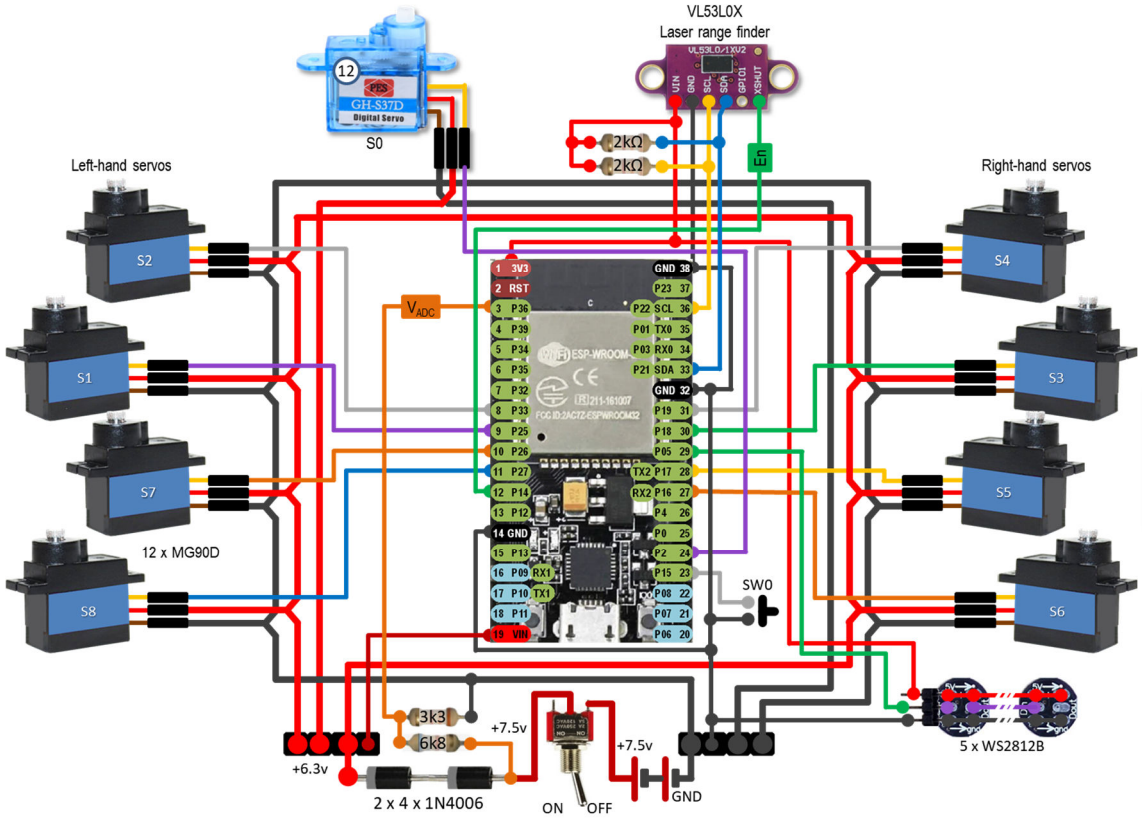
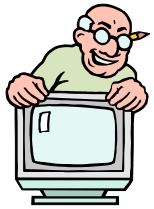
QuadAuto (ESP32)

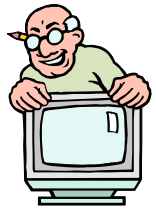
Circuits & Wiring





Good advice: read through the whole of this document before attempting this project.

CAUTION



Lithium batteries can be extremely dangerous, if not handled and cared for properly. This design does not include any form of current limiting circuit, like a fuse. So, care must be taken to ensure that the wiring guidelines are followed accurately, that checks are made for short-circuits, and that battery polarities are marked, and they are inserted the correct way round. Failure to do so, could result in an explosive fire.

Charging Practices: Always remove batteries from your project to charge them. Use a charger, designed for the battery used, and from a trusted supplier. Choose a flat, non-flammable surface to charge on, away from flammable materials. Never leave unattended when charging. Don't charge overnight. Monitor charging to ensure charge characteristics are as expected. Only pair batteries with similar characteristics. Do not overcharge, or leave charging for prolonged periods. This increases the risk of damage and fire.

Battery care & maintenance: Stop using a battery if it is swollen, damaged, dented or leaking. Never charge a damaged battery. Never allow a Lithium battery to discharge below 3.2 volts, as cell damage will occur. Avoid extreme temperatures. Do not charge or store batteries in very hot or cold environments. Don't cover batteries whilst charging, as this can trap heat, causing overheating.

In case of fire: Get out and stay out. If a fire starts, leave immediately, and call the fire brigade. For low voltage Lithium batteries, water is a safe extinguisher.

Built-in Monitoring: Most of my project designs include code, and circuitry, to monitor battery voltage, whilst in use. This code then seeks to alert the operator, when the battery has reached a critical low voltage, before shutting down power consuming circuitry; including the micro. Time should therefore be spent on calibrating this feature, as a precaution, for good battery management and maintenance.

Carefully dispose of batteries that damaged, or discharged below their critical voltage.

Hand Tools:

Recommended:

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

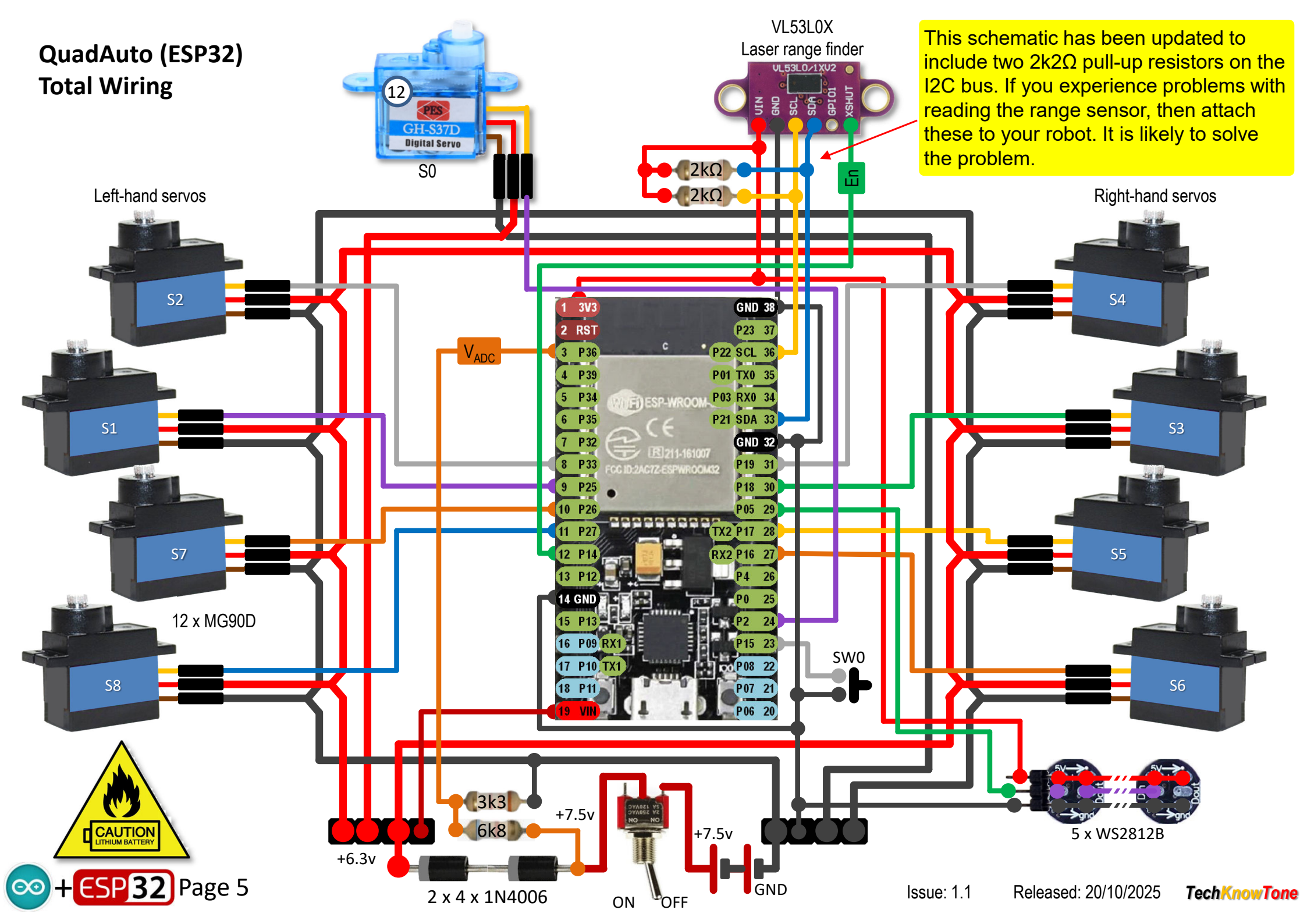
Note: Not all items are shown here.

