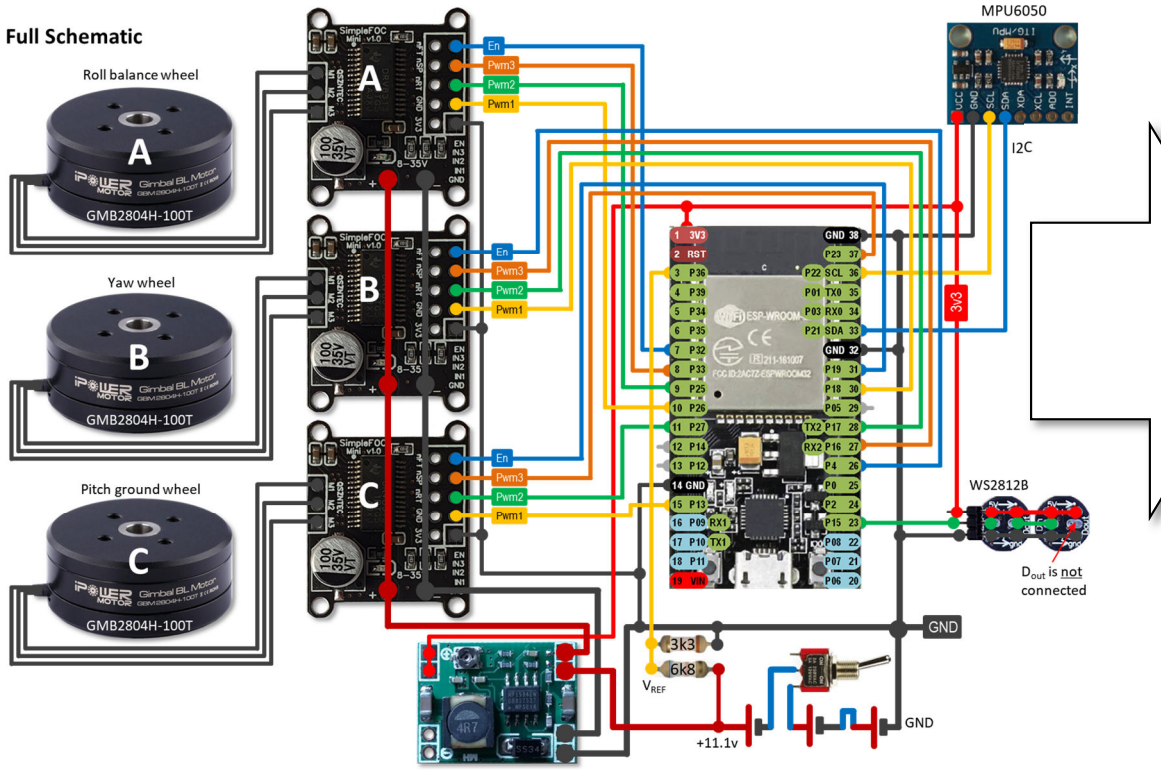
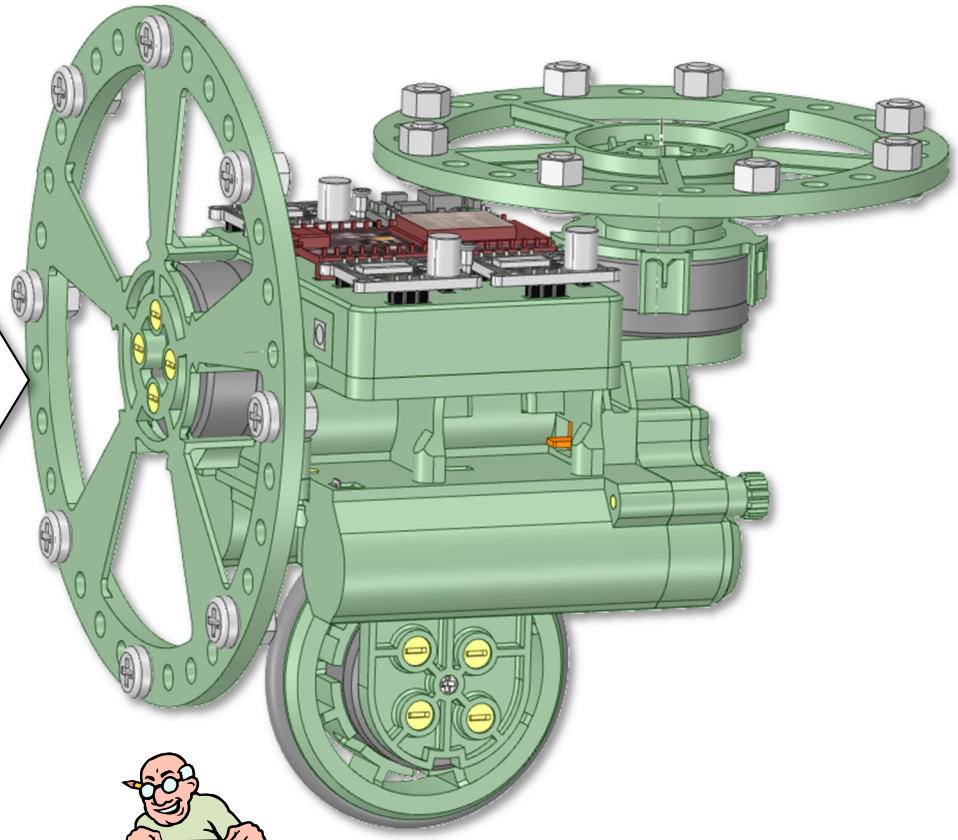
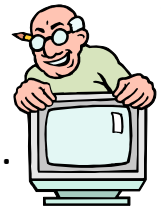
Uni-Bot (ESP32)

Circuits & Wiring







Read through the whole document before starting.

Hand Tools:

Recommended:

- Fine Nosed Pliers
- Side Cutters
- 1.5 mm Drill
- 2.0 mm Drill
- 2.4 mm Drill
- 4.0 mm Drill
- M3 Tap
- Needle Files
- Screwdrivers
- Craft Knife

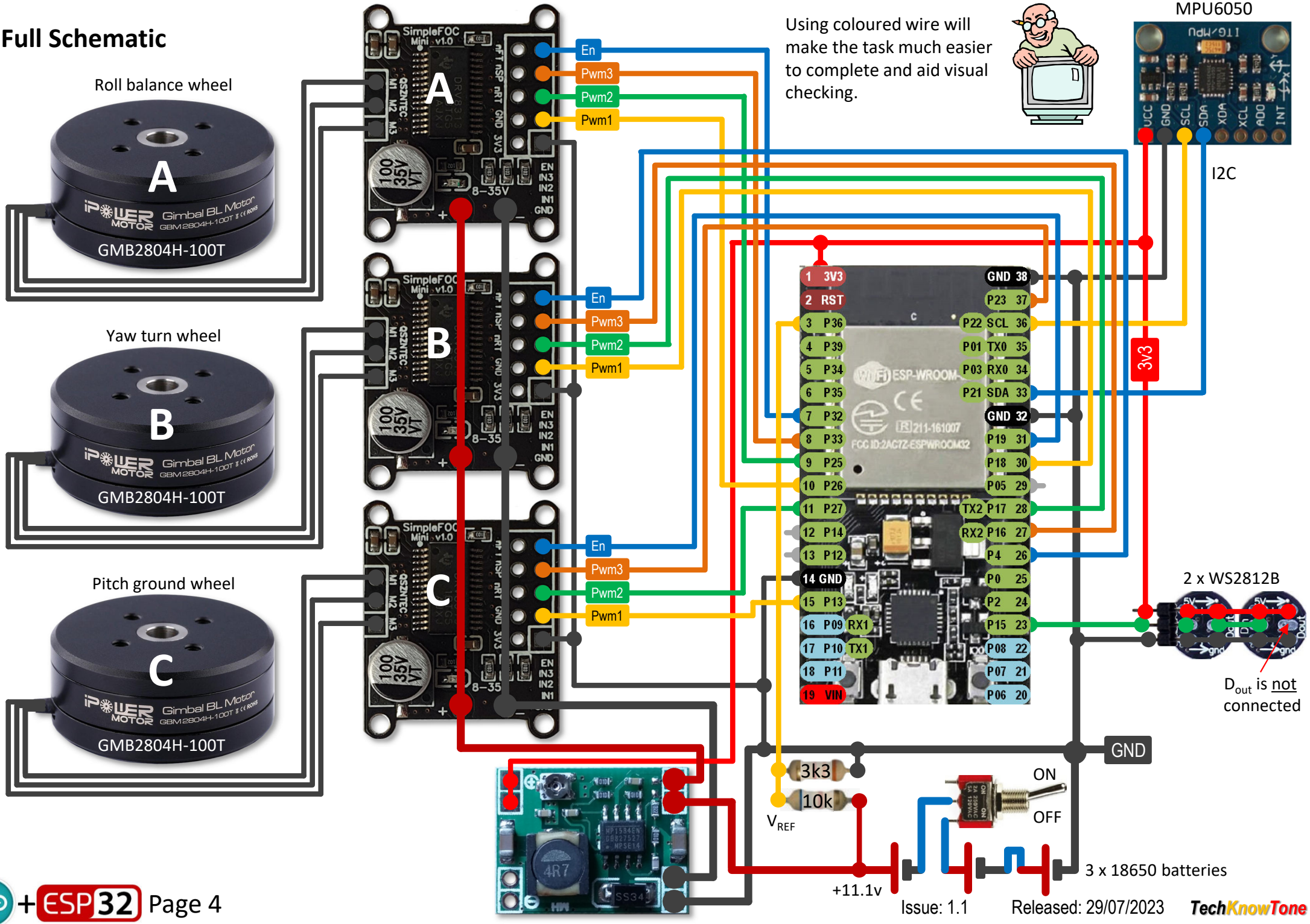
Note: Not all items needed are shown here.

Tools & Materials:

Temperature controlled iron
Solder flux
Resin cored solder
Hot melt glue gun
2-part epoxy resin glue
Screw drivers
Wire wrapping tool
Wire wrapping wire 30 AWG
24 AWG stranded wire (red & black)
Multimeter

Issue: 1.1 Released: 29/07/2023

Full Schematic



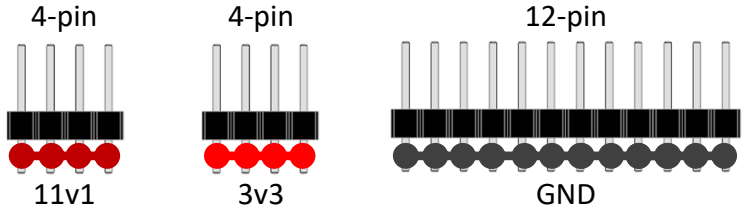
Micro Plate Wiring - Total

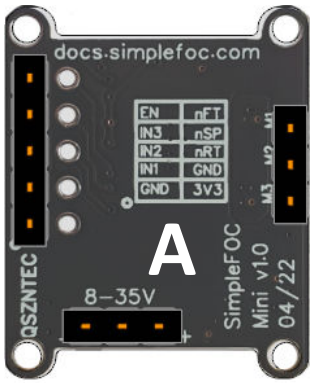
The micro plate hosts the majority of the wiring, with the device socket strips and pin strips acting as terminals, onto which the wires can be wrapped. Two small support brackets are used to hold the Micro Plate in a vertical position, next to the 'Turn' motor, to aid the wiring process.

The wires from the BLDC motors are shown here in purple. They are routed through the Body Plate, then into the Micro Plate housing. The wiring is concealed once the Micro Plate is attached to the Body Plate.

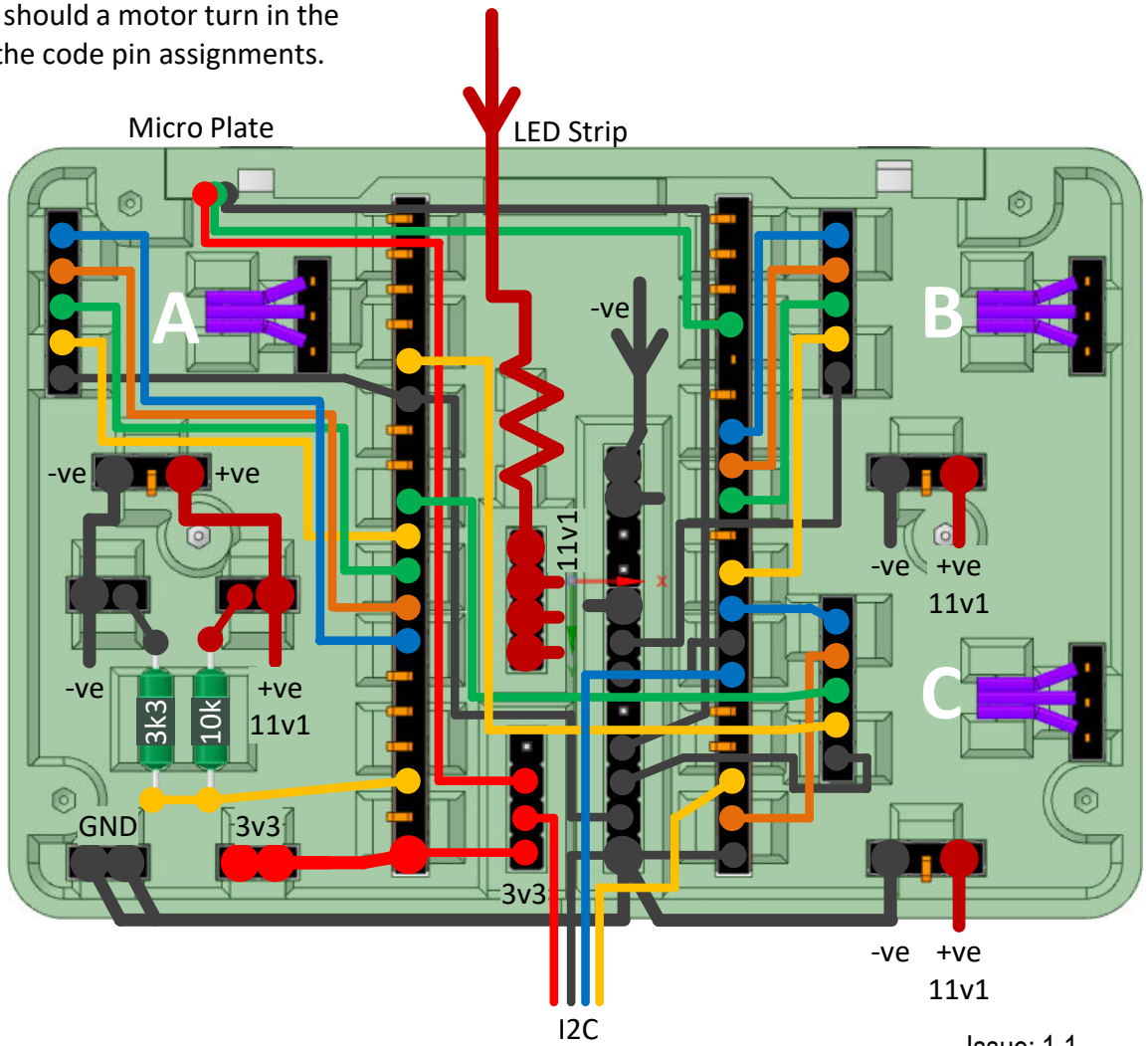
The wires are not colour coded. However should a motor turn in the wrong direction, this can be corrected in the code pin assignments.

