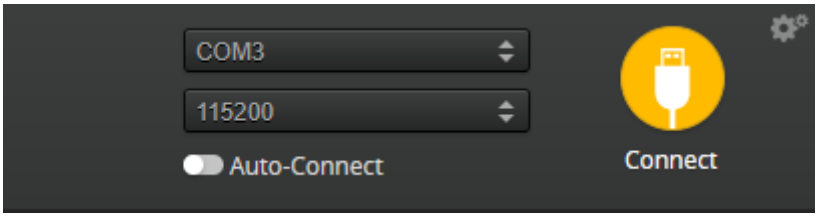

Figure 2 Betaflight if the controller is successfully recognised

6. Clicking connect should enter the setup for your flight controller and you should be presented with an graphical representation of your aircraft (see Figure 3) which should move in response to movements to the physical board.

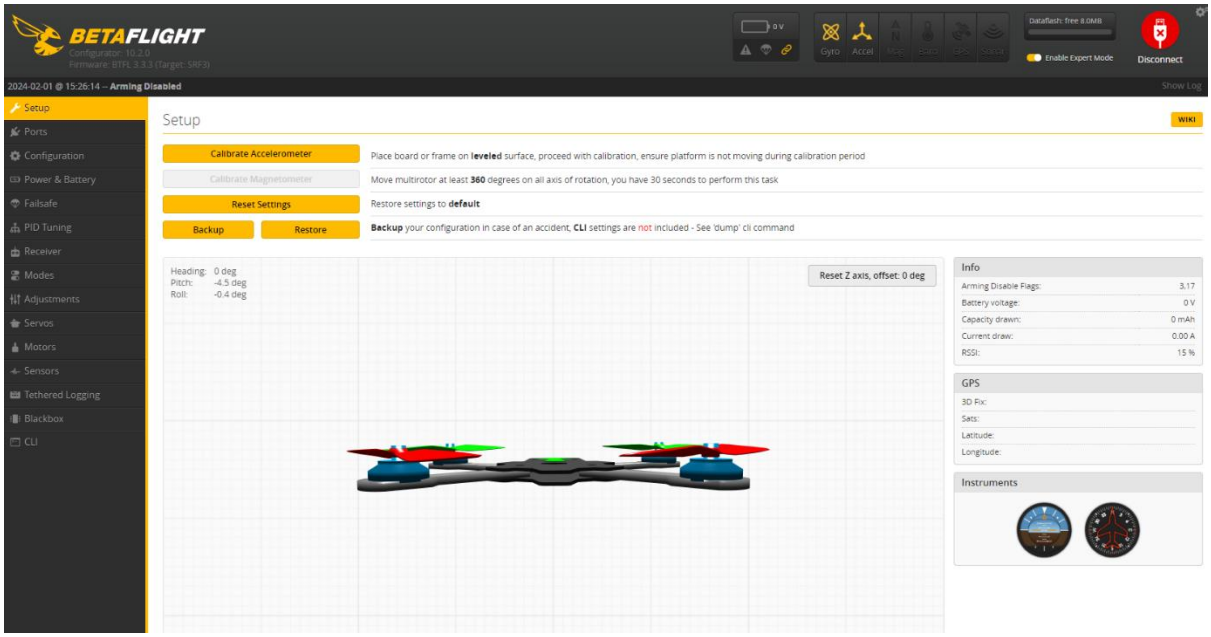

Figure 3 Betaflight flight controller setup screen

Configuration Menu

The configuration menu enables a number of the flight controller configuration settings to be adjusted. These include options for the mixer, an important option depending on the selected planform of your aircraft, sensor alignment, trim and throttle settings. The question mark next to each category will explain more about each setting but generally these can be left as the defaults. It is highly recommended that you mount the flight controller within your aircraft in a traditional manner with the arrow on the controller facing up and pointing towards the front of the aircraft.