Tools & Materials:

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

Issue: 1.1 Released: 20/10/2025

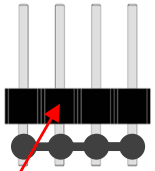
QuadAuto (ESP32)
Total Wiring



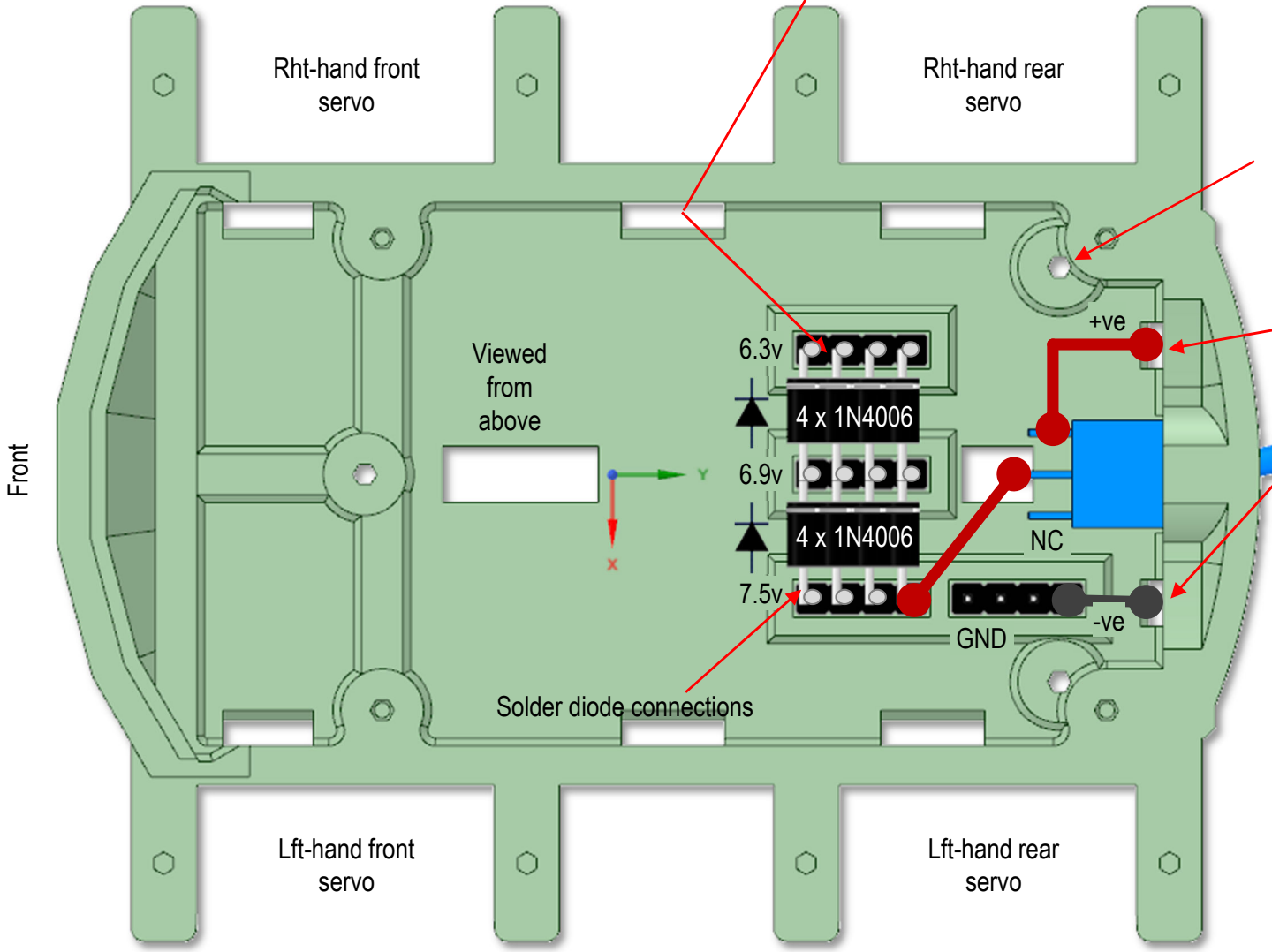
Issue: 1.1 Released: 20/10/2025

Base Plate Wiring

The Base plate connects to the battery case and distributes power connections to both the Middle and Upper plates.



4 x 4-pin strips
Pins wired together,
then glued into Base plate
as common connection point

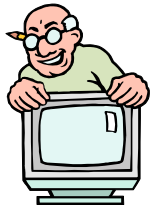


The battery box base is fitted with spring contacts (glued into position) then attached to the Base plate using three 2x10mm screws.

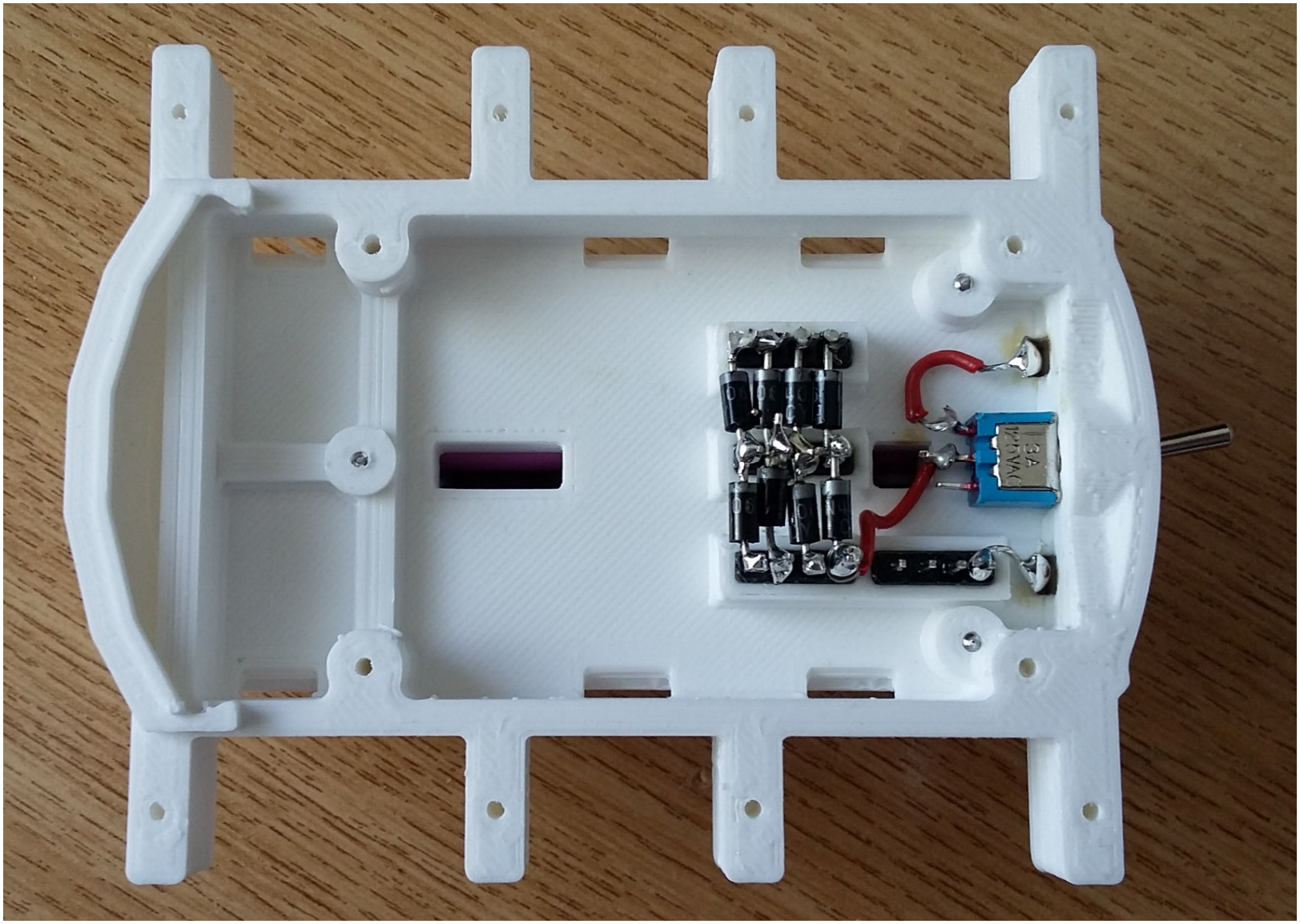
The two connection points protrude through the Base plate and are connected as shown.