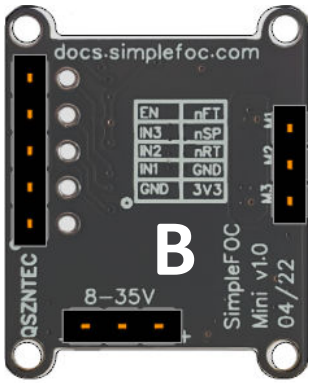
The pin strips for the common connections are prewired, shorting the pins together, before they are glued into the Micro Plate.

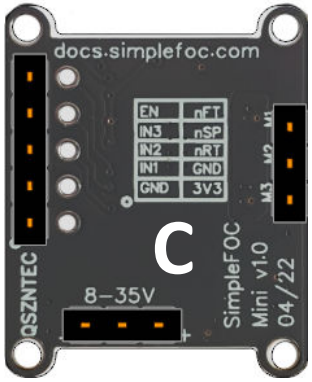




3v3, 3A buck regulator







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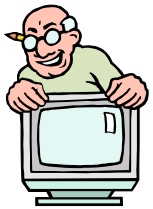
Micro Plate Wiring – Step 1

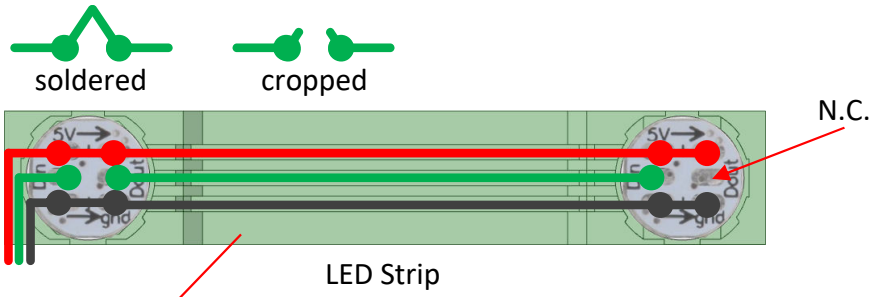


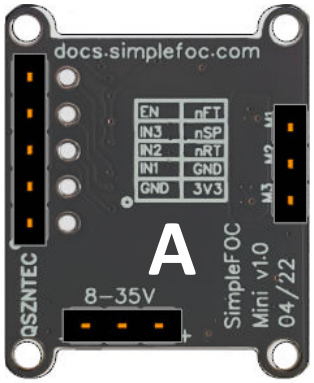
Start by wiring in the supply lines, and the two resistors for battery monitoring, as shown here.

Since the solder pads on the RGB LED are small and a little tricky to solder, they have been mounted in a separate strip. Which you pre-wire, prior to gluing into the main Micro Plate housing. Glue the WS2812B chips into the strip first, then wire, leaving sufficient length for connections to the ESP32 and supply lines.

Once wired into position you can temporarily insert the ESP32 micro and test the LED strip, before gluing it into the Micro Plate, using USB power fed into the micro from you PC.

The wires running along the LED strip do not need to be insulated, as long as they are prevent from touching each other. The data wire is run in as one wire, bent up/down between the first two pads, soldered in place, and then cropped out after soldering to break the in/out data connection.

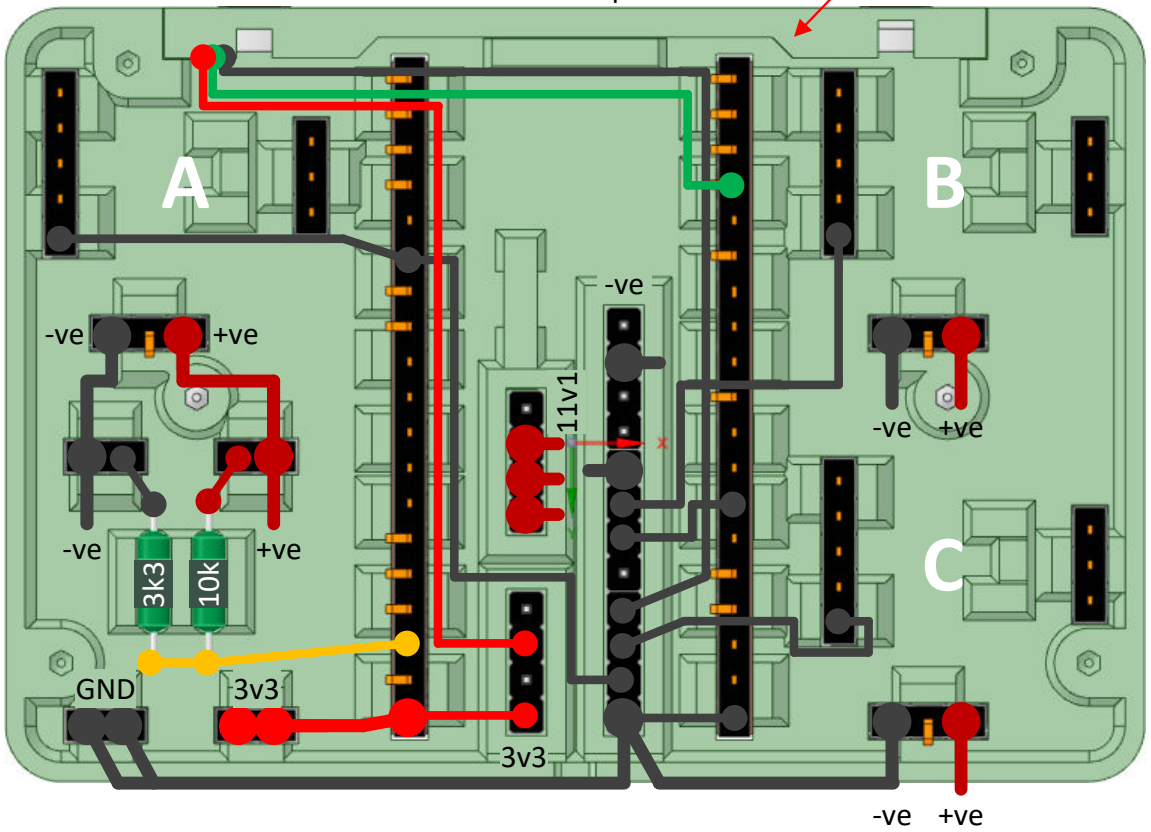




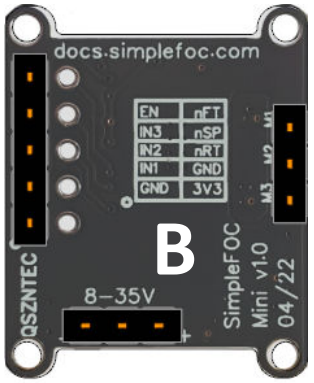
3v3, 3A buck regulator

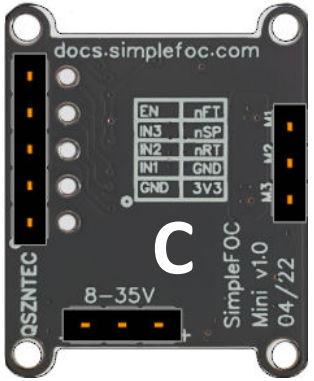
Micro Plate

LED Strip

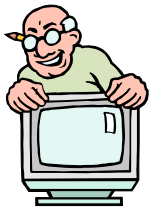


Viewed from inside the case





Micro Plate Wiring – Step 2

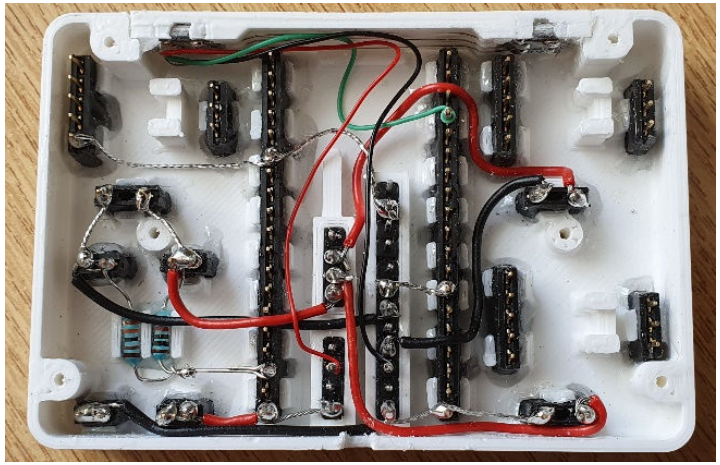


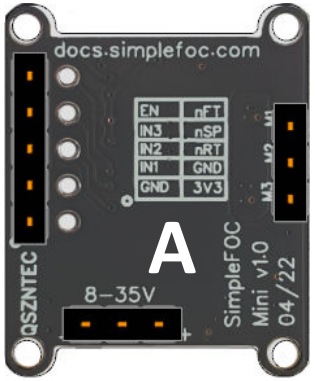
Next complete the wire wrap connections, between the ESP32 micro and the SimpleFOC mini driver boards A, B and C.

Note that the voltage regulator board is adjustable, and should be set to provide a 3v3 output, from a 12v input; either before insertion into the micro case, or with the ESP micro is not inserted.

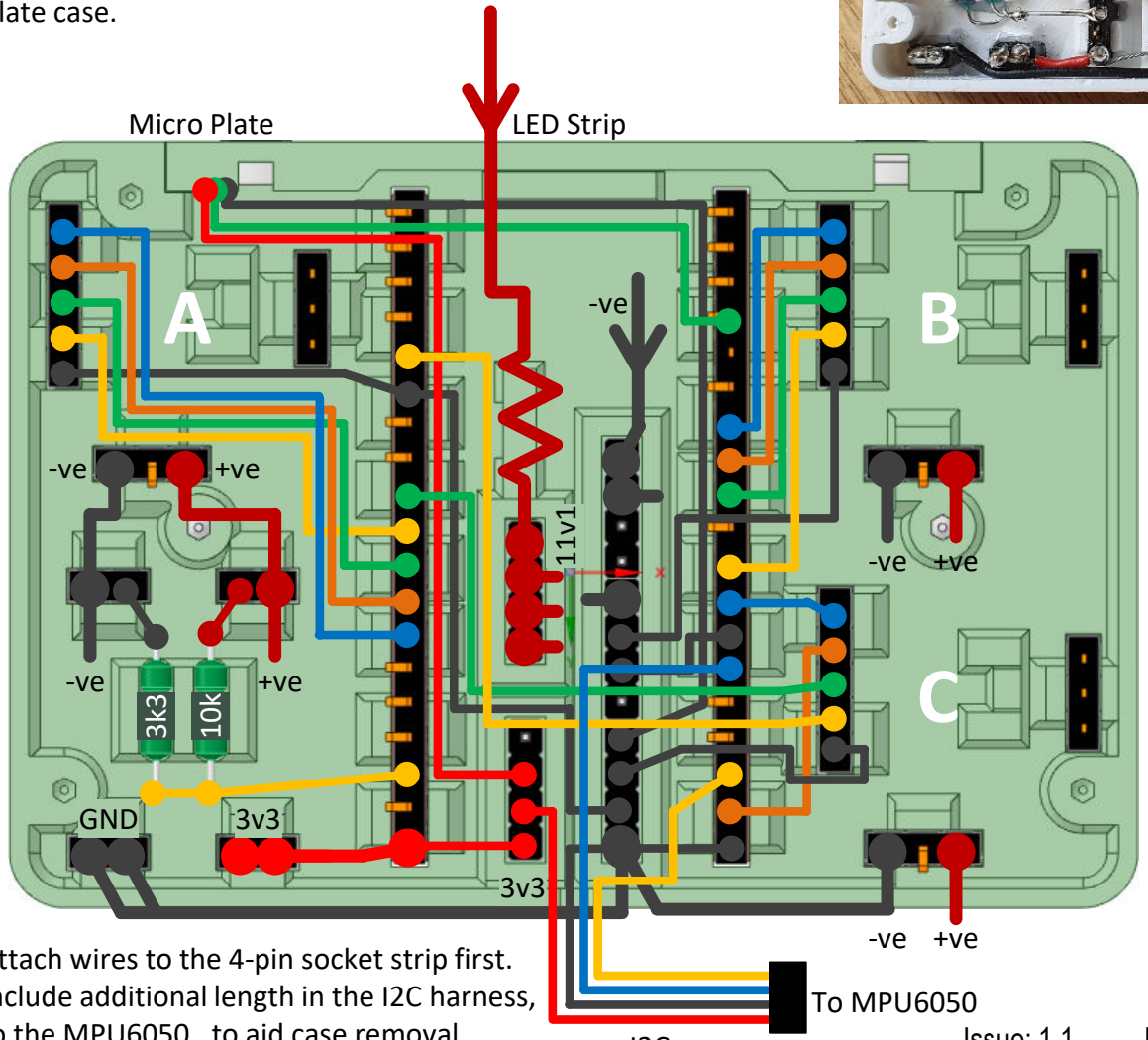
Unused pins on the micro can be bent over, to aid the routing of wires. Once the wiring is complete, crop any excess material off the pin strips to provide more space within the micro plate case.

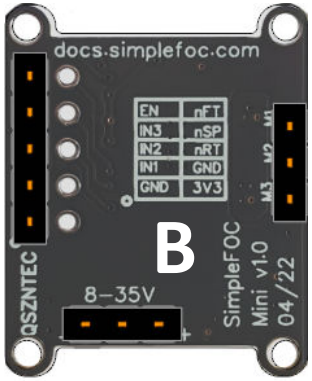
The previous step should look like this as the starting point:.

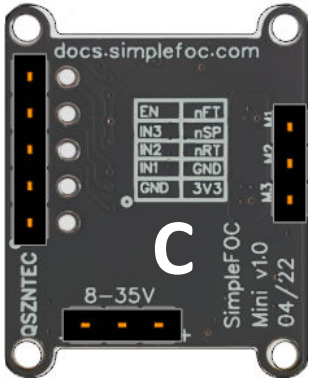




3v3, 3A buck regulator





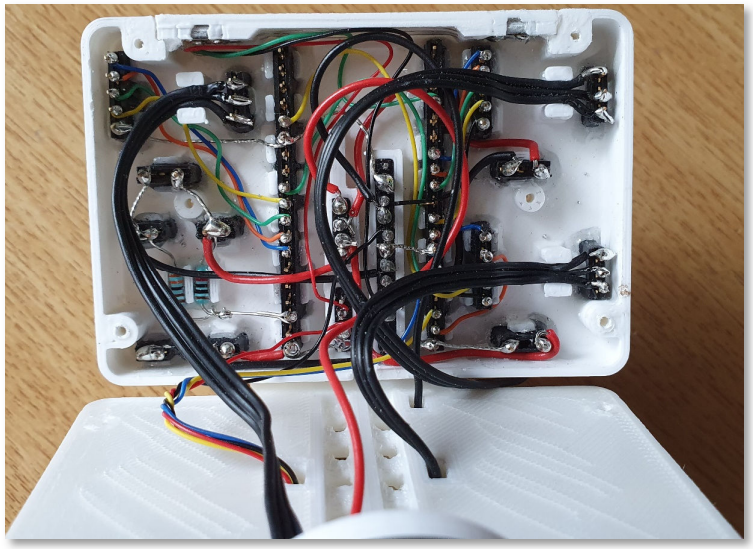


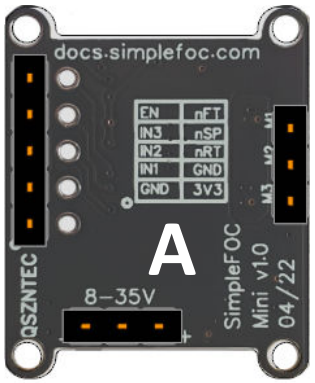
Attach wires to the 4-pin socket strip first. Include additional length in the I2C harness, to the MPU6050, to aid case removal.

