N.B. - Warning! The information below is my best shot as a guide. Flight batteries contain large amounts of energy which can be dangerous if things go wrong. Following this guide is at your own risk. If you are not sure what you are doing get help.

This article may be corrected or updated at any time. If you find a mistake or a significantly better way of doing the job please let me know.

Why have a flight battery monitor?

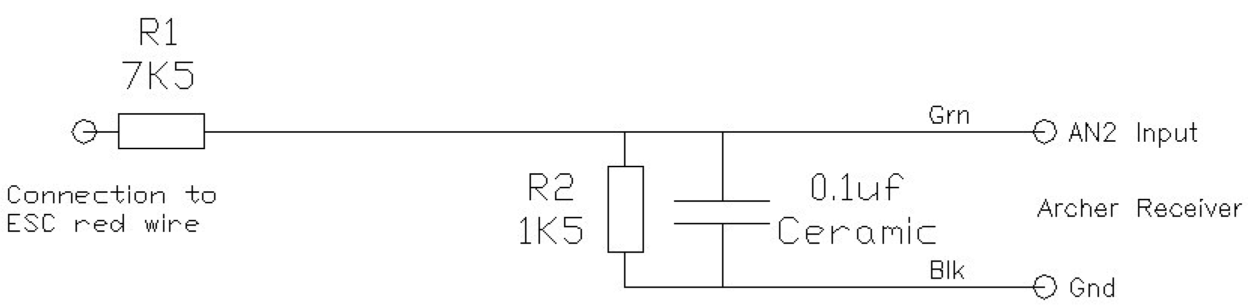
On two occasions I have had to do deadstick landings on an electric power model. Perhaps sadly, this was not because of a failure of the battery or motor, but because I accidentally put a used battery back in the model and the ESC shut the motor off. Battery monitoring telemetry seems a good idea to me.

How it works

Most FrSky Access receivers have an analog telemetry input, AN2, which is easily accessible. This monitor should work for Archer R4, R6, R8 Pro, R10 Pro, GR6 and GR8 receivers. It may work with other receivers with an AN2 input (I cannot test everything!).

FrSky make a monitor unit which the circuit below mimics, but is “slimmed down” a bit.

This is the circuit for the monitor. It is a simple divider, similar to the FrSky unit.



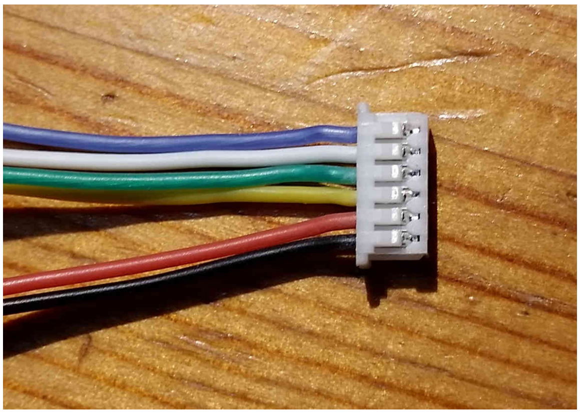
The resistor values shown are those used in the FRSky divider for a 3S battery. Calculations of values for other batteries are given later in this article. I use 1/4 watt metal film resistors but you can use as small resistors as you like (or can manage to solder!) as heat dissipation is very low in this circuit. I prefer metal film resistors which are usually robust and stable.

The 7K5 resistor R1 is connected directly to the + battery connection of the speed controller or the wire from the battery connector. This reduces transmission of any electrical noise and protects the wire to the AN2 input against short circuit.

The capacitor helps to keep electrical noise from the AN2 input. I used a 50V capacitor which I happened to have but any rated above about 10V should be OK.

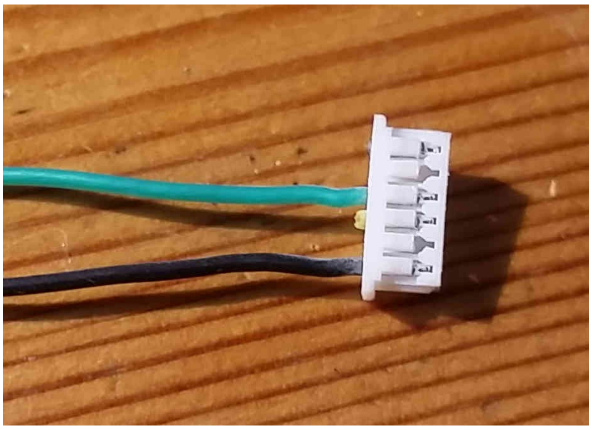
Wiring

The smart port plug supplied with the receiver has 4 or 6 wires depending on the receiver type.



