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DRONE SHOW SOFTWARE

Drone Show Software

Version 3.0

Hardware Manual

SUPPORT@UGCS.COM

DRONESHOWSOFTWARE.COM

Table of Contents

Required components and materials

Pixhawk Wi-Fi ESP-07
http://www.banggood.com/2_4G-Wireless-Wifi-Telemetry-Module-With-Antenna-For-Pixhawk-APM-MiniAPM-Flight-Controller-p-1013677.html

Spektrum 2.4 GHz DSMX Remote Receiver
https://www.spektrumrc.com/Products/Default.aspx?ProdID=SPM9645

DuPont connectors for DroPix
https://www.aliexpress.com/item/620pcs-Dupont-Wire-Cable-Jumper-Pin-Header-Connector-Housing-Kit-Male-Crimp-Pins-Female-Pin-Connector/32765198055.html

DJI FLAME WHEEL F450 ARF or similar class UAV
http://www.kopterworx.com/dji-flamewheel-f450-arf-v2-e300.html

LiPo 4s 4,000 mAh GensAce or similar class battery
http://www.kopterworx.com/lipe-4s-4000mah-gensace-tbs.html

DroPix board with soldered connectors
https://drotek.com/shop/en/drotek-parts/478-dropix-flight-controller.html#/34-connectors-soldered_angle_connector

Drotek XL RTK GPS
https://drotek.com/shop/en/home/792-xl-rtk-gps-neo-m8p-rover.html
Please note that RTK mode will only work in conjunction with a base station. If a 6 meter error is acceptable, a cheaper onboard GPS may be used instead.

Power module
https://drotek.com/shop/en/drotek-parts/809-voltage-current-53v-power-supply-mounted.html?search_query=power&results=36

GPS holder
https://drotek.com/shop/en/home/614-gps-folding-mount-with-2-size-poles.html

Preparation

General considerations:

- Assembly of one drone may take approximately 3 hours
- When assembling, don't hurry and be extremely careful. The most common causes behind UAV crashes, putting aside operator's errors, are loose connectors and screws, poor soldering, and damaged wires
- Apply a soft threadlocker to all screws to prevent vibration-caused loosening

Figure #1. Soft threadlocker

Unboxing

Unbox the DJI F450 airframe and read the user manual:
http://dl.djicdn.com/downloads/flamewheel/en/F450_User_Manual_v2.2_en.pdf

Read DroPix autopilot setup manual:
https://drotek.com/en/documentation/docs-dropix/

Figure #2. DJI F450 airframe box

Figure #3. DJI F450 airframe box contents

Figure #4. Bottom and top plates

Figure #5. Arms

Figure #6. Misc. package

Figure #7. Misc. package contents

Figure #8. Propellers

Figure #9. Propeller removal clamp, motors, and ESCs

Power module

The 6-pin connector of an autopilot power module should be replaced with another one according to DroPix pinout.

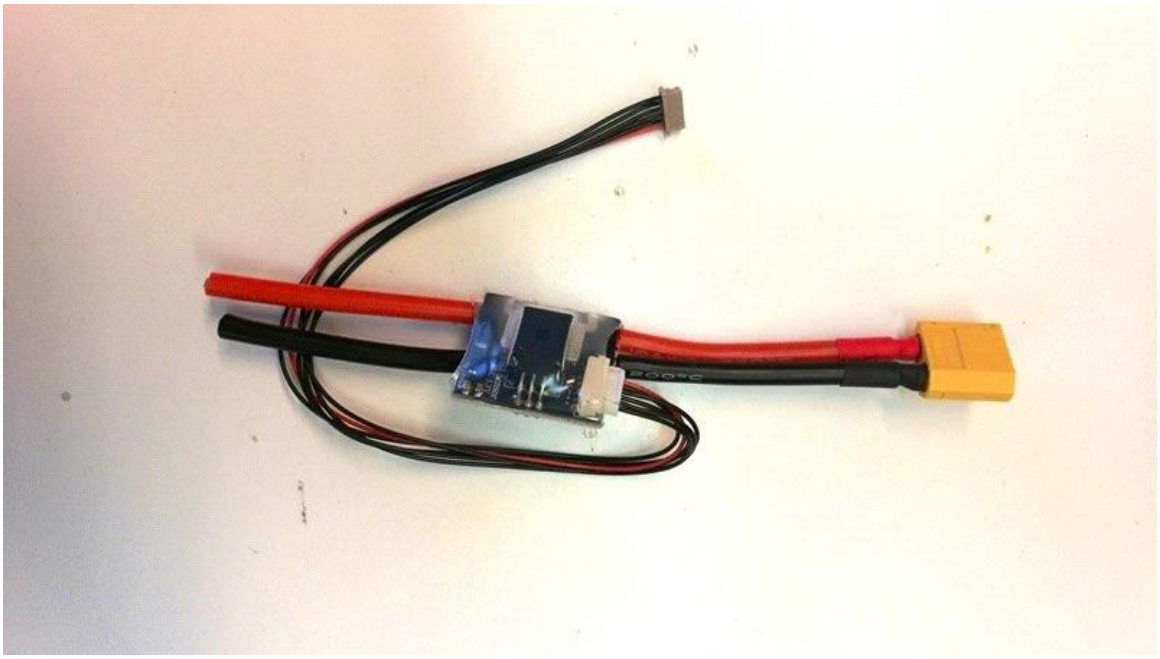


Figure #10. Power module (supplied separately from an airframe)

Cable length should be about 11 cm. Pinout description is provided on the power module PCB.

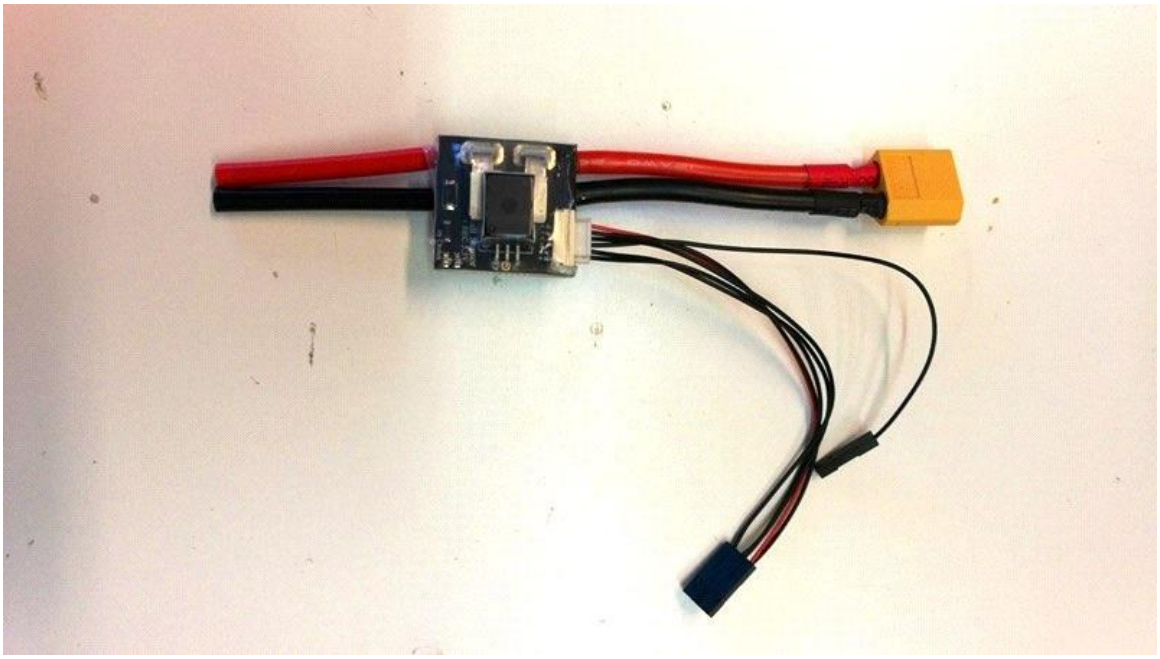


Figure #11. The result

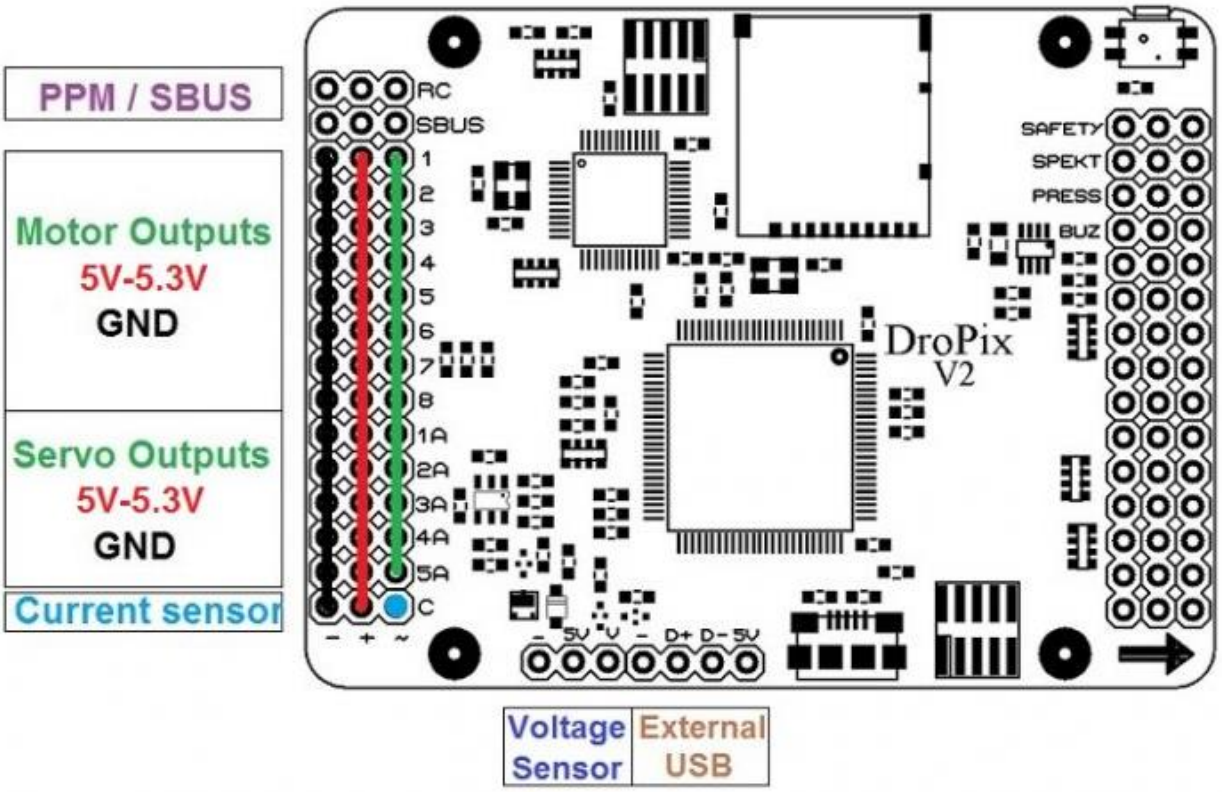


Figure #12. A cable from the power module should be connected to the autopilot voltage sensor and current sensor pins
(Image: © DroPix)

Wi-Fi module (telemetry) connection cable

This cable is not supplied and therefore should be made or purchased separately.

The connector with a white mark (on the left cable end in Figure 13) is connected to a Wi-Fi module. The other connector (on the right cable end in Figure 13) is connected to an autopilot. Recommended cable length is about 18 cm.

Figure #13. Connector with a white mark

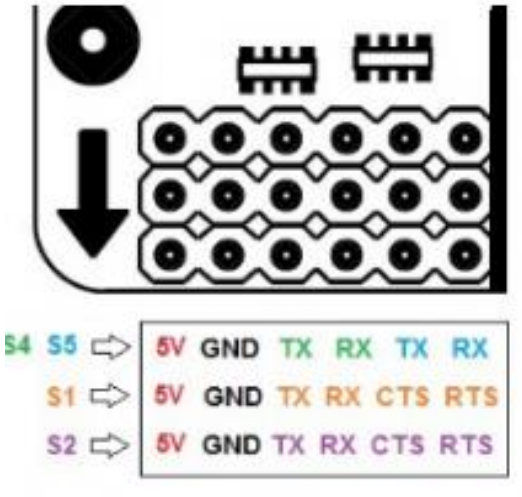


Figure #14. Telemetry module should be connected to the first 4 pins in the S1 row of the autopilot (5V, GND, TX, RX) (Image: © DroPix)

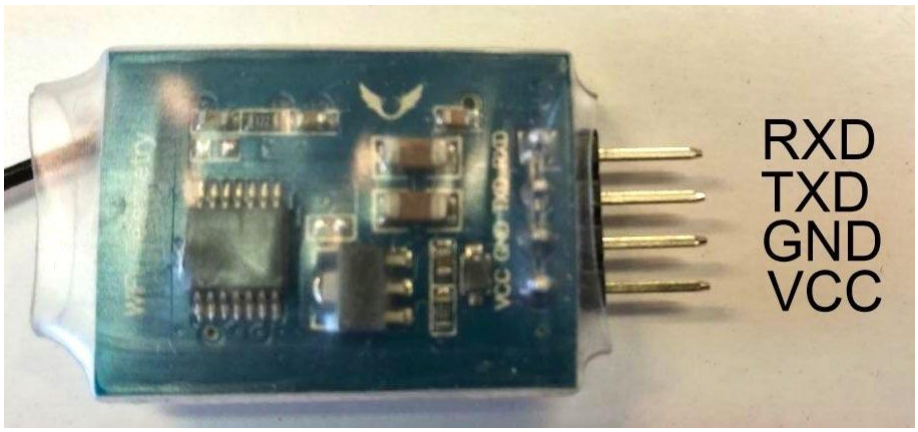


Figure #15. Wi-Fi telemetry pinout

Remote controller receiver (satellite) connection cable

This cable is not supplied and should be purchased separately or made of components you may have at hand. Recommended cable length is 18 cm.

Figure #16. The cable

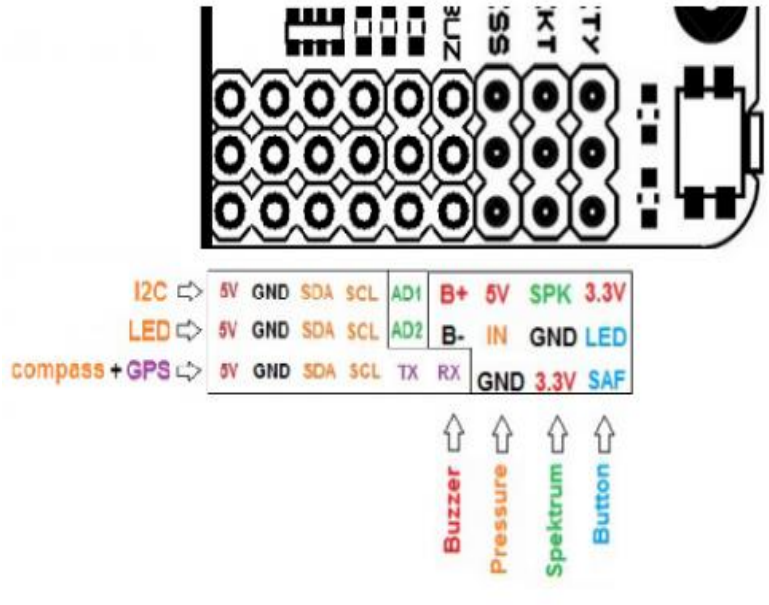


Figure #17. RC module should be connected to the Spektrum pins on the autopilot (Image: © DroPix)

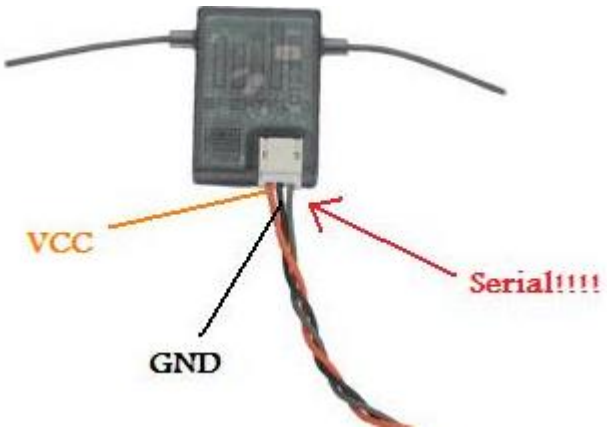


Figure #18. RC satellite pinout

Battery connection cable

Solder an XT60 connector to two AWG14 wires from the DJI F450 airframe kit to made a cable for battery connection.

Figure #19. Battery connection cable

Step-by-step assembly instructions

An autopilot is placed inside the airframe and the cables are pulled through the airframe arms. To complete this procedure please follow the steps below.

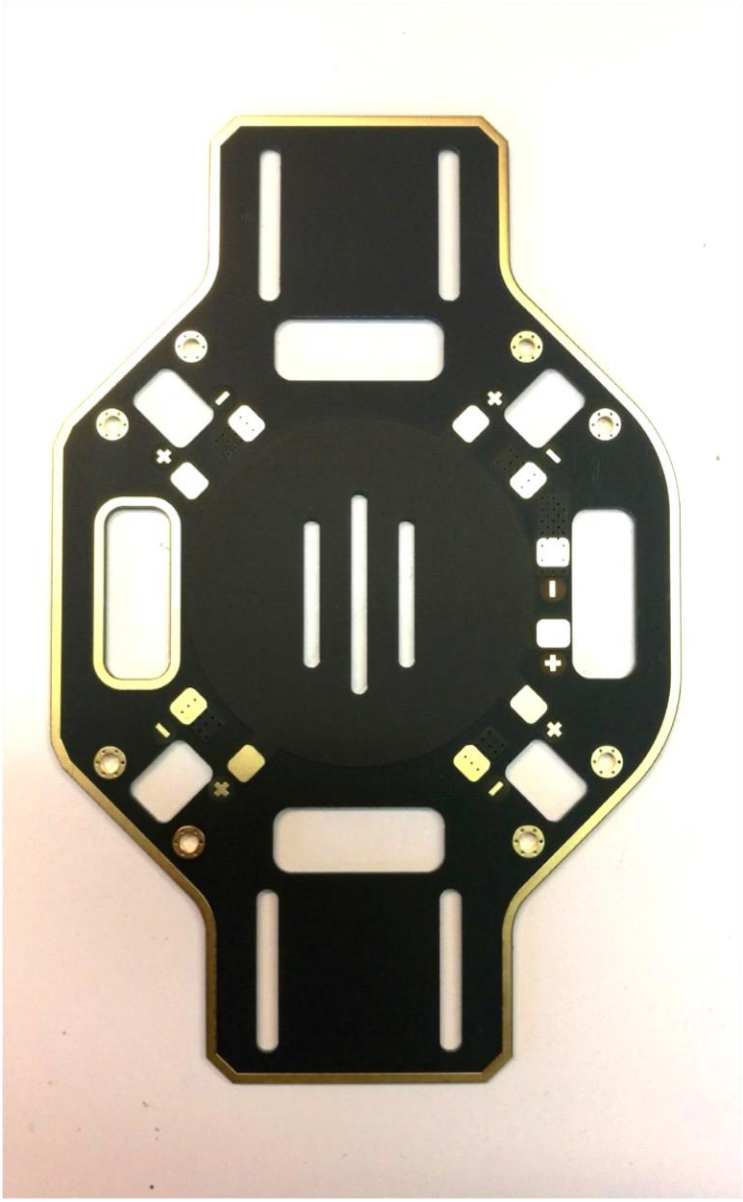


Figure #20. Bottom plate

Bottom plate. Main power input wires should be connected to the central right-side terminals.

First, attach arms to the bottom plate:

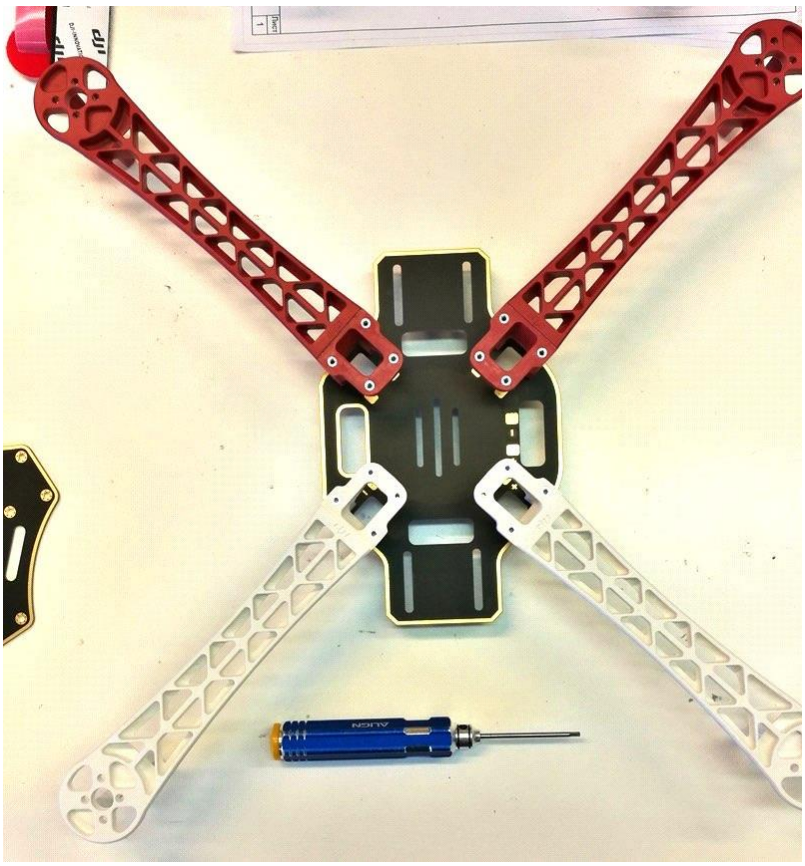


Figure #21. Step 1

Then, install motors. Make sure that the motors are installed correctly in terms of rotation direction. The installation correctness is indicated by dots on the motor shafts.

Figure #22. Step 2

At this point, the airframe should look like this:

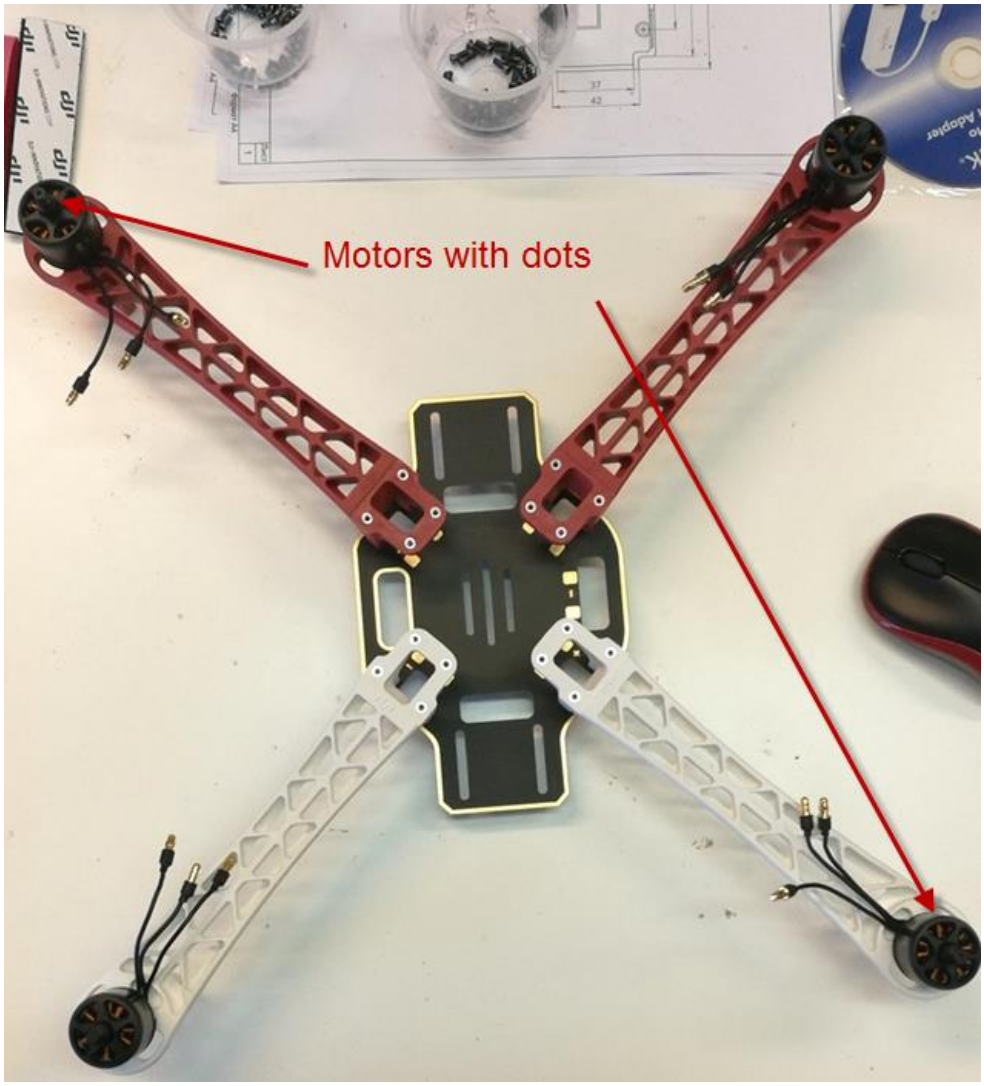


Figure #23. Motors with dots

The motors on the left red arm and the right white arm should be marked with dots on their shafts.