Micro Plate Wiring – Step 3

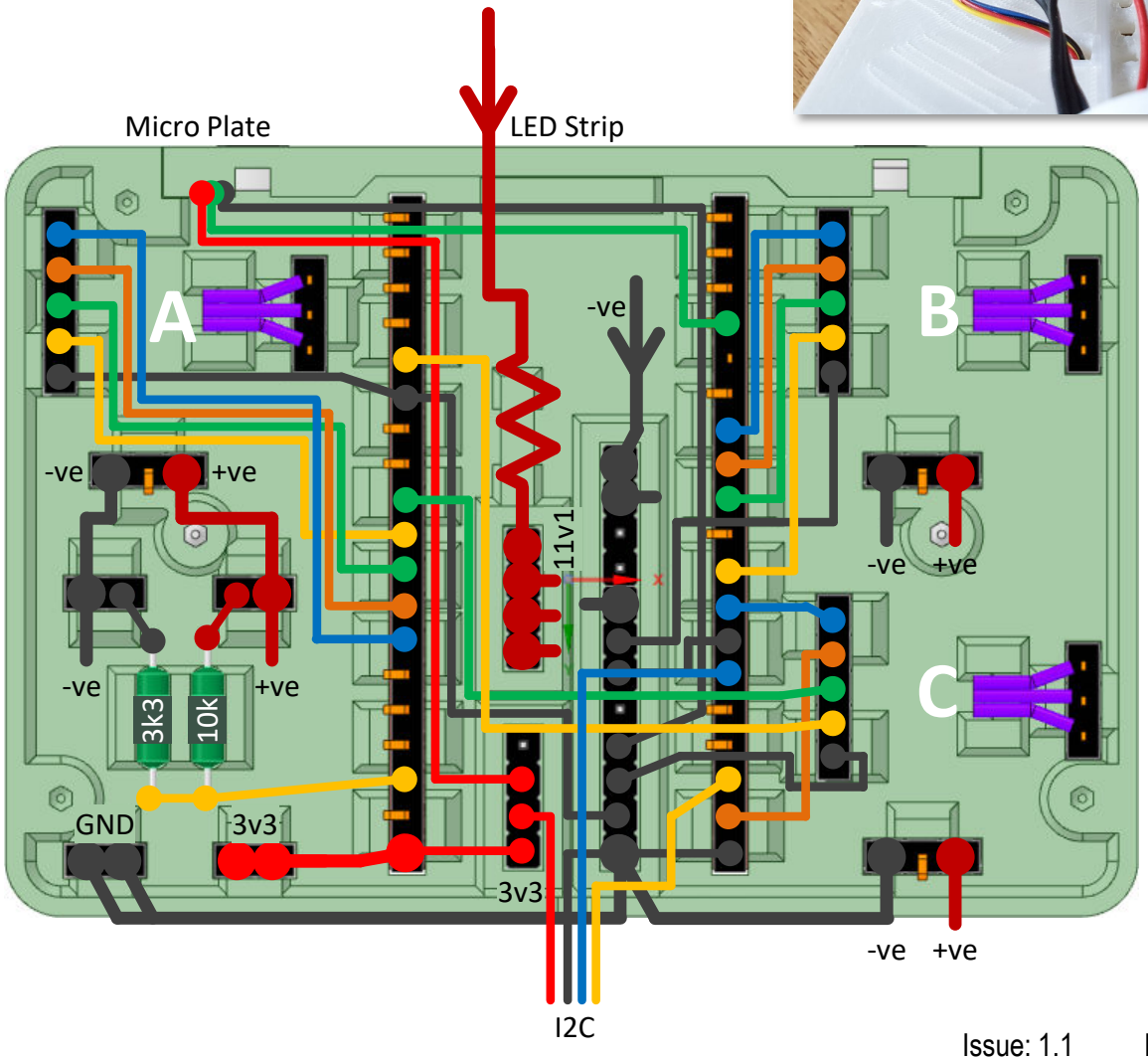
Then finally, wire in the three motors. If the motors happen to turn in the wrong direction, when powered up and tested, we can simple change the pin assignments in the code to correct the SimpleFOC phase orientation.

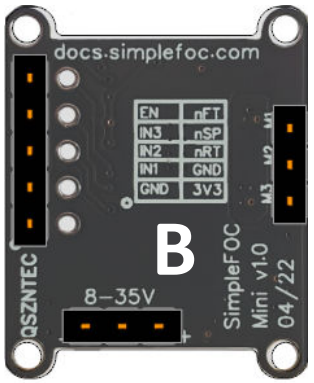
The image on the right (enlarged on the next page) shows the internal wiring of my Uni-Bot micro plate housing.

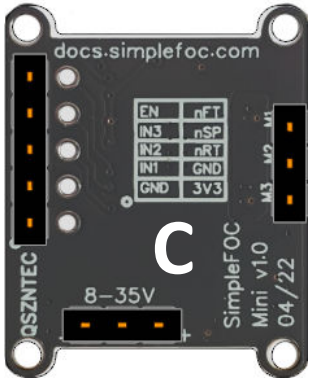




3v3, 3A buck regulator







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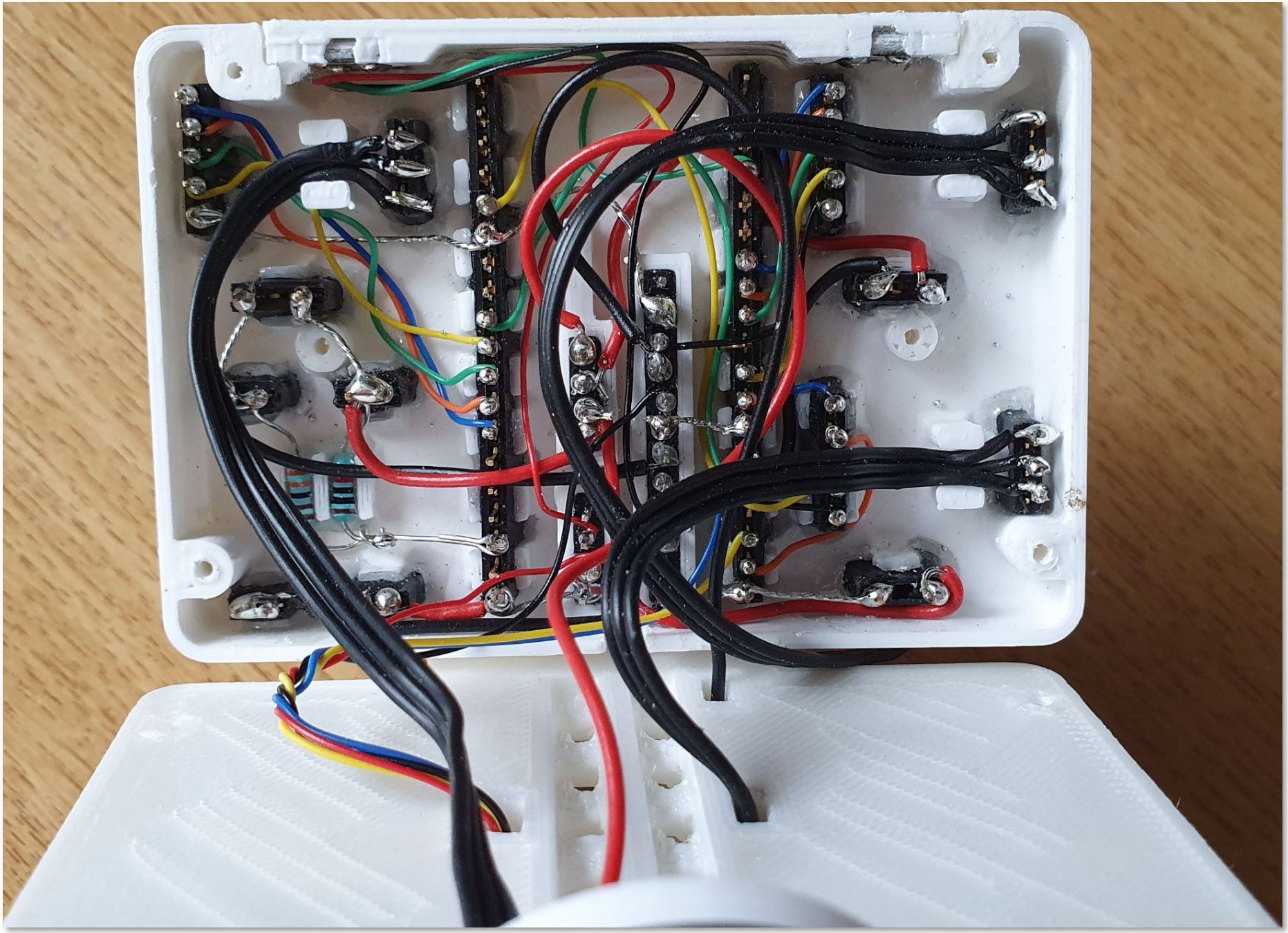
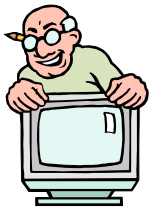
Micro Plate Wiring – Complete

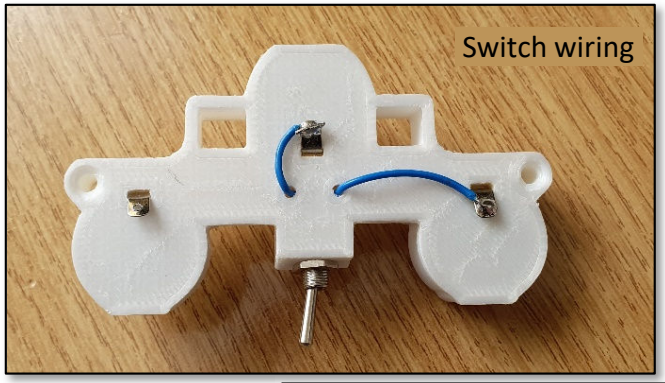


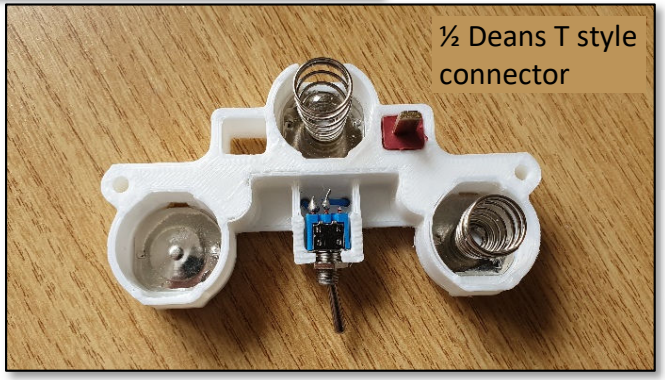
Battery Wiring

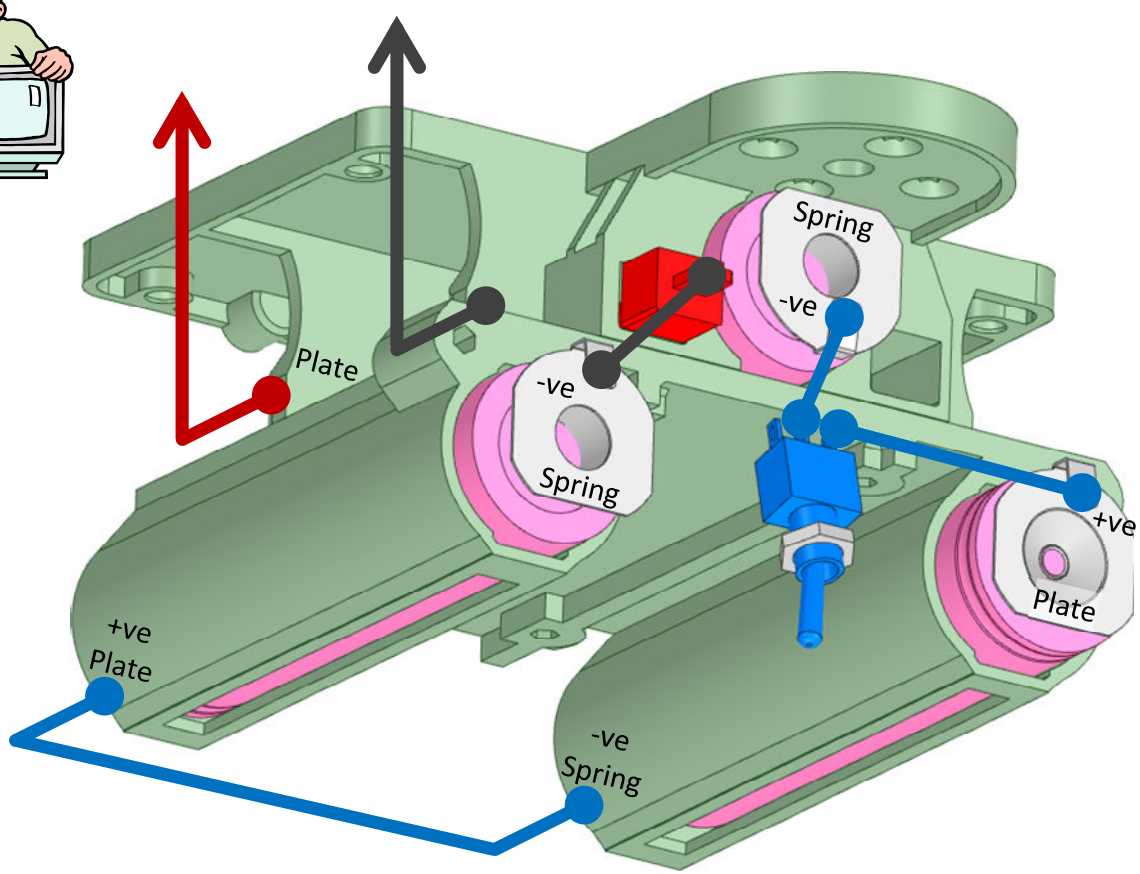


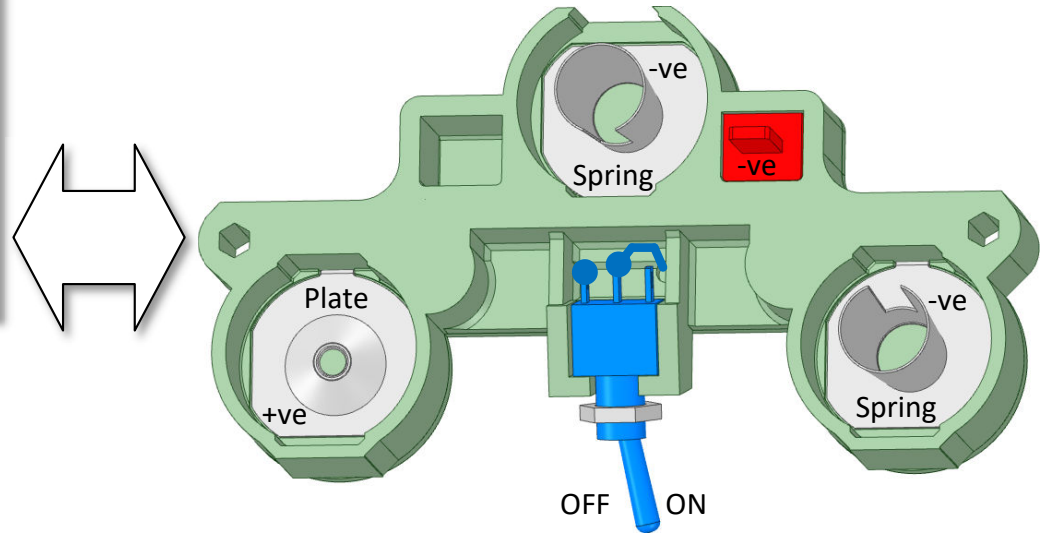
This diagram shows the wiring of the Battery Plate and the Battery Cover connections. The negative connection, of the right-hand battery, is soldered, then passed round the front of the Uni-Bot, behind the motor mount, to the positive connection of the left-hand battery.