The power connections to the Middle and Upper plates are made there first, then later fed down to the Base plate to complete the circuits.

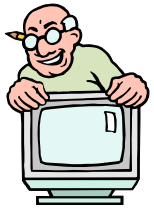
Base Plate Wiring



Your Base plate connections should look something like this.

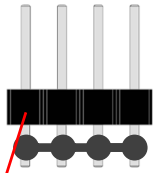


Upper Plate Initial Wiring

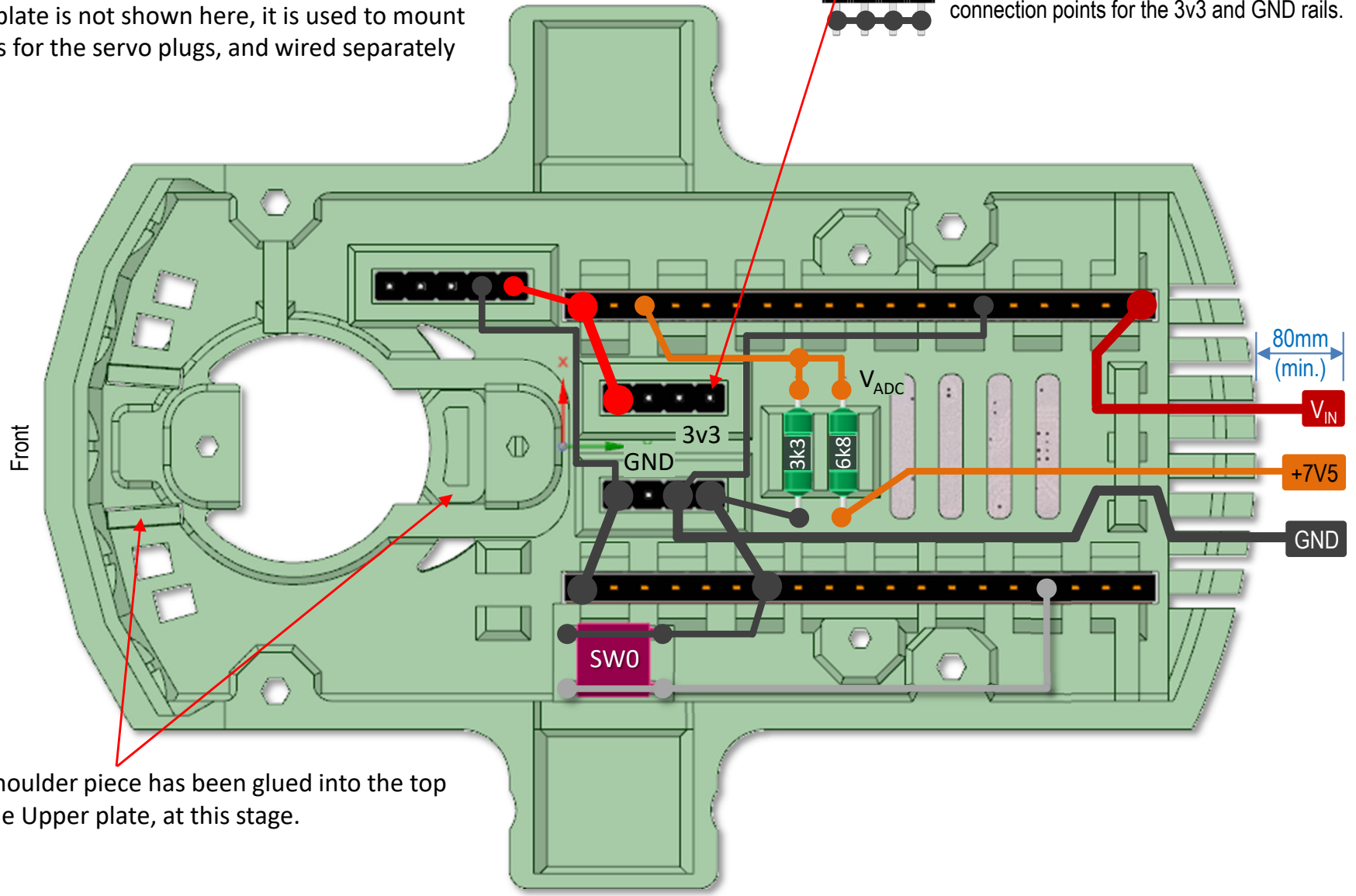


Start by making the power connections to the micro, the battery monitoring resistors network, and button switch SW0. Solder these connections.

The Middle plate is not shown here, it is used to mount the pin strips for the servo plugs, and wired separately initially.



2 x 4-pin strips. The pins are wired together, then glued into Base plate as common connection points for the 3v3 and GND rails.

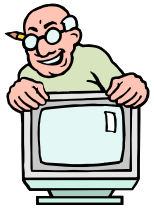


These three wires need to be long enough to reach contact points in the base plate, when assembled. 80mm minimum.

Note neck shoulder piece has been glued into the top surface of the Upper plate, at this stage.

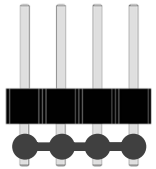
Upper Plate Wiring I2C

We now move on to wiring in the I2C connections for the laser range finder.



This diagram has been updated to include two 2k2Ω pull-up resistors on the I2C bus. If you experience problems with reading the range sensor, then attach these to your robot. It is likely to solve the problem.

The 5-pin I2C pin strip acts as terminal posts for the individual signal paths.