We only need the green (A2 telemetry input) and black (ground). Clip the unused wires close to the connector or, alternatively, lever up the plastic latches which retain the unused crimps with the tip of a craft knife, watchmakers screwdriver or similar and remove the crimps from the housing.

The connector below has one clipped wire and two crimps removed.

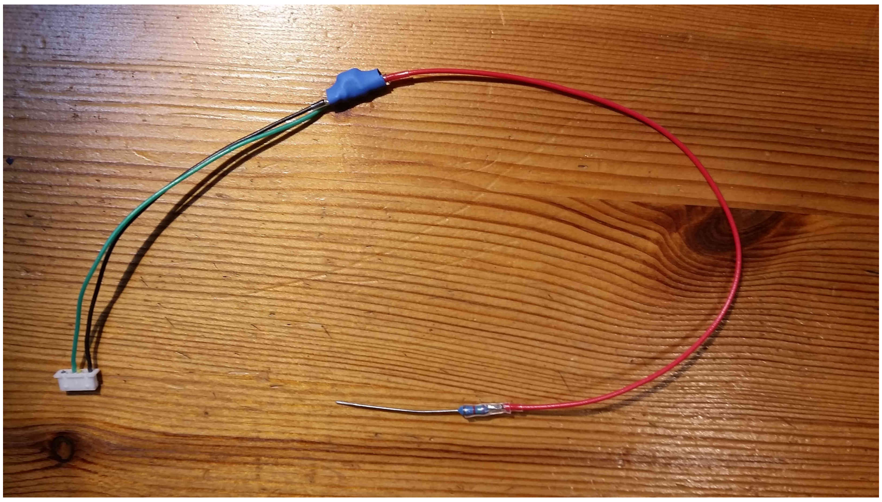


At the other ends of the black and green wires solder the 1K5 resistor R2 in parallel with the 0.1uf ceramic capacitor. Shorten the black wire so the resistor and capacitor lie along the green wire.

Solder a piece of wire (red used here) which will reach the ESC in the model.

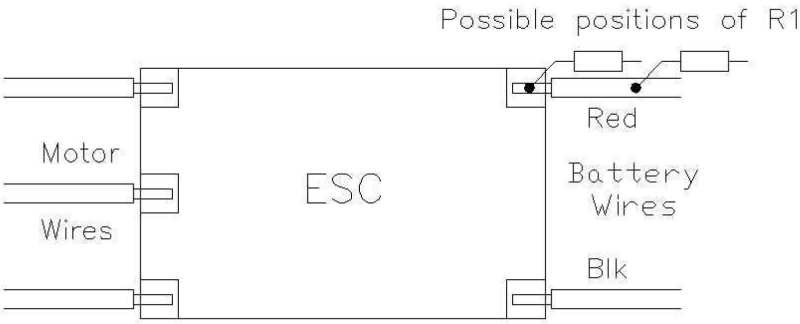
Solder the 7K5 resistor R1 to the other end of the wire, put heat shrink sleeve over the soldered ends and a larger piece over the capacitor and resistor.

We should now have a harness which looks a bit like this:



We could shorten the black and green wires and have a longer red wire to bring the resistor and capacitor closer to the receiver if we wish.

We now have to connect the 7K5 resistor R1 to the battery power connection at the ESC. We can either connect it to the the red battery wire or the solder pad on the ESC.



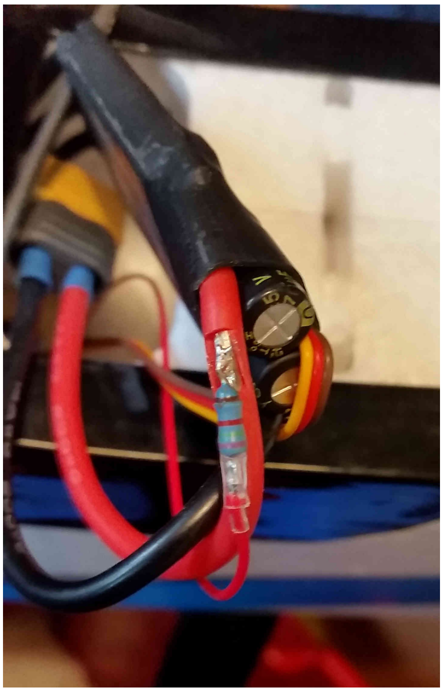
Either:

Cut a piece of insulation away from the red wire from the battery connector to the ESC as in this picture.