The Cover Plate, Deans T battery spade connector and toggle switch are prewired before gluing the two halves of the Cover Plate together. The toggle switch connects the negative of the centre battery to the positive of the right-hand battery. The negative of the left-hand battery is wired to the spade connector.







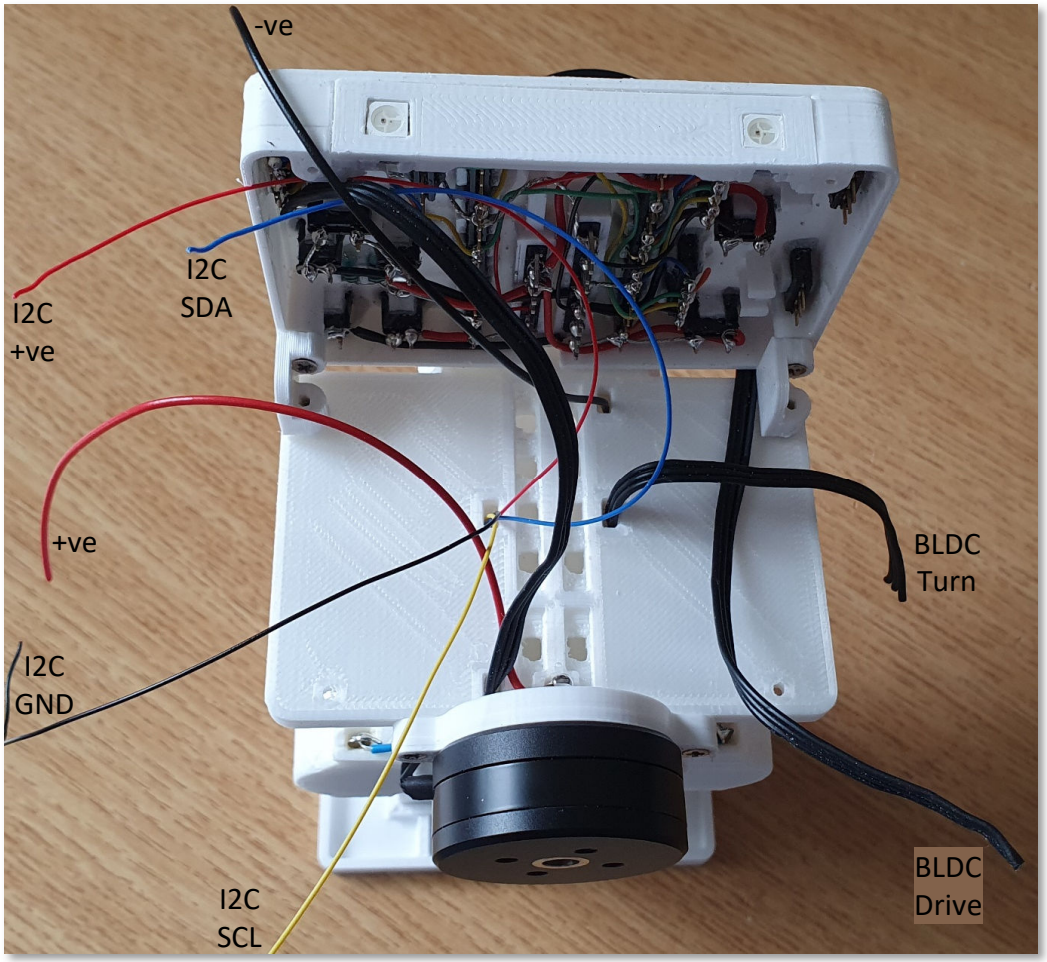


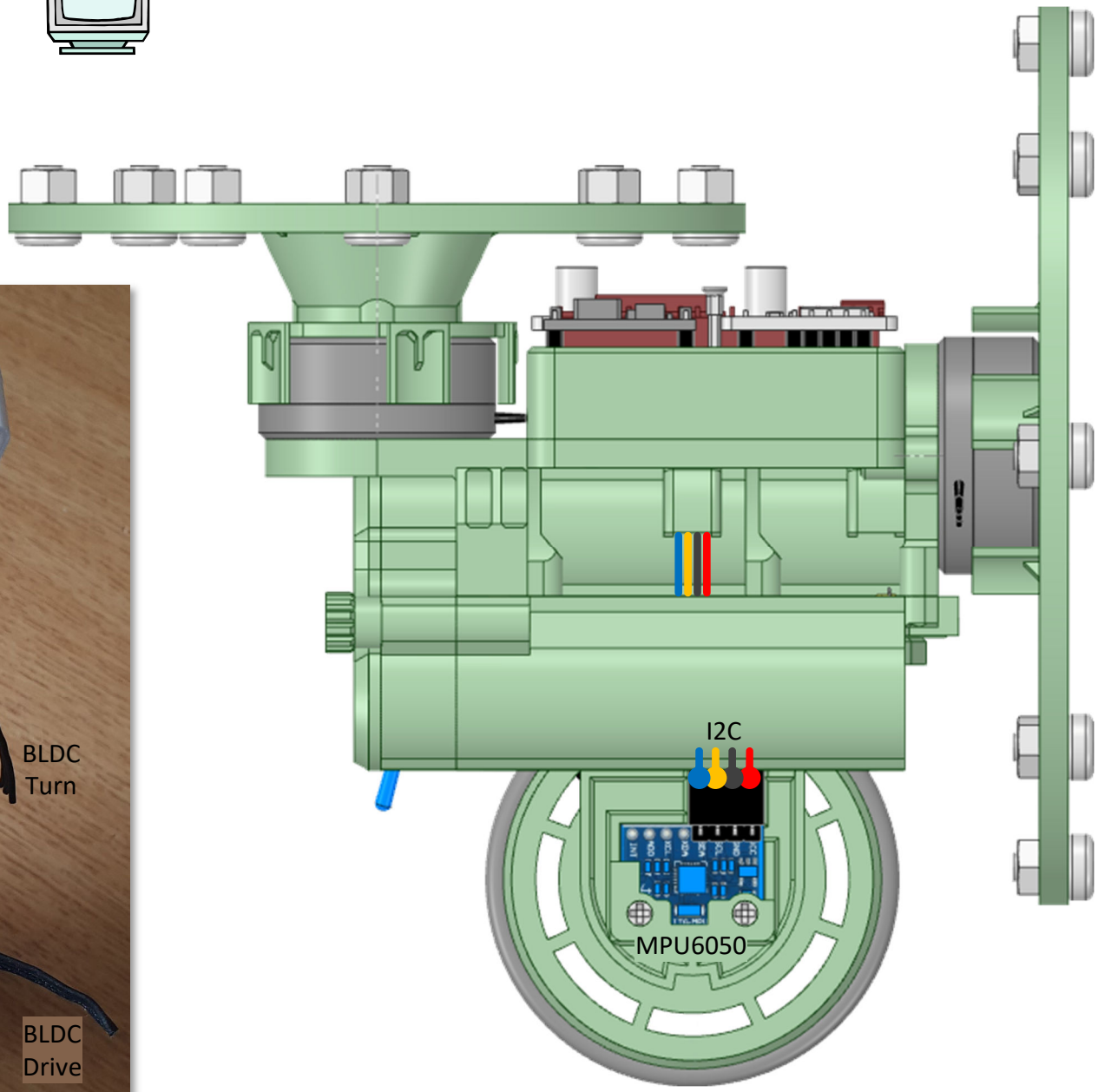
WARNING: this design does not include any form of circuit protection, like a fuse; so considerable current can flow from the batteries if a short circuit fault occurs. There is a lot of energy stored in these batteries, so please take care, and insulate connections accordingly.

MPU6050 Wiring

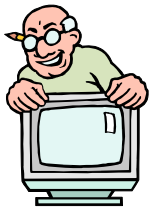
The four wire I2C harness, connecting the MPU6050 sensor to the ESP32 micro, is wired to a 4-pin socket.

I would recommend that you make this part of the harness first, prior to passing it through the body plates, to the micro housing, and then wire wrapping the connections to the ESP32 micro socket pins.





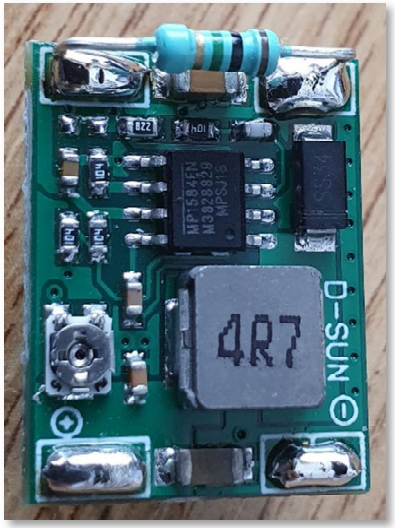
Voltage Regulator



Set up the voltage regulator independently using an external power supply and multimeter. The input voltage source should be >= 8 volts, and we trim the regulators output to achieve 3.3 volts. This is normally done by turning the small potentiometer on the pcb in a clock-wise direction, to reduce the output voltage.

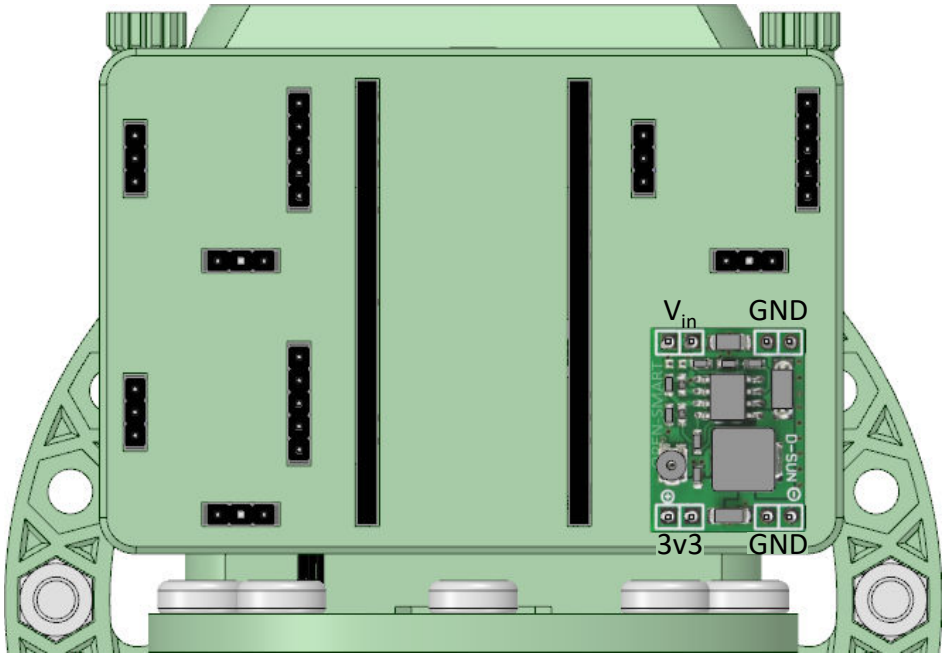
Once the robot is wired and assembled, plug in the voltage regulator, ensuring the correct orientation, with the potentiometer and inductor towards the lower edge. Install the three batteries, and check that the output of the voltage regulator is at 3.3 volts.

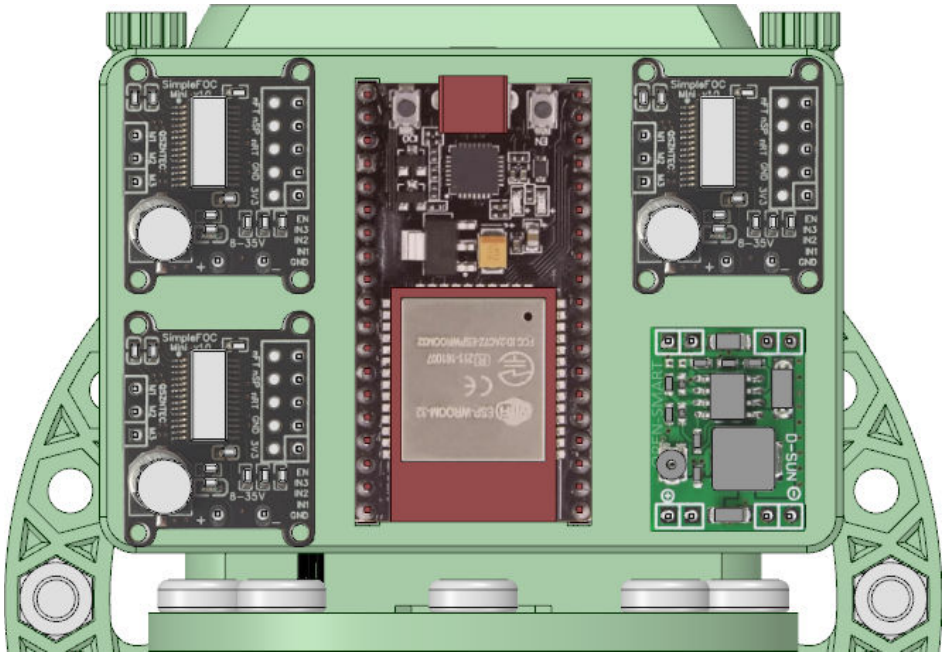
Now insert the ESP32 micro, with the power off, and download the code into it. When power is re-applied, this should confirm that the RGB LED's are working. All three SimpleFOC mini drivers power LEDs should also light up.



The accuracy of the analogue to digital converter (ADC) in the ESP32 can be improved by calibrating it's measurements against a multimeter, whilst using an adjustable voltage supply. This is important for setting the correct motor PWM values, to prevent them over-heating.

I soldered a 1MΩ resistor across the voltage regulators input pins, to make it easier to attach an external power supply for these measurements.