The left red arm:

Figure #24. Left red arm

The right white arm:

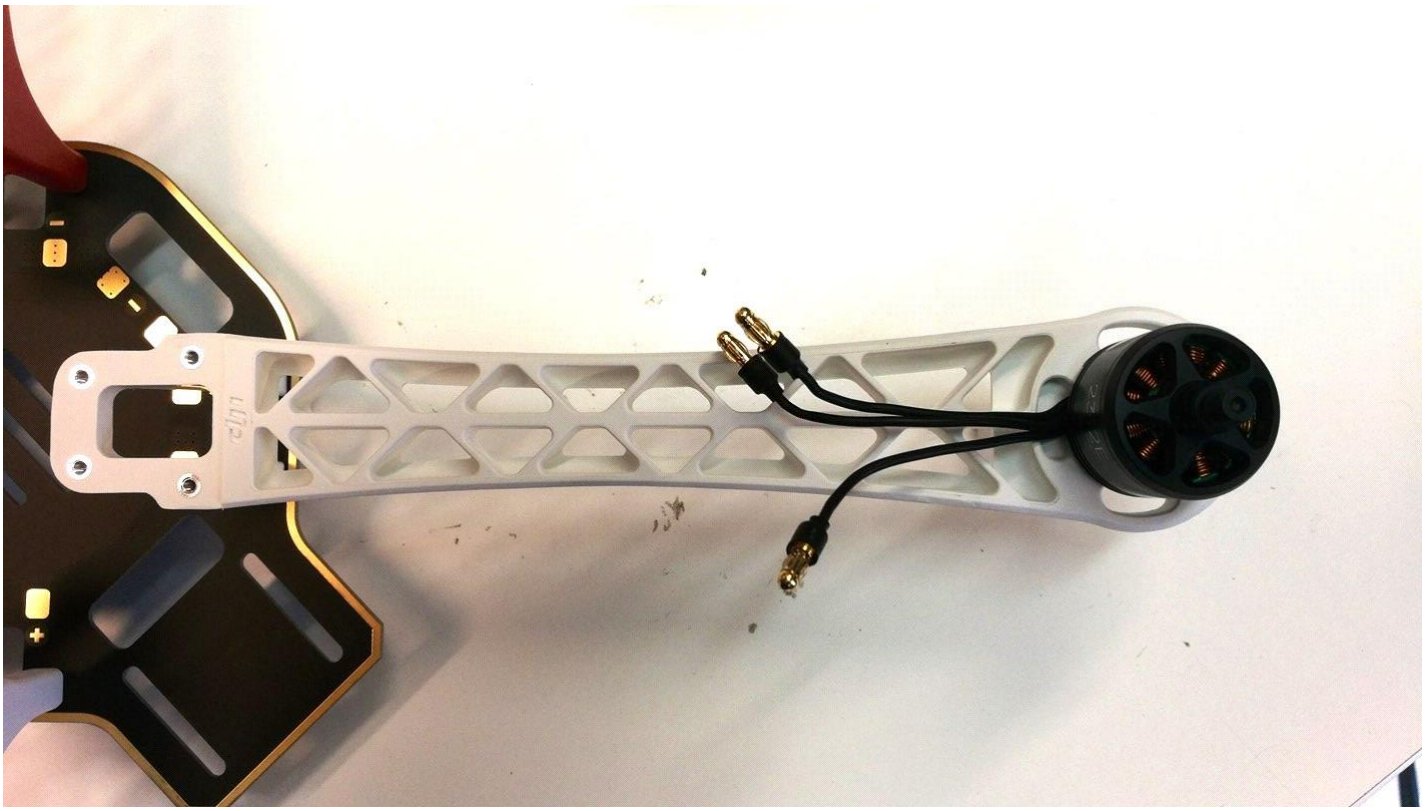


Figure #25. Right white arm

Then, mount ESCs (Electronic Speed Controllers) on each arm using a double-sided tape.

Figure #26. ESCs (Electronic Speed Controllers)

After an ESC is mounted on an arm, connect the respective motor wires to the ESC. The sequence does not matter at this point, since later the motor rotation direction will be tested and, if necessary, changed by changing connection points of any two wires:

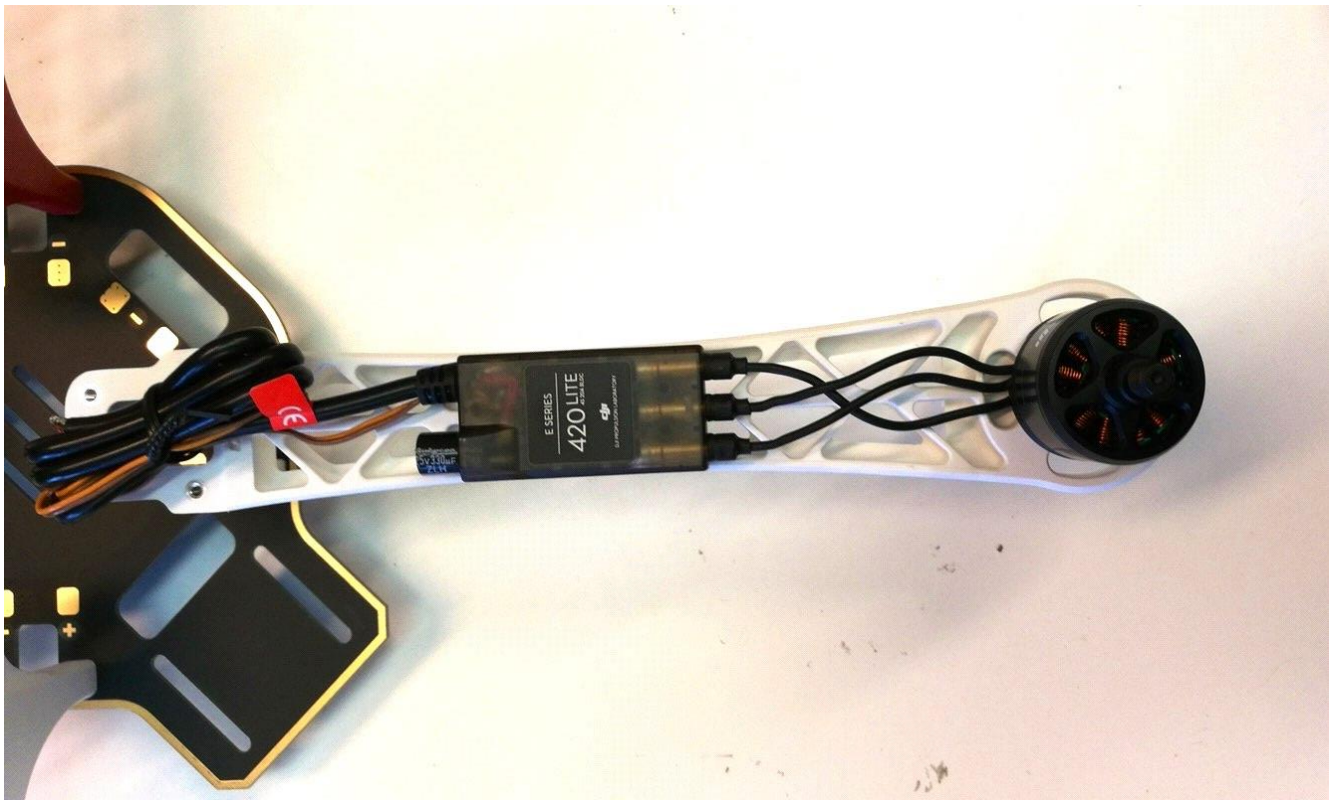


Figure #27. ESC is mounted on an arm

In addition to the double-sided tape, secure each ESC to its respective arm with a cable tie. At this step, tie only two ESCs: the one on the left white arm and the one on the right red arm. The other two ESCs should be secured with cable ties when the Wi-Fi and RC satellite modules are installed.

Figure #28. ESC secured with cable ties

Pull ESC power cables through respective holes in the places where the arms are attached to the bottom plate:

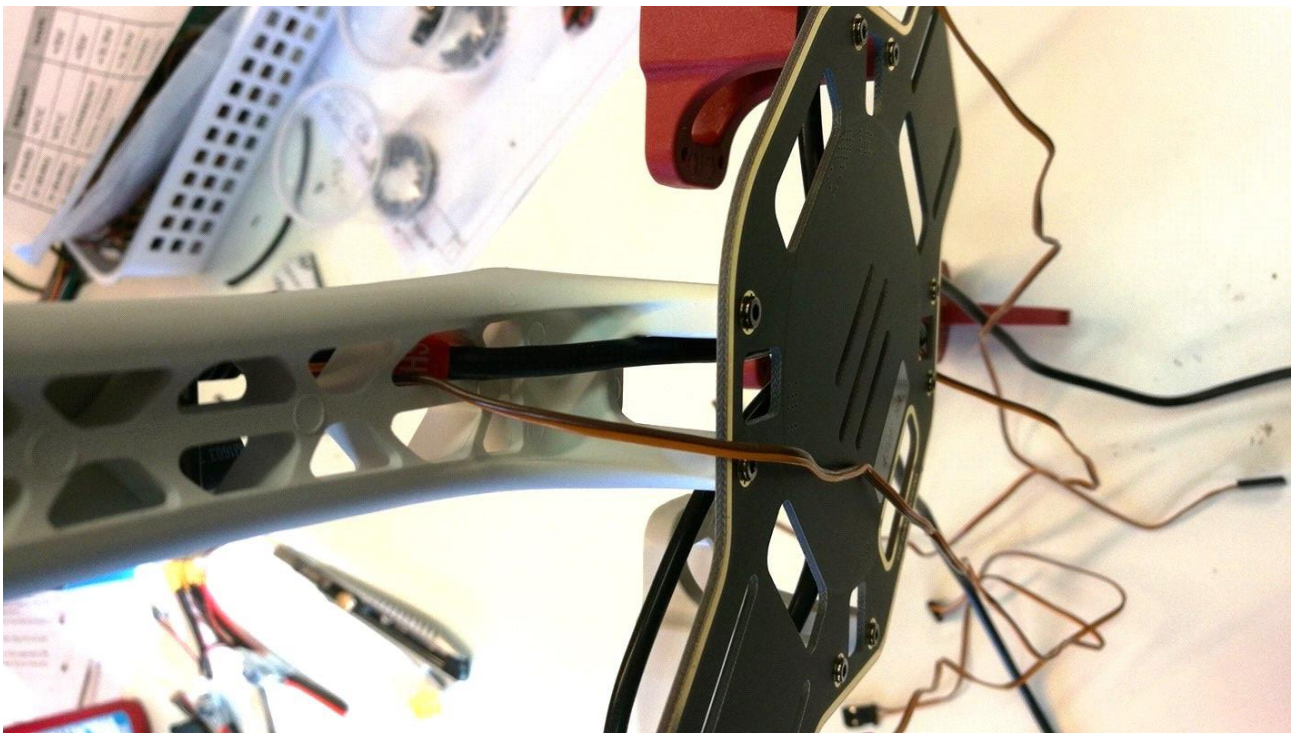


Figure #29. ESC cable placement

Cut off any excessive power supply wires. Recommended length is approximately 7-8 cm.

Figure #30. ESC power wire placement and length

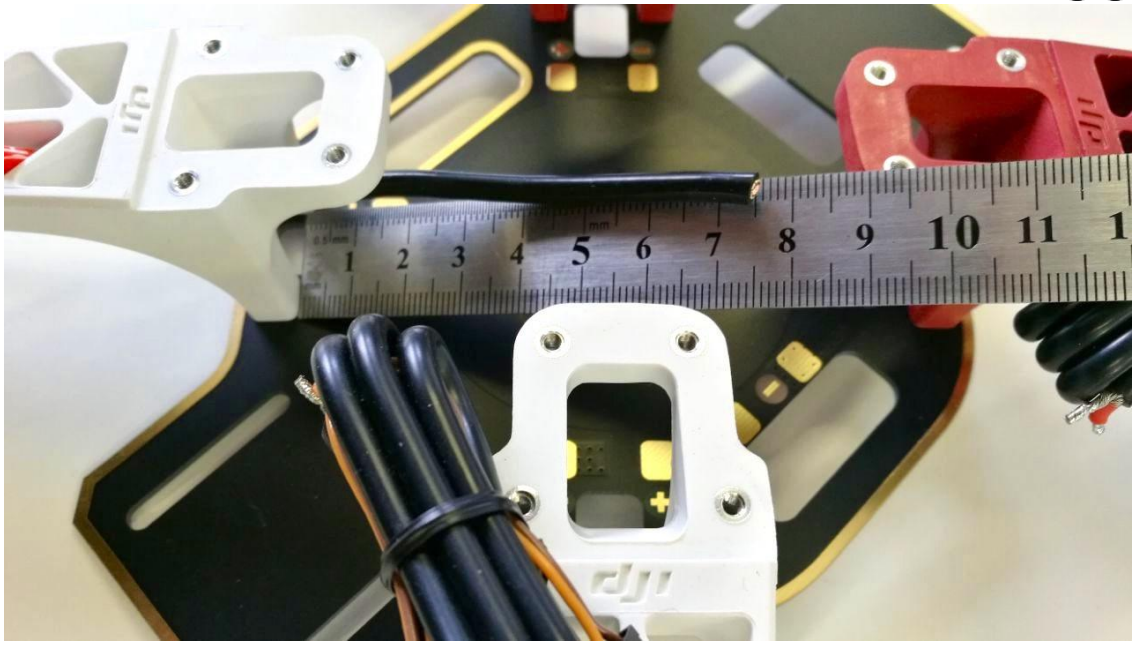


Figure #31. ESC power wire length

Then, solder the wires to the bottom plate. For each arm, solder ESC power supply wires to respective “+” and “–” terminals at the mounting points of each arm.

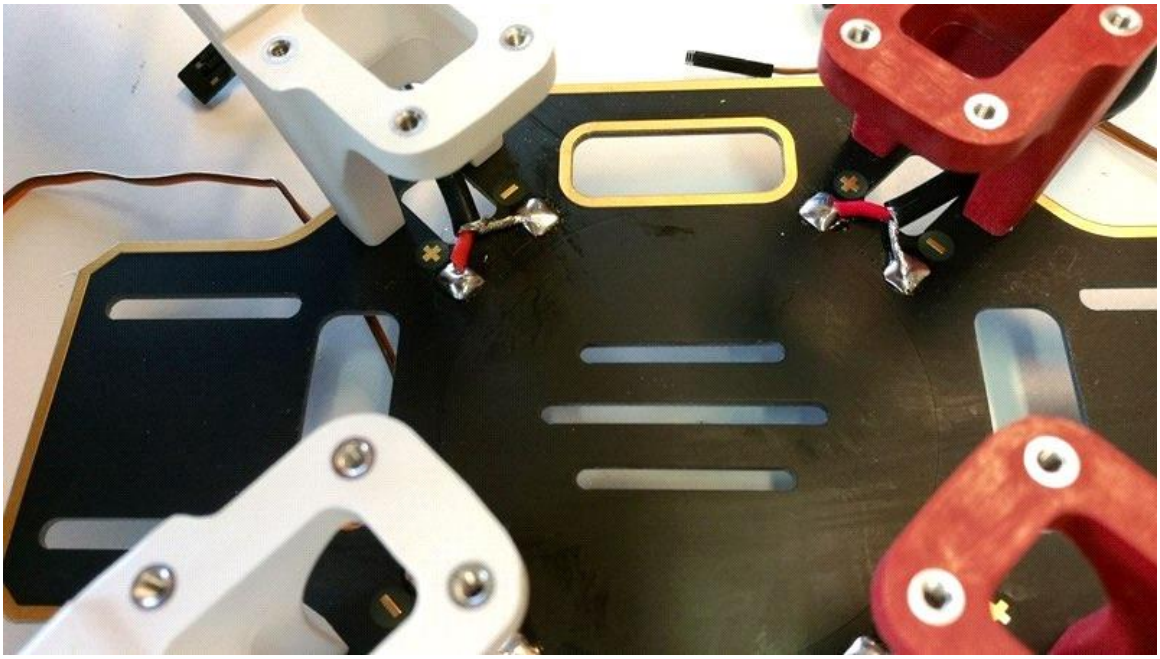


Figure #32. ESC power wire when soldered

Solder payload power supply wires together with power module wires to the main power terminals in the center of the right side of the bottom plate.

After the wires are soldered, apply some insulation material such as protective lacquer or hot glue to make sure that no non-insulated contacts are exposed.

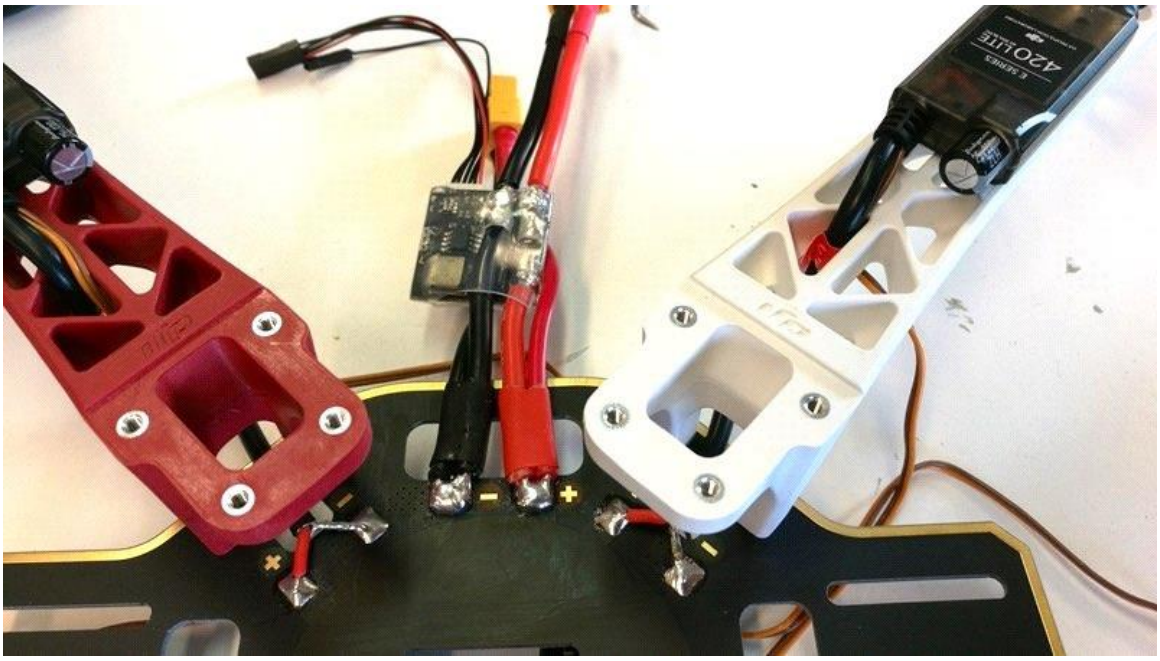


Figure #33. Payload and main power wires

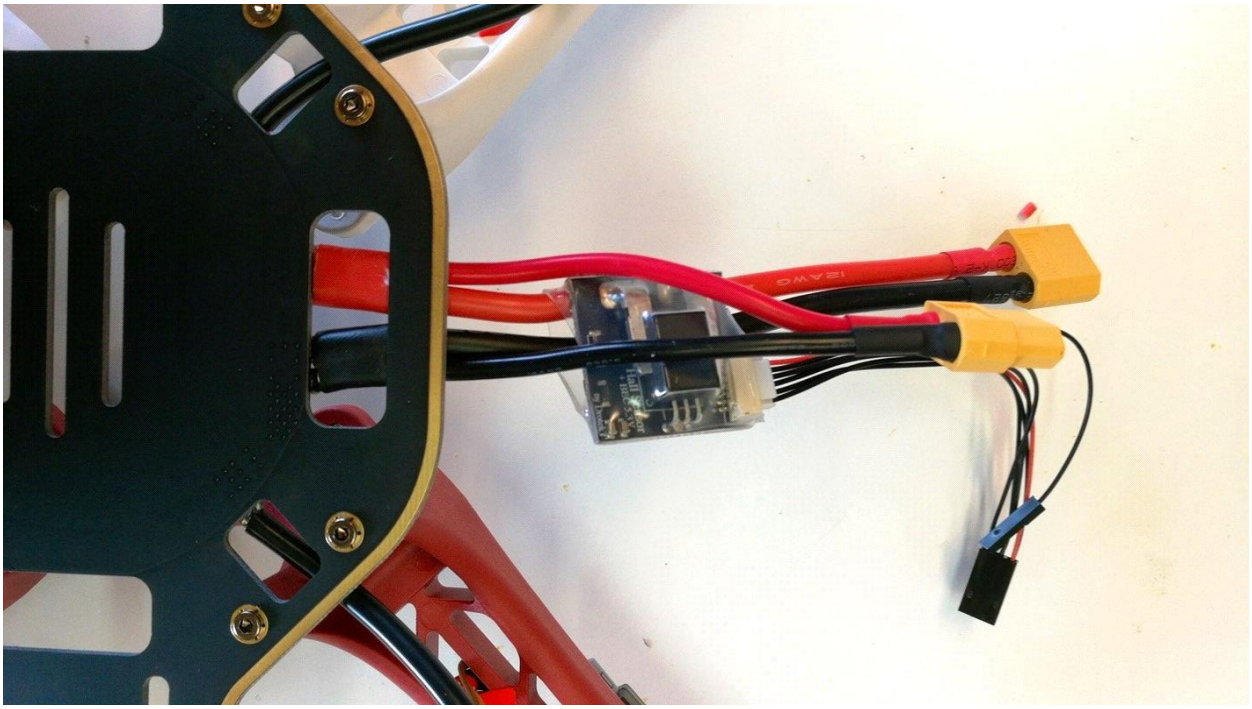


Figure #32. Power module and payload connection wire soldered to a bottom plate

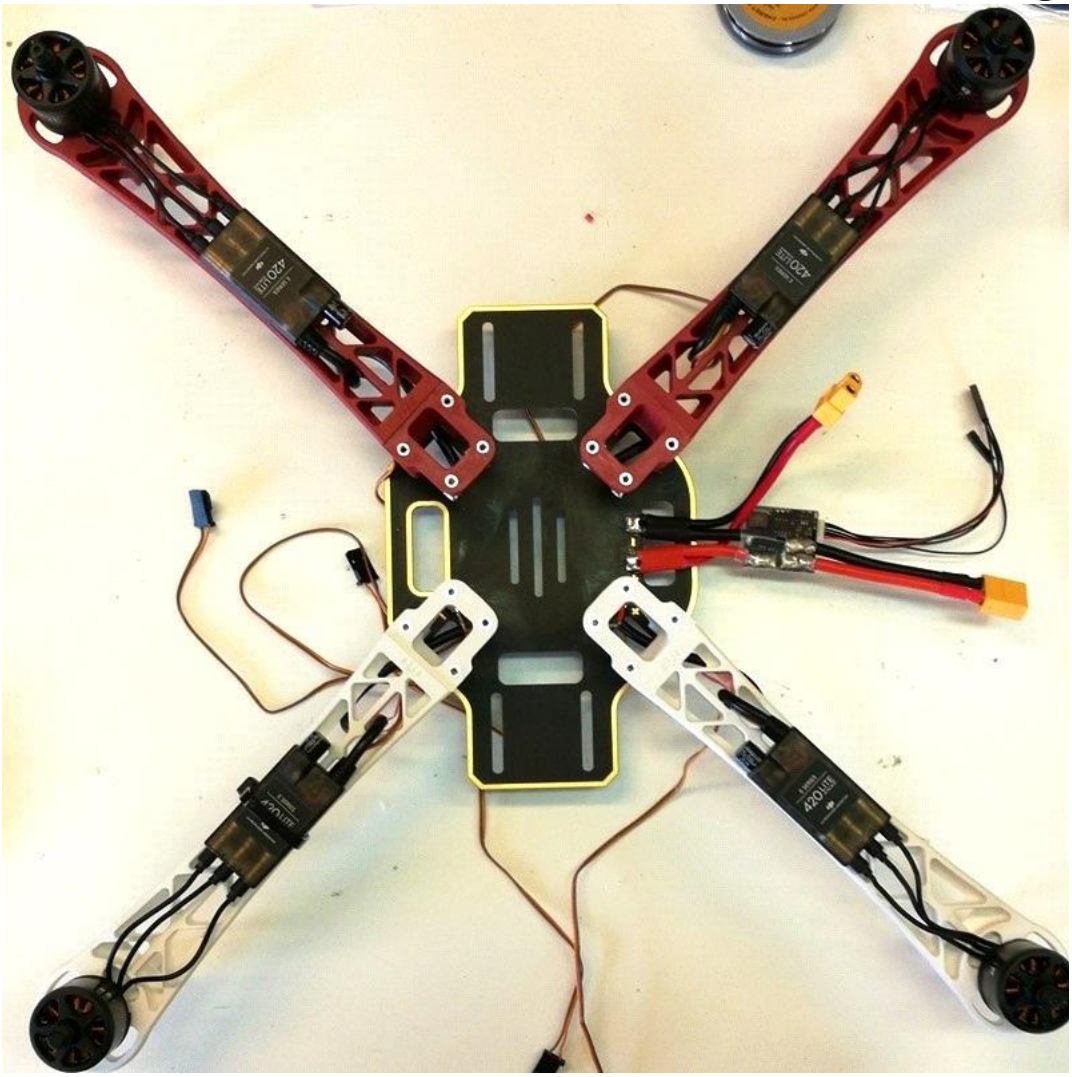


Figure #33. At this point, the airframe should look like this

Mount an autopilot box to the bottom plate using vibration dampers or several layers of double-sided tape.

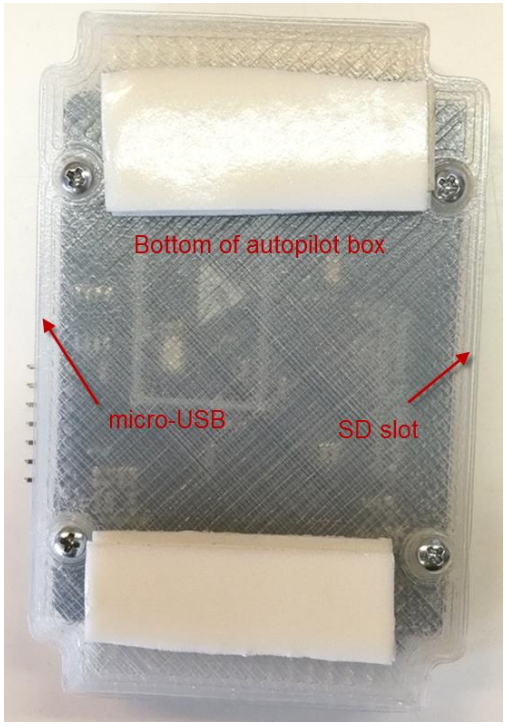


Figure #34. Autopilot box bottom

Orient the autopilot in such a way that an SD card slot is on left side and micro-USB connector is on the right side of the airframe.