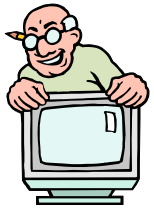


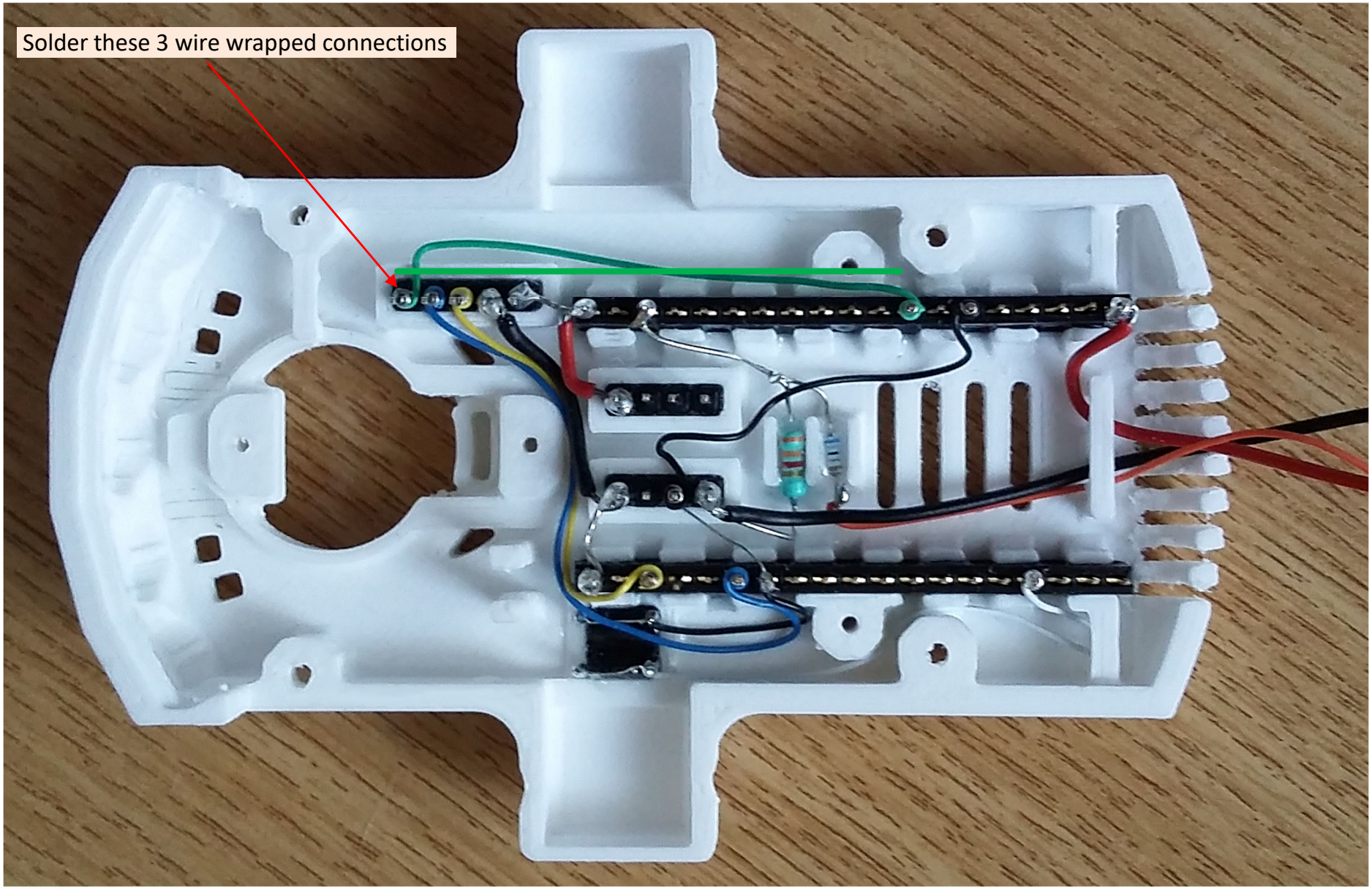
2 x 4-pin strips. The pins are wired together, then glued into Base plate as common connection points for the 3v3 and GND rails.

These three wires need to be long enough to reach contact points in the base plate when assembled. 80mm minimum.

Upper Plate Wiring I2C

Your initial Upper plate connections should look something like this.





WS2812B RGB strip Wiring

The five WS2812B LEDs are difficult to wire up in position, within the front of the Upper Plate. So to make the task much easier we use a small jig, which holds the LEDs in the correct orientation for wiring. Once wire we can then simply transfer the assembly to the upper plate, test it and them glue the LEDs into position.

Start by placing the LEDs in the jig, in the correct orientation. We will be attaching wires from the left to the right, by soldering them onto the WS2812B pads. Holding the jig in a small vice can help.

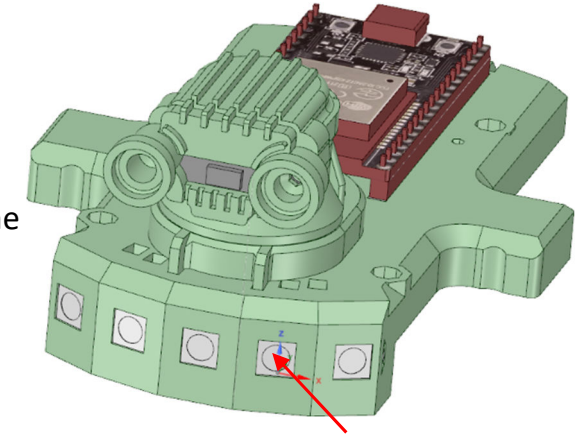
The wires will be of different length, with the green wire being much longer, due to its data loops and the micro connection.

Then solder in the red wire along the 5v pads. The stripped wire needs to exceed the length of the jig, and the insulated portion needs to be able to reach the 5v common pin strip. Crop excess, once soldered onto pads.

Then solder in the green data wire, raising the wire into a small loop between each data pad on the LED chip, so that this can be cropped off afterwards to break the connection as shown. Inspect the soldered joints before cropping.

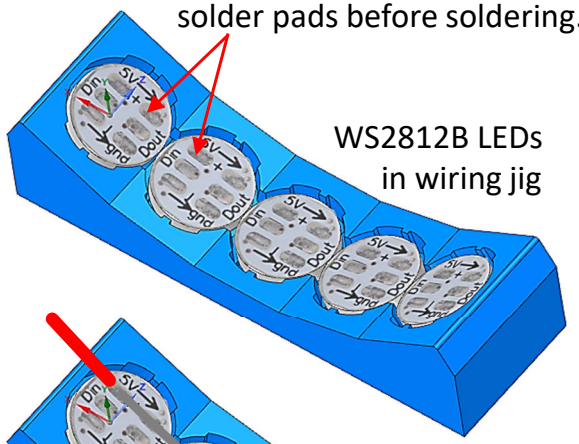
The solder in the black GND wire, connecting all of the GND pads together. Crop excess once soldered.

Transfer the wired components to the robots upper plate, and wire wrap the three connections. With a micro inserted and programmed you can test the LED strip before finally gluing in the LEDs. See photos later for more information.

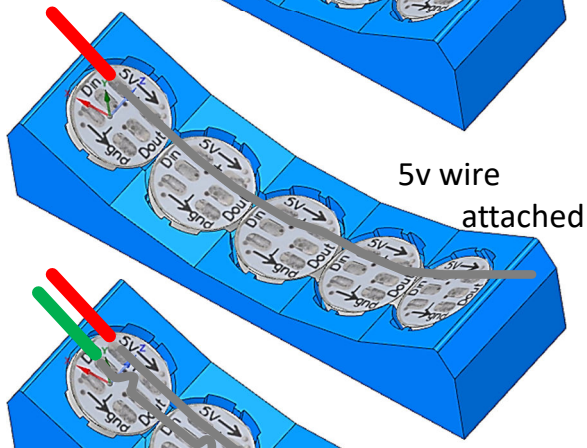


WS2812B LEDs in robot facia.
Check apertures for clearance.

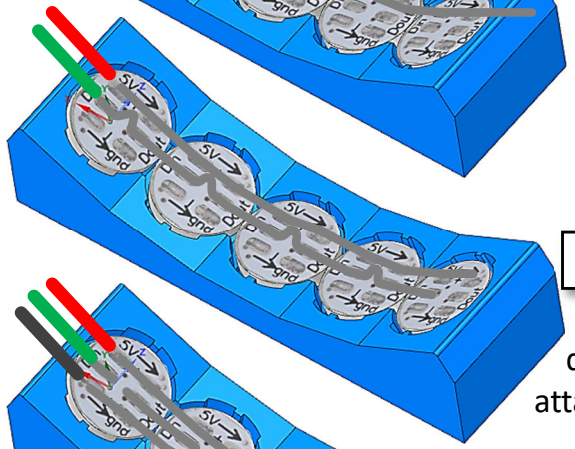
Apply a light smear of flux to the solder pads before soldering.