Battery Voltage Health Monitoring

See Lithium discharge curve obtained from the internet. In this analysis the lipo battery consists of three identical batteries connected in series.
Assume fully charged 11.1v battery max voltage is V_{BM} >= 12.9v max
Set battery warning point at V_B = 10.5v (3 x 3.5v)
Set battery critical point at V_{BC} = 9.9v (3 x3.3v)

The ESP32 is powered via a voltage regulator connected to the 3.3v pin.
V_{ADC} == 4095 on 12-bit converter (4095 max).
If we use a 10k resistor feeding A0 and a 3k3 resistor to GND, we get a conversion factor of 13.3v == 4095, or 3.25mV/bit, or 307.9 bit/v
Using a Multimeter I determined the following V_{ADC} values for corresponding threshold voltages:

MAX: (100%) V_M = 12.3v, gave A0 = 3841 on V_{ADC} (3 x 4.1v)

HIGH: (80%) V_H = 11.4v, gave A0 = 3402 on V_{ADC}

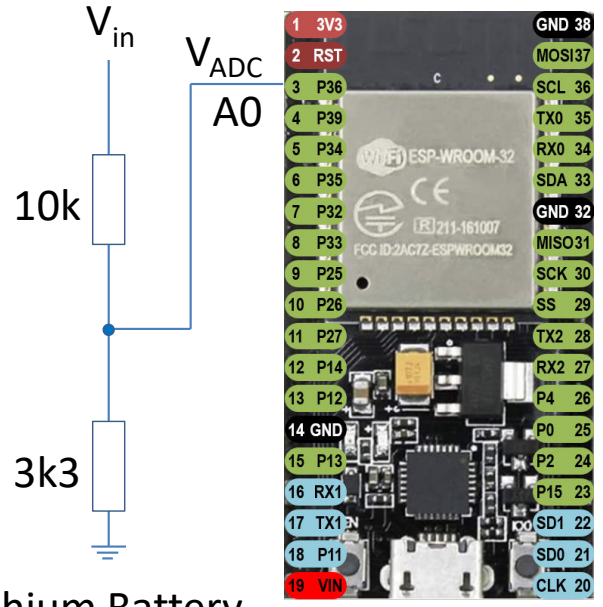
WARNING: (20%) V_B = 10.8v, gives A0 = 3175 on V_{ADC}

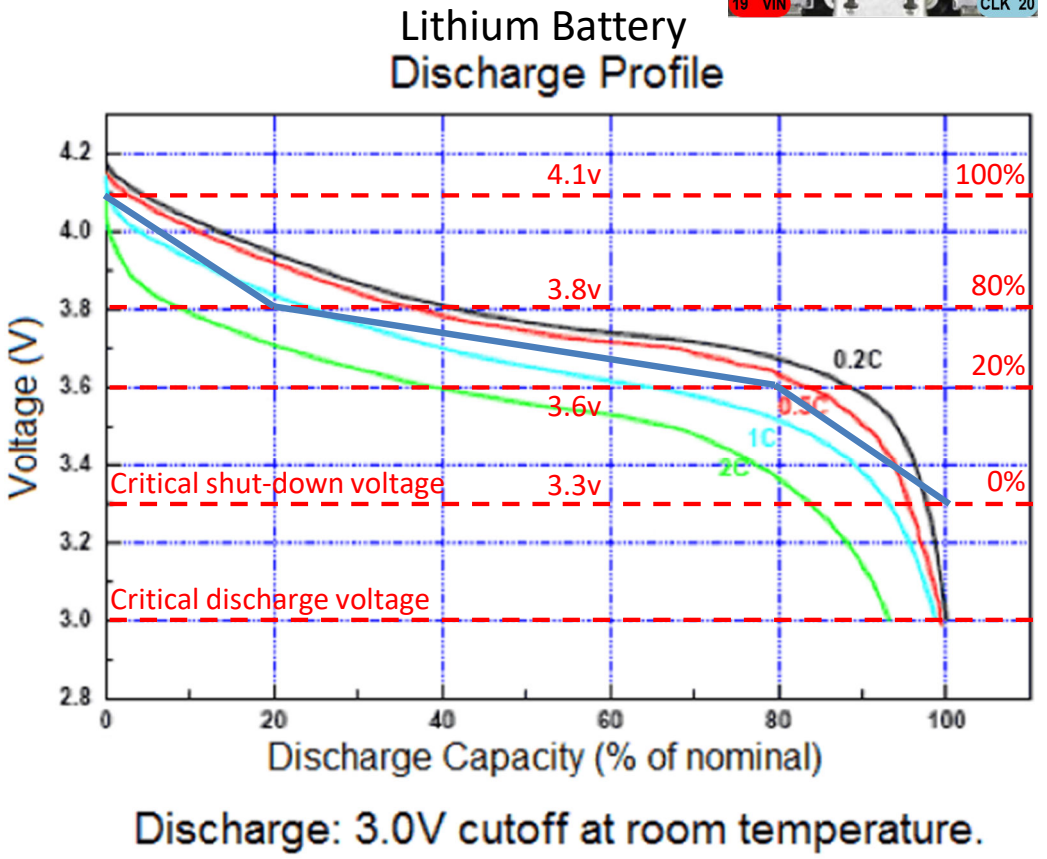
CRITICAL: (0%) V_{BC} = 10.0v, gives A0 = 2895 on V_{ADC} (3 x 3.3v+)

The code will sample the battery voltage on power-up to ensure it is sufficient, then at every 40ms interval, calculating an average (1/20) to remove noise. It also detects no battery as USB mode.

In the code I have assumed a discharge curve ranging from 12.3v (100%) to 10.0v (0%) capacity, using the overlay lines shown. The rate of discharge is monitored and used to predict the life of the battery in use.

Note: If connected to USB port with internal battery switched OFF the ADC will read a value 5 volts (A0 = 1919) or less. So if the micro starts with such a low reading it knows that it is on USB power.





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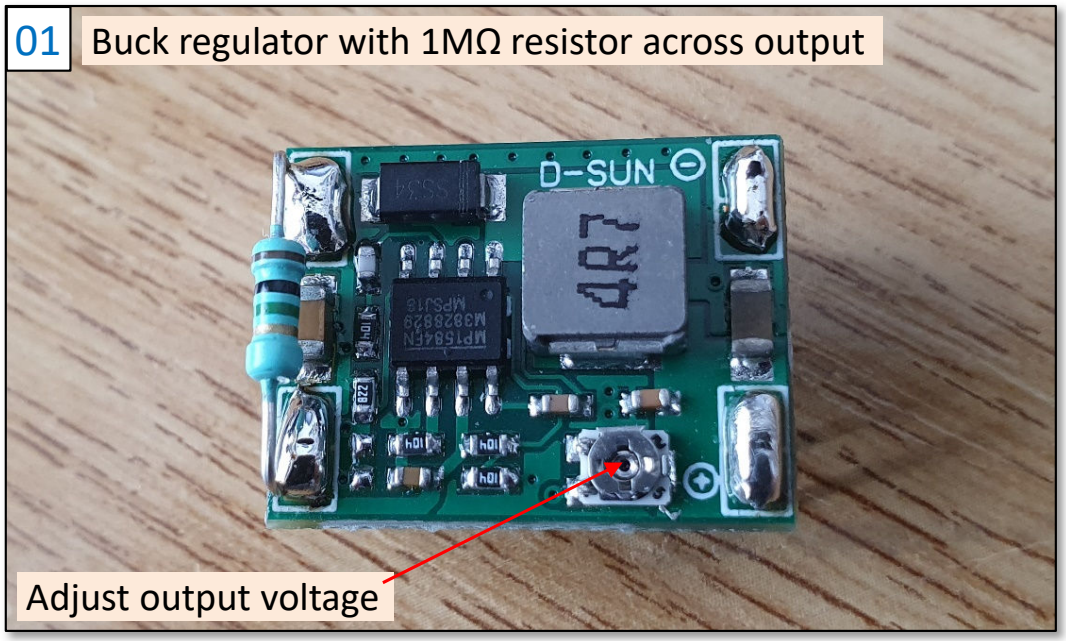
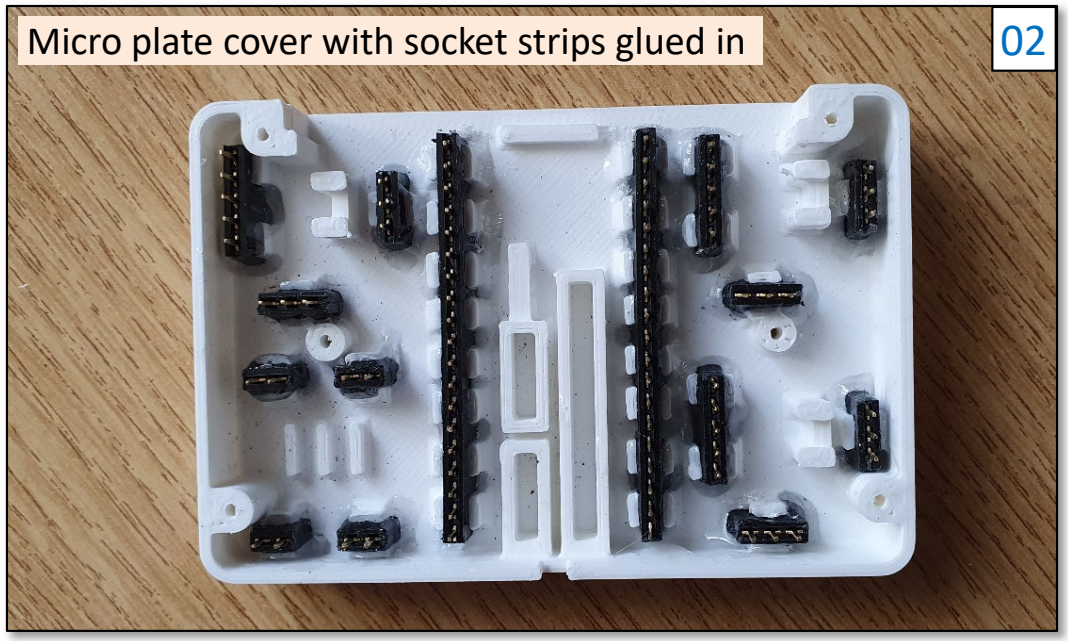
Build Images

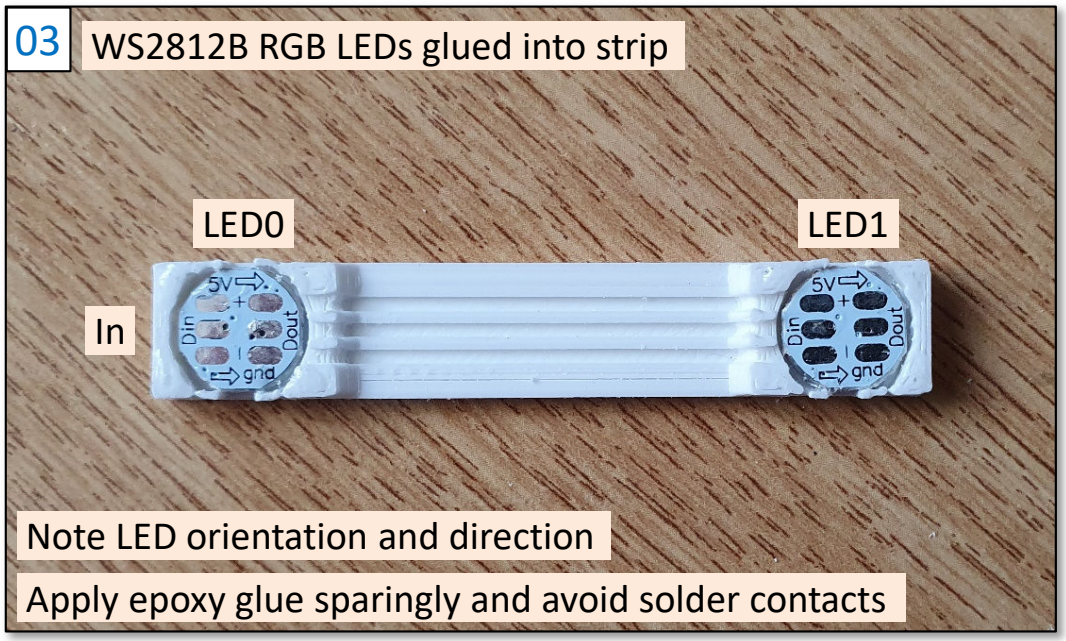
01 Buck regulator with 1MΩ resistor across output



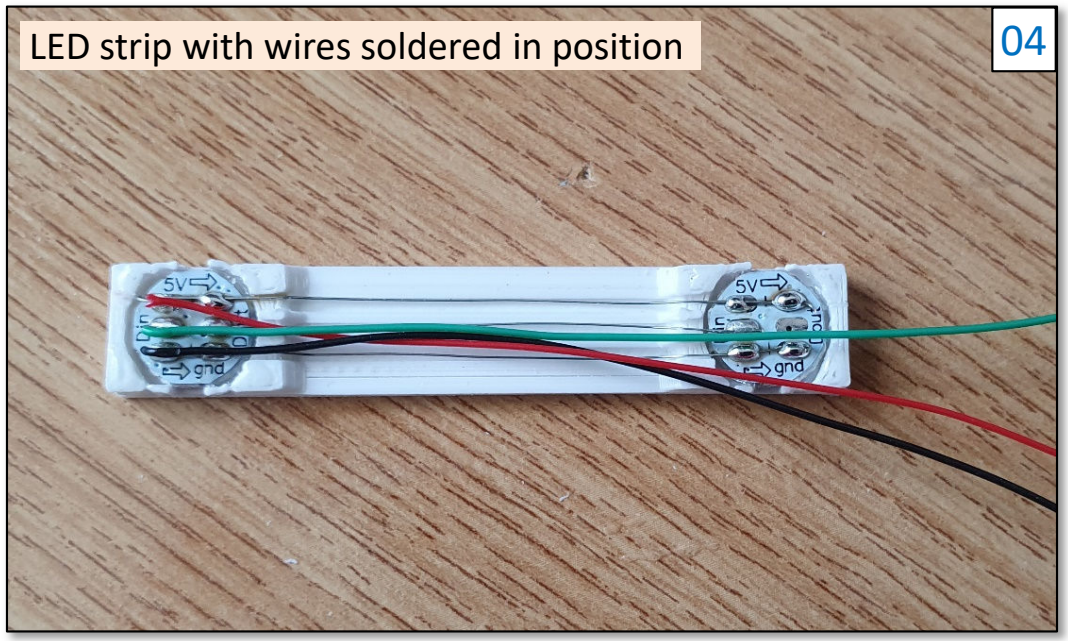
Micro plate cover with socket strips glued in 02