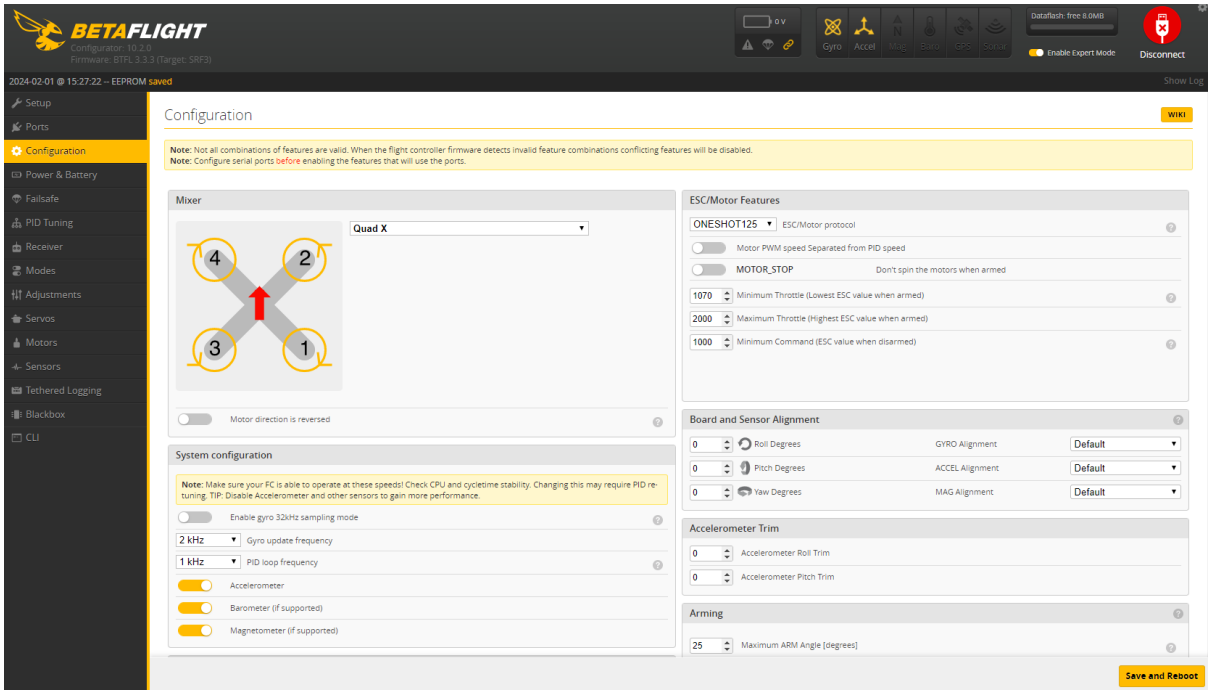

Figure 4 Betaflight configuration menu

There are a number of settings which require some adjustment here:

1. Under mixer select “Quad X” – note that the diagram here indicates the direction the motors at each corner of the aircraft should spin in. It is important that the physical motors spin in these directions for the aircraft to fly successfully.
2. Under receiver select “PWM (one wire per channel)”
3. Under ESC/Motor Features, select PWM for the protocol. In order for the motors to respond correctly it may be necessary to adjust the minimum throttle and minimum PWM values. If the controller thinks the throttle is engaged when it boots up, it will remain in a permanent disarm state.
4. Save and reboot

Connecting the Receiver

The next step is to connect the receiver to the autopilot and configure it in the Betaflight.

1. Connect the receiver based on the wiring diagram for the flight controller i.e. throttle on the receiver should go to throttle on the flight controller
2. Open Betaflight – Configurator and connect to the board
3. Go to the “Receiver” tab (see Figure 5)
4. Under “Channel Map” select “TAER1234 JR / Spektrum / Graupner”
5. Click the “save and reboot” button on the bottom right of the screen
6. Reconnect to the flight controller once it has rebooted. If the receiver is connected, powered and bound to a transmitter you should see the PWM values in the horizontal bars change as you manipulate the sticks on the transmitter. You should also see the time history of your inputs be updated on the scrolling plot at the bottom of the menu.
7. If all is working correctly the aircraft in the “preview” window at the top of the receiver menu will also move around per your inputs to the transmitter.