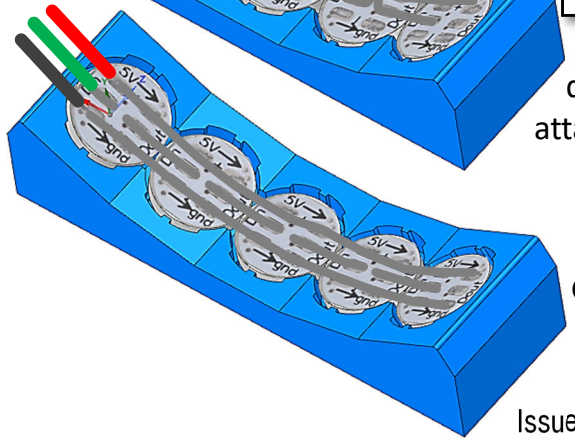
WS2812B LEDs in wiring jig



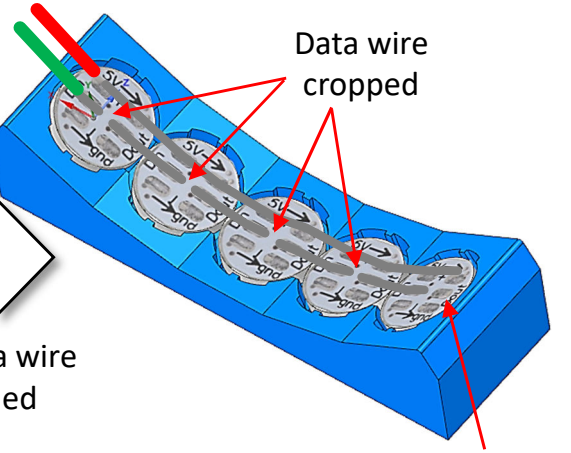
5v wire attached



data wire attached

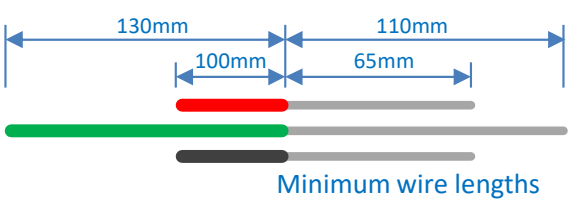


GND wire attached



Data wire cropped

Final pad is not connected



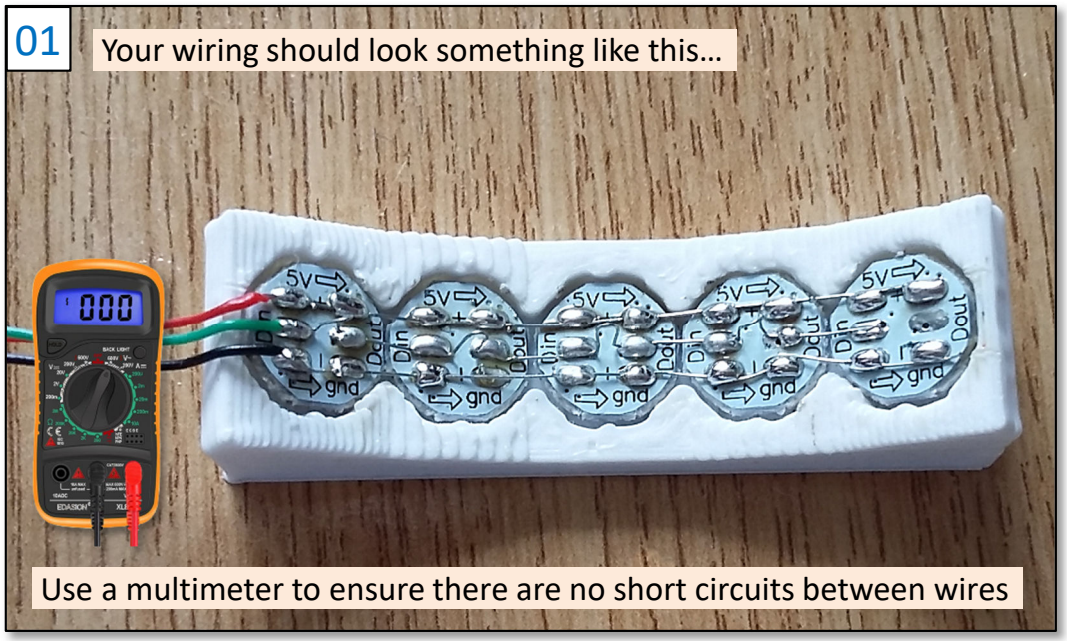
Minimum wire lengths

Issue: 1.1 Released: 20/10/2025 TechKnowTone

WS2812B RGB strip Wiring

01

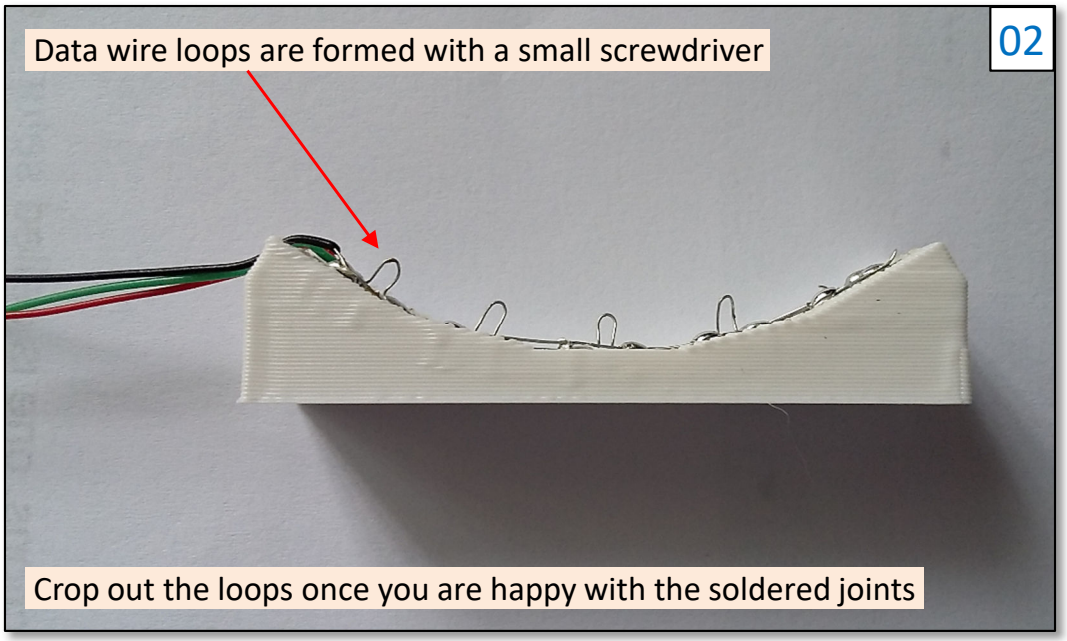
Your wiring should look something like this…