03 WS2812B RGB LEDs glued into strip



LED strip with wires soldered in position 04



Build Images

05 Battery cover with plates formed, ready for gluing

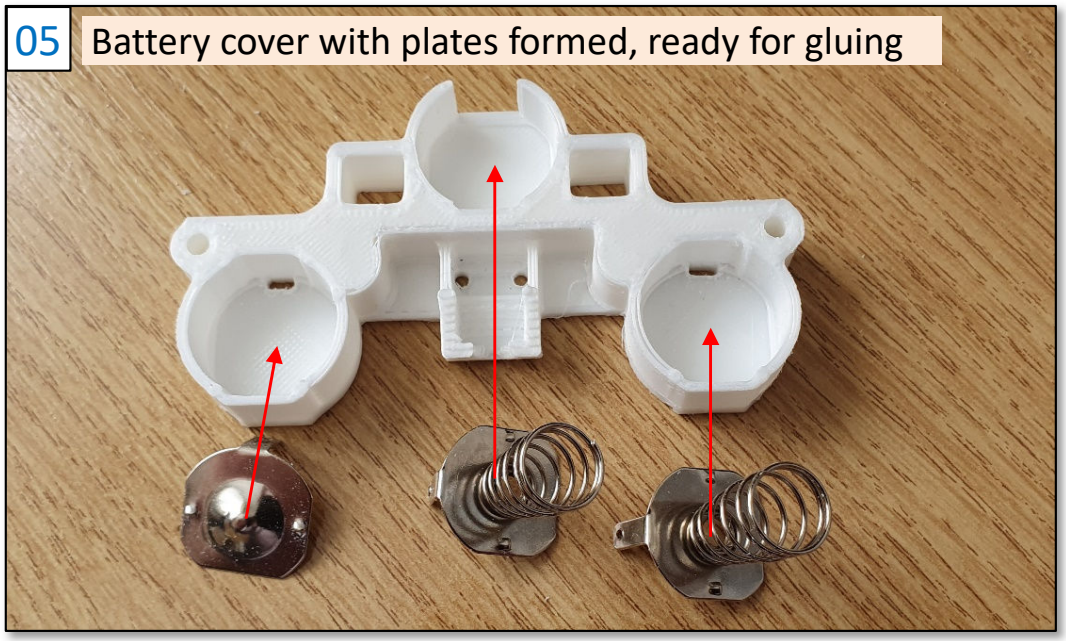
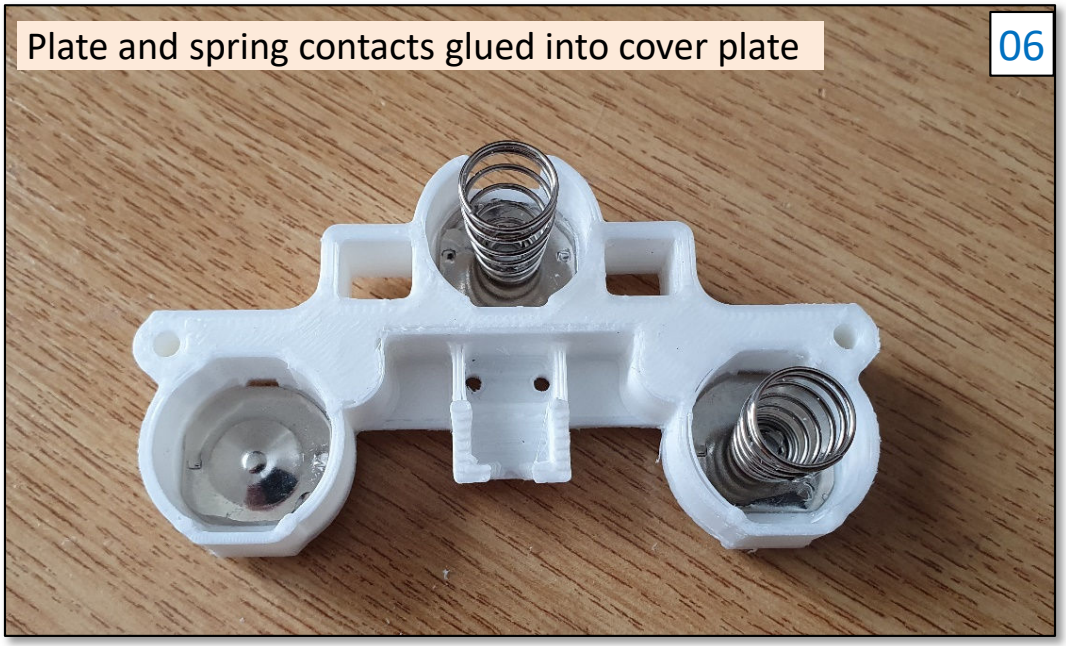
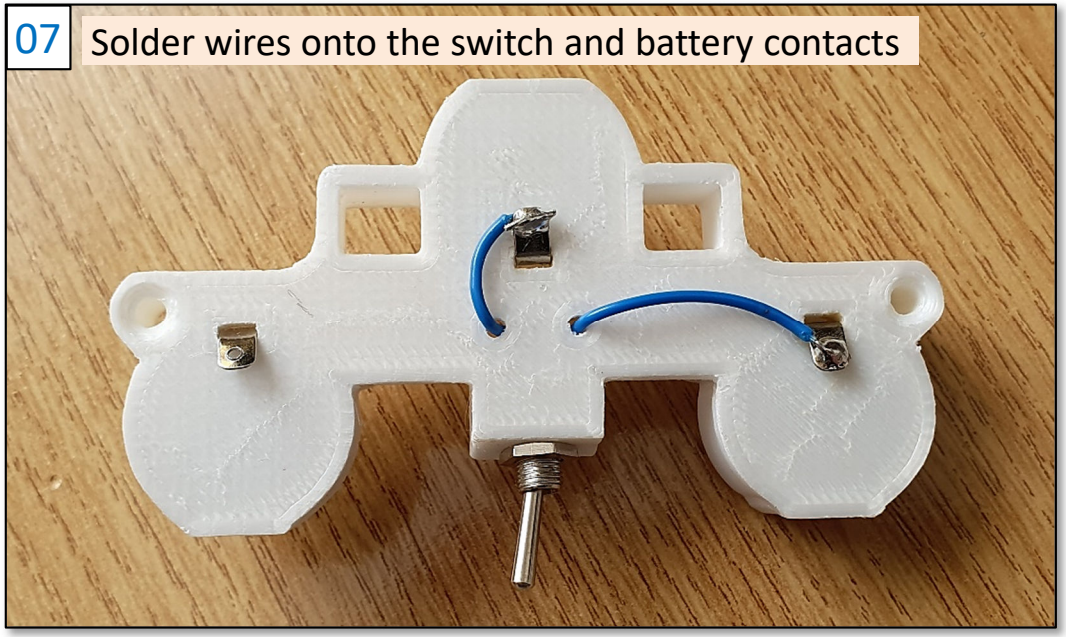


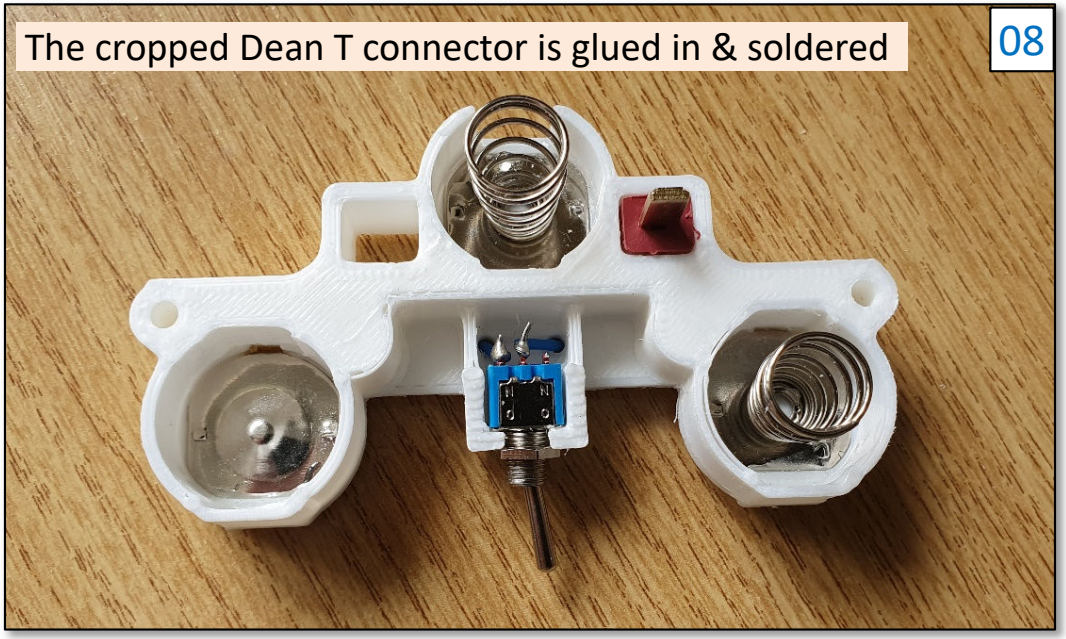
Plate and spring contacts glued into cover plate 06



07 Solder wires onto the switch and battery contacts

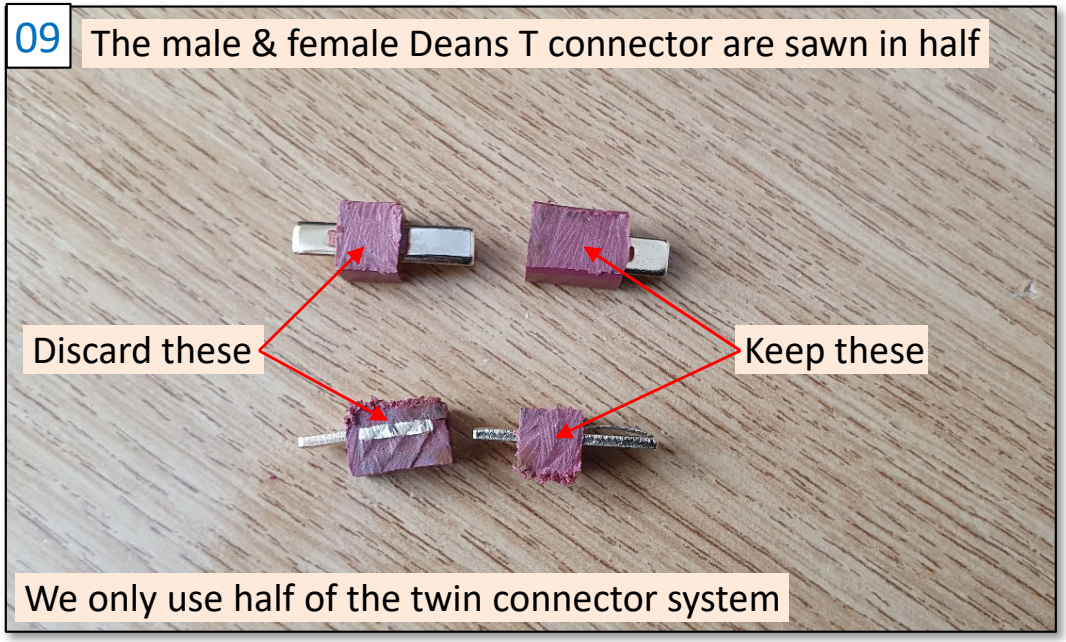


The cropped Dean T connector is glued in & soldered 08



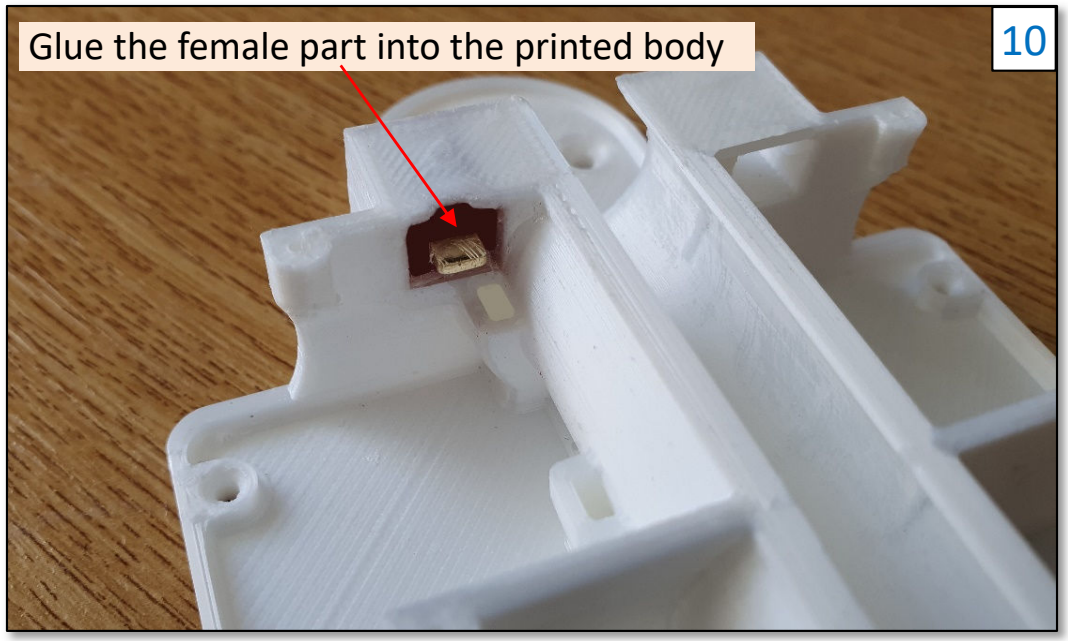
Build Images

09 The male & female Deans T connector are sawn in half

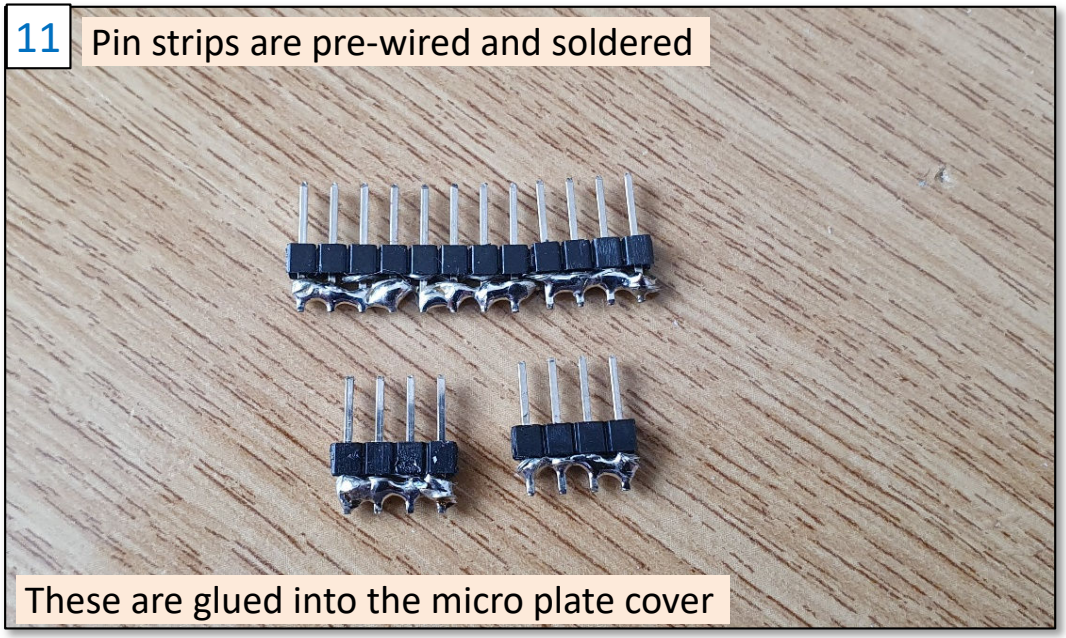


We only use half of the twin connector system

Glue the female part into the printed body 10

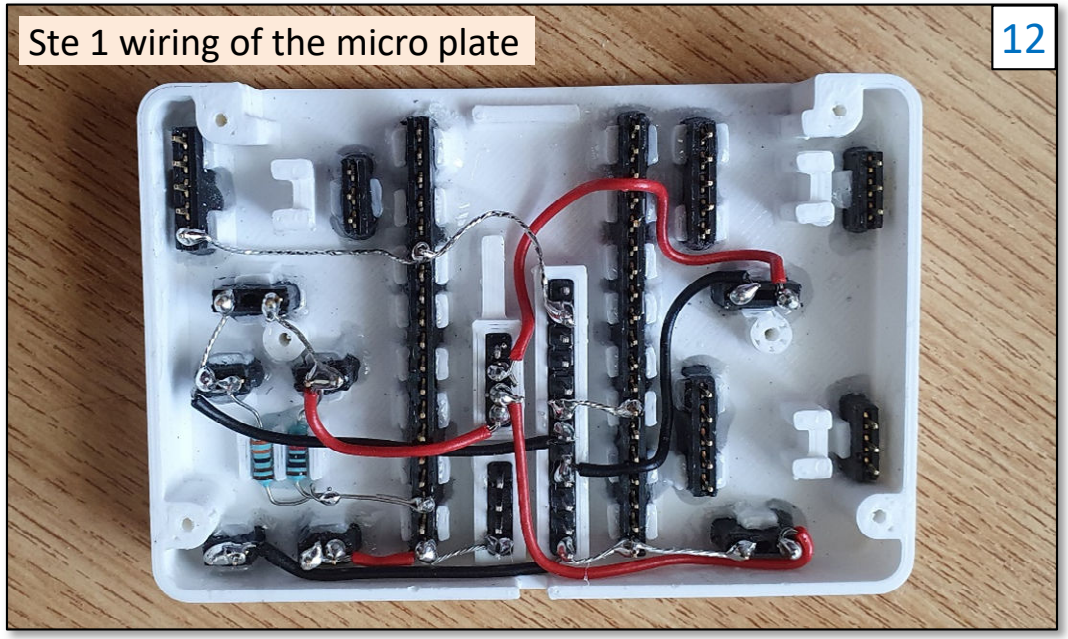


11 Pin strips are pre-wired and soldered



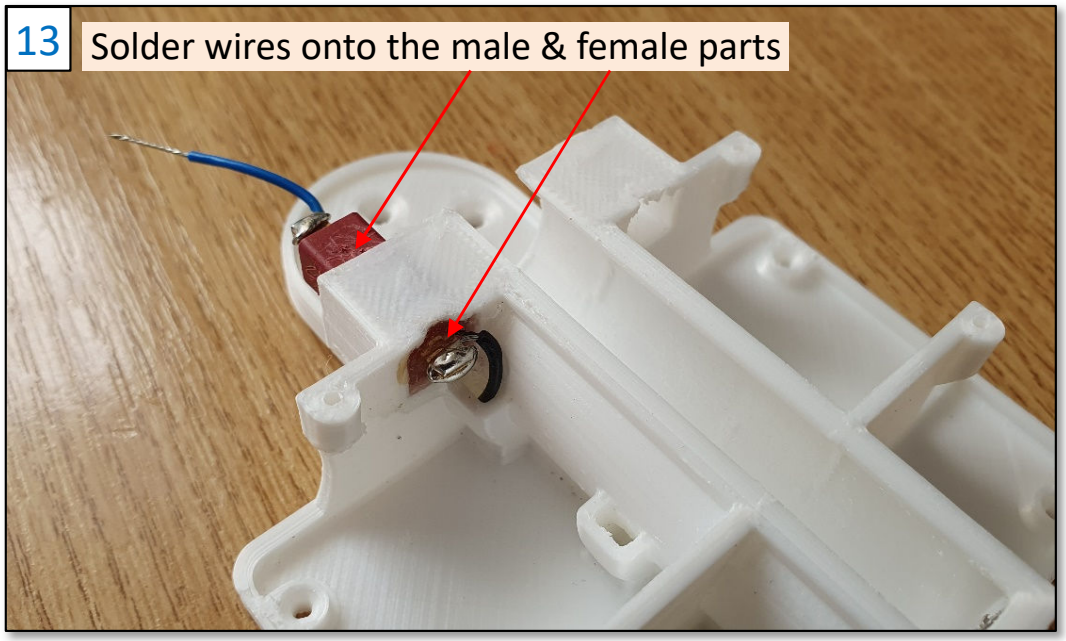
These are glued into the micro plate cover