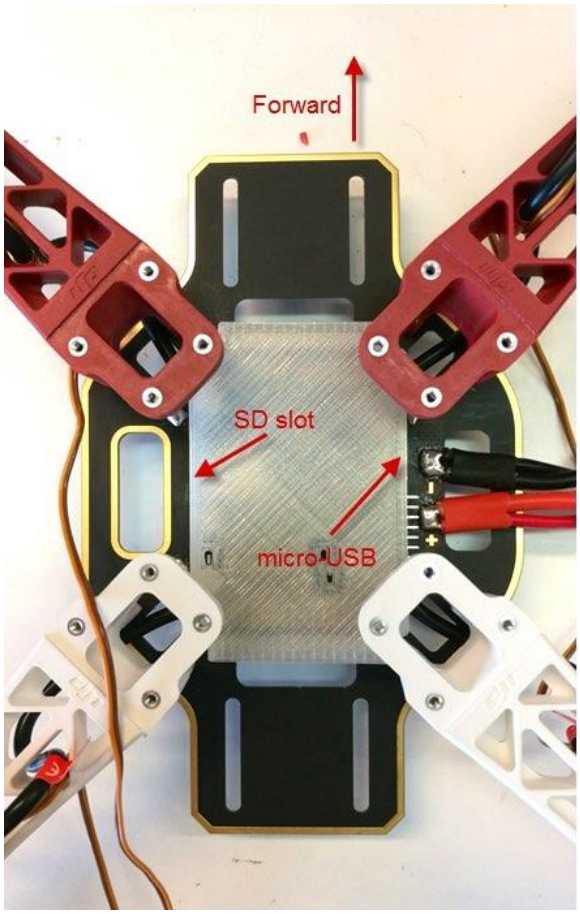


Figure #35. Autopilot should be placed at the very center of the bottom plate

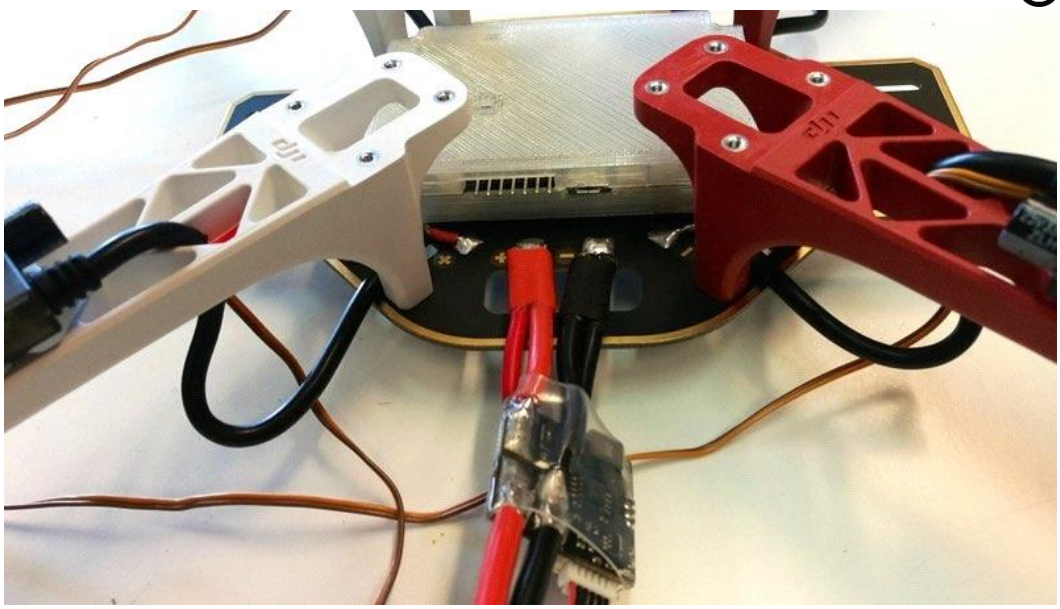


Figure #36. Autopilot micro-USB port and power module pins should be accessible from the right side

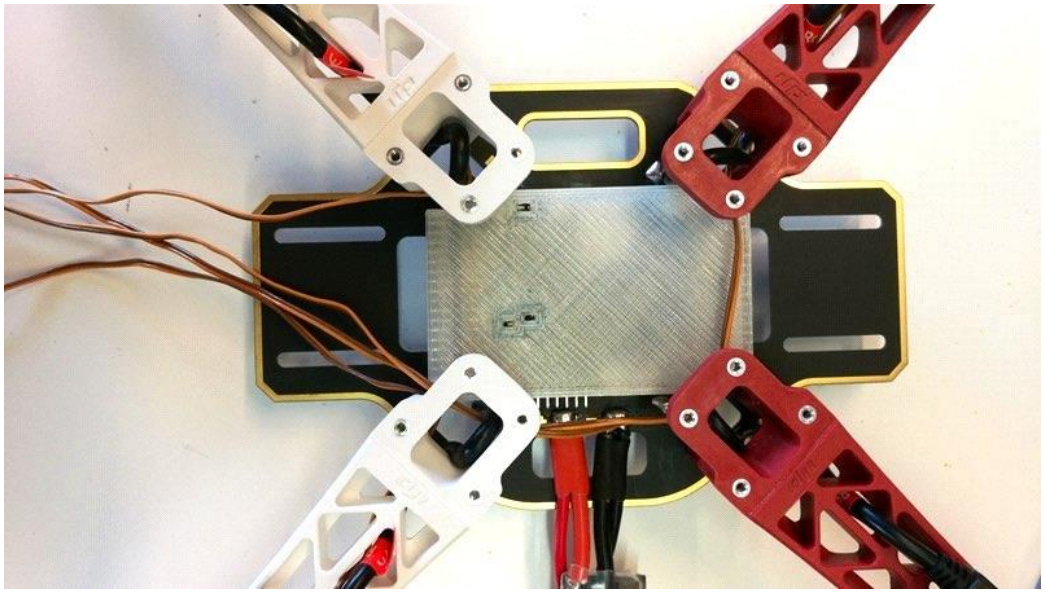


Figure #37. Position ESC PWM wires as shown

Figure #38. Pull the main power connector through the hole in the right white arm

Then, shorten ESC PWM wires.

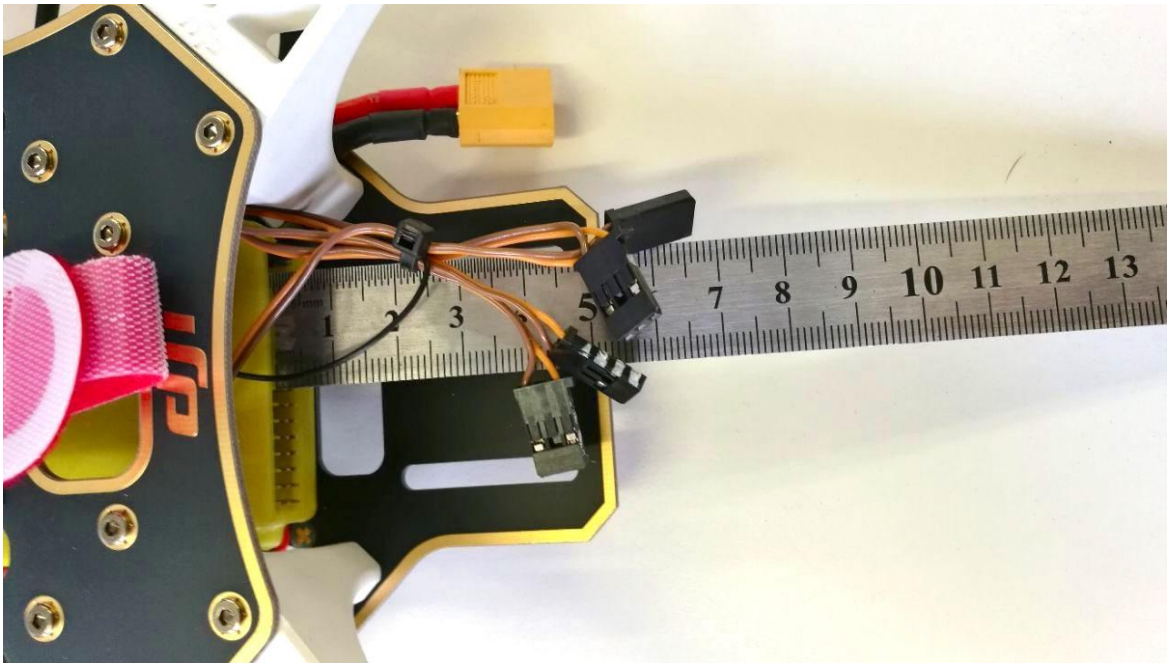


Figure #39. Recommended length of ESC PWM wires

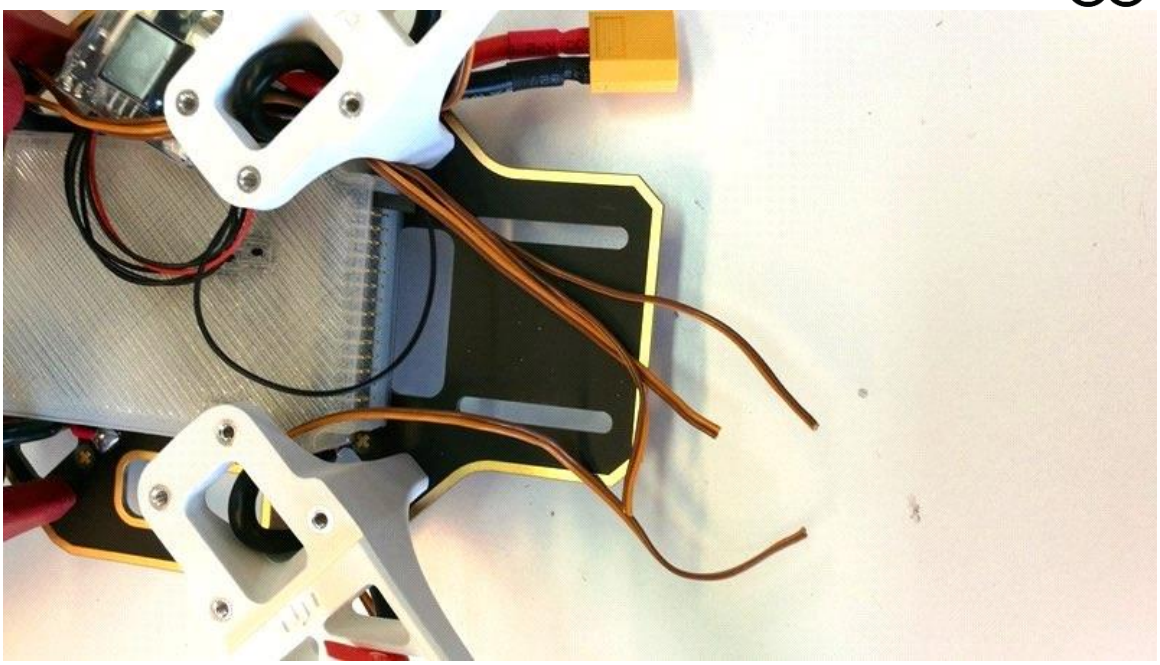


Figure #40. Cut off ESC PWM wires

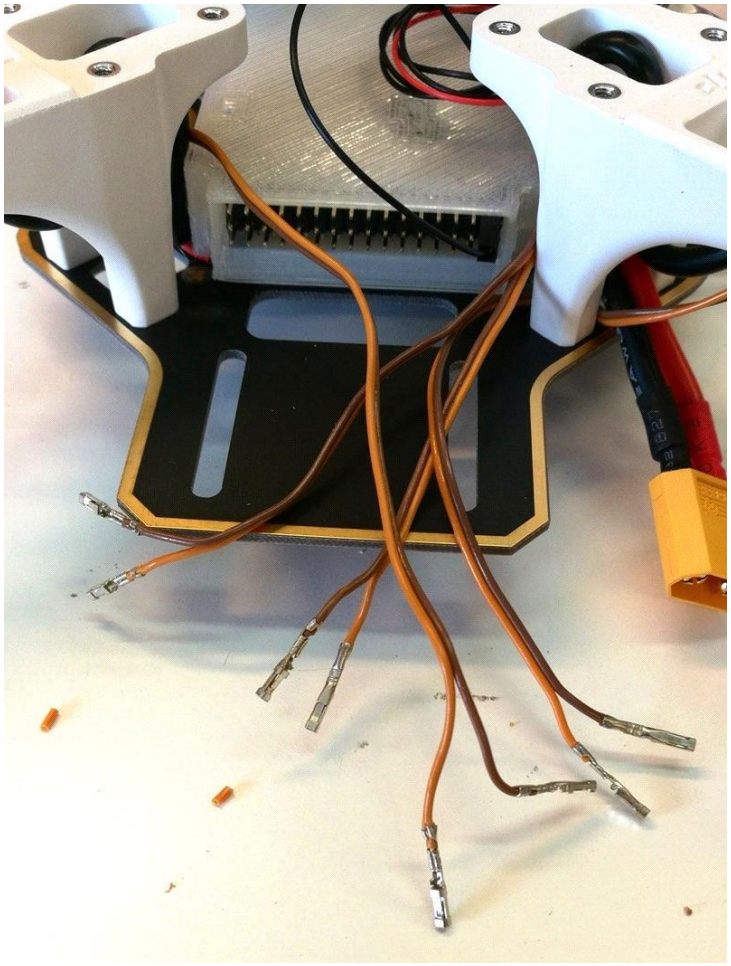


Figure #41. Terminate wires with connector pins

Insert terminated wires in respective plastic bodies. Some of the 3-pin servo connectors have a plastic guide, which, depending on the autopilot box, will keep the cable from being fully inserted.

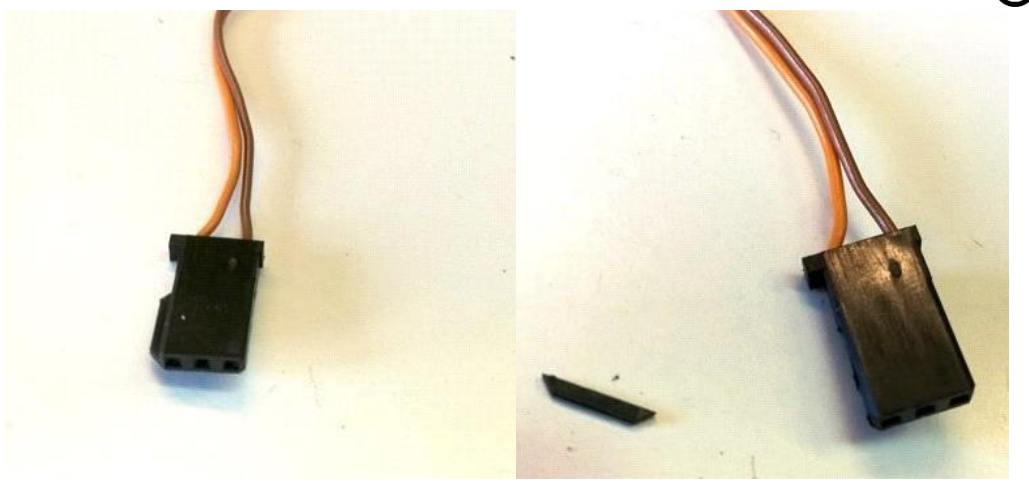


Figure #42. If necessary, cut off plastic guide from connector body

Figure #43. Now the airframe should look like this

Connect the ESC wires to the autopilot according to the pinout.

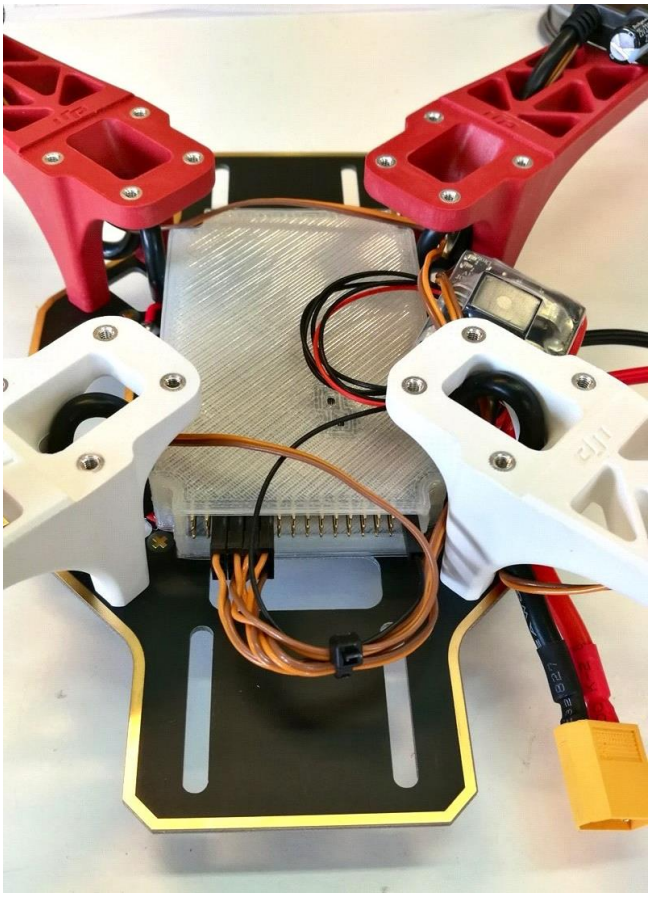


Figure #44. Fix the wires together with a cable tie

The DJI F450 airframe type is QUAD X. Below are the motor numbers and rotation directions. Motor ESC wires should be connected to respective autopilot motor output pins according to the schematic below.

For example, the top left motor is designated as number 3. So ESC PWM wires from this motor should be connected to the autopilot motor output pins with the same number 3.

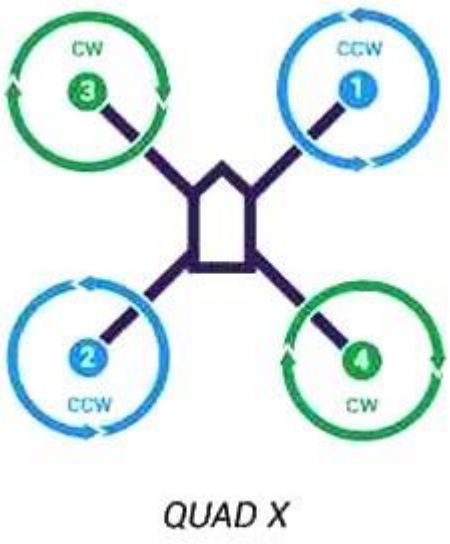


Figure #45. Ardupilot Quadro motor numbering

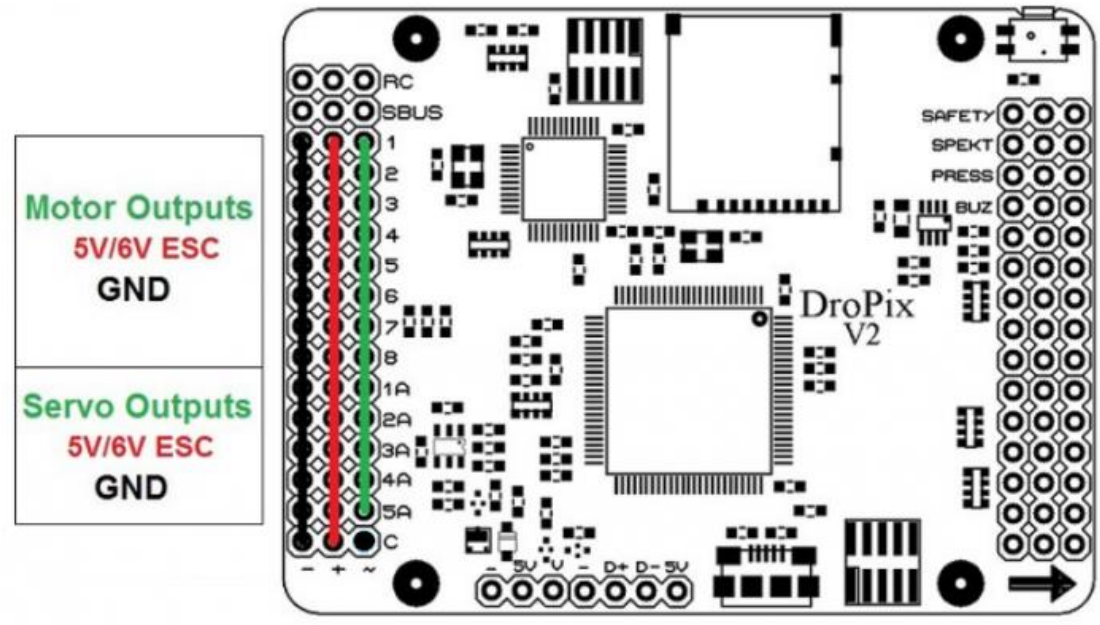


Figure #46. Dropix autopilot pinout

Then, attach Wi-Fi and Spektrum receiver modules to the arms using a double-sided tape. Looking from the top, the Spektrum receiver should be mounted on the left top arm and the Wi-Fi module should be mounted on the right bottom arm.