Use a multimeter to ensure there are no short circuits between wires

02

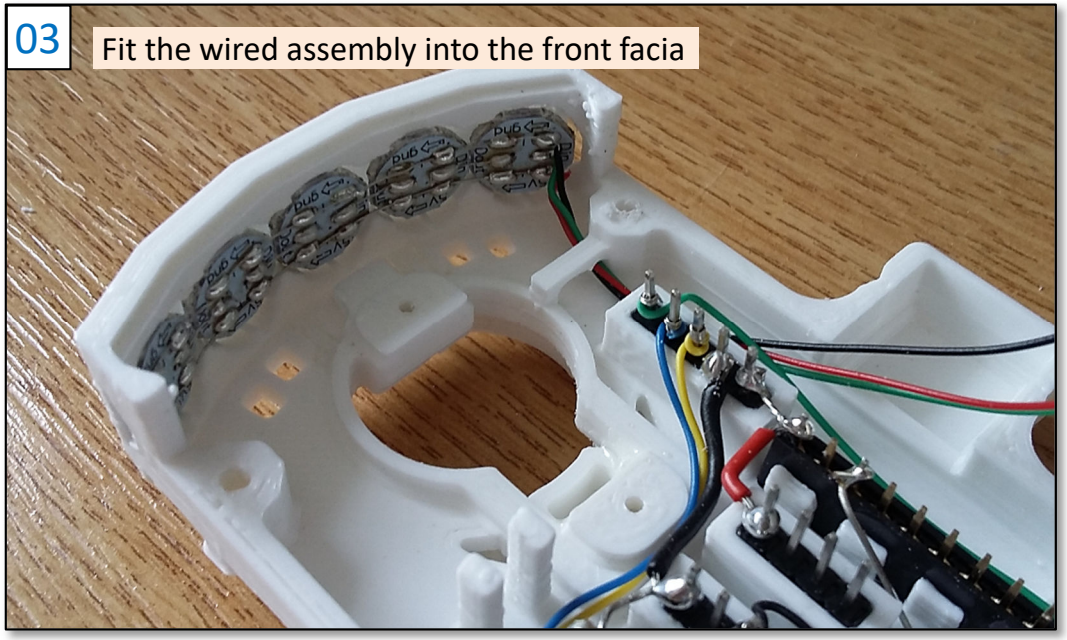
Data wire loops are formed with a small screwdriver



Crop out the loops once you are happy with the soldered joints

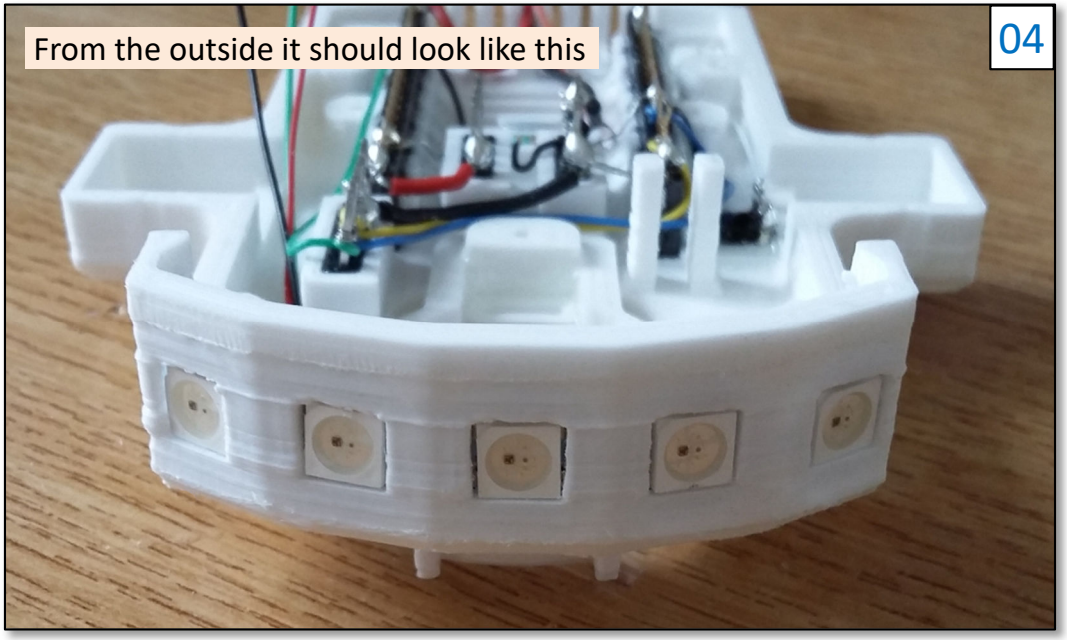
03

Fit the wired assembly into the front facia

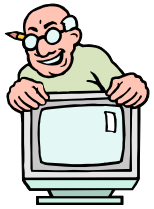


04

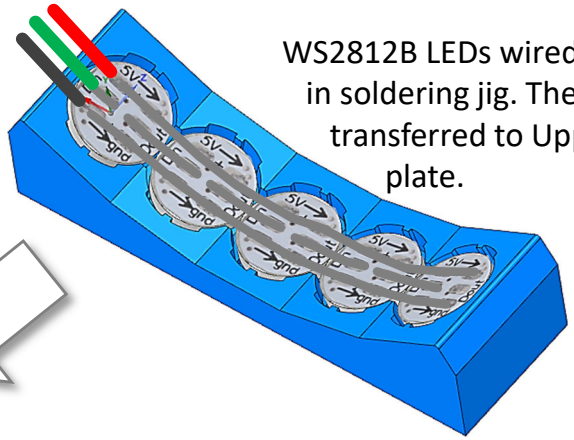
From the outside it should look like this



Upper Plate WS2812B Wiring

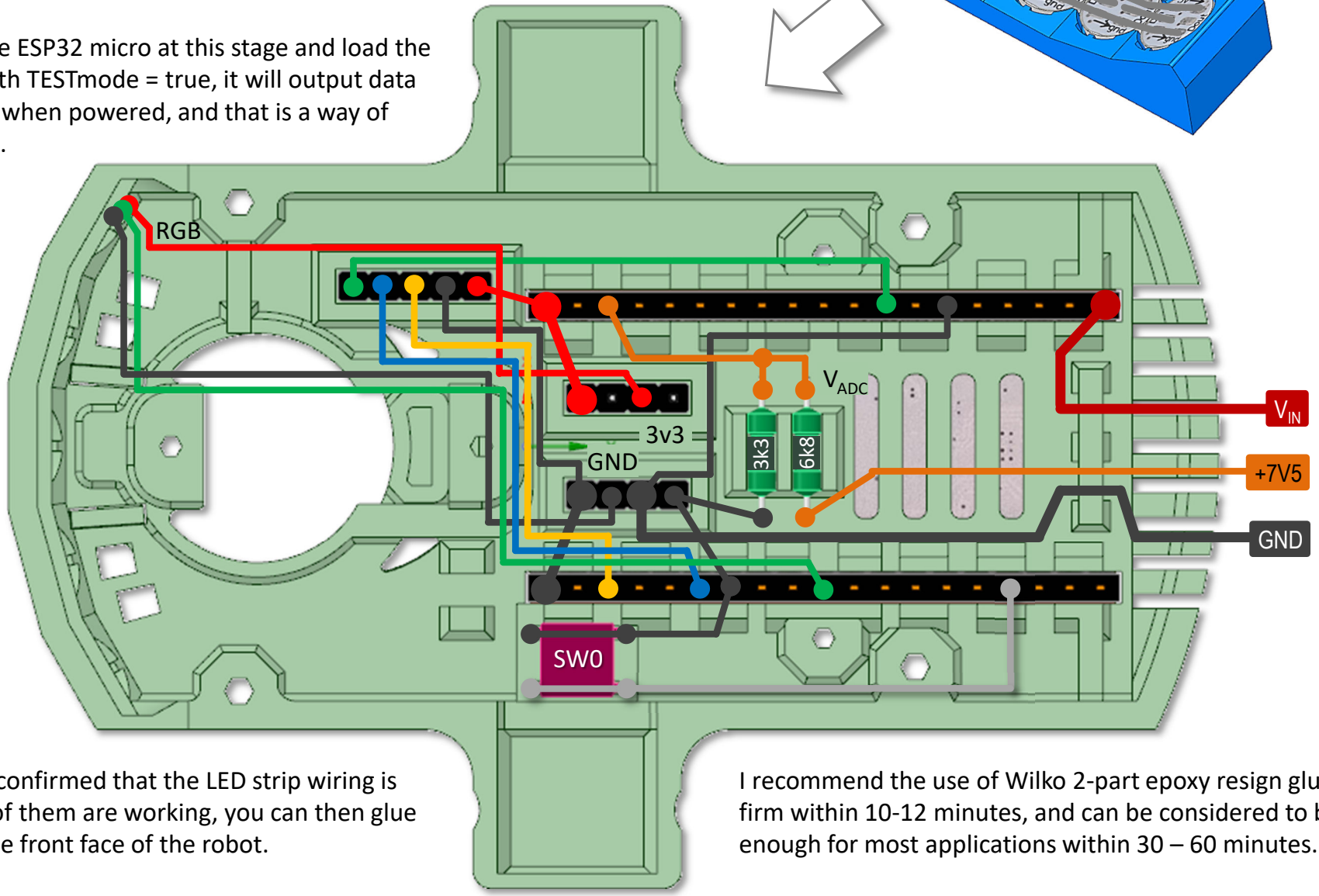


Now we carefully transfer the wired WS2812B LEDs from the soldering jig, into the front face of the Upper plate. From that position we run and terminate the three wire connections.