Ste 1 wiring of the micro plate 12

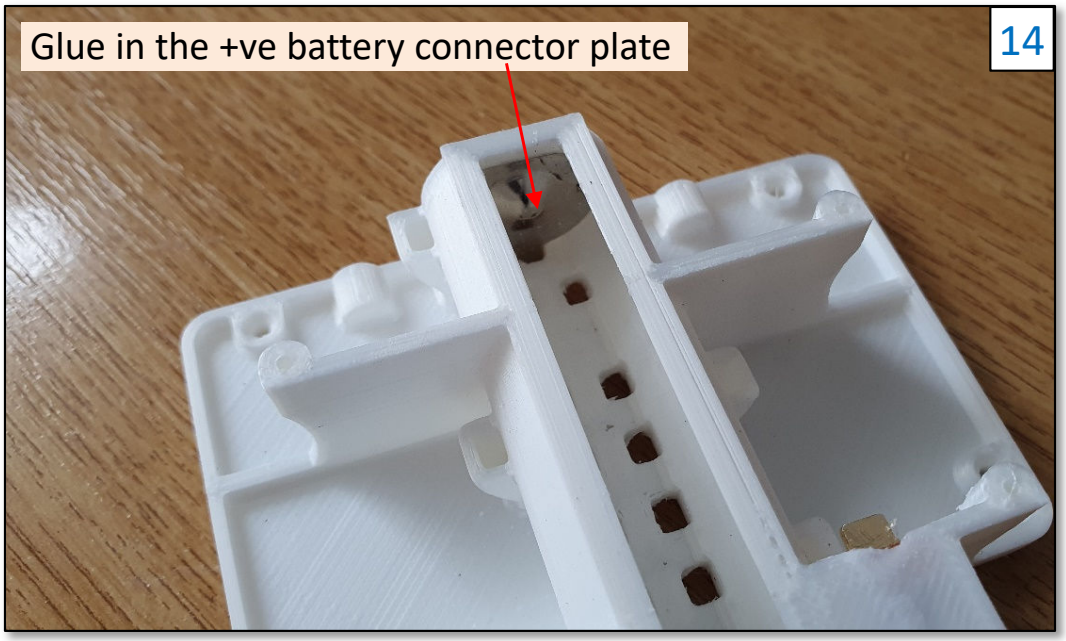


Build Images

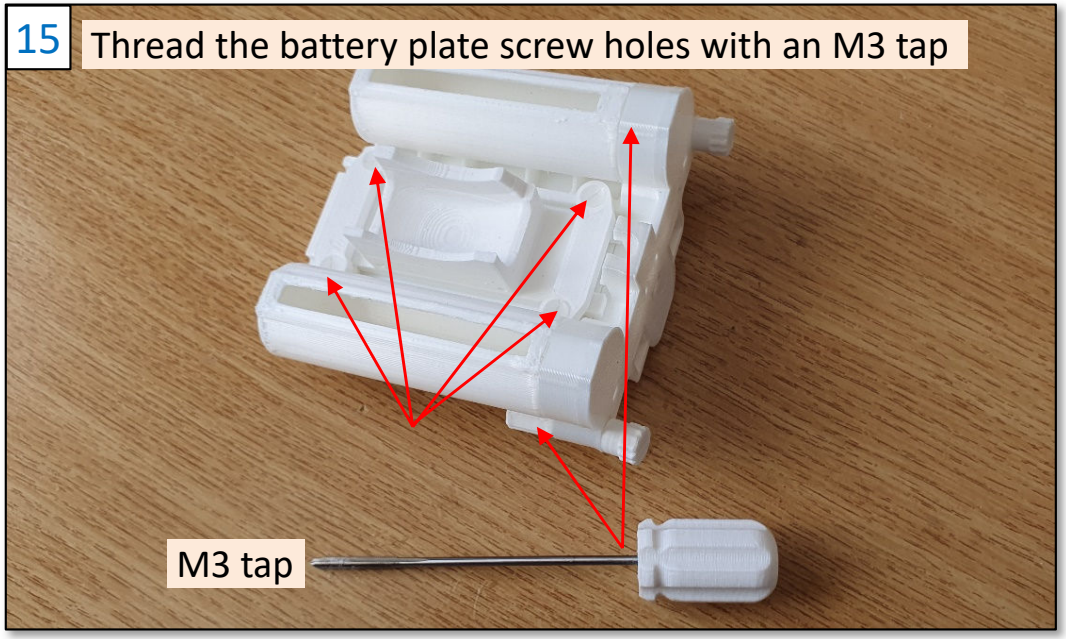
13 Solder wires onto the male & female parts



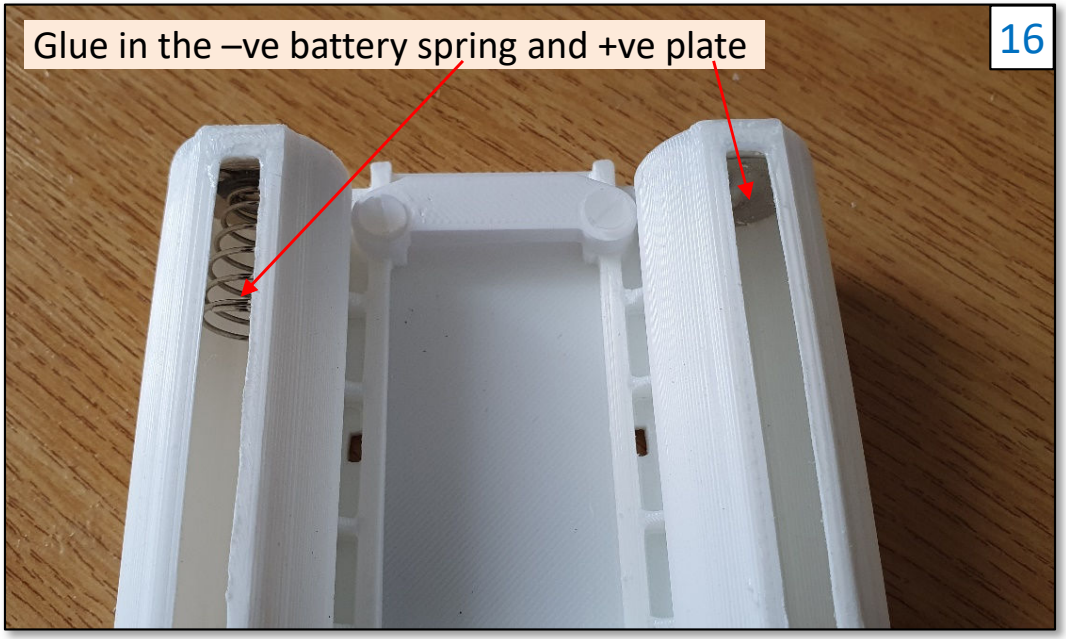
Glue in the +ve battery connector plate 14