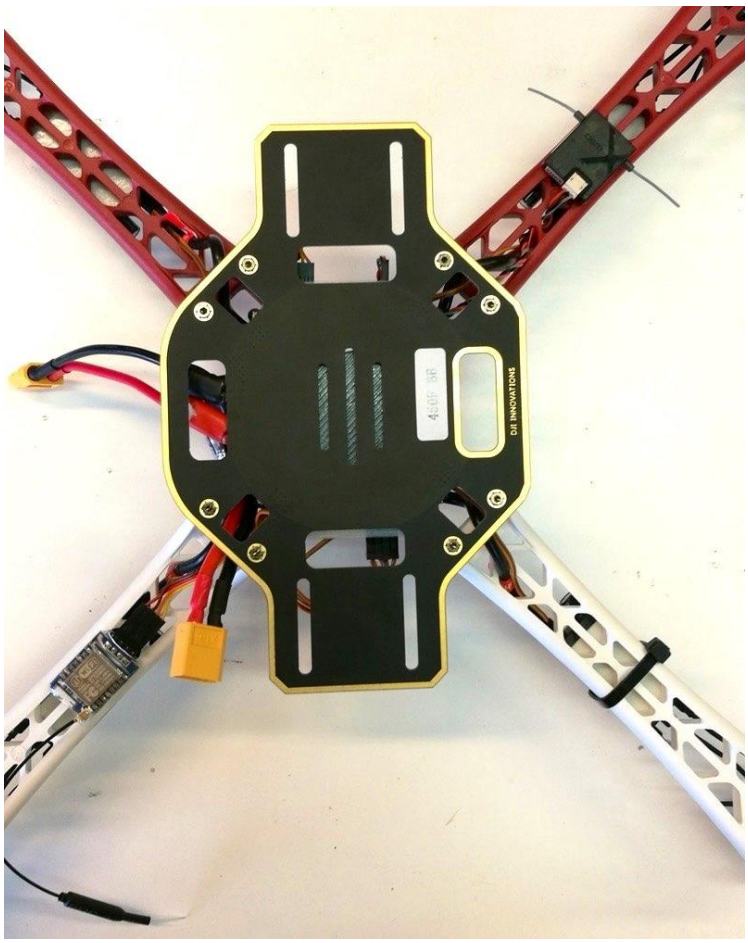


Figure #47. Cables should be connected to respective autopilot pins

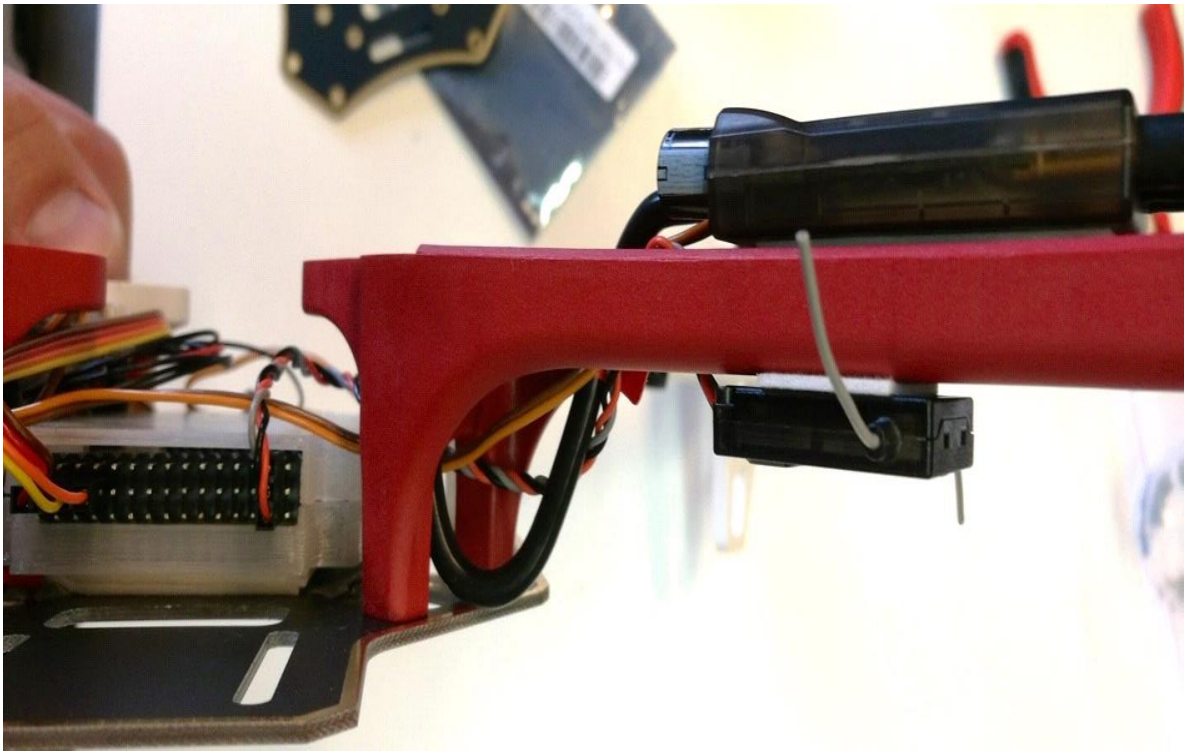


Figure #48. Spektrum RC receiver placement

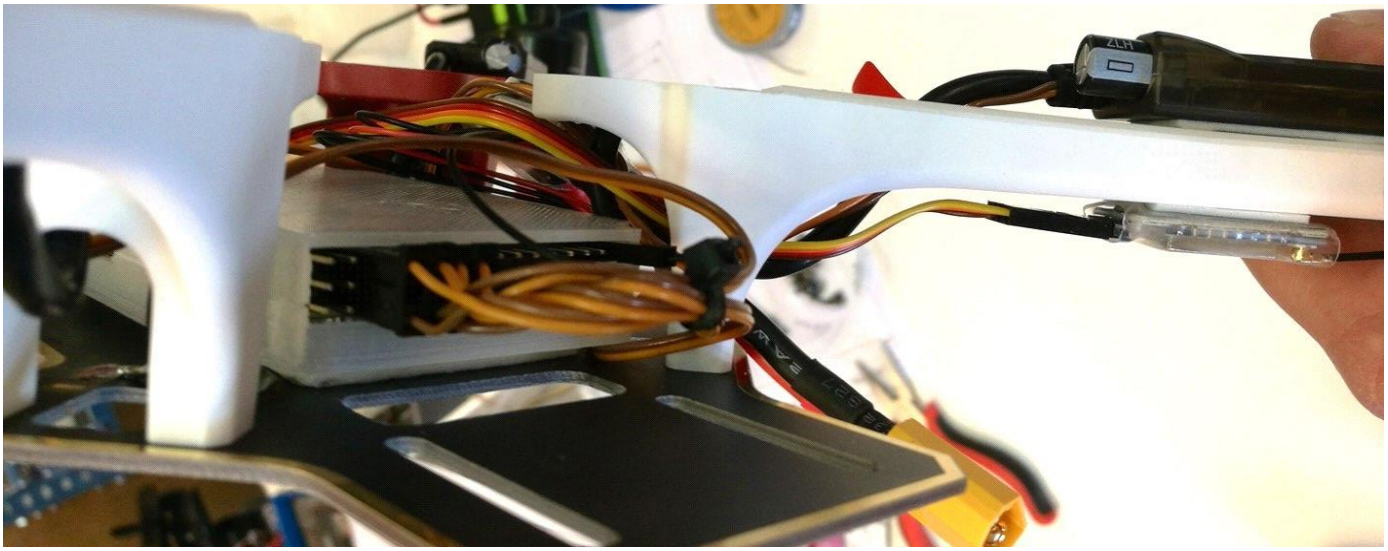


Figure #49. Wi-Fi telemetry module placement

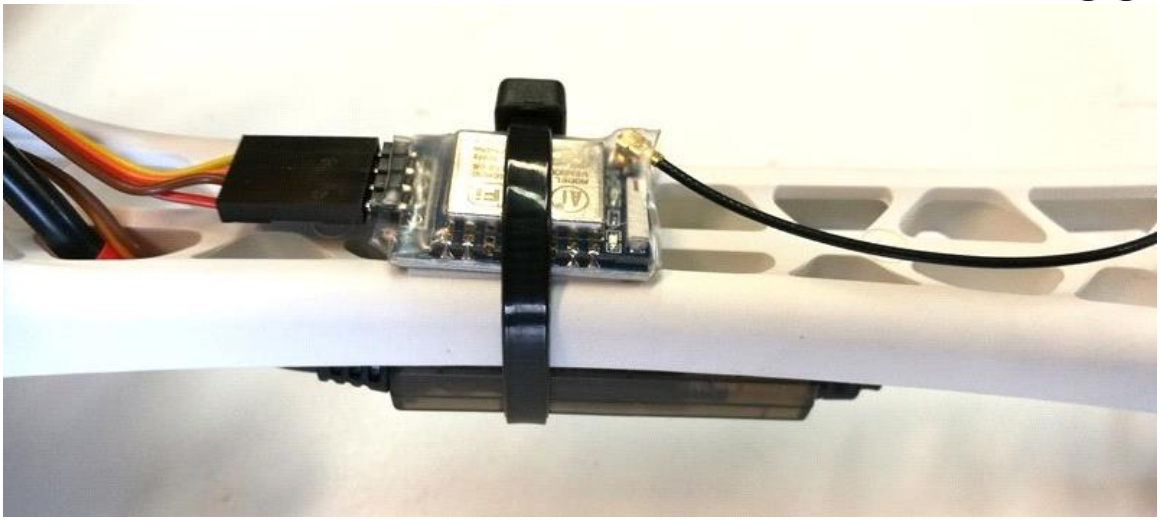


Figure #50. Use a cable tie to affix Wi-Fi and RC modules together with the remaining ESCs to the arms

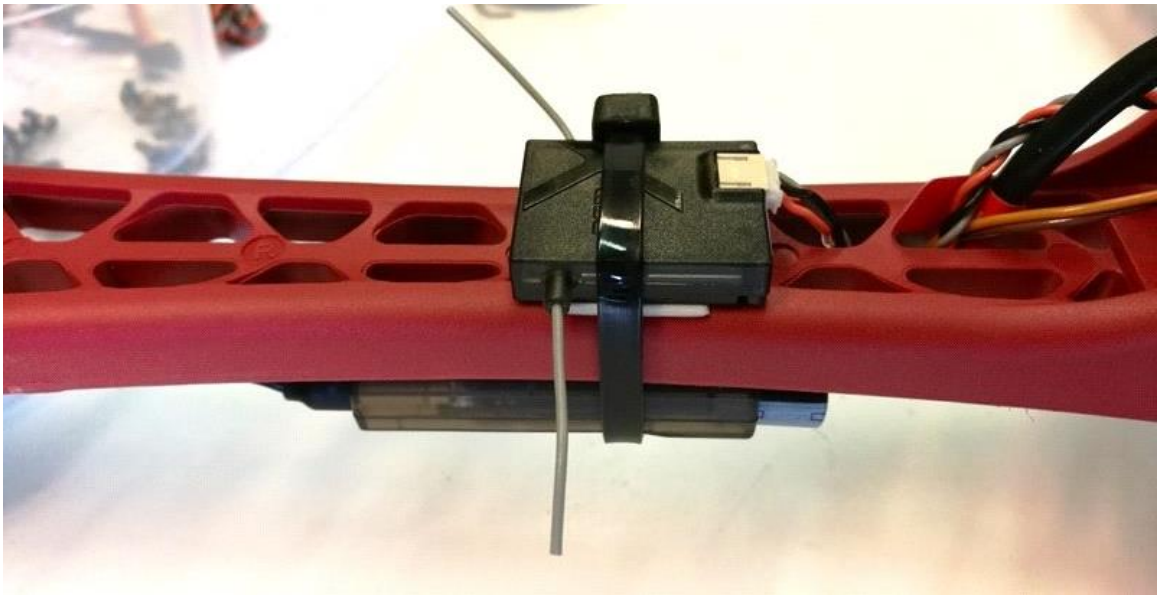


Figure #51. Use a cable tie to affix Wi-Fi and RC modules together with the remaining ESCs to the arms (2)

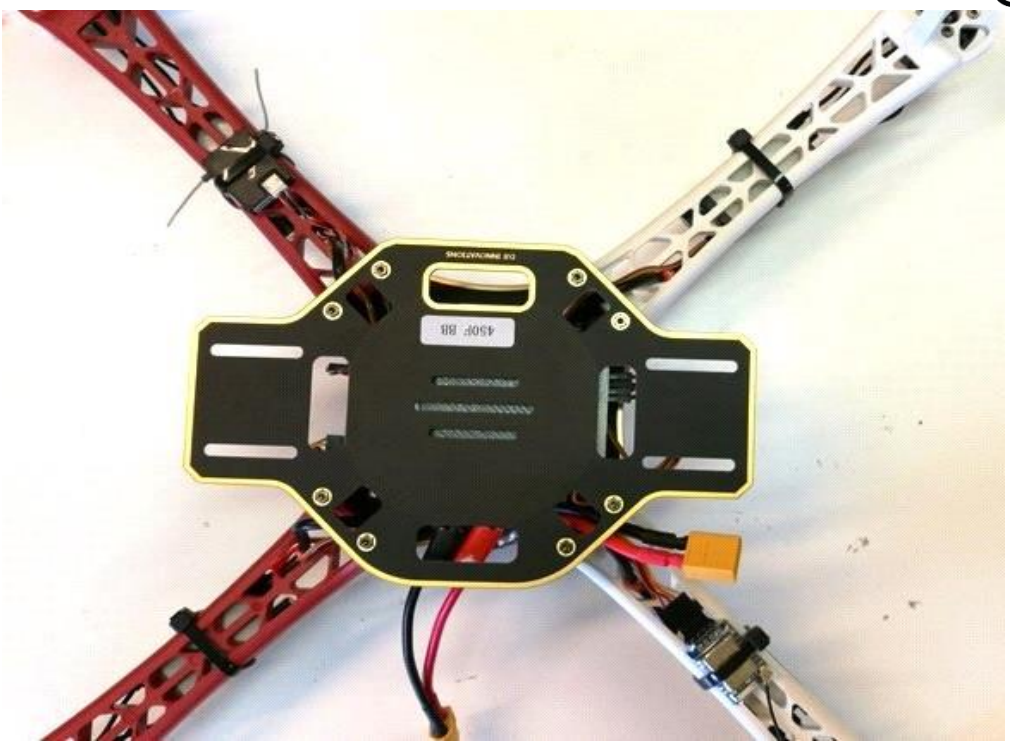


Figure #52. At this step, the airframe should look like this

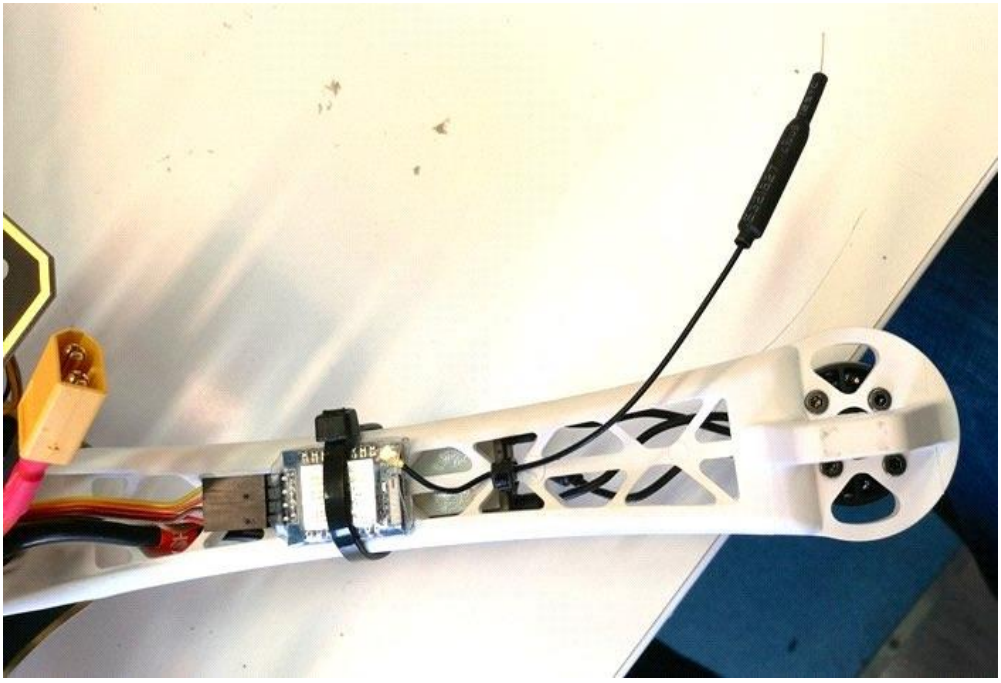


Figure #53. Use a cable tie to fix Wi-Fi antenna to the arm

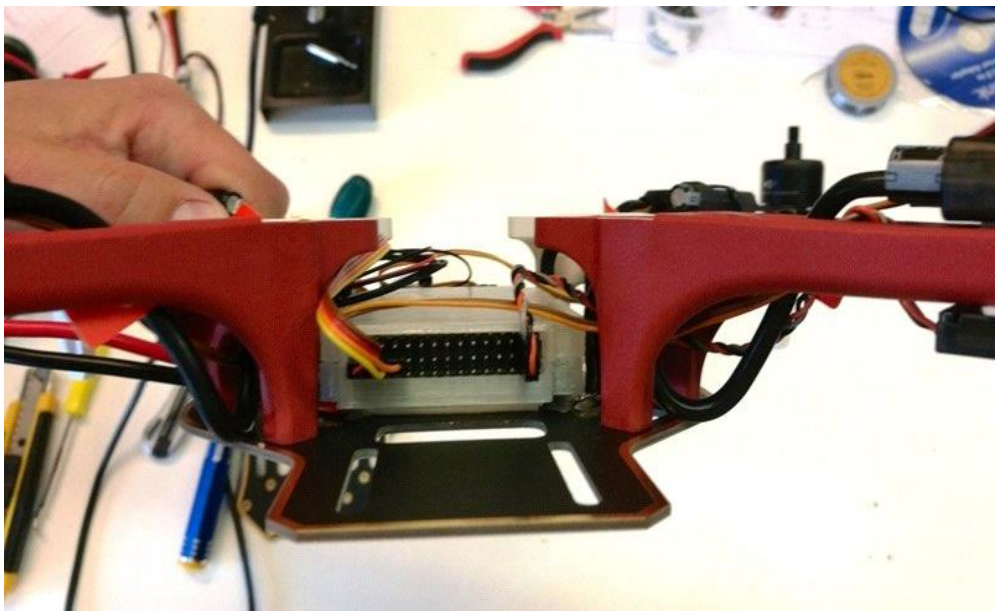


Figure #54. The RC and Wi-Fi modules should be connected to the autopilot

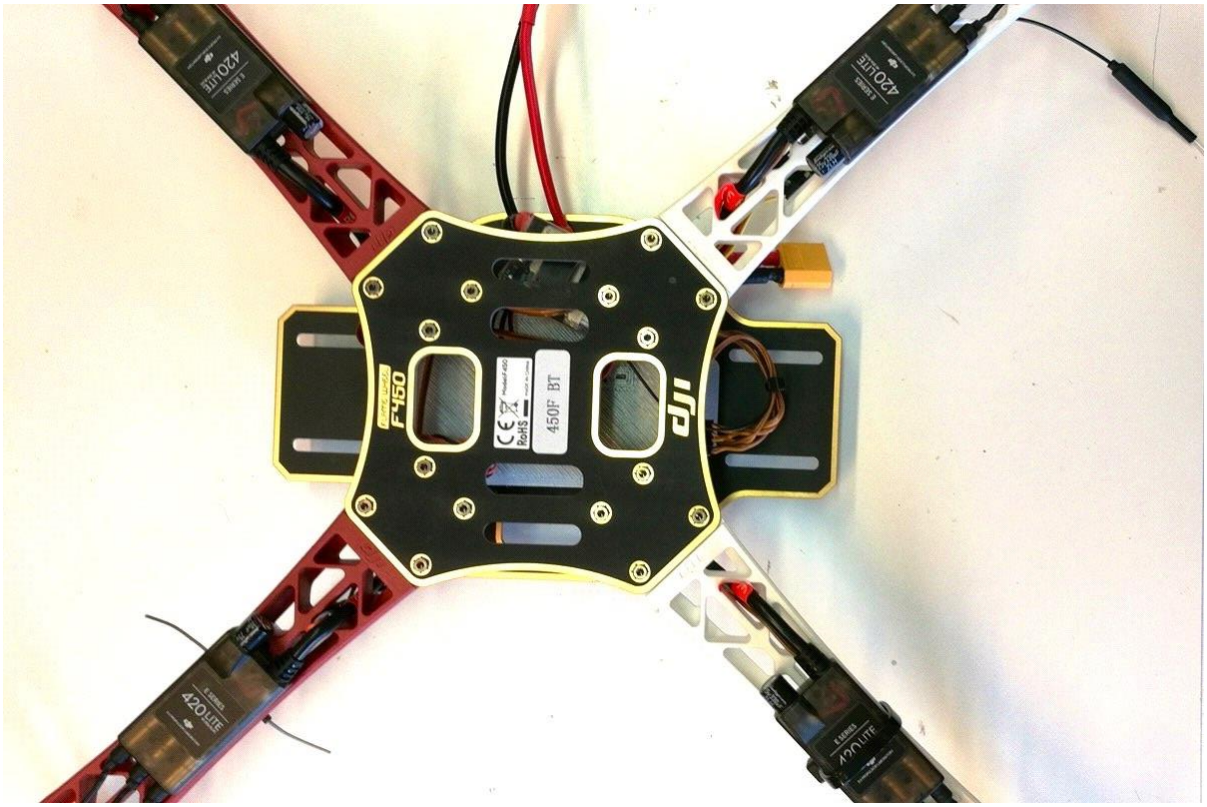


Figure #55. At this step, an airframe top plate may be attached

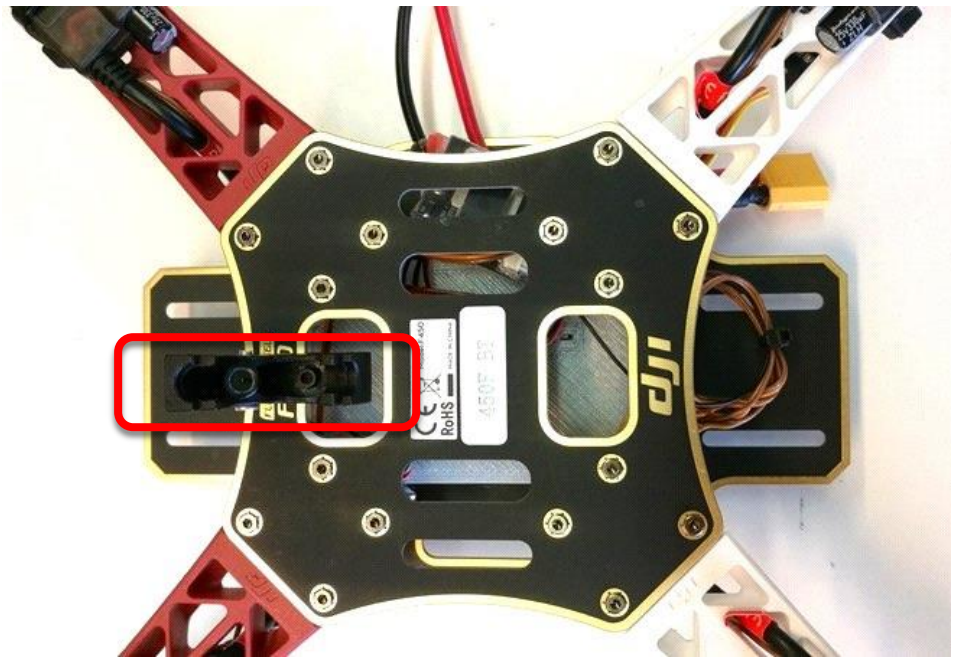


Figure #56. Fix bottom part of the GPS holder to the top plate

Drotek XL RTK GPS

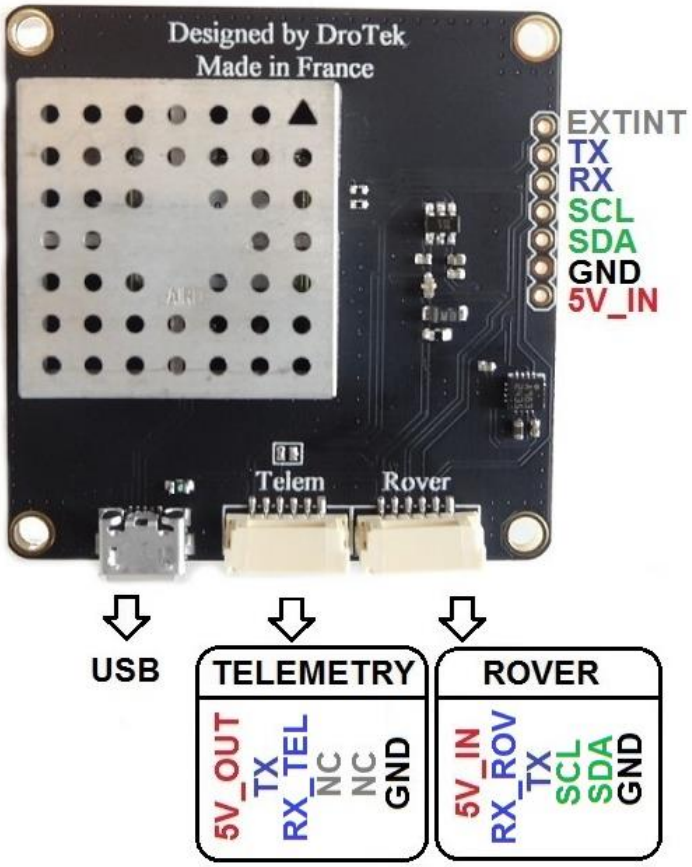


Figure #57. The wire from the autopilot should be connected to the Rover port of the GPS unit (Image: © DroPix)

A GPS unit case is not provided by the manufacturer and should be 3D printed.

A GPS unit mast should be fixed to the top GPS mounting plate using a glue or epoxy. After that the GPS unit itself (case) should be fixed to the mounting plate at the top of the mast using double-sided tape.

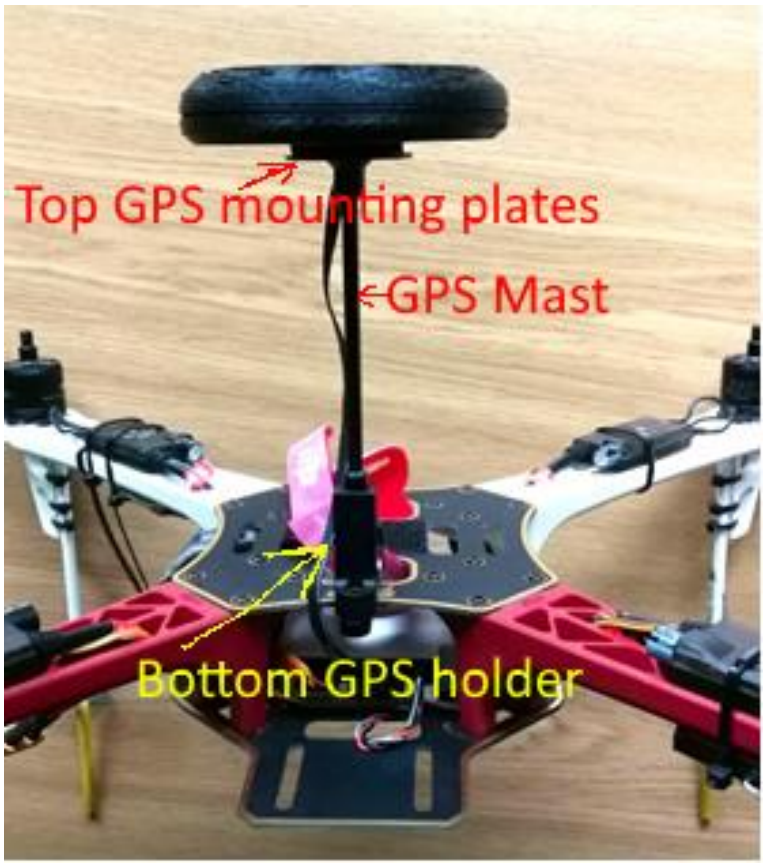


Figure #58. Cables from the GPS unit should exit on the rear side

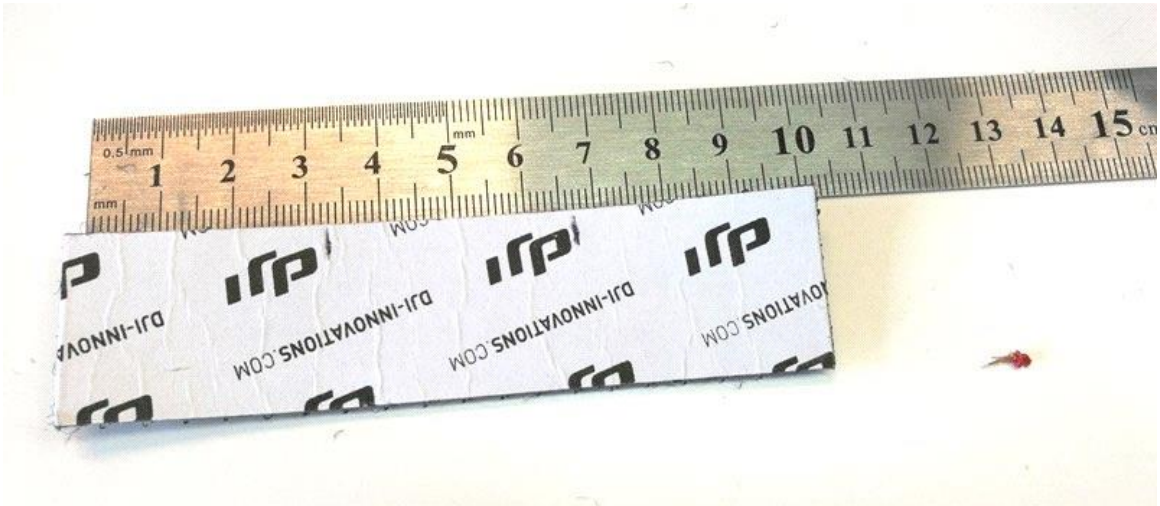


Figure #59. Cut the provided self-adhesive velcro tape in three parts

Figure #60. Cut the provided self-adhesive velcro tape in three parts (2)