WS2812B LEDs wired in soldering jig. Then transferred to Upper plate.

If you plug in the ESP32 micro at this stage and load the code onto it, with TESTmode = true, it will output data to the LED strip when powered, and that is a way of testing the strip.

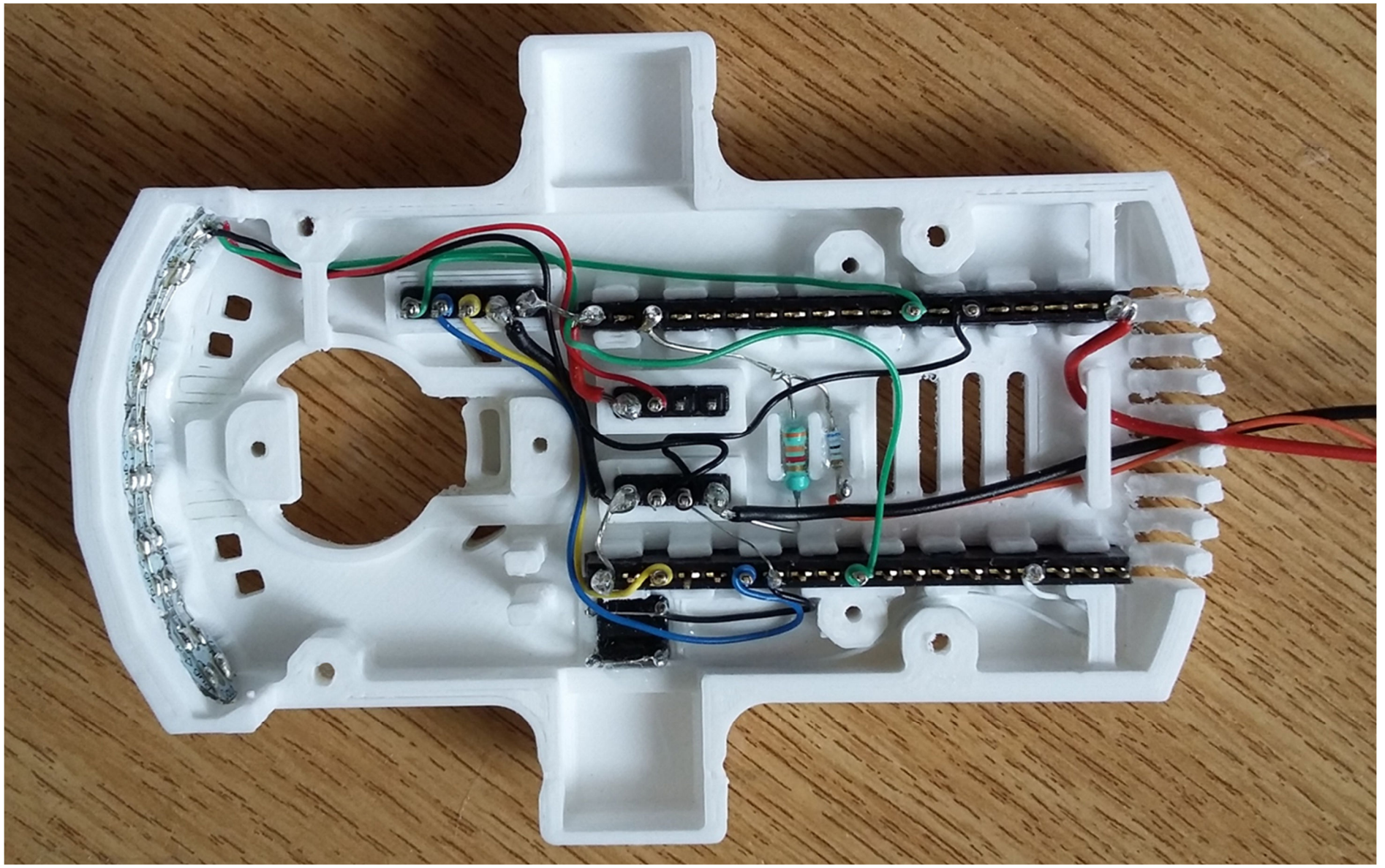


Once you have confirmed that the LED strip wiring is correct and all of them are working, you can then glue the LEDs into the front face of the robot.

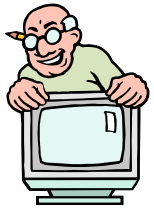
I recommend the use of Wilko 2-part epoxy resign glue, as it sets firm within 10-12 minutes, and can be considered to be hard enough for most applications within 30 – 60 minutes..

Upper Plate WS2812B Wiring

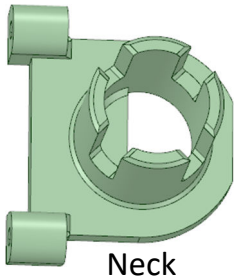
Your Upper plate connections should now look like this.

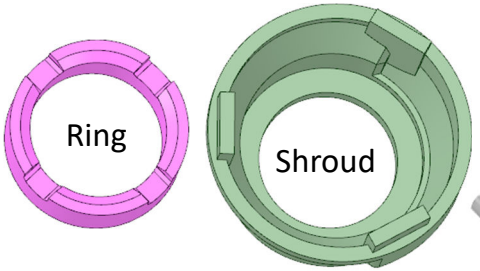


Head assembly



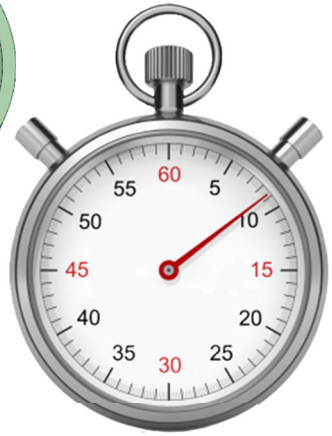
The neck is held into the shroud piece by a retaining ring, which is glued onto the neck tube.



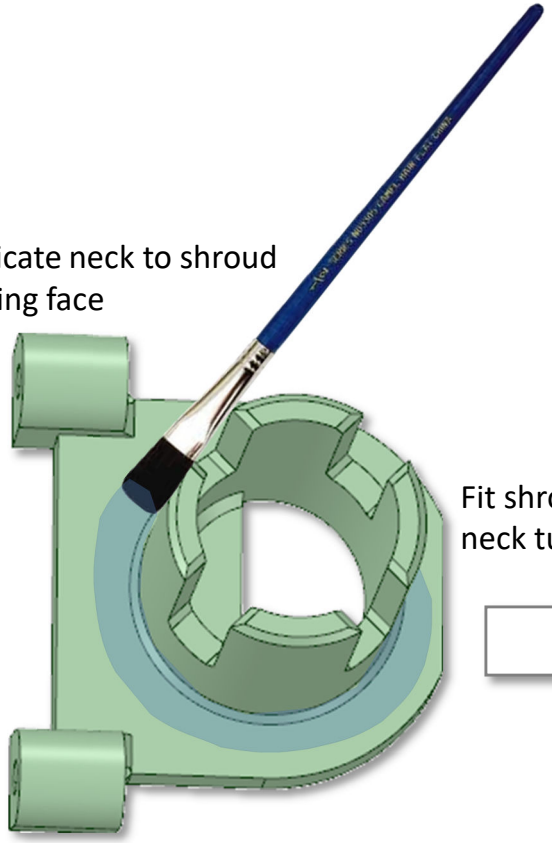


Prior to gluing the components we apply a small amount of lubricant the load bearing surfaces, to reduce friction and wear. I used Vaseline for this.