Or:

Cut a hole in the heat shrink covering the pad where the battery wire is soldered to the ESC. (Not illustrated)

Fit the harness into the model and solder the end of the 7K5 resistor R1 to the red wire or connection point on the ESC.

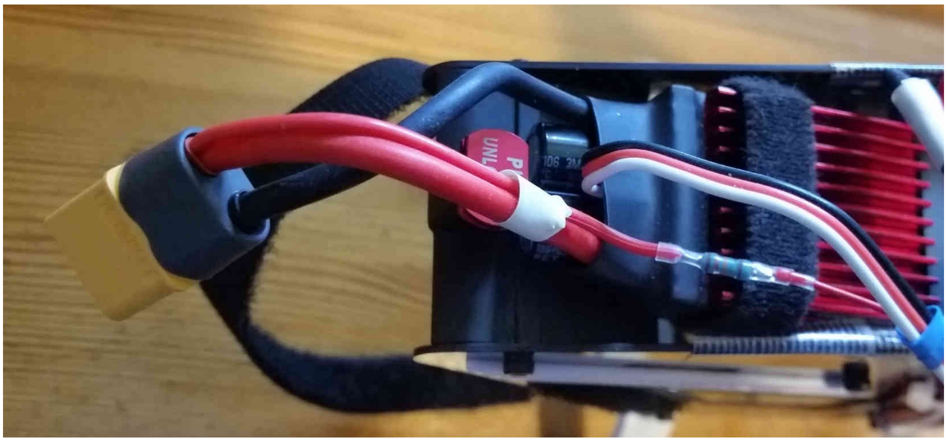


Cover the soldered joint and the resistor with some PVC insulating tape. PVC insulating tape is not the ideal solution, so if you find something better let me know! If you are prepared to disconnect and re-connect the power wire at the battery connector socket you can use heat shrink sleeve instead.

Plug the connector into the AN2 “smart” socket on the receiver.

Connection to the battery plug

Another option. On an ESC which came with a helicopter I purchased, the warranty threatened invalidation if the supplied connection wires were interfered with. On this one I connected a short red wire to the XT60 battery connector and placed the resistor a few centimetres away from it.



Setting up the transmitter (Taranis)

On the telemetry screen of the model edit the AN2 channel:

Change the name to MBat (motor battery).

Set Precision to 0.0

Set Ratio to 20 (to start with - this value calibrates the reading)

Put a battery in the model and connect a battery checker or voltmeter to the balance connector to measure the voltage. This same voltage measured through the telemetry system will be displayed at the top of the edit screen but will probably be rather different to the voltage at the balance connector because it has not yet been calibrated.

Calibration is done by adjusting the “Ratio” setting so the displayed voltage is the same as the voltage measured through the balance connector.

This voltage can now be displayed on the transmitter screen by selecting MBat in a display location.

Setting a low battery alarm

Create a logical switch:

Function - a<x

V1 - Tele4:MBat (Tele4 in my system)

V2 - 10.4V (Voltage you wish the alarm to trigger at) I chose 10.4V for a 3S battery to start with. This voltage needs to be a bit above the voltage at which the ESC shuts down the motor so we have some reserve for landing. My current policy is to adjust this so each cell ends up at about storage voltage (3.8V) if I check it a short while after taking it out of the model.

Note the battery voltage will drop significantly when the motor is running due to the internal resistance of the battery.

AND Switch - SF↓ (Optional - SF is my motor arming switch)

Delay - 0.5 (put in to stop transient dips in the battery voltage from triggering the alarm)

Create a special function for the alarm sound:

Switch - L11 (The logical switch above)

Action - Play Track

Parameters - Select the file name of track you wish to play when the alarm is activated (I created a track saying “Flight Battery Low” using OpenTXspeaker.exe)

Repeat - 30s (optional or as you wish)

There are, of course, many other ways of setting up alarms in OpenTX.

Calculating resistor values for different battery voltages

Resistor values are not critical because we calibrate the reading with the “Ratio” setting in OpenTX. However the AN2 input should not be taken above 3.3 volts. If we aim for, say, around 2.7 to 3.0 volts at full battery voltage we need have no worries about overdriving it.