15 Thread the battery plate screw holes with an M3 tap

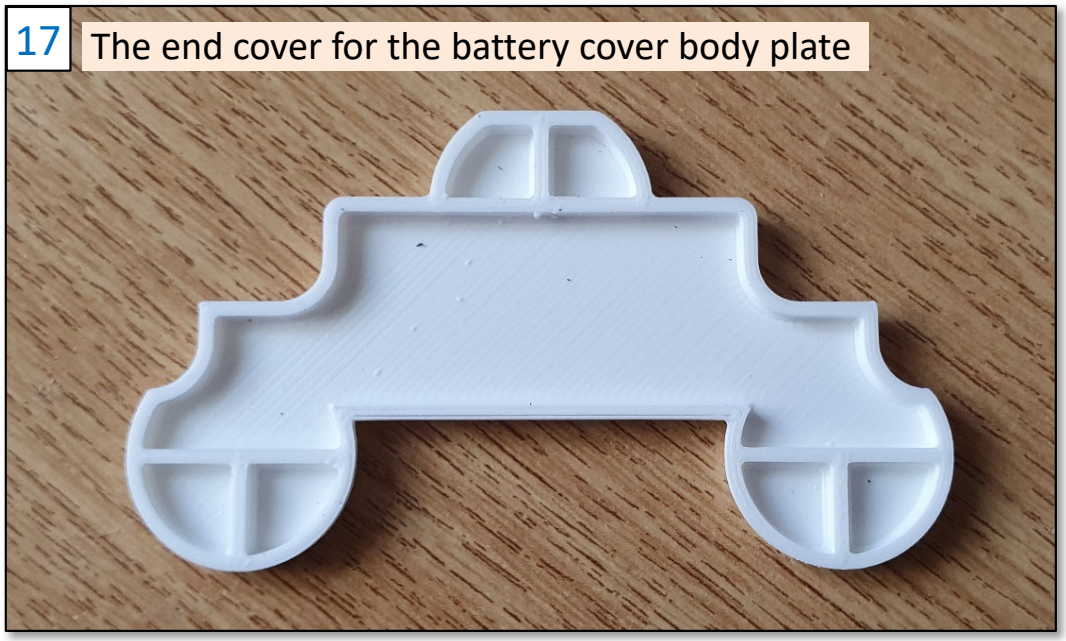


Glue in the –ve battery spring and +ve plate 16

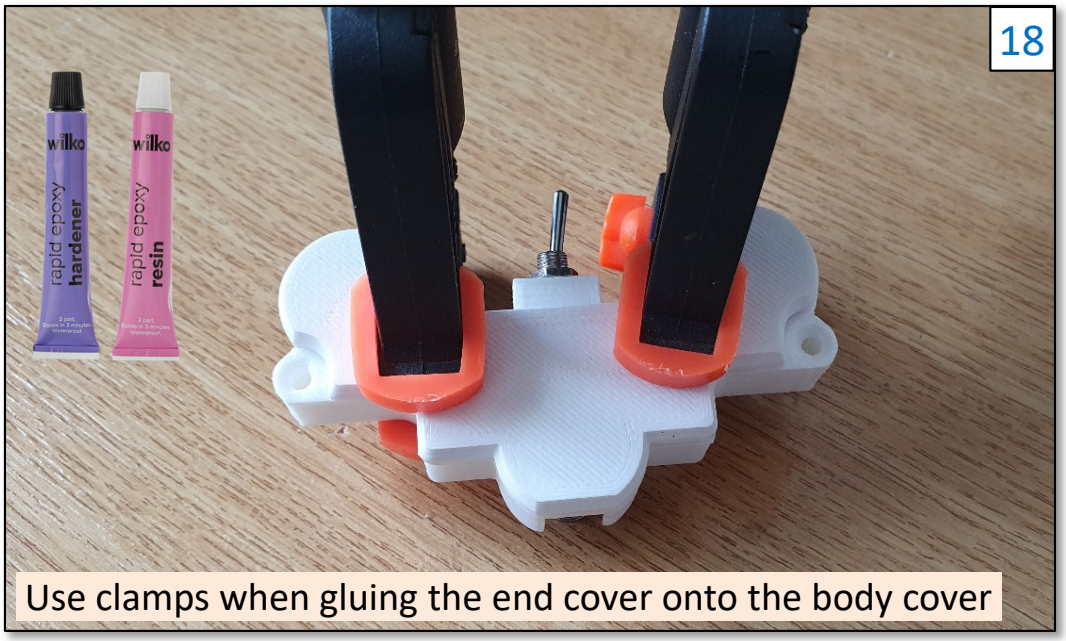


Build Images

17 The end cover for the battery cover body plate

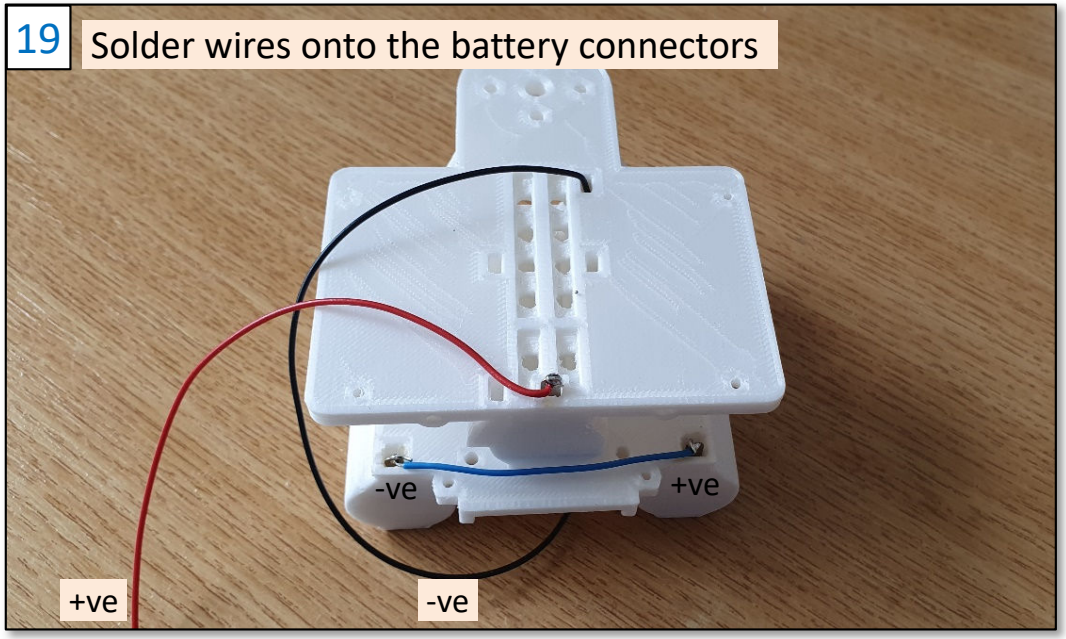


18

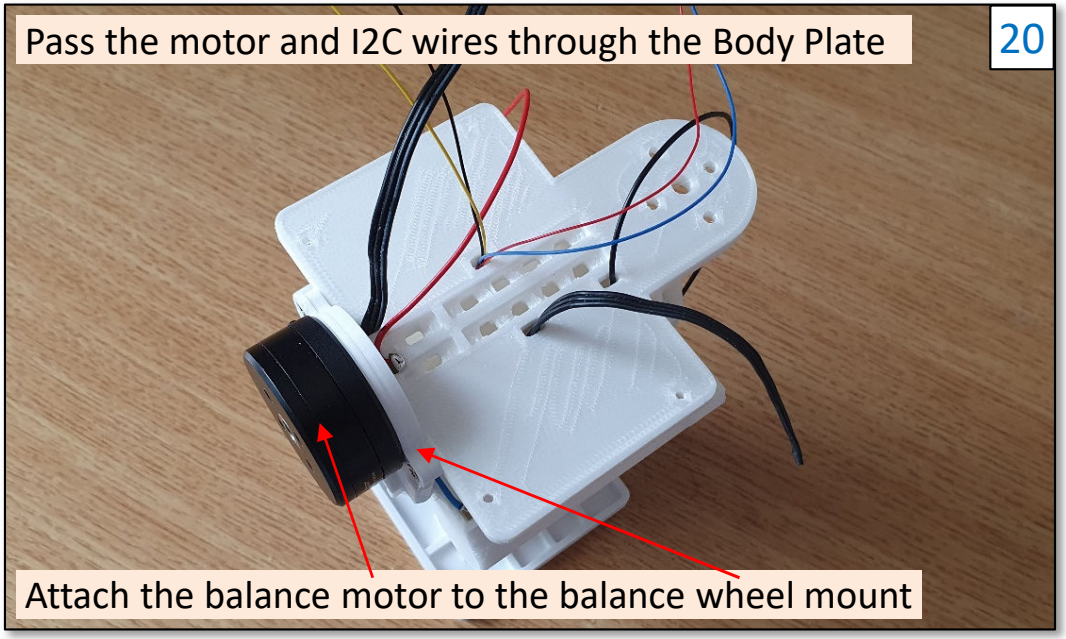


Use clamps when gluing the end cover onto the body cover

19 Solder wires onto the battery connectors



Pass the motor and I2C wires through the Body Plate 20



Attach the balance motor to the balance wheel mount

Build Images

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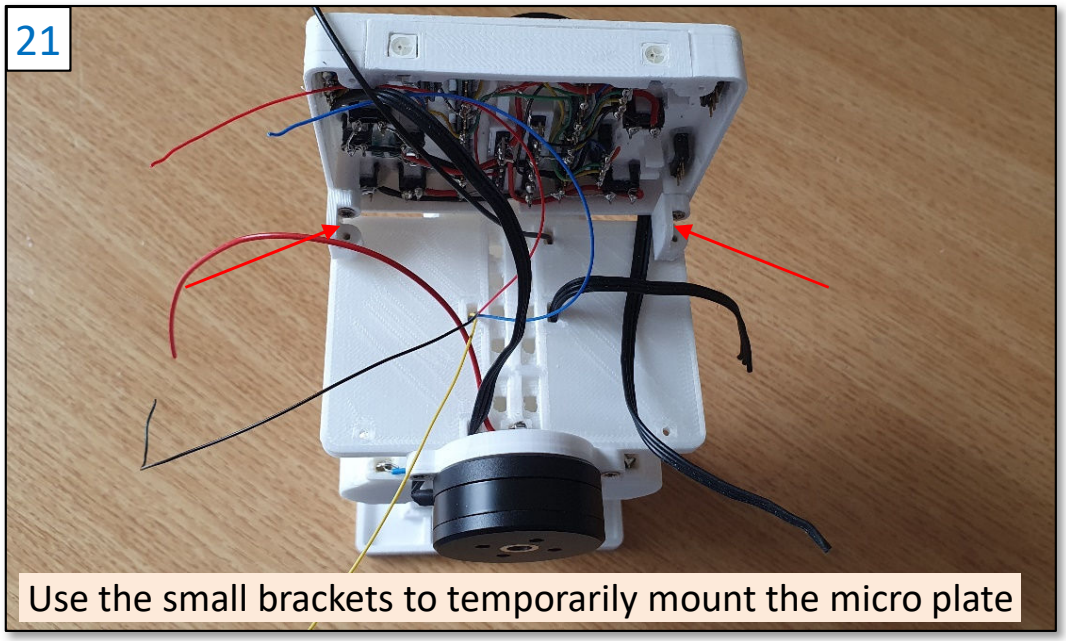
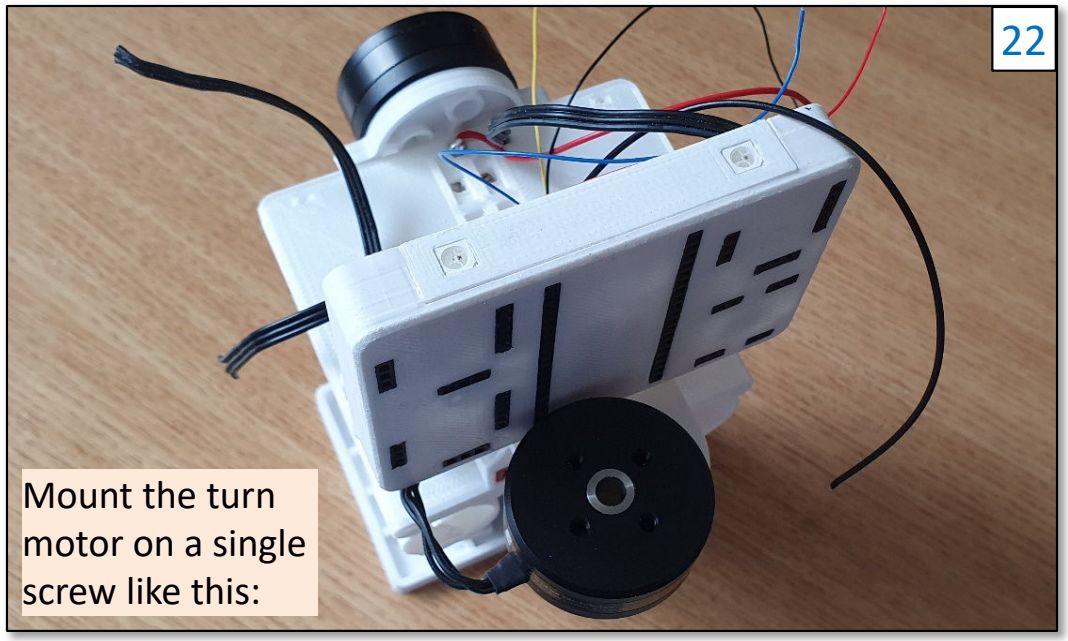


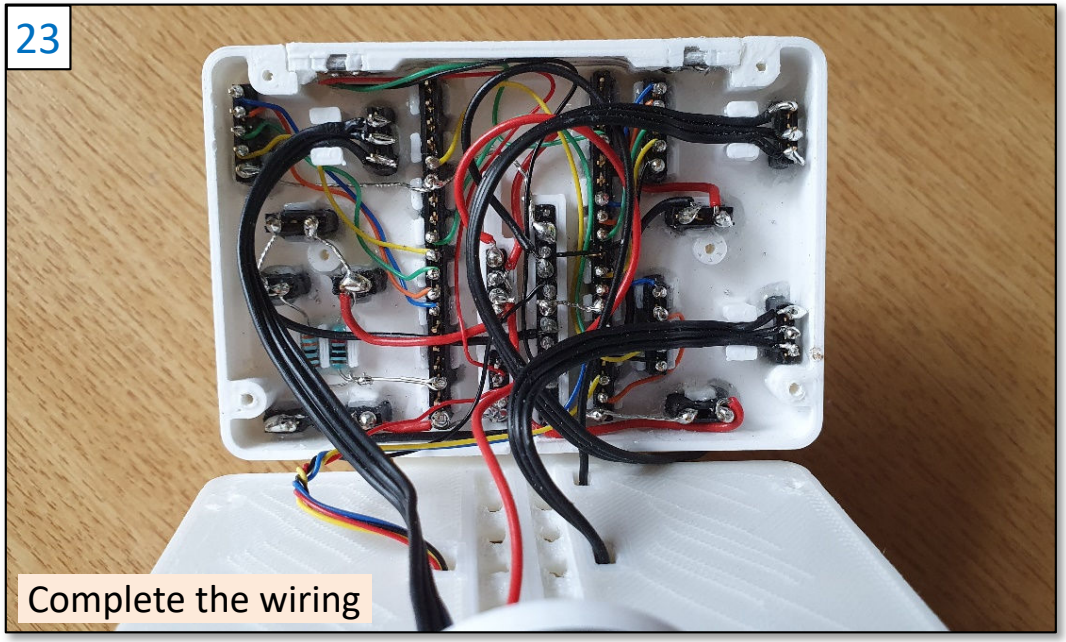
Use the small brackets to temporarily mount the micro plate

22



Mount the turn motor on a single screw like this:

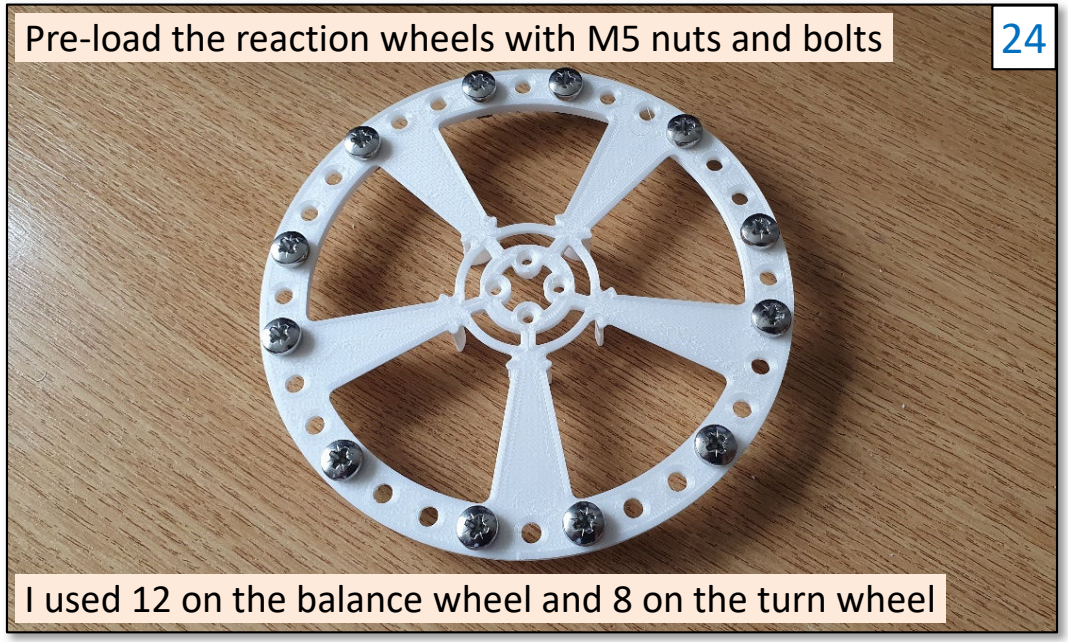
23



Complete the wiring

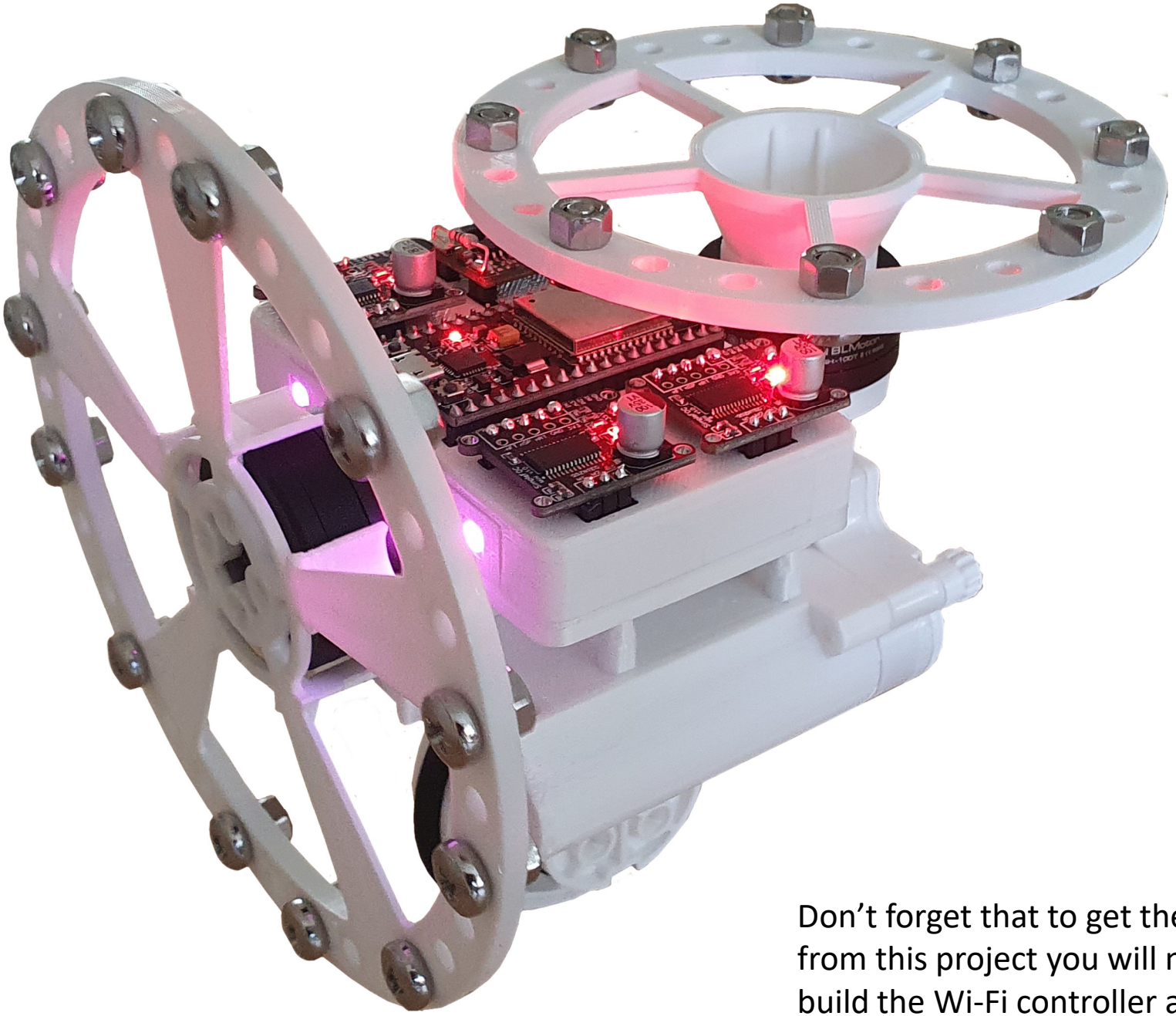
Pre-load the reaction wheels with M5 nuts and bolts

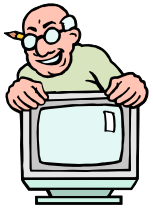
24



I used 12 on the balance wheel and 8 on the turn wheel

Finally…





Don’t forget that to get the most from this project you will need to build the Wi-Fi controller as well.