Care must be taken to lubricate sliding faces only, whilst not compromising the glued faces. The glue dabs acts to retain the ring on the neck tube; we are not trying to glue the ring fully.

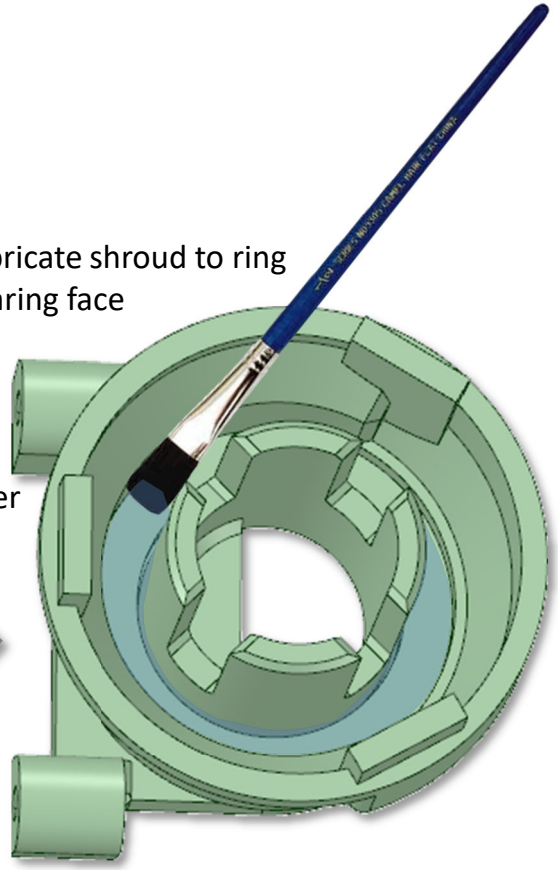


Lubricate neck to shroud bearing face



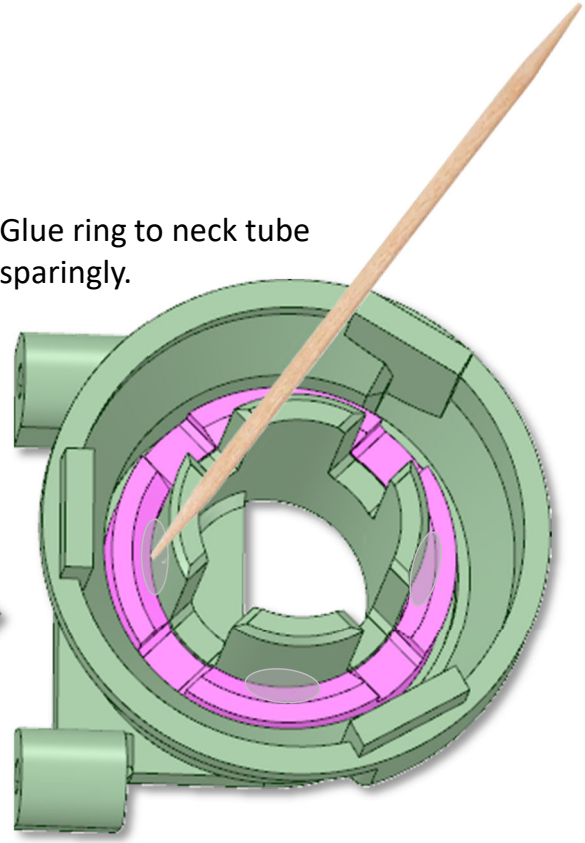
Fit shroud over neck tube

Lubricate shroud to ring bearing face



Fit ring over neck tube

Glue ring to neck tube sparingly.

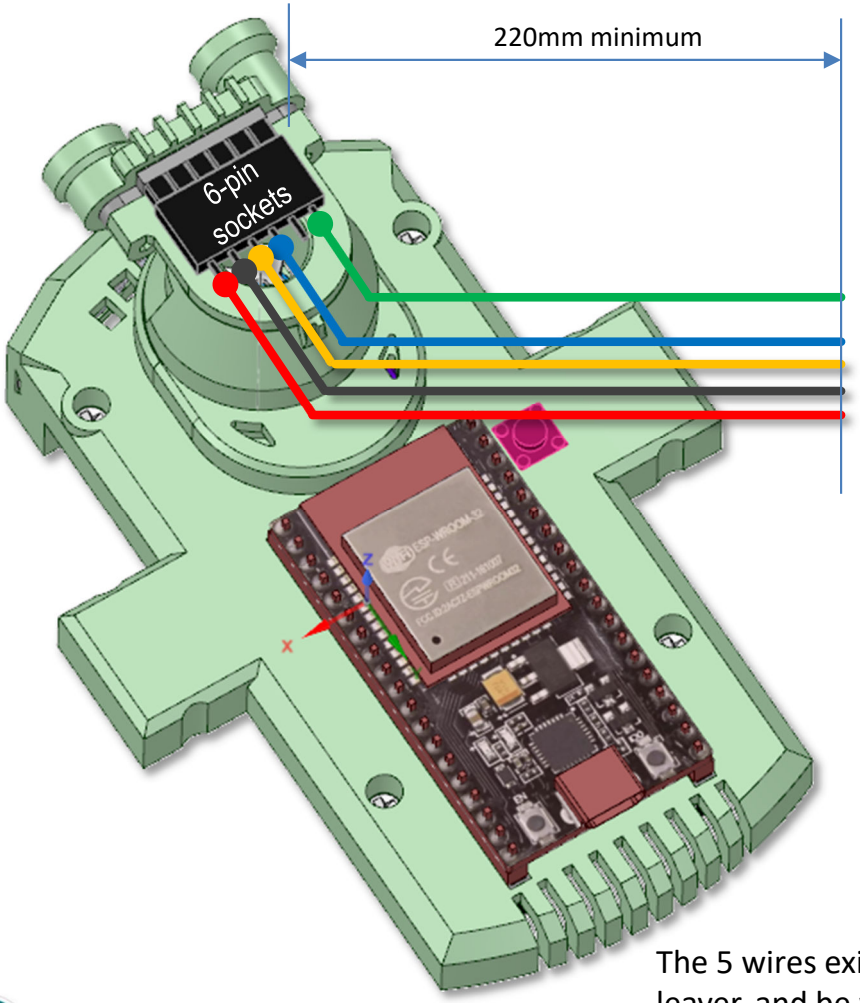


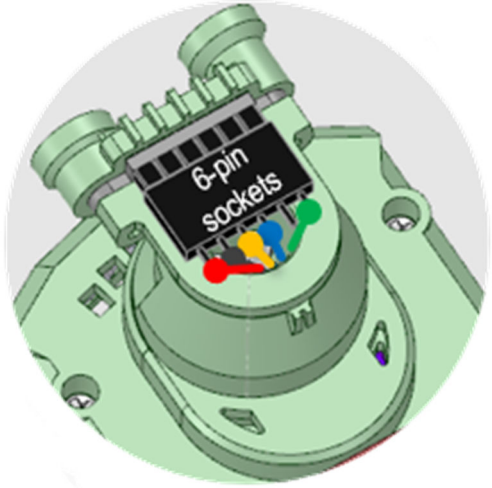
Allow the glue to go firm, then carefully rotate the neck within the shroud, to ensure that it is not glued also. Leaving the tooth pick on the mixing card gives a good indication as to when