Resistor calculation example for a 5 cell (5S) battery

Maximum battery voltage = 5 x 4.2V = 21 volts

Divider ratio for 2.7V at AN2 input = 21/2.7 = 7.8

If we keep R2 at 1K5 then: R1 + R2 = 7.8 x 1.5 = 11.7 K ohms

The value of R1 needs to be: 11.7 - 1.5 = 10.2 K ohms

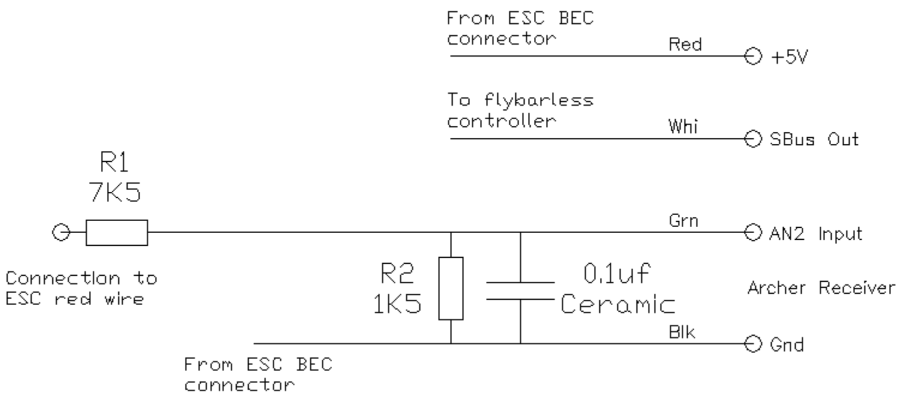
Standard resistor values 10K, 11K or 12K should all work OK for R1.

Table of values for common cell numbers

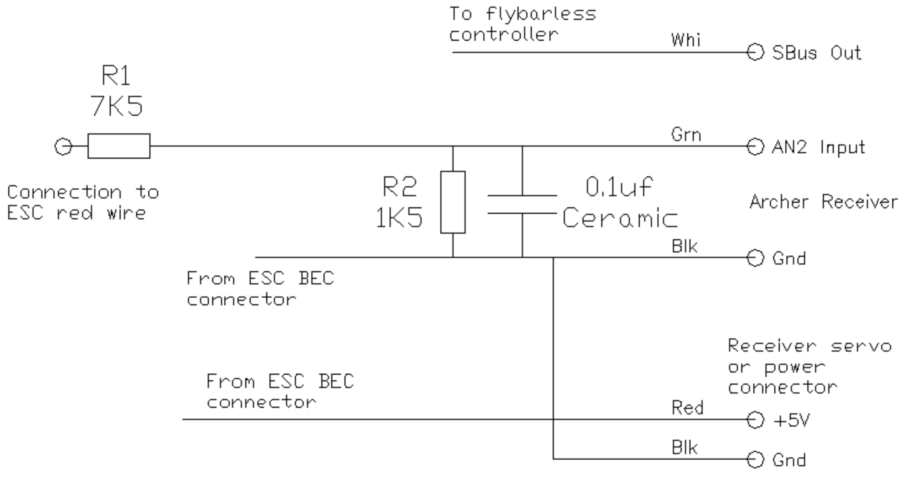
Divider values for for max. voltage at AN2 input of Access RX					
R1	R2	Divider Ratio	Battery Cells	Battery Max.	AN2 Max.
K Ohm	K Ohm		S	V	V
2.7	1.5	0.36	2	8.4	3.00
3	1.5	0.33	2	8.4	2.80
4.7	1.5	0.24	3	12.6	3.05
5.1	1.5	0.23	3	12.6	2.86
5.6	1.5	0.21	3	12.6	2.66
8.2	1.5	0.15	4	16.8	2.60
7.5	1.5	0.17	4	16.8	2.80
6.8	1.5	0.18	4	16.8	3.04
9.1	1.5	0.14	5	21	2.97
10	1.5	0.13	5	21	2.74
11	1.5	0.12	6	25.2	3.02
12	1.5	0.11	6	25.2	2.80

Voltage inaccuracy problems

Since the original version of this article I have had some problems with the voltage reading at the transmitter fluctuating and causing false triggering of my low battery alarm. These turned out to be poor connection of the smartport plug which connects the AN2 input to the receiver. I fixed one of these by re-seating (unplugging and plugging back in) the connector, but on another the problem came back. Changing the connector helped but the problem came back again. Eventually I realised that on the persistently bad one I was using the smartport connector to supply power to the receiver. On this installation I was using SBus out of the connector to drive a flybarless helicopter controller so did not have anything plugged into the receiver servo sockets.