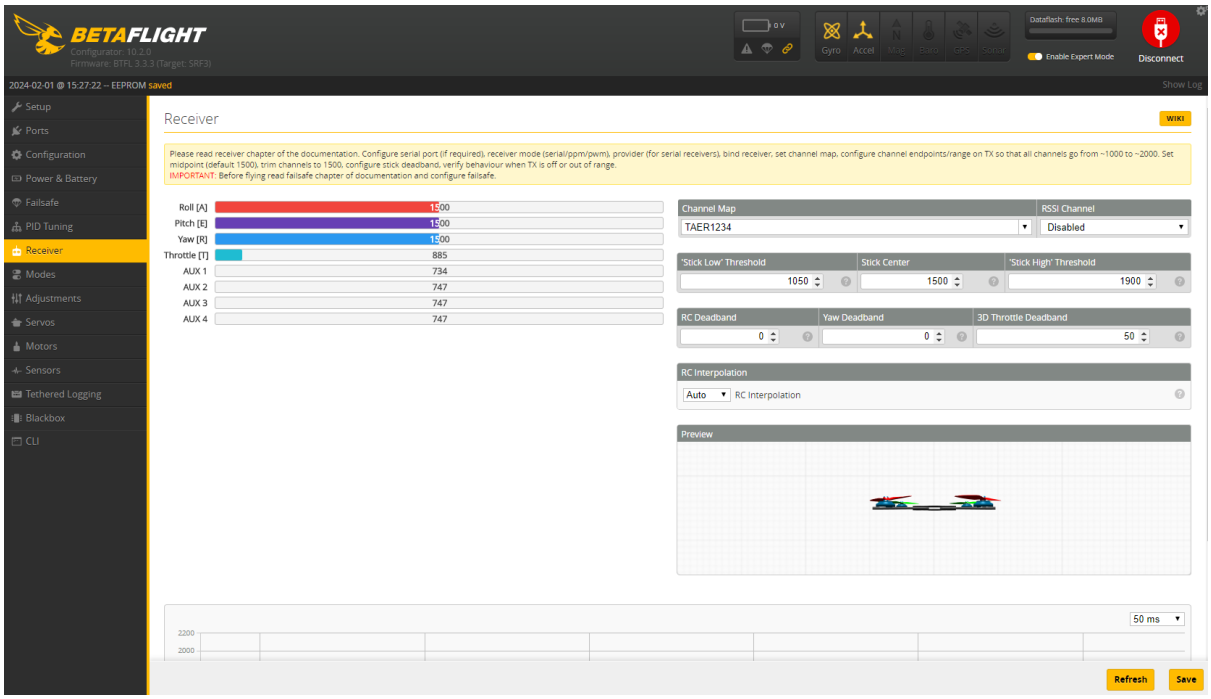

Figure 5 Betaflight receiver configuration menu

Setting up the Arm Switch & Horizon Mode

The “arming” feature allows the operator to arm/disarm the quadcopter using a switch on the transmitter. When the quadcopter is disarmed, the motors will be turned off and will not start spinning under any circumstance. This increases safety during operation and manipulation with the quadcopter.

The flight controller can operate in two modes, the default “Rate” mode and the “Horizon” mode. In the Rate mode, the control input from pilot’s transmitter controls the rate of change of the roll, pitch and yaw. In the Horizon mode, the pilot controls the roll, pitch and yaw angles directly. The Horizon mode results in the quadcopter returning into a stable level position when the controls sticks are in a neutral position. Only the horizon mode should be used for this project.