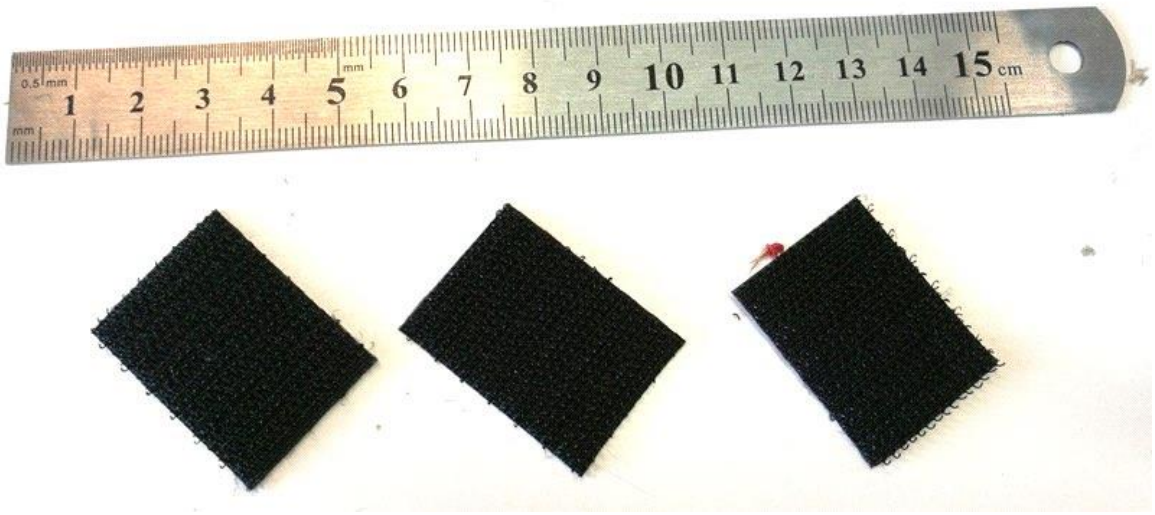


Figure #61. Cut the provided self-adhesive velcro tape in three parts (3)

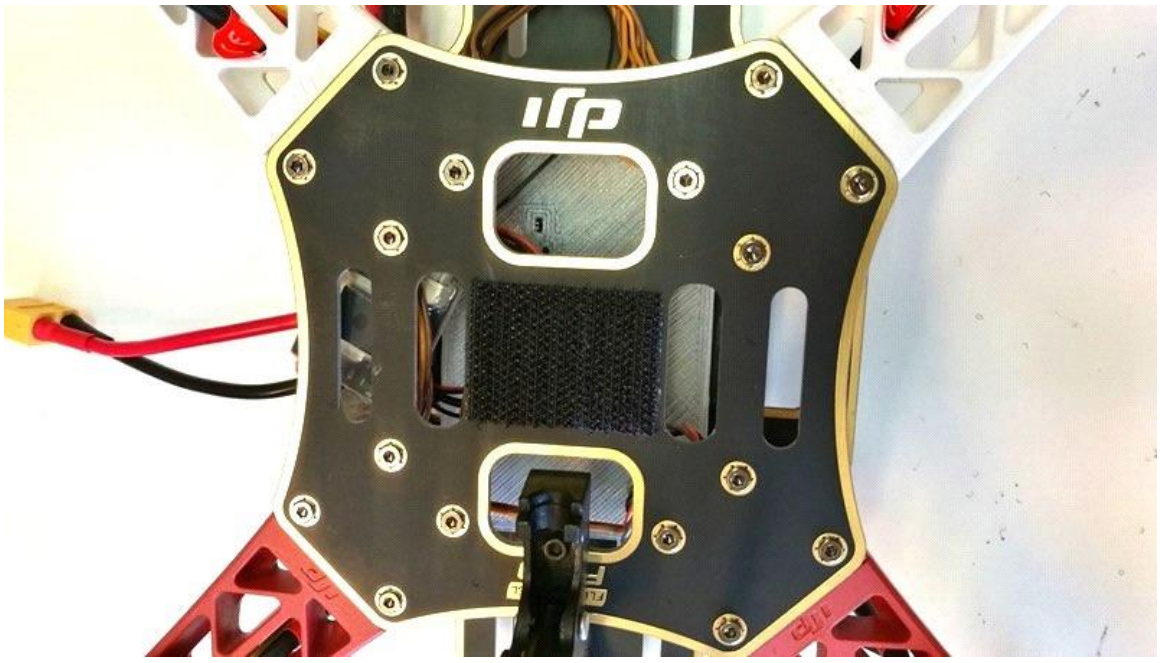


Figure #62. Apply one part of the self-adhesive velcro tape to the top plate

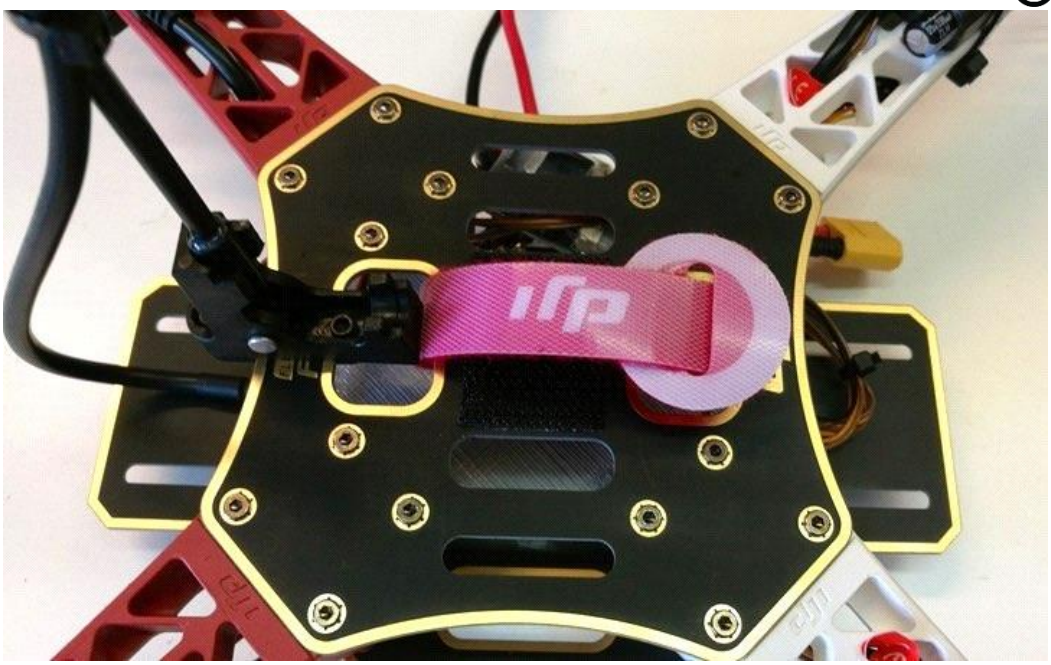


Figure #63. Pull a battery band through the designated holes of the top plate

We recommend using LiPo 4-cell 4000 mAh GensAce or similar batteries.

Firmware and parameters

Usually, a standard ArduPilot's firmware may be used.

For better flight control with RTK GPS, an improved ArduCopter-3.5.1 version is advised, which is available from **UgCS** GitHub repository: https://github.com/ugcs/Ardupilot/releases.

Along with the improved ArduCopter's firmware, the **UgCS** GitHub repository also contains example parameters to be used for flying with a standard GPS or RTK GPS.

NOTE: **We cannot guarantee that the provided firmware and parameters are correct for your flights! Use with caution!**

Firmware and parameter upload and drone calibration

UgCS team provides a configuration tool for Ardupilot firmware.

It allows you to:

- flash firmware
- upload parameters
- calibrate accel and compass
- set UAV ID

```
D:\UGCS\dd\config_tool>ConfigTool.exe

Usage: ConfigTool.exe [-f firmware_file] [-p param_file] [-a] [-c] [-i id] [-udp port] [-h]
         -f   - path to firmware file
         -p   - path to parameters file
         -a   - do accel calibration
         -c   - do compass(es) calibration
         -i   - UAV identificator to be set
         -baud - baud rate for the com port
         -udp - set UDP port to establish UDP connection rather then serial
         -h   - Show this help
Example : ConfigTool.exe -f firmware.px4 -p 1.param -i 101
         Will upload firmware.px4, set parameters from 1.param and set UAV identificator to 101
Example : ConfigTool.exe -c -a
         Will start accelerometers and complass calibration process.
Done
```

Figure #64. Configuration tool

Execution example:

```
ConfigTool.exe -f firm_par\ddc-2.12-px4-v3-7799077.px4 -p "firm_par\f450-px4-v2-ext-compass-old-esc-drotek-lis.param" -a -i 148
```

You need to specify correct paths to firmware and parameter files. It is recommended to flash your autopilot with custom APM:Copter firmware. The firmware may be downloaded from **UgCS** GitHub repository: https://github.com/ugcs/Ardupilot/releases. The parameter file may also be downloaded from **UgCS** GitHub repository: https://github.com/ugcs/Ardupilot/releases.

- -f – a path to a firmware file
- -p – a path to a parameter file
- -a – calibrate accel

- -i – assign an UAV ID

Execute the configuration tool and follow the instructions:

```
D:\UGCS\dd\config_tool>ConfigTool.exe -f firm_par\ddc-2.12-px4-v3-7799077.px4 -p "firm_par\f450-px4-v2-ext-compass -old-esc-drotek-lis.param" -a -i 148
Firmate file: firm_par\ddc-2.12-px4-v3-7799077.px4
Parameters file: firm_par\f450-px4-v2-ext-compass -old-esc-drotek-lis.param
Accel Calibrate: True
UAV identificator: 148
Read File firm_par\ddc-2.12-px4-v3-7799077.px4
image_size 1020780 size 1020780
Loaded firmware for 9,0 waiting for the bootloader...Please, reset Autopilot board
Found board type 9 boardrev 0 bl rev 5 fwmax 2080768 on COM5
Old Flash erase...
New Flash program...
Programing packet total: 17013
New Flash verify...
Expected 0x88298591 -1853544056
Got      0x88298591 -1853544056
Done. Rebooting...
Waiting for EEPROM got initialized...Done.
Firmware upload complete.

Looking for heartbeat...Found on COM5
Requesting parameters...Done.
Reading parameters from file firm_par\f450-px4-v2-ext-compass -old-esc-drotek-lis.param
Requesting parameters from vehicle...Done. 786 parameters received
Sending 490 new parameters to vehicle...Done.

Setting UAV identificator to 148...Done.
Starting accel calibration.
Place vehicle level and press any key.
 Place vehicle on its LEFT side and press any key.
 Place vehicle on its RIGHT side and press any key.
 Place vehicle nose DOWN and press any key.
 Place vehicle nose UP and press any key.
 Place vehicle on its BACK and press any key.
 Accel calibration complete

Rebooting....
Looking for heartbeat...Validating UAV state...
Done.
```

Figure #65. Configuration tool (2)

For wireless compass calibration, you need to specify a UDP port to establish connection:

Execution example: `ConfigTool.exe -udp 14548 -c`

```
D:\UGCS\dd\config_tool>ConfigTool.exe -udp 14548 -c
UDP port: 14548
Complass Calibrate: True
Looking for heartbeat...Found on UDP port
Requesting parameters...Done.
The UAV identificator 148 will be left unchanged. Press any key.
Starting compass calibration.
Rotate the vehicle...
doCommand cmd resp DO_START_MAG_CAL - ACCEPTED
Compass:0 progress:5%
Compass:1 progress:5%
Compass:2 progress:7%
Compass:0 progress:15%
Compass:1 progress:16%
```

Figure #66. Configuration tool (3)

…

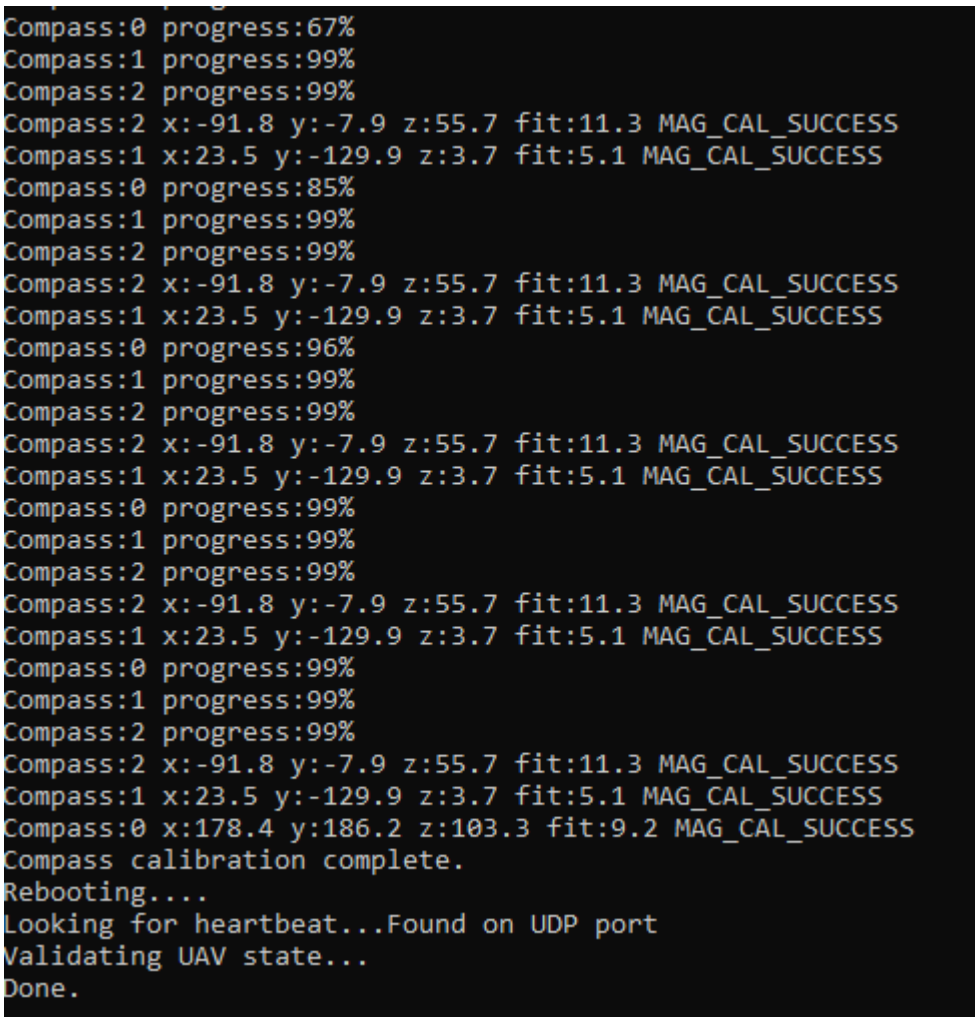


Figure #67. Configuration tool (4)

Radio calibration and RC transmitter binding

Calibrate Radio as described here: http://ardupilot.org/copter/docs/common-radio-control-calibration.html.

Before radio calibration, bind the RC transmitter. If you are using Spektrum DX8 or a similar RC transmitter, then copy the existing profile and give it an easily recognizable name.

In our case, the first manually configured profile was DDC1. This profile was then copied and renamed according to last two digits of each vehicle IP: DDC2,…, DDC10, DDC11, etc.

In order to bind vehicle with IP 192.168.0.110, use DDC10 profile.

Figure #68. Mission Planner (RC binding and calibration)

The ESCs are pre-calibrated, therefore ESC calibration is not required.

Checking flight modes

Flight mode 1 should be Loiter, others should be Stabilize.

Figure #69. Mission Planner (Flight Modes configuration)

Setting Failsafe actions

Specify the failsafe actions in case of Low Battery as RTL and specify a low battery voltage threshold. In our case, it is 13 V.

Figure #70. Mission Planner (FailSafe configuration)

For safety purposes during the first manually-controlled flight, enable RC FailSafe action. Currently, it is Disabled.

Checking Battery Monitor settings

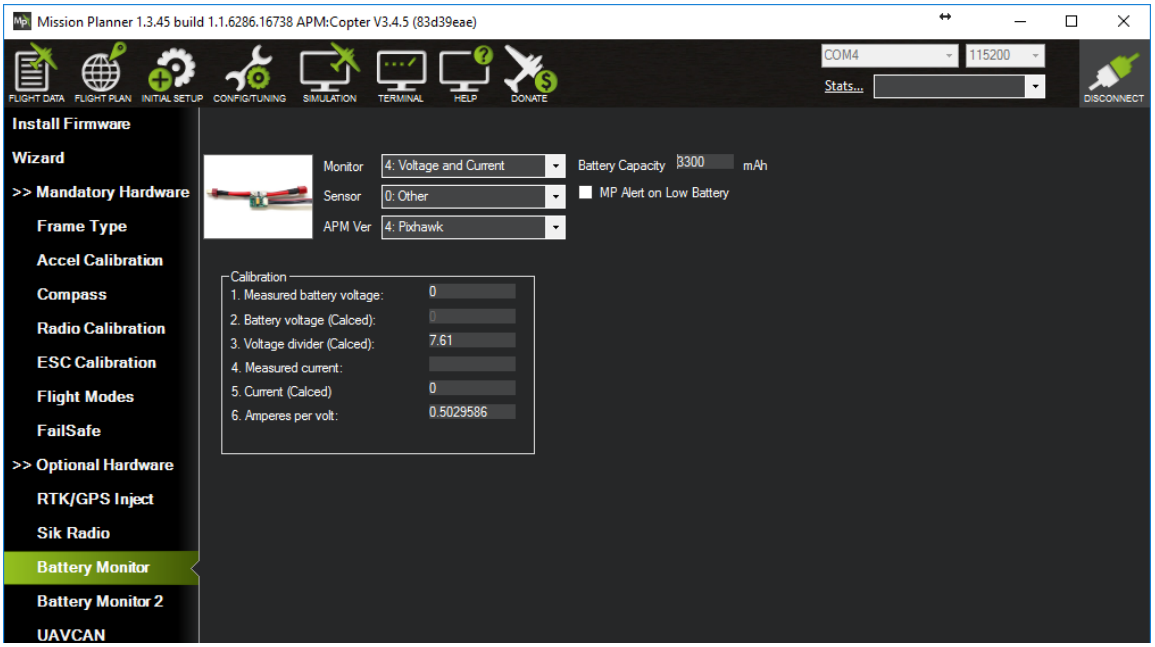


Figure #71. Mission Planner (Battery Monitor configuration)

Run Motor test. To run it, remove propellers and connect a battery. Increase the Throttle % to 10%. Click Test motor A. The Forward Right motor should start spinning for 2 seconds.

- B – Backward Right Motor.
- C – Backward Left Motor.
- D – Forward Left Motor.

NB! Make sure that the motor rotation directions are correct and correspond to the schematic shown earlier in this manual. If a motor is spinning in a wrong direction, remove two of the three motor wires plugged in the ESC and flip them.

Figure #72. Mission Planner (Motor test)

Checking telemetry via Wi-Fi

In Mission Planner, choose Connection type: UDP. A port should be used from the respective Wi-Fi module configuration.

Figure #73. Mission Planner (Connection via UDP)

The first flight

During the first flight, check if manual (stabilize and loiter) and auto modes work correctly. Before the flight, make sure that you can switch between the modes using the RC transmitter. It is also useful to add an RTL mode that can be switched on using the remote control.

Using the RC, arm the drone and slowly take off in the Stabilize mode. When the drone is sitting safely in the air, switch to the Loiter mode and observe behavior attentively. If the drone has troubles with keeping its position, recalibrate the compass.

To check auto modes, switch the autopilot to the Guided mode and click Arm, Takeoff, and Land.

Secondary channel configuration

During a drone show stable Wi-Fi connection with all drones cannot be guaranteed. However, even when drones are flying autonomously and are not controlled from the ground, they still need to receive RTK GPS corrections and must respond to emergency commands such as ('HOLD', 'LAND', 'RETURN HOME' or 'DISARM'). A secondary channel is designed to reduce the risk of losing control of a drone during a show.

Architecture

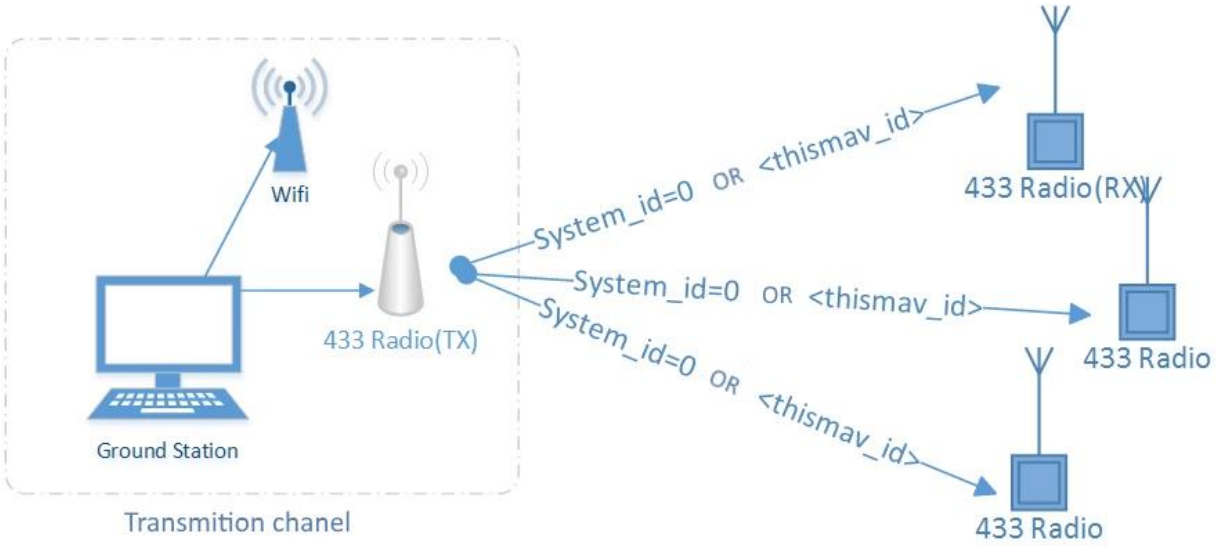


Figure #76. Architecture of secondary channel configuration

Reading RTCM corrections via a radio link:

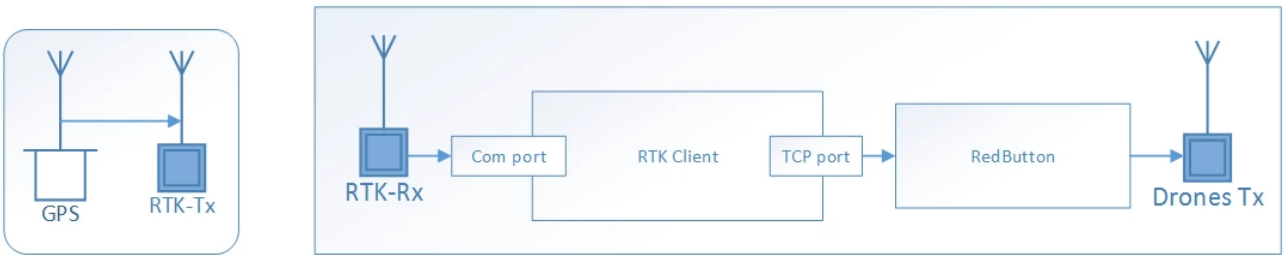


Figure #77. Reading RTCM corrections via a radio link

This option is good in a situation when an RTK GPS base station is located away from operators.

Direct connection:

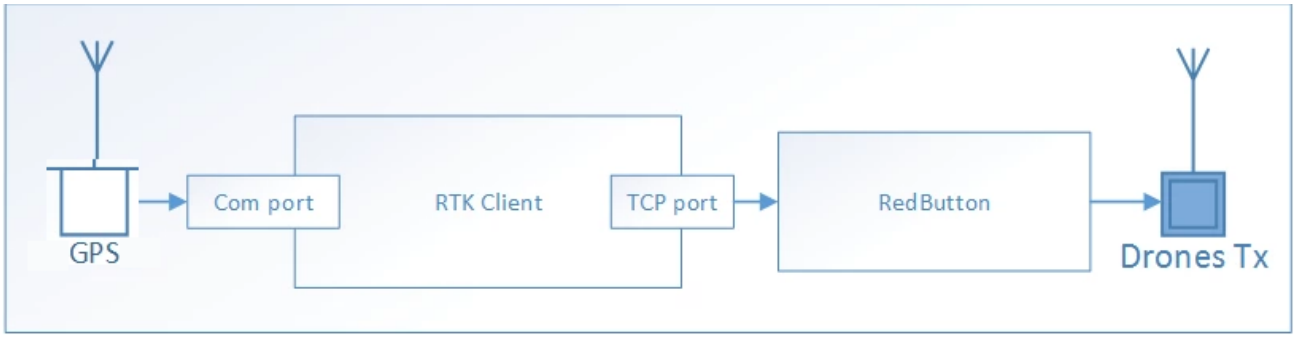


Figure #78. Direct connection

Direct connection is the best solution when high interference is expected, for example – when flying drone shows with 50 drones or more.

An RTK GPS base station is operating at a fixed location and sending its RTCM data to RTK Client application.

RTK Client parses incoming packages, "wraps" them into MAVLink, and retransmits them to consumer sinks.

RedButton is responsible for sending commands to a swarm of drones. It reads data from one of RTK Client's sinks and broadcasts packages to the fleet.

Hardware

Radios

3DR radios have been chosen as a secondary channel between drones and flight control software. Depending on the region, various versions (433, 868 or 915 MHz) can be used to satisfy local requirements.

Figure #79. 3DR radio modules

Be aware that the default firmware does not support any encryption or channel securing, and communication can therefore be subject to hijacking.

GPS

A module based on u-blox NEO-M8P-2 chip is used as the RTK GPS base station.