This should have been OK because the receiver only consumes about 50 mA. However I suspect 50 mA through a poor connector contact in the supply negative (ground) was making the receiver ground a slightly higher voltage than the negative wire from the ESC. This did not affect the SBus signal which is a relatively large voltage digital data stream. However it did make the AN2 input voltage appear low at the receiver and consequently the battery voltage appeared low at the transmitter. The simple solution was to connect the receiver power (+ and -) to one of the servo sockets instead of the smartport connector.



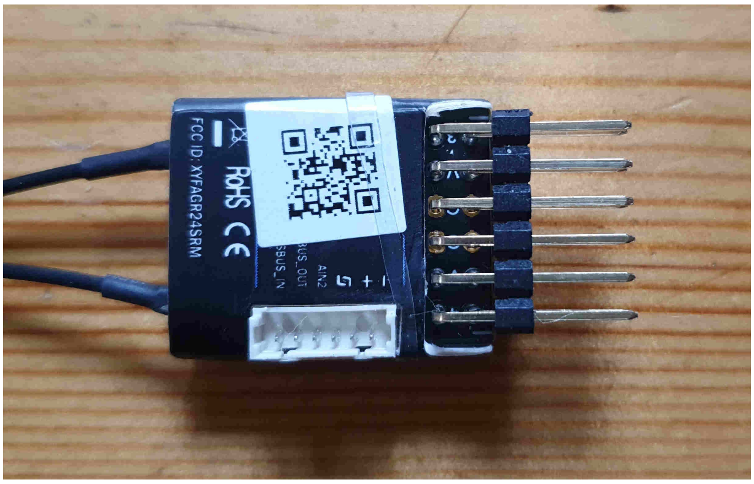
In this diagram I have shown the ground connected to both the smartport and servo connectors and the +5V connected only to the servo connector. We can connect both + and - to both connectors or only to the servo connector as we wish.

It looks like the bottom line on this issue is that the digital and analog inputs and outputs are probably OK through the smartport connector but powering or grounding the receiver through it can create problems if we are using the AN2 input. The smartport connector appears to be Molex Picoblade or compatible. This should be able to handle the 50 mA supply but appears not to provide a reliable low resistance connection at this current.

Voltage monitoring in small models

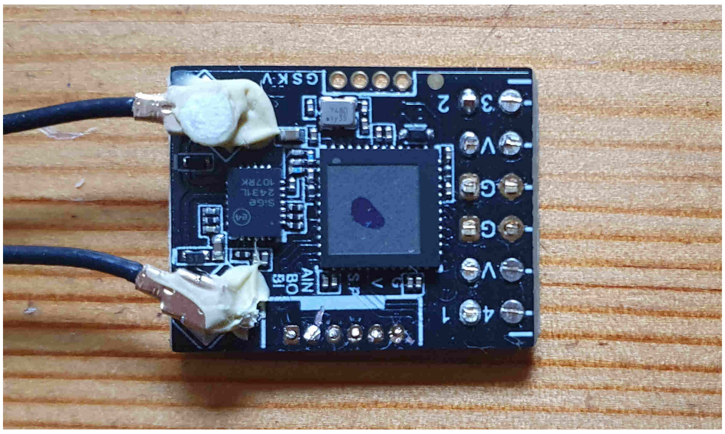
The smallest FrSky Archer receiver which has an AN2 input is the R4. The next sizes down are the Archer RS and Archer M+, neither of which have an AN2 input. For my smallest helicopters which require SBus I have taken an Archer R4, removed the casing and connectors, and soldered wires on directly. This also eliminates the above problem with the smartport connector. Very careful cutting and soldering is needed so be very sure you have the skills before attempting this and are prepared to accept the risk of damaging the receiver.