1. Open Betaflight and connect to the board
2. Navigate to the “Modes” tab
3. If necessary click the “add range” button under the “ARM” mode. This will enable you to adjust the range of the signal value and link this command to a signal
4. With the “ARM” mode, make sure the AUX1 is selected as the input and then move the sliders around, so that the mode is engaged when the PWM values range from 1500 to 2100.
5. Under the “HORIZON” mode, select AUX4 as the input and move the sliders so that this mode is engaged for all PWM values. There is no switch associated with AUX4, so this mode will be engaged at all times.
6. The final menu should look something like Figure 6

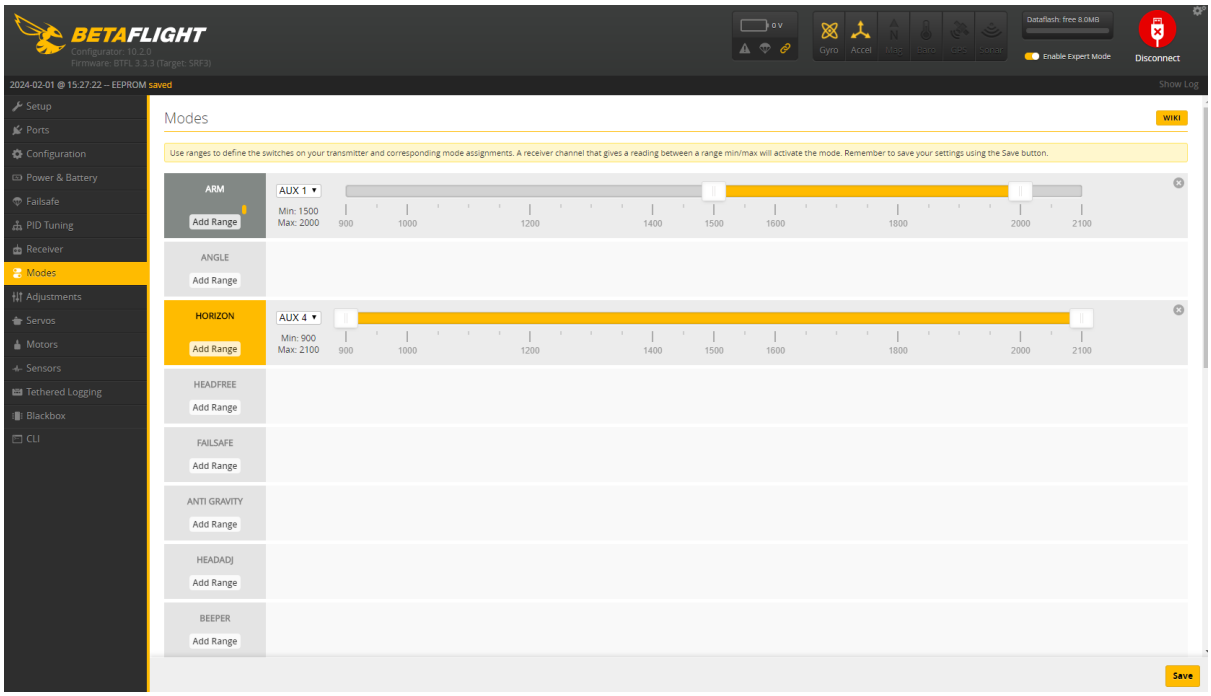

Figure 6 Arm and horizon modes enabled

If the transmitter is bound correctly to the receiver and the receiver is connected correctly to the flight controller when moving the switch you should see the yellow vertical line underneath the slider move around accordingly.

It is recommended that you use the provided transmitter and receiver to test that all of the signals are being correctly received by the flight controller using the Betaflight GUI. On the receiver tab a series of sliders are visible which indicate the PWM value read by the flight controller on each channel. Moving the sticks should move the aircraft in the preview window correctly.

At least the first four channels must be sending PWM signals to the flight controller otherwise the system will lock out. This is the equivalent to losing a signal during flight and the controller is designed to enter a failsafe mode if this occurs.