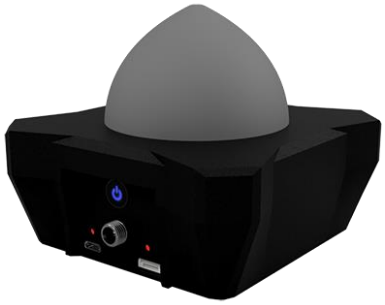


Figure #80. RTK GPS base station based on u-blox NEO-M8P-2 chip

The base station can be connected and configured either locally via USB or remotely via radio modems. RTK Client application is ideal for this purpose.

Radio module connection to RTK base station

To connect 3DR radio module to Drotek RTK base station use the following pin assignment

Wire Nr	Corresponding pinout	3D Radio pin
A1	GROUND	GND
A2	-	
A3	-	
A4	TX	TX
A5	RX	RX
A6	5V OUT	5V IN

Radio module configuration for RTK correction transmission

To configure the radio modules, download Radio-updater tool and the corresponding config file from GitHub: https://github.com/ugcs/radio-updater/releases

The basic configuration settings to use new modules to connect RTK Base to PC are:

- Baud: 9
- Mavlink: RawData
- Tx Power : 20
- ECC : on

To use the Radio-updater tool:

1. Connect the radio module you wish to configure to the PC
2. Check the according COM port that has been assigned to the Radio module in Device manager.
3. Open Command Prompt in the directory where radio-uploader.exe is located
4. Use the following line to configure the Radio module (change COM39 to the necessary port number)

```
radio-uploader.exe -port COM39 -b 57600 -c gps_rtk.cfg
```

5. Repeat step 4. with the second Radio module
6. If you have questions, use radio-uploader.exe -h to display additional information

Now that both modules are configured, try to connect the modules – one to the RTK Base and the other to the PC to check if configuration was successful.

Software

Installing drivers

Windows 10 users (and perhaps others) will need to download and install the u-blox GNSS Standard Driver for Windows, v1.2.0.8.

If this link is broken you may find a newer version under the Driver section of this ublox page.

When first installed, the device may show up in the Sensors category in Device Manager. In this case, please right-click it and select Update Driver Software —> Browse my computer for driver software —> Let me pick from a list of devices. In the next screen, you will see a list of possible drivers. Select USB Serial Device —> Next —> Finish.

If installed correctly, the GPS should appear in the Device Manager as USB Serial Device when plugged in.

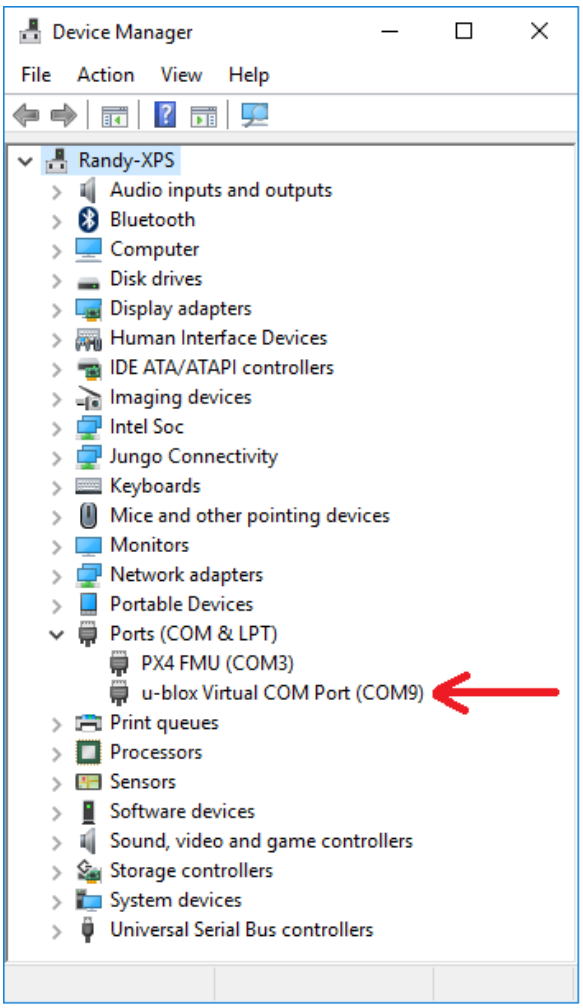


Figure #81. Device Manager

RTK Client

This tool is designed to configure an RTK GPS base station and read corrections provided by it, as well as retransmit data as MAVLink messages to multiple consumers.

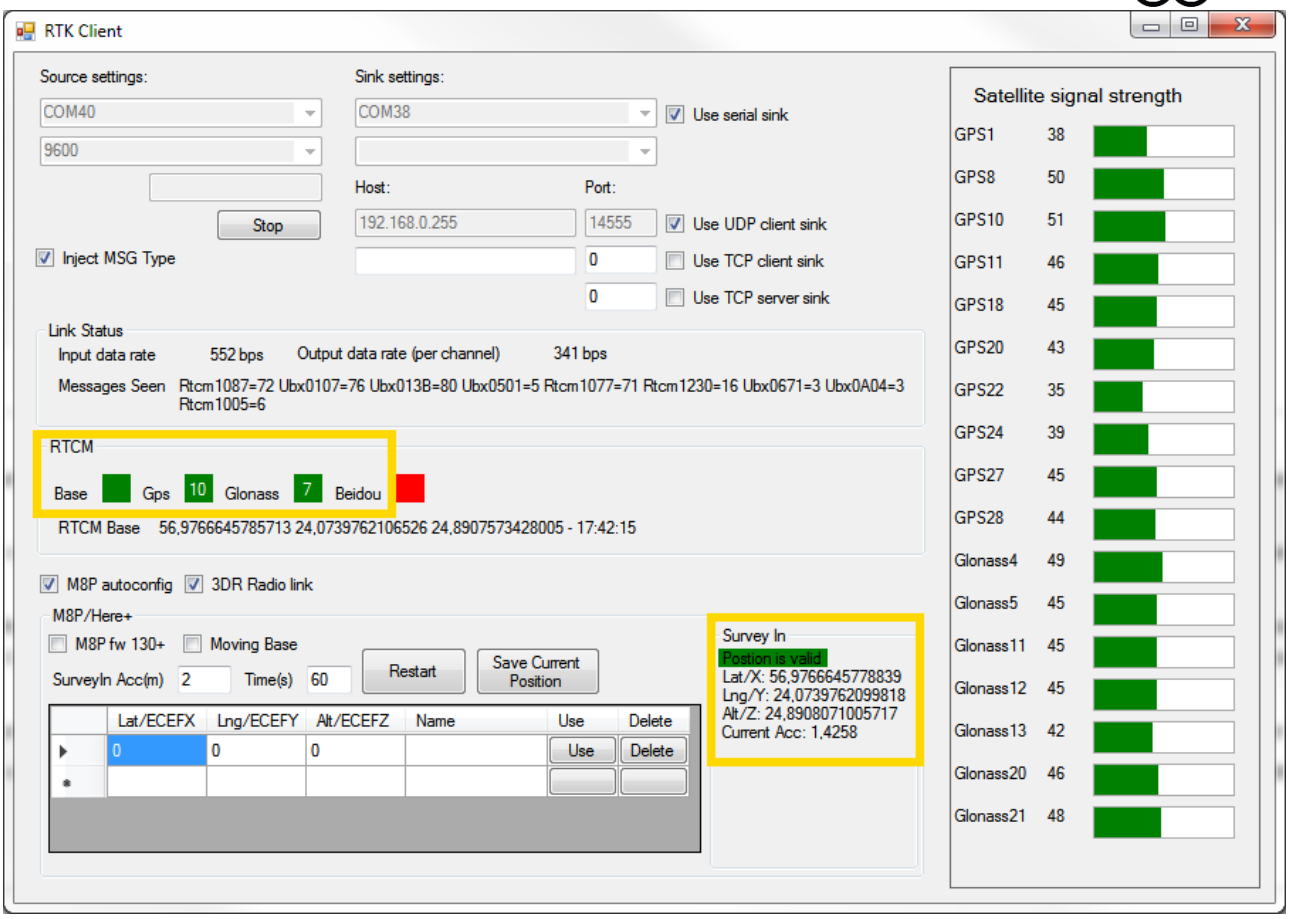


Figure #82. RTK Client

Typical use case:

- Connect RTK base station to your workstation
- Identify “Source settings” - COM port and baud rate to be used by RTK GPS base station (default baud rate after the GPS restart is 9600). Refer to VCP Device driver manual (https://www.u-blox.com/en/product/u-center-windows)
- Choose a desired port and baud rate in Source settings (COM9 and 9600)
- If you are using a secondary channel, in the field “Sink settings” enter the COM port and baud rate (default 56700) and check the box “use serial link”
- Choose consumer sinks. Fill text fields and click the desired checkboxes:
    - Use UDP client sink (broadcasts UDP corrections to drones via Wi-Fi network) (192.168.0.255, port: 14555)
    - (optional) Use TCP client sink (a direct TCP connection to a remote host)
    - Use TCP server sink (opens a server port and delivers RTCP corrections to external clients) (port: 8000)
- Click Connect.

If everything is connected correctly, the following green boxes will appear:

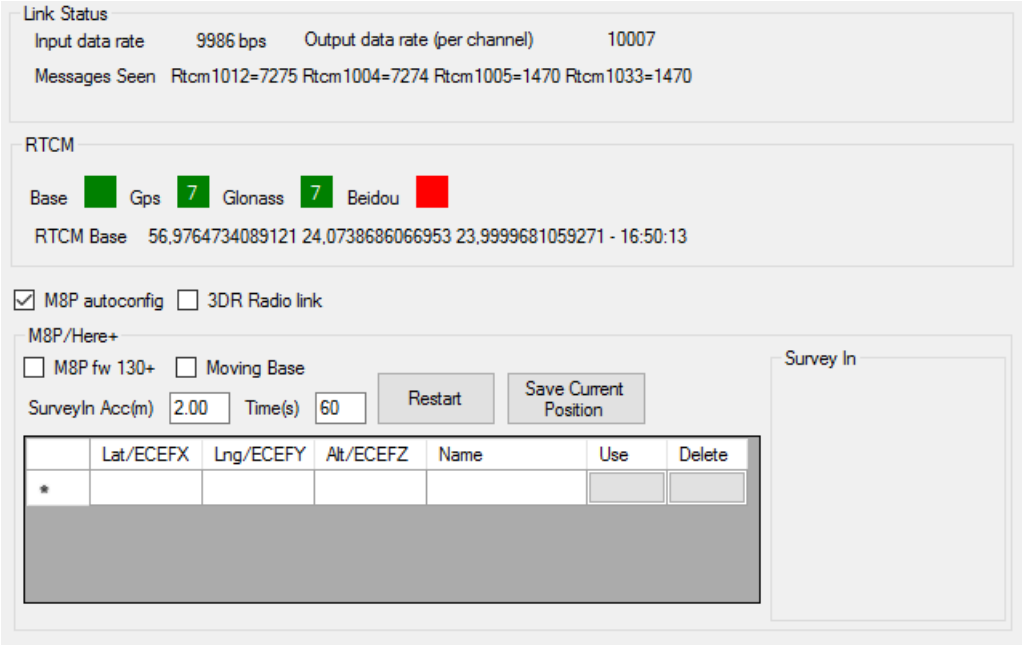


Figure #83. RTK Client (2)

If RTK GPS base station is connected to the workstation using USB cable, then GPS module will be automatically configured when M8P autoconfig is checked.

If RTK GPS base station is connected via radio modems like 3DR Radios, then check 3DR Radio link checkbox to prevent the base station from using higher speed.

In the SurveyIn Acc field, enter the absolute geographic accuracy that you expect from your RTK GPS base station. The default accuracy is 2 meters. In the Time field enter the minimum survey time you expect. The default suggested surveying time is 60 seconds. Click Restart; RTK Client will transfer the entered data to the RTK GPS base station, which will start a new round of surveying.

The Survey In field will display: InProgress indicates that the survey is ongoing. A completed survey of the current base station position is indicated by the status messages SurveyIn Valid: True and InProgress: false.

Duration: the survey duration in seconds.

Obs: the number of observations used for the survey.

Acc: current accuracy in meters

- When the survey is completed, as indicated by the SurveyIn: True message, you may click Save Current Position and enter a name for the saved position.
- RTK messages from the base station are sent to a drone as MAVLink message through consumers sinks.

RedButton

This app is a supporting tool for DDC Client. Its key function is to control individual drones or the whole fleet. It also sends RTCM corrections through an emergency radio channel.

Main screen shows all drones in a fleet with buttons against each one. Commands may be broadcasted by clicking buttons in the bottom of the screen.

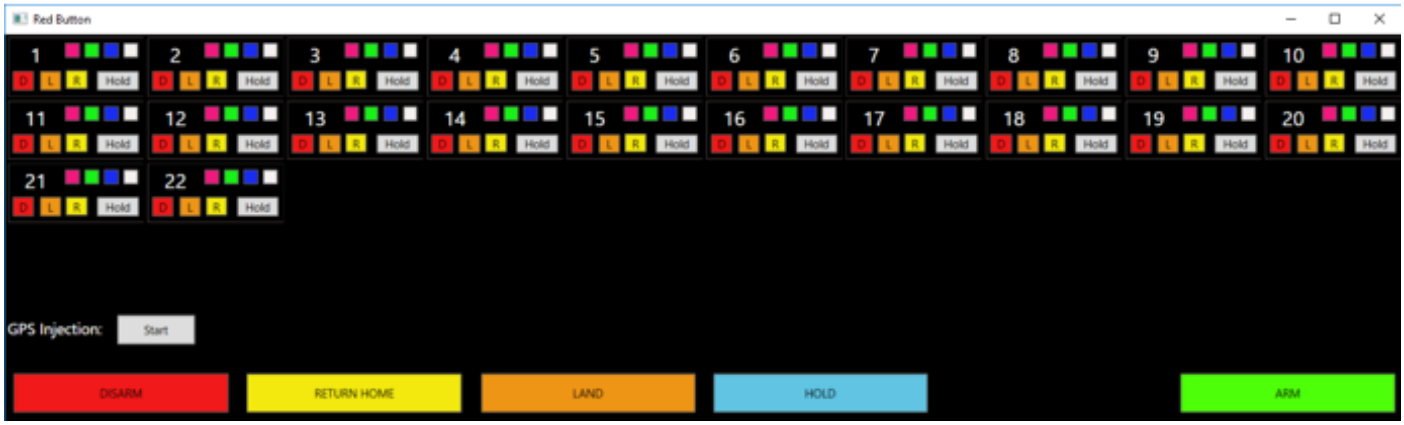


Figure #84. Main screen

Color boxes next to the drone number allow you to send commands to particular drones to change the LED colour, allowing you to easily detect problems such as malfunctioning LED modules or incorrectly connected wiring.

- D – Disarm (no confirmation required, be careful)
- L – Land
- R – Return Home
- Hold – Suspend mission performance if something goes wrong

RedButtonDDC.exe.config is a configuration file for RedButton application. Here are its key parameters:

```
<applicationSettings>
  <Drones.Properties.Settings>

    <setting name="BaudRate" serializeAs="String">
      <value>57600</value>
    </setting>
    <setting name="PortName" serializeAs="String">
      <value>com3</value>
    </setting>
    <setting name="ddcClientConfig" serializeAs="String">
      <value>c:\Program Files (x86)\UgCS\client-DDC\DDClient.exe.config</value>
    </setting>
    <setting name="RtcmSourceHost" serializeAs="String">
      <value>localhost</value>
    </setting>
    <setting name="RtcmSourcePort" serializeAs="String">
      <value>8000</value>
    </setting>
  </Drones.Properties.Settings>
</applicationSettings>
</configuration>
```

Figure #85. Configuration file

- BaudRate – baud rate for a radio link used to send commands to drone fleet
- PortNumber – COM port where a radio link is detected
- ddcClientConfig – a path to DDC Client configuration file used by RedButton to retrieve the list of detected vehicles

- RtcmSourceHost – a host where RTK Client opening its server port and supplies packed RTCM corrections

RtcnSourcePort – a port number at RTK Clie

LED Payload

The LED payload used on our DDC drones consists of a PCB, power cable with an XT60 connector as well as a PWM (input signal) cable. The power cable is connected to the drone battery in parallel. The signal cable is plugged in the servo output channels of the autopilot.

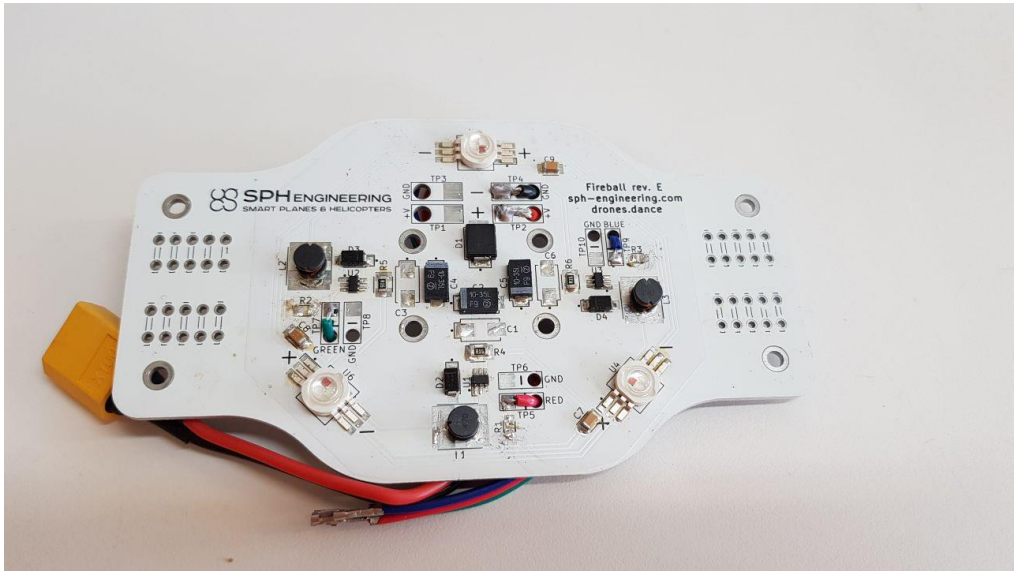


Figure #86. LED payload

To enable the LED module operation in automated flights, servo channels need to be assigned in Ardupilot configuration file. To do this, the following lines should be added/uncommented in the Ardupilot configuration file. As mentioned earlier, the Ardupilot configuration file is usually located here: “C:\Program Files (x86)\UgCS\bin\vsm-ardupilot.conf”

```
# G

vehicle.ardupilot.parameter.SERVO9_FUNCTION = 82
# B
vehicle.ardupilot.parameter.SERVO10_FUNCTION = 83
# R
vehicle.ardupilot.parameter.SERVO11_FUNCTION = 81
```

Wi-Fi Configuration

Router Configuration

Recommended Wi-Fi setup

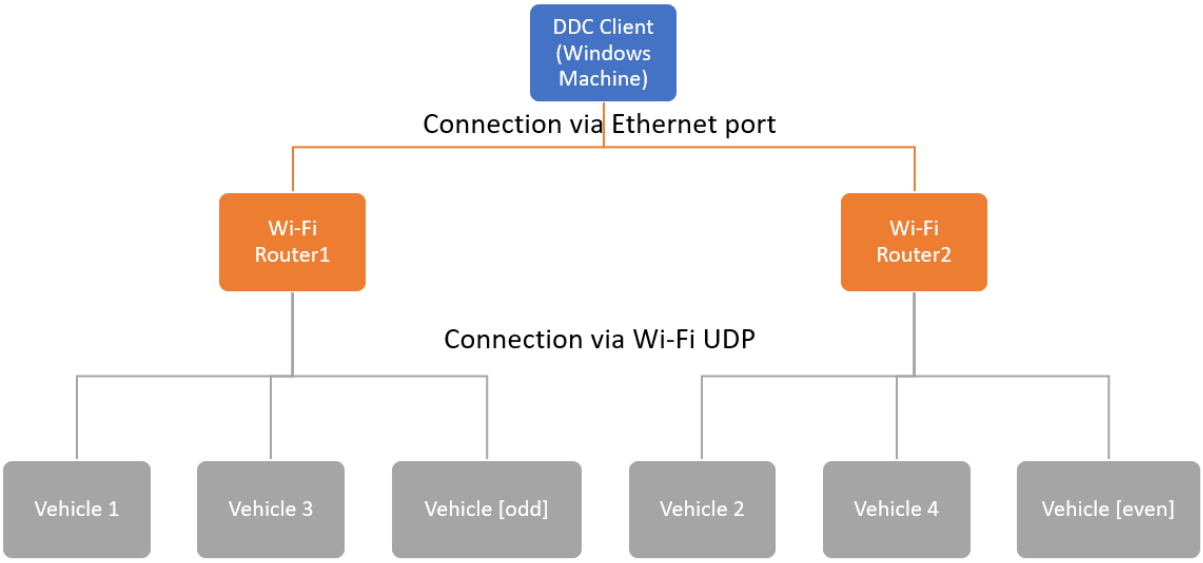


Figure #87. Recommended router-drone setup

Wi-Fi routers are connected to each other Ethernet LAN port. Windows machine (DDC Client) is connected to one of the routers LAN Ethernet port.

Routers, DDC Client and Vehicles are at the same sub net (as example 192.168.0.XXX). All devices should have static IP addresses:

- Router1 – 192.168.0.1
- Router2 - 192.168.0.2
- DDC Client - 192.168.0.50
- Vehicle 1 – 192.168.0.101
- Vehicle 2 – 192.168.0.102
- Vehicle X – 192.168.0.[100+X]

Router configuration

Typically router configuration can be accessed via any browser when connected to the router either through Ethernet or Wi-Fi. The initial IP address of the router is usually printed on it together with the default username and password (typically “admin”).

The interface will change from router to router and routers from the same manufacturer can have different configuration interfaces depending on the firmware used.

Router DHCP server IP addresses shouldn’t cross the Vehicle static IP addresses. As example settings for the Router2. DHCP server start IP address is 192.168.0.4 and maximum number of users is 46. As result the last IP address given by router DHCP server will be 192.168.0.49:

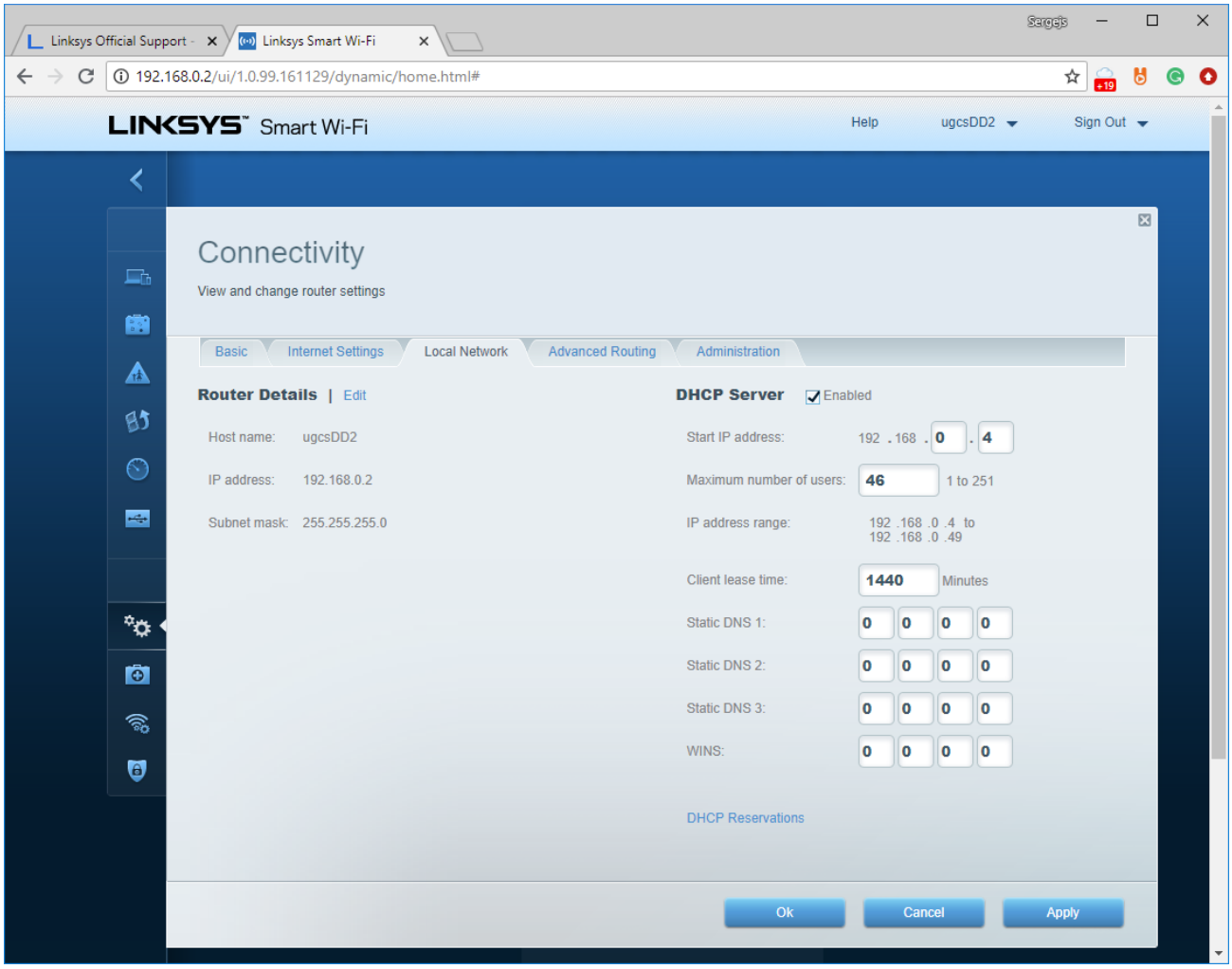


Figure #88. DHCP Server configuration

Its recommended to switch off additional router features like Parental Controls, Guest Access, Media Prioritization, USB storage …

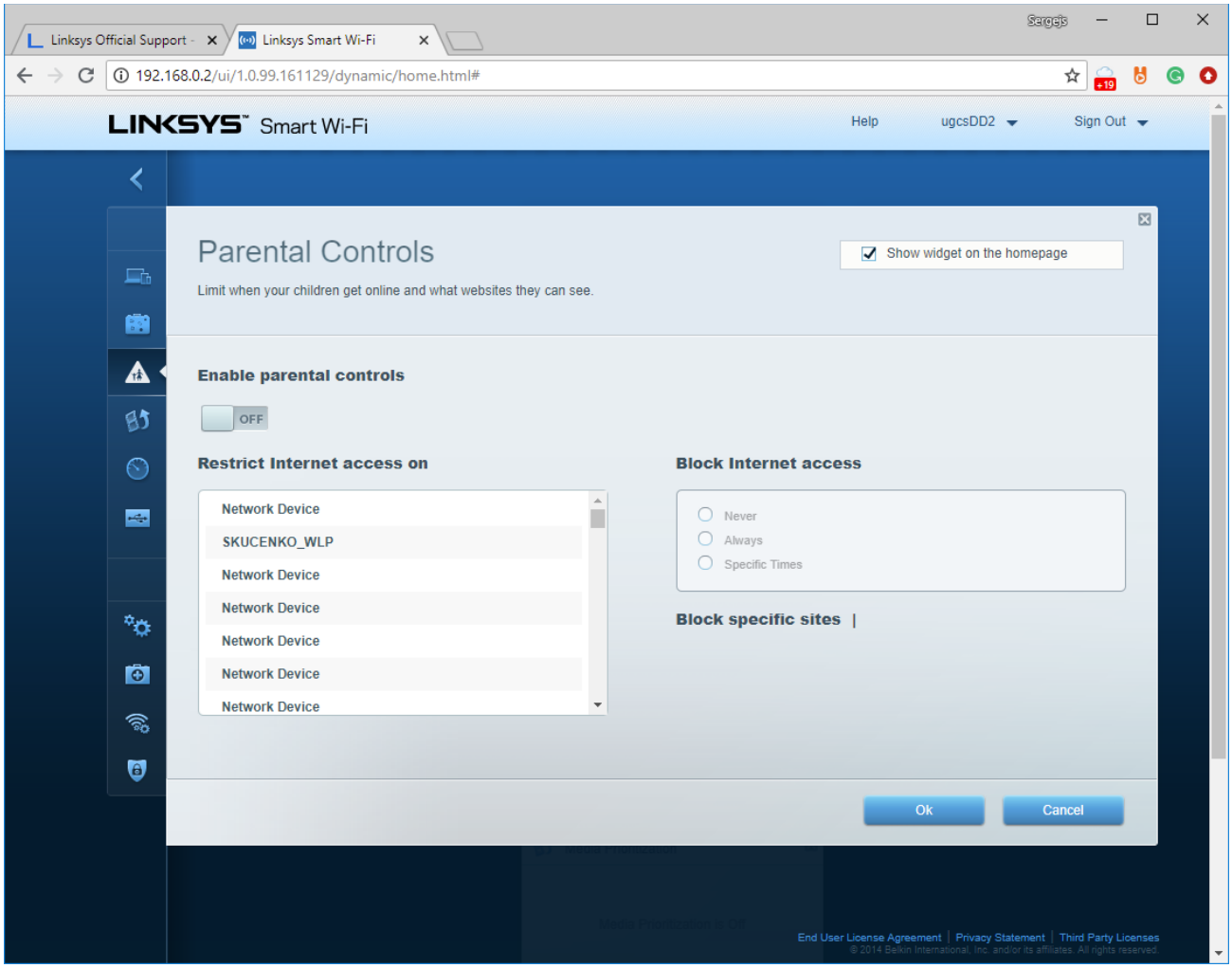


Figure #89. Turning off additional router features

After network setup please ensure that you can access all switched on and connected devices from Windows machine by IP address.