The unmodified receiver looks like this:

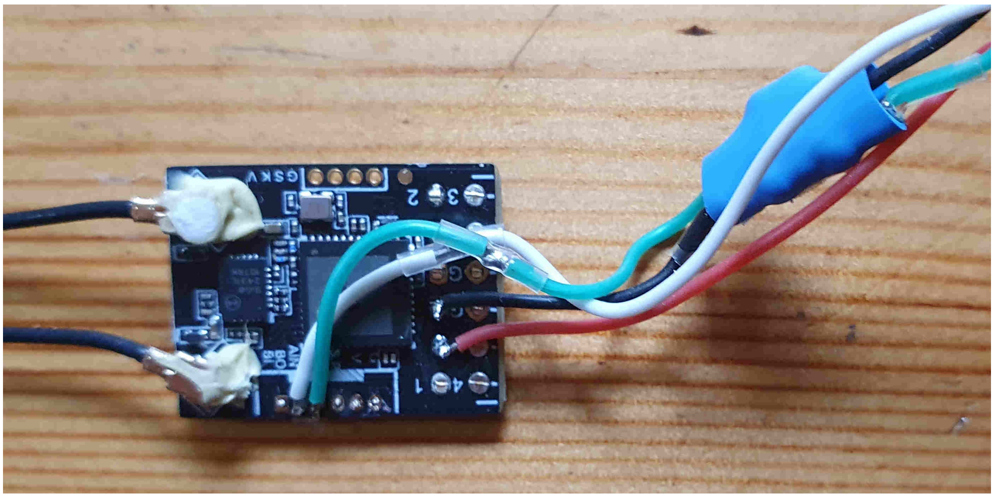


Firstly, remove the case and cut the servo connector pins off using very sharp side cutters. De-soldering and pulling out the pins is possible but not necessary and increases the risk of damage to the board. Carefully crop the ends close to the PCB.

Next cut the plastic of the smartport connector back revealing bits of the pins, and crop these back close to the PCB.

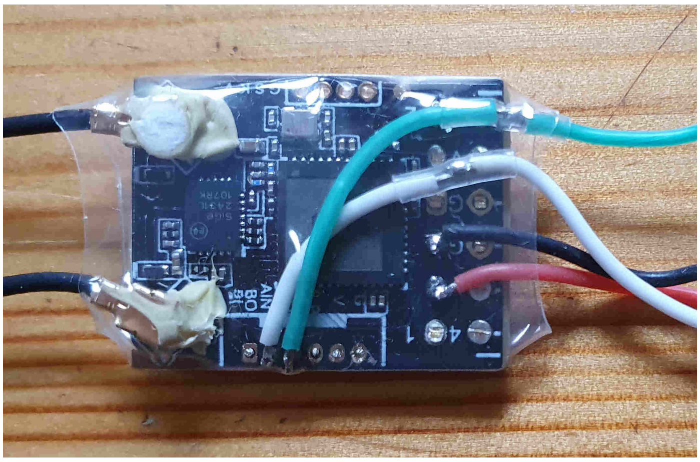


Wires can now be soldered directly to the pads. In this one you can see the green and white wires have been extended about 2cm. The blue heat shrink package contains the resistor and capacitor for the voltage divider.



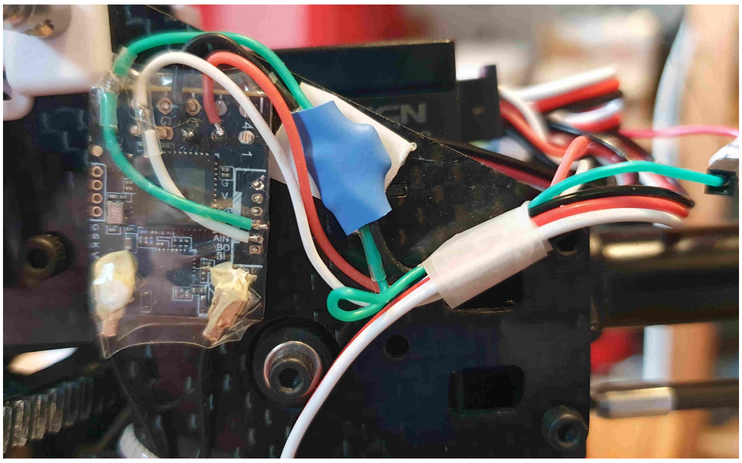
Note that the push button and indicator light are underneath the board in this orientation. Now is a good time to bind and test the receiver.

The board can be covered with heat shrink for some protection. In this one I used thin walled high shrinkage tube.



Part of the heat shrink can be cut away on the underside to access the push button.

In this installation the receiver and the blue package are fixed to the helicopter frame with double sided foam tape.



The receiver can be mounted on its other side to retain access to the push button. However the orientation shown gives the flattest surface for sticking with double sided tape.

Incidentally, in the above installation I taped the antennae ends to the plastic undercarriage legs.

This gets the antennae away from the carbon fibre frame and sets them at approximate right angles to each other. It gives good range check results. This should not be done on metal or carbon fibre legs.

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