When the flight computer powers up the throttle signal should also be in a dead zone otherwise the system will lock out the pilot and disarming will not be possible. The throttle settings in Betaflight may need some tuning to prevent this. This is an additional safety feature which prevents the system from throttling up uncontrollably once disarmed.

Calibration Menu

The first menu encountered when running Betaflight is the setup menu. This menu is used to calibrate the onboard sensors, specifically the accelerometer. It is highly recommended that a calibration is performed prior to any tests with the aircraft and flight computer on a flat surface like a table.

Moving the flight controller around when in this window will display a graphical interpretation of the aircrafts orientation. Before any flight ensure that this graphical representation moves correctly with respect to your manual movements of the aircraft or flightcomputer.

Failsafe Menu

You may need to enable “expert mode” using the sliding switch on the top right to see this menu within Betaflight. As described within the configurator this enables you to define what the aircraft will do in the event of an unrecognised input PWM or if the signal is lost.

Valid pulse ranges should be entered beyond which it will be assumed that the PWM is invalid. Options for roll, pitch, yaw, throttle etc. can then be entered if an invalid PWM is found on one of these channels. It is recommended that an invalid arming signal force the aircraft to enter a disarmed state.

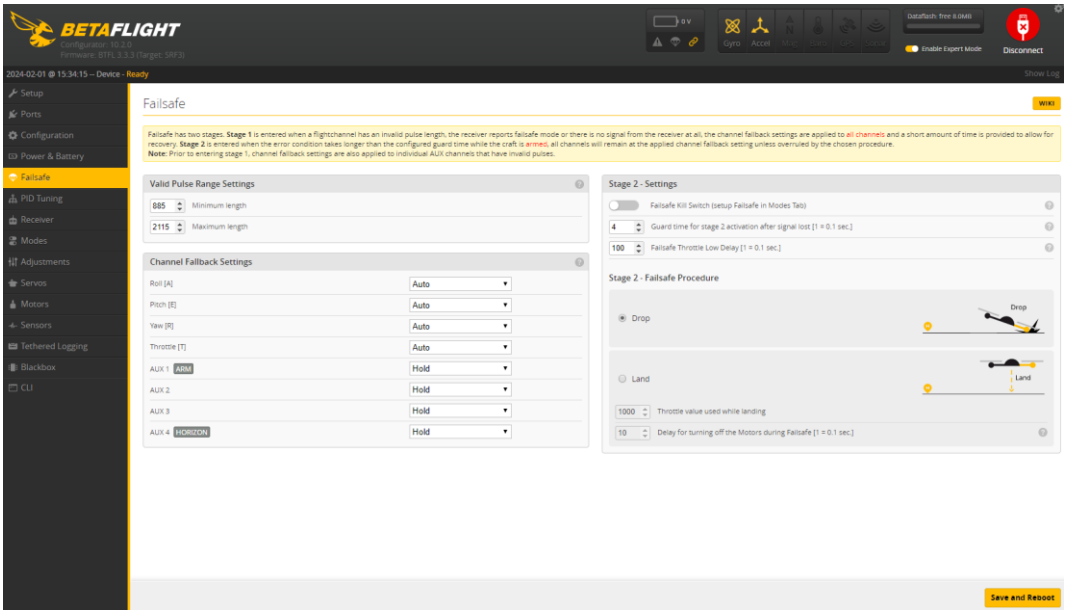

Figure 7 Betaflight failsafe menu – note that expert mode is enabled

PID Tuning Menu

This menu enables the PID parameters for roll, pitch, yaw, level etc. to be altered. The default values shown in the figure below are a good starting point and should not be adjusted.