Router2:

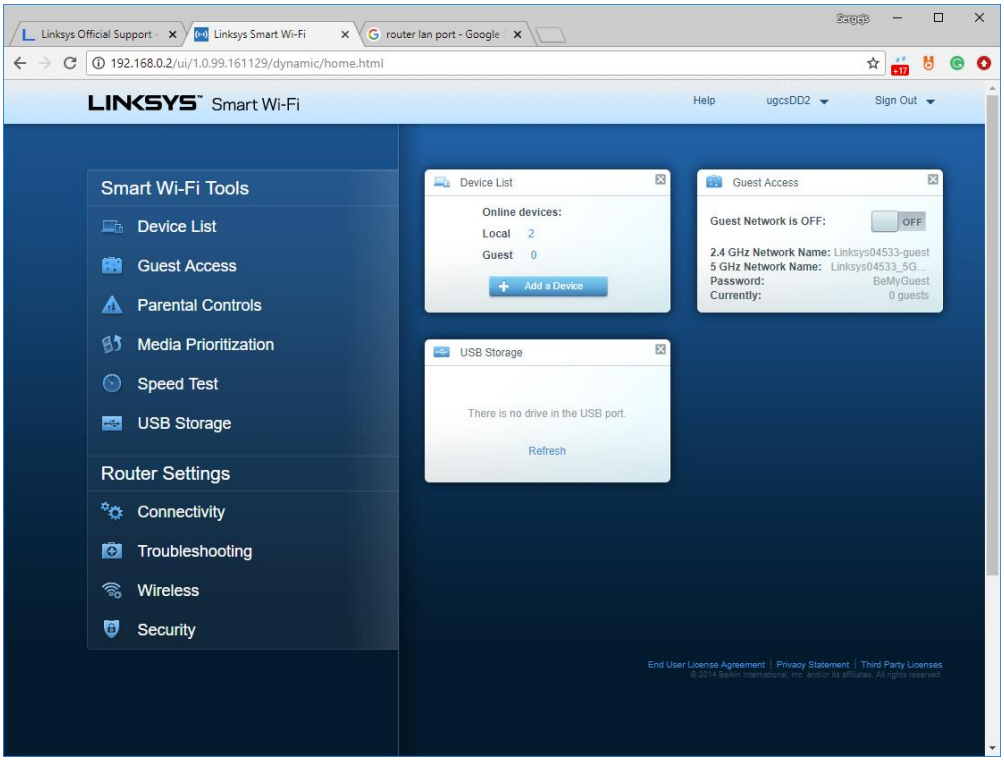


Figure #90. Detecting connected devices

Vehicle 105 with 5 GHz Wi-Fi module:

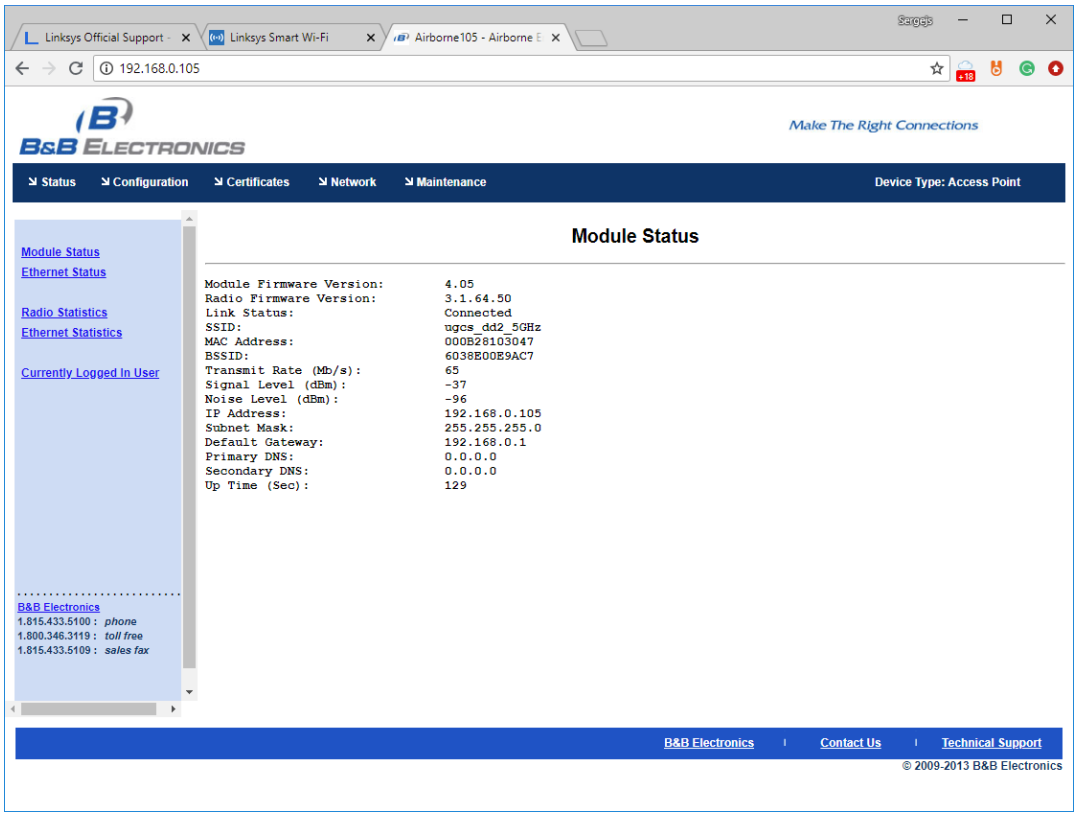


Figure #91. Onboard Wi-Fi module status after having connected to the router

Wi-Fi Module configuration

In the chapters below the configuration of two Wi-Fi modules will be explained – SPH Engineering's dedicated Airborne 5 GHz – capable Wi-Fi module and ESP-07 module.

SPH Engineering Airborne Wi-Fi Module

1. Connect both antennas to the Wi-Fi adapter.
2. Power-up the adapter.
3. Connect to the "AirborneAP" network. This access point is created using default configuration:

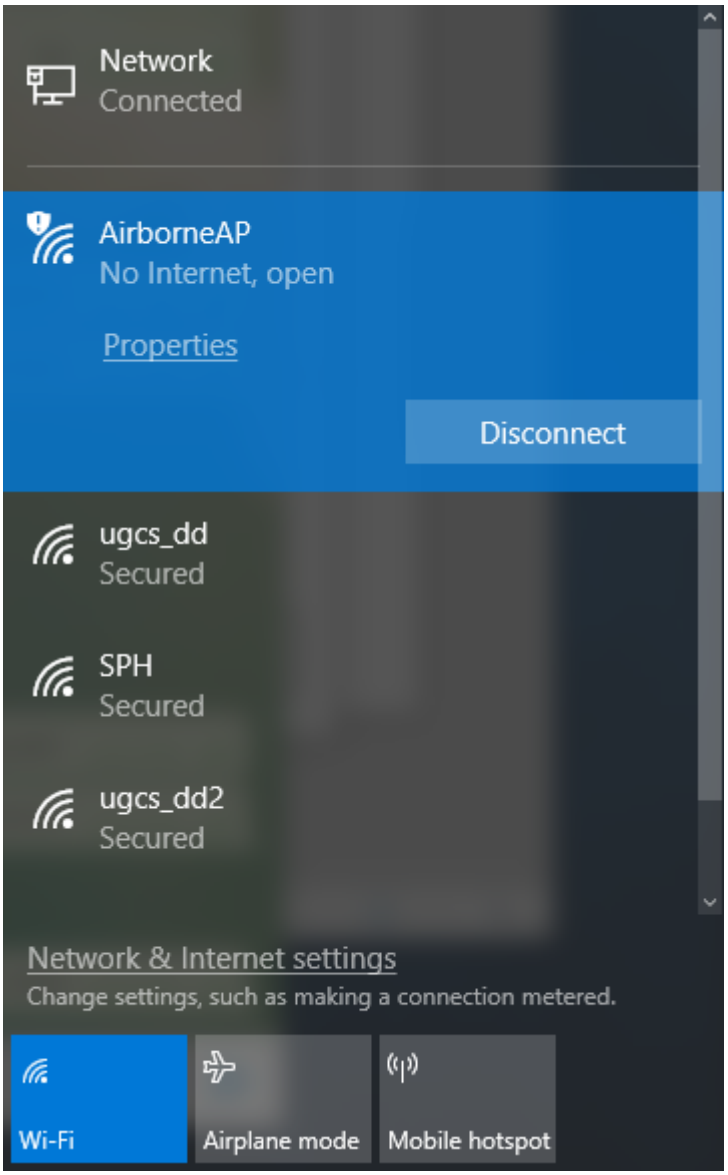


Figure #92. AirborneAP network detected

4. Open browser and go to the page - http://192.168.10.1. You will be prompted to log in. The default username is “root” and the default password is “rootpassword”.

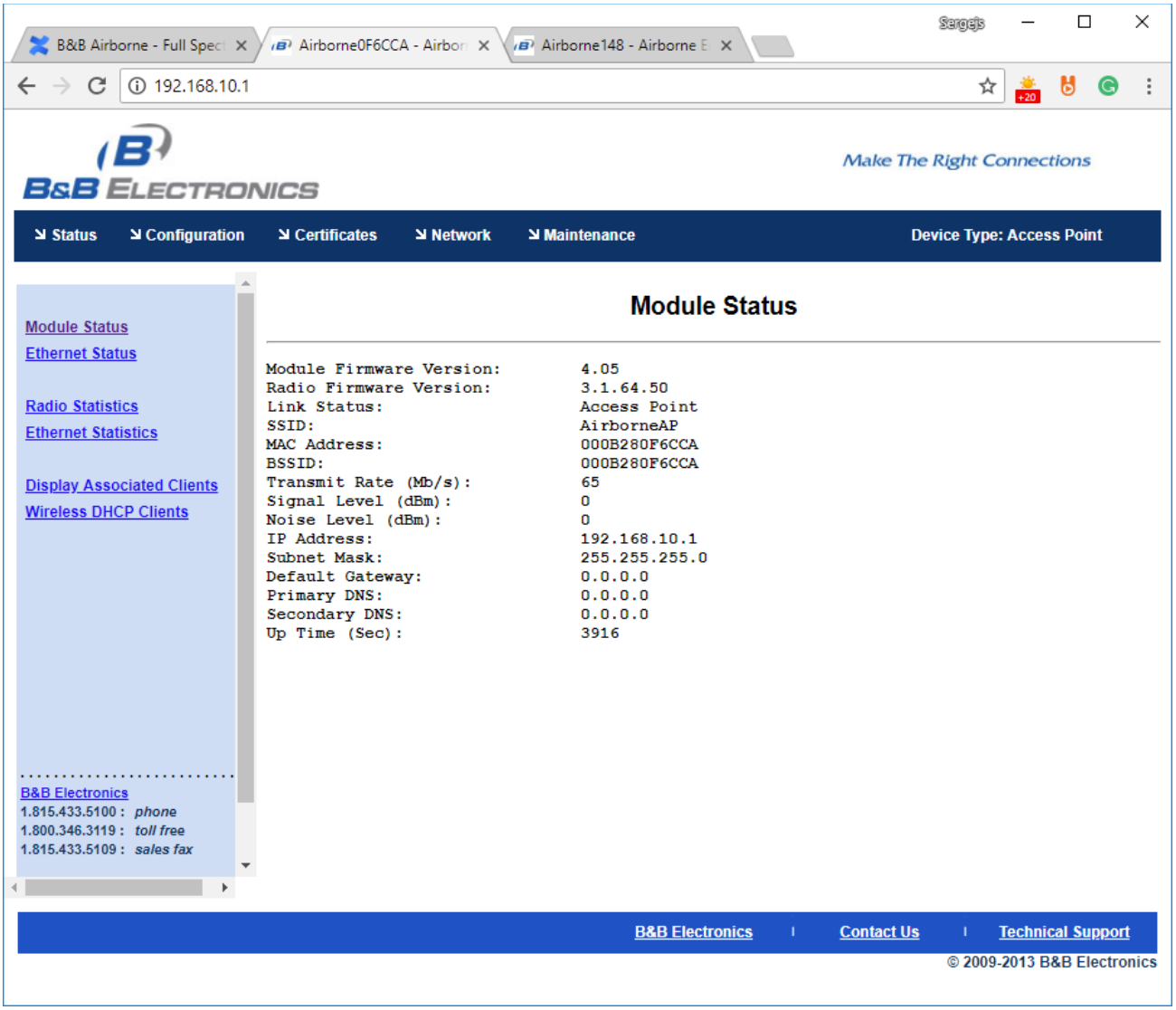


Figure #93. Configuration page after logging in

5. Open the configuration page in a browser. Go to the "Configuration" → "Serial Port 2 Settings" and set all the values exactly as shown in the image below.

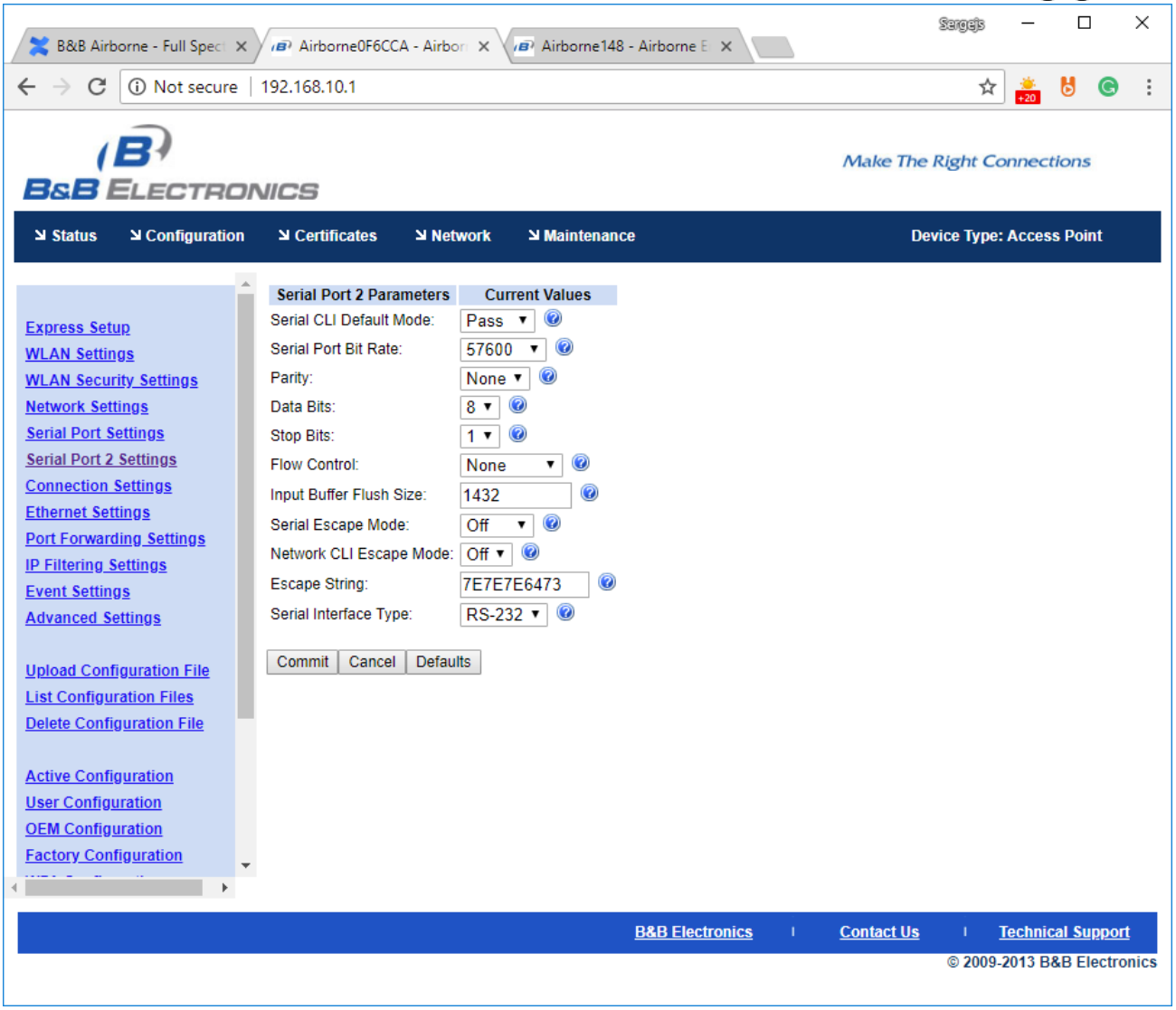


Figure #94. Serial Port 2 settings

Press Commit to save changes.

6. Go to the "Configuration" → "Connection Settings" → "Common Settings" and set the following parameters. In this case the parameter “UDP Port – Serial Port 2” is set to 14501 since this is an example for a drone with a frame number “1”. For a drone with a frame number, for example, “43”, the parameter would be set to 14543. Also, take note that “UDP Port – Serial Port 2” and “UDP Receive Port – Serial Port 2” are not allowed to be the same.

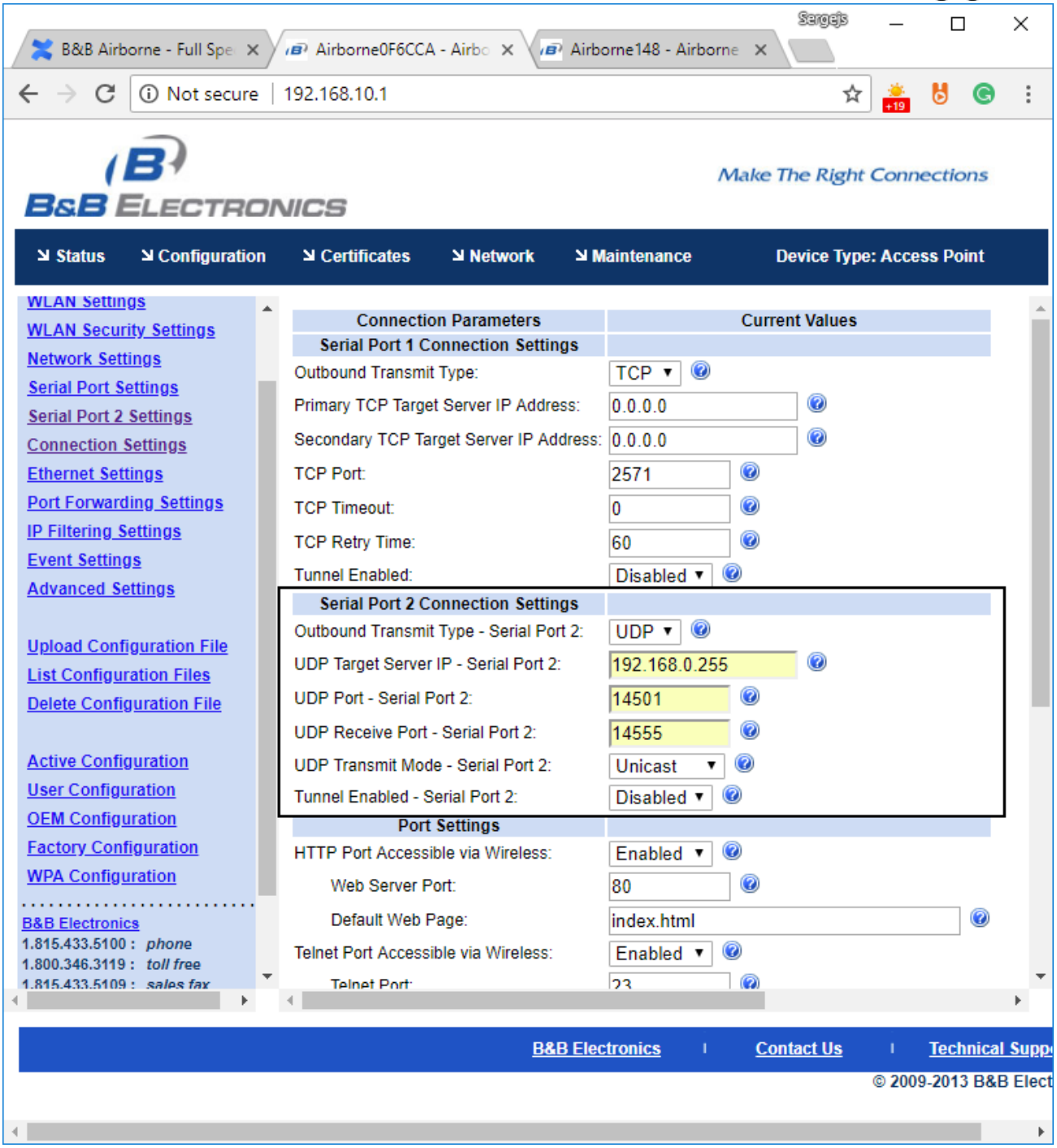


Figure #95. Connection settings

Scroll down to the section “Common Settings” and change the “Connect LED Mode” parameter to “Pass”.