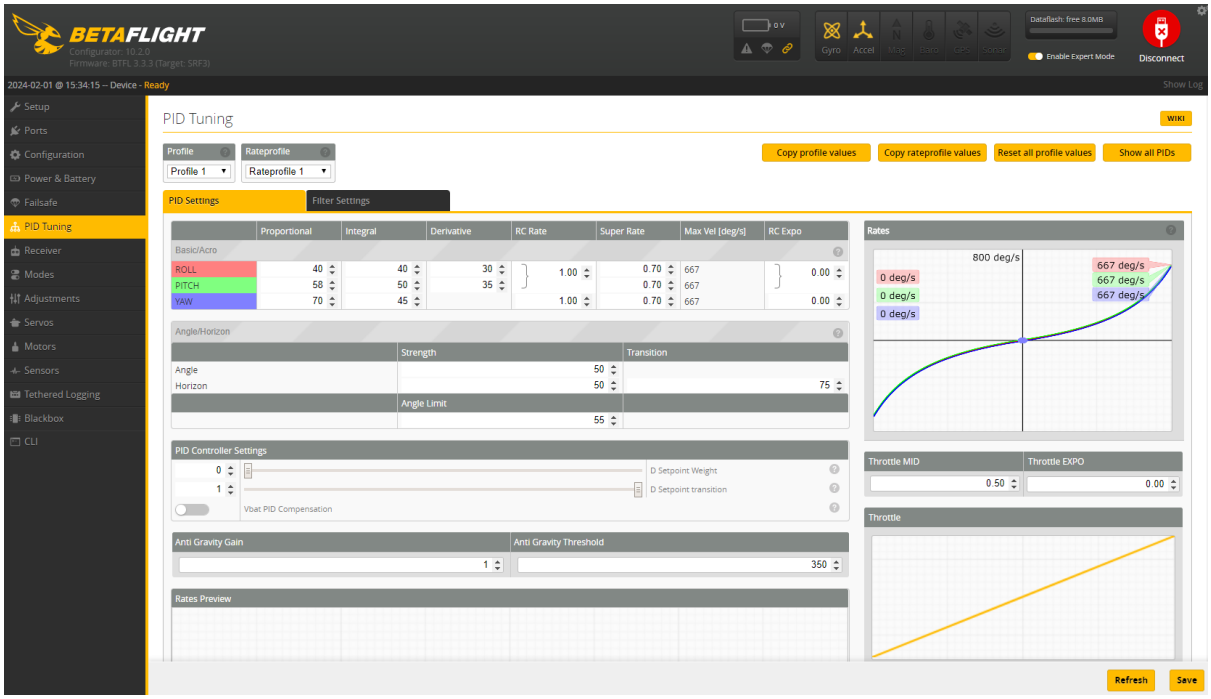

Figure 8 Betaflight PID tuning menu

Receiver Menu

The receiver menu (see Figure 5) displays the PWM values from the receiver in real time via the channel mapping in the top left of the menu and over a period of time via the scrolling graph at the bottom of the menu. This menu is useful when trying to determine if signals are reaching the flight controller as expected.

Power & Battery Menu

The power and battery menu allows you to set up a sensor to monitor the voltage and capacity of your battery during flight. This is not necessary for this project, the voltage levels in the battery will be assessed prior to any flight.

Adjustments Menu

This is not required for this project.

Sensors Menu

This menu displays real time values of the sensors on board the flight computer. Moving the board around you should see the response of these graphs change accordingly. The scale of the plots can be adjusted via the corresponding dropdown menus. Using the tick boxes plots of specific sensors can be enabled or disabled.