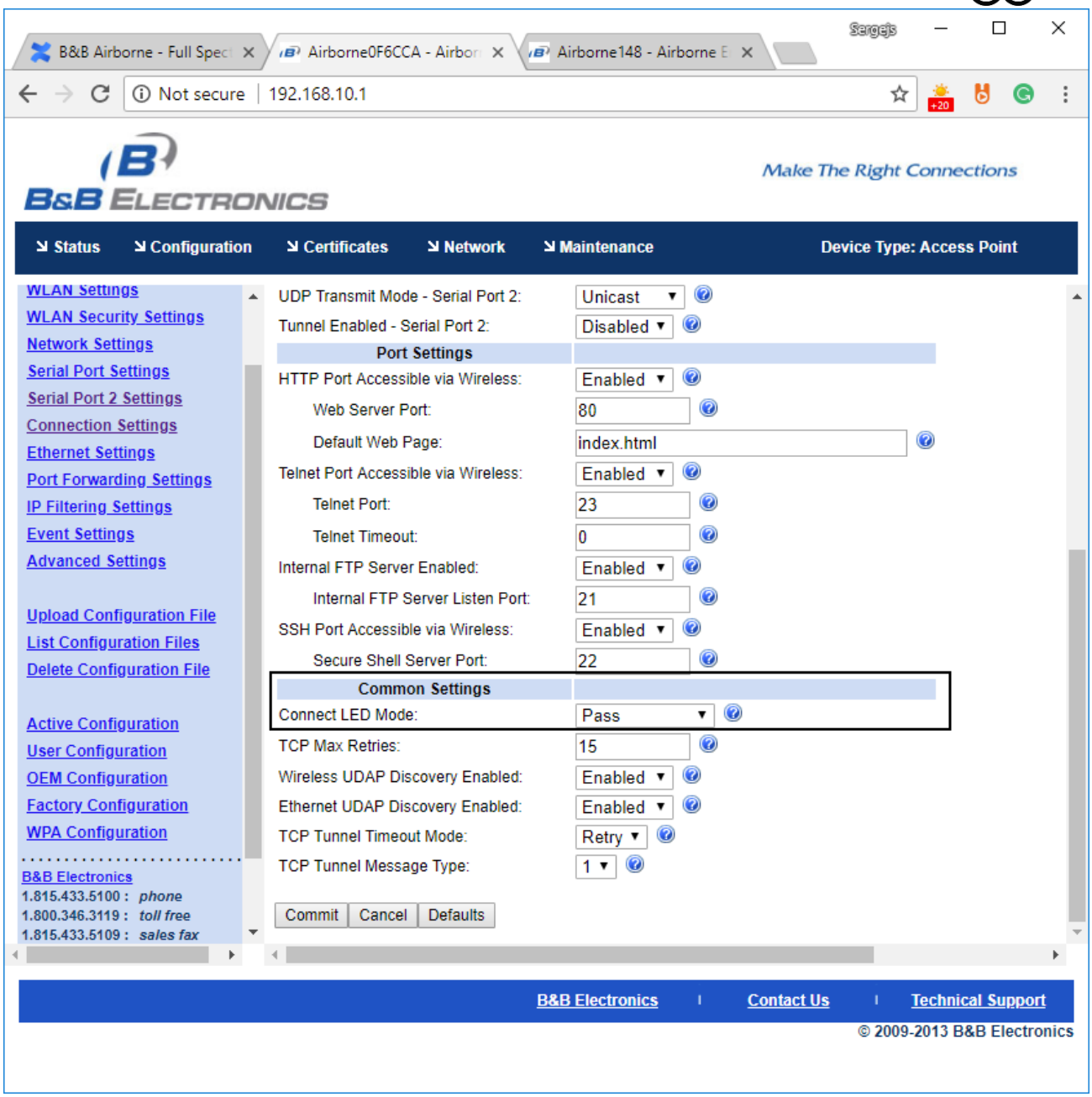


Figure #96. Connect LED Mode parameter

Press Commit to save changes.

7. Next go to "Configuration" → "Network Settings" and set the following parameters. These parameters are set for a vehicle with a frame number 1. For example, for a vehicle with a frame number “43”, it is suggested WLAN DHCP Client Name as well as Static IP Address are set like so:

   WLAN DHCP Client Name: Airborne143
   WLAN Static IP Address: 192.168.0.143

   The rest of the parameters should be as shown in the image below.

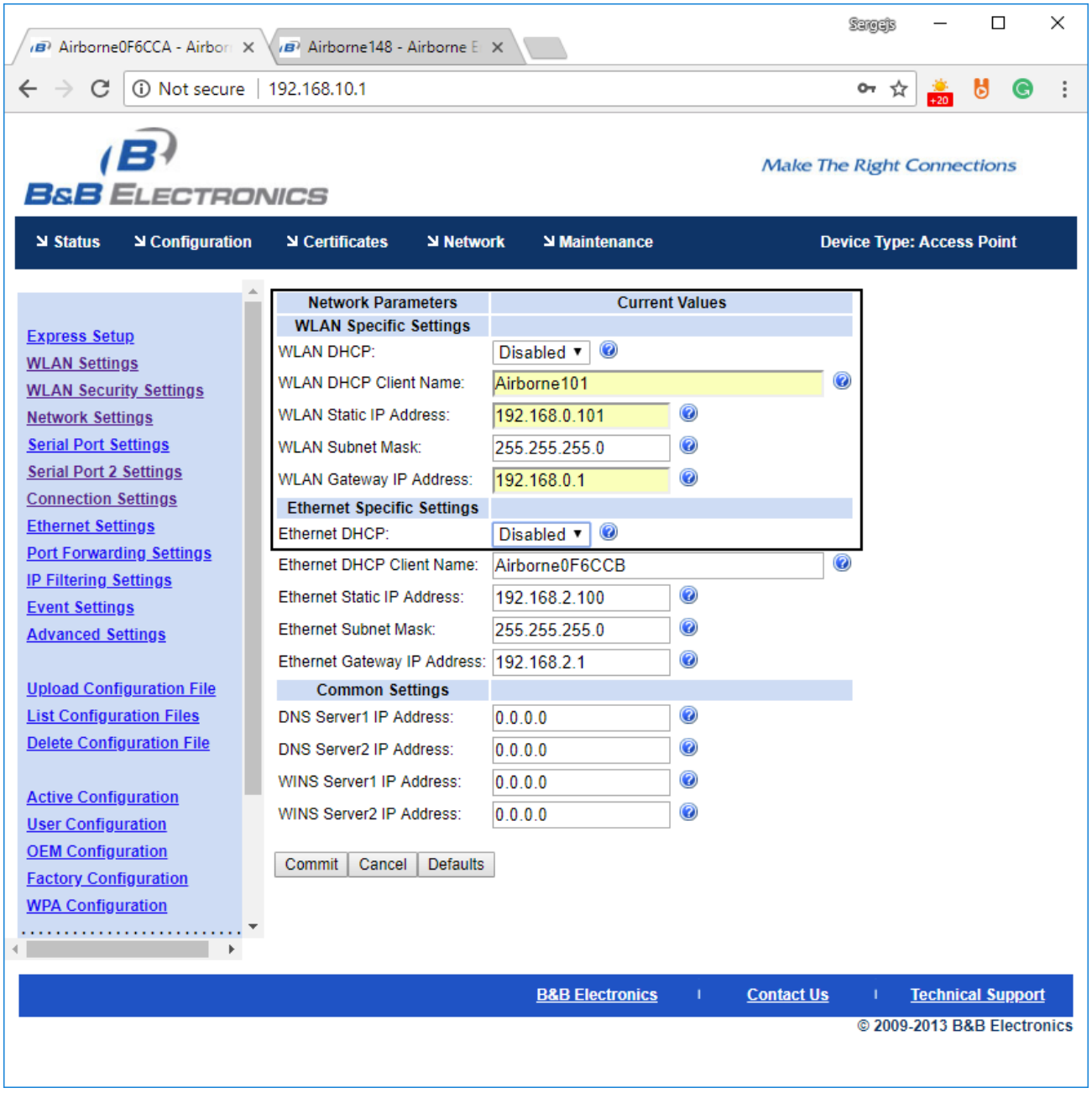


Figure #97. Network settings

Press Commit to save changes.

8. To establish an AP connection we must specify SSID and password. First we have to open "Configuration" → "WLAN Settings" page. Here change the WLAN Connection Type to Infrastructure and change the SSID to the name if your router Wi-Fi. In our case it's "ugcs_dd_5GHz. Keep in mind that if you are using a setup of multiple routers, you can set up some of the drones to connect to one of them and some of them to connect to the other one.

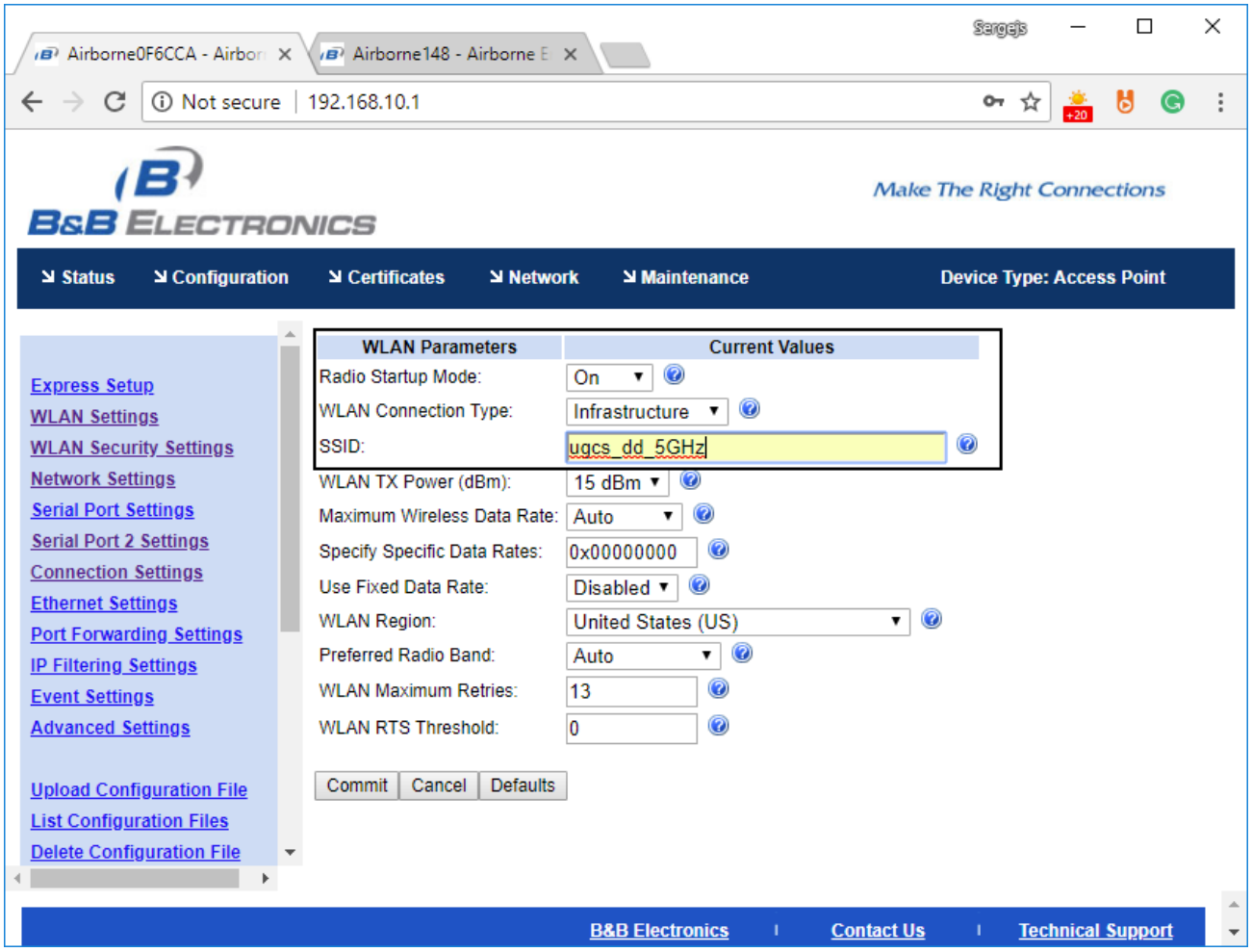


Figure #98. WLAN Settings

Again, press Commit to save changes.

9. Then on the "Configuration" → "WLAN Security Settings" page set the WLAN Security Type to the one your router is using, in our case it's "WPA2-PSK". And enter the password of the Wi-Fi network.

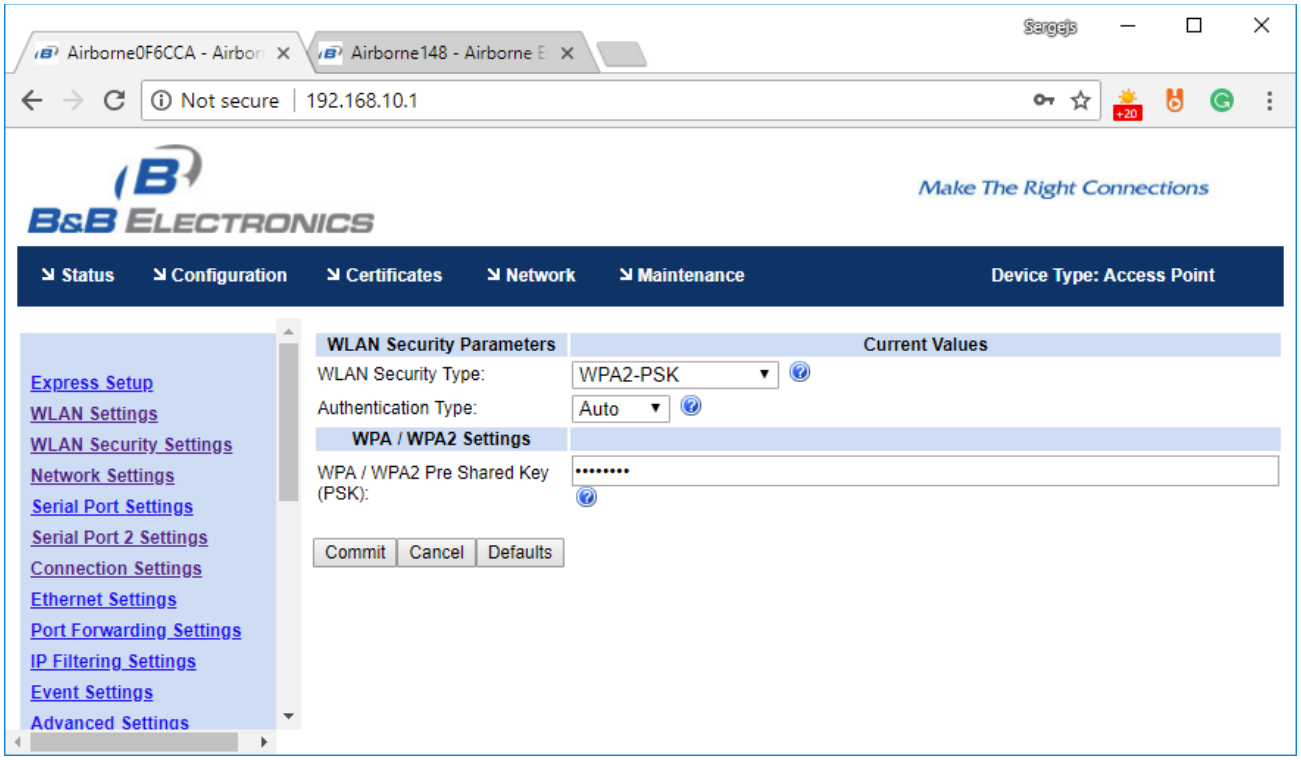


Figure #99. WLAN Security Settings

Press Commit to save changes.

10. After configuration is done, restart the Wi-Fi module. This can be done either in the section "Maintenance" as shown in the image below or using the Restart button that is shown after committing changes in the previous step. Once it starts back up again, it should connect to the Wi-Fi network that was specified in step 8. Once connection is established, 4 LEDs should light up on the Wi-Fi module.

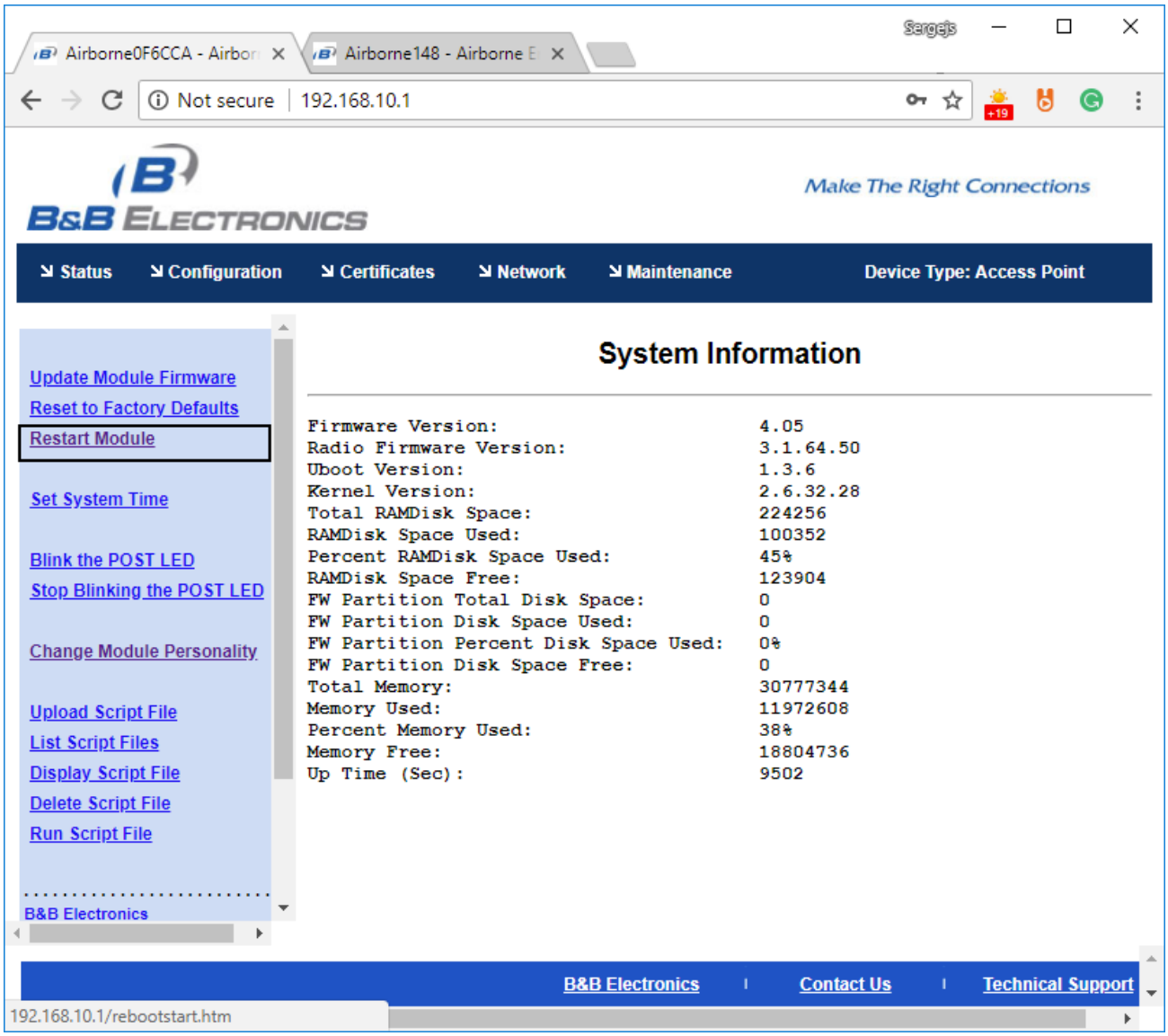


Figure #100. Restarting the module

ESP-07

This chapter explains how to flash ESP-07 modules with firmware for use with UDP protocol and how to configure connection settings in **UgCS**.

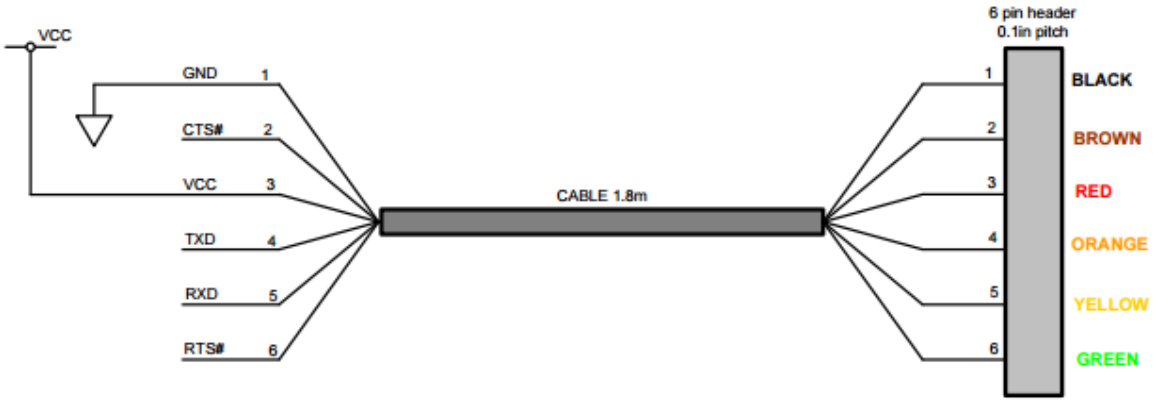
Figure #100. ESP-07 Wi-Fi module

Preparing for firmware update

- Download custom firmware:
  https://github.com/ugcs/ddc/blob/master/WiFi/firmware_UDP_2016-12-05.bin
  Download firmware flashing utility ESP8266Flasher:
  https://github.com/nodemcu/nodemcu-flasher/raw/master/Win32/Release/ESP8266Flasher.exe

Connect ESP-07 to PC via any appropriate USB-UART adapter like **TTL-232R-3V3**

Manual: http://www.ftdichip.com/Support/Documents/DataSheets/Cables/DS_TTL-232R_CABLES.pdf



TTL-232R-3V3	ESP-07
5V	5V/3V
GND	GND
TXD	RXD
RXD	TXD

Figure #101. Connection diagram

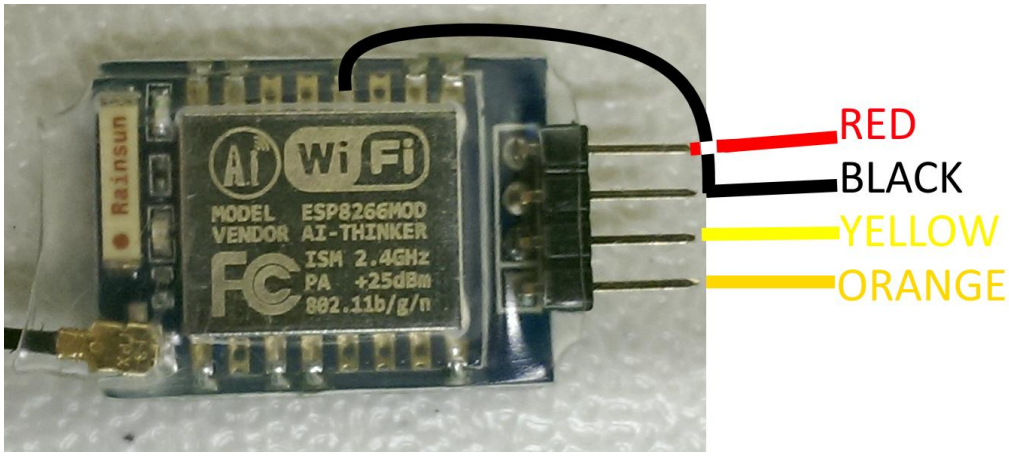


Figure #102. Image displaying the colored wire connection from UART to ESP module during flashing

NOTE: to initialize flash mode for the ESP-07 module, it is necessary to ground pin GPIO0 (see picture above) during powering on the module and recommended to leave grounded throughout the flashing.

Flashing the firmware

Run ESP8266Flasher **as administrator** and use following settings (**Config** and **Advanced** tabs):

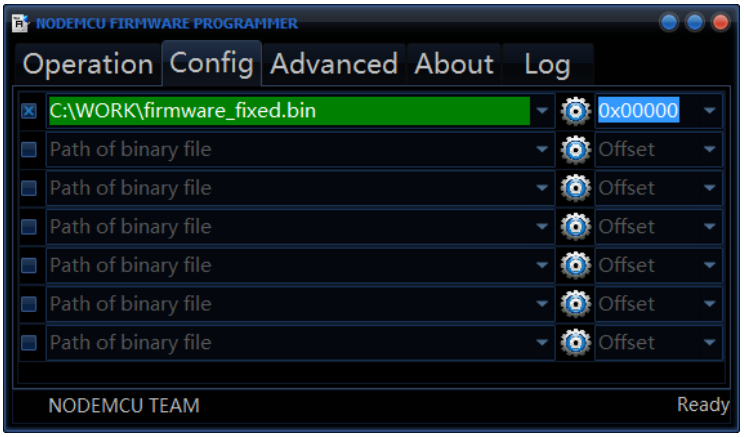


Figure #103. Choosing the firmware

Figure #104. Advanced settings

Configuring the module

After successfully flashing and power cycling the module, a new wireless network should be avaliable: PixRacer.

Connect to the network and enter “pixracer” as password.

SSID: PixRacer

Key: pixracer

Now to configure each module, a network address must be followed while connected to the PixRacer network.

For example this: http://192.168.4.1/setparameters?hport=14560&mode=1&ssidsta=DRONE-DANCE&pwdsta=1234567890&gatewaysta=192.168.0.1&subnetsta=255.255.255.0&ipsta=192.168.0.10&baud=57600

In this link there are the following important parameters:

- *hport=14560* this sets the UDP port of the module, each module must have an unique port, it is recommended to use increasing port numbers starting from 14560, t.i. 14561, 14562…
- *ipsta=192.168.0.10* sets the IP address of module, each module must have an unique address according to subnet mask

The following parameters will remain the same for all modules:

ssidsta=DRONE-DANCE sets the SSID or network name

pwdsta=1234567890 sets the network key (password)

gatewaysta=192.168.0.1 sets the default gateway

subnetsta=255.255.255.0 sets the subnet mask

baud=57600 sets the connection baud rate

As an example, the first module of the swarm would have the configuration mentioned above, but second would have the following: http://192.168.4.1/setparameters?hport=14561&mode=1&ssidsta=DRONE-DANCE&pwdsta=1234567890&gatewaysta=192.168.0.1&subnetsta=255.255.255.0&ipsta=192.168.0.20&baud=57600

Notice that only *hport* and *ipsta* parameters change.

After setting the parameters (following link), it is recommended to restart the module and check if the parameters were correctly set, by following this link:

http://192.168.4.1/setparameters?reboot=1

Now a list of parameters should appear on screen, two can be checked to confirm successful settings change:

WIFI_UDP_HPORT	14560
UART_BAUDRATE	57600

Configuring Ardupilot VSM to connect to modules

After successfully configuring modules, it is necessary to configure *vsm-ardupilot.conf* file accordingly. The following example shows how the settings for one module must look:

connection.udp_in.1.local_port = 14561

To add additional modules, just add the same line and edit like this, for example:

connection.udp_in.2.local_port = 14562

connection.udp_in.3.local_port = 14563

Notice how only the port number and number after *udp_in*. changes.