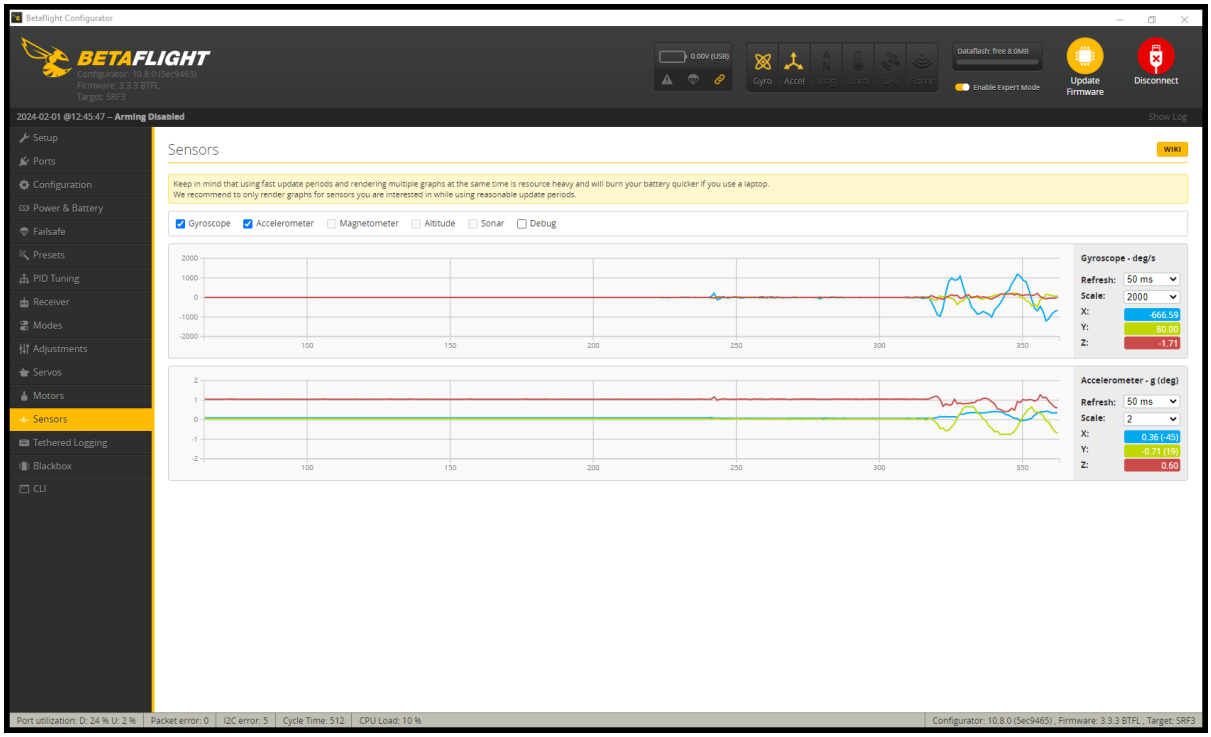

Figure 9 Betaflight sensor menu – only visible when expert mode is enabled

Servos Menu

The servos menu enables the flight computer to output servo values to a specific channel. This can be used, for example, to activate or move a servo during flight. The generated servo signal can also be sent to another device, such as an Arduino. This is particularly useful if you have use a different mode from the “PWM one wire per signal” to enable communications between receiver and flight computer.

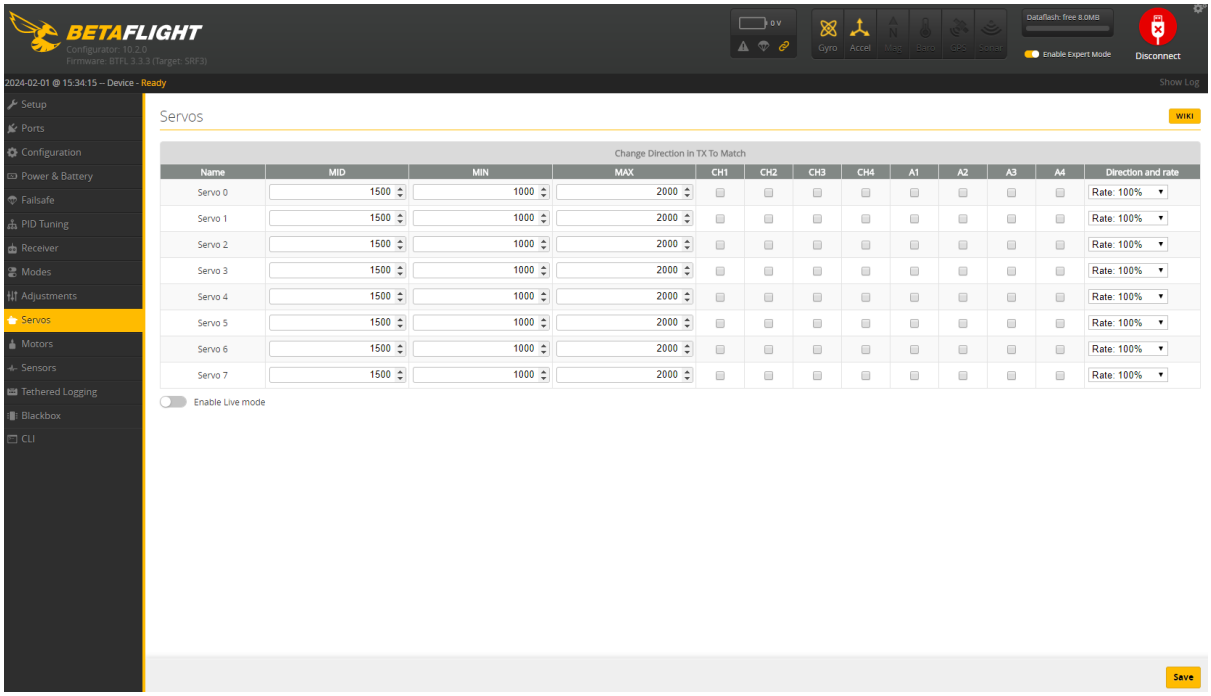

Figure 10 Betaflight servo menu

Motors Menu

The motors menu enables you to control the motors manually from the configurator if the system is disarmed. This can be very dangerous so it is recommended not to do this without an academic present and if the throttle for each motor is increased it should only be done so slowly and without any propellers attached. Manually throttling individual motors enables you to check the motor spin direction and for faulty motors.

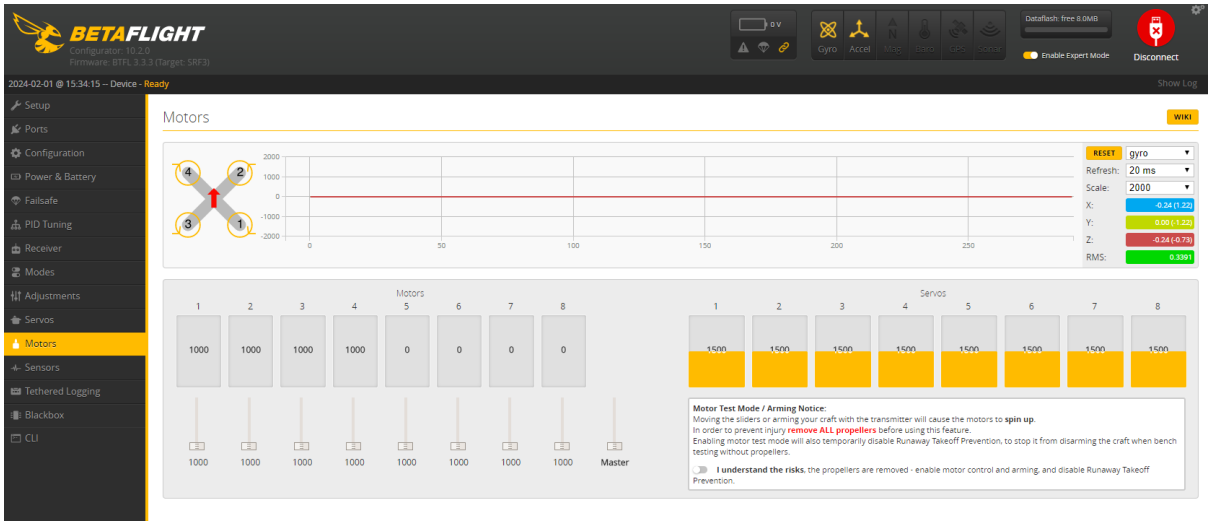

Figure 11 Betaflight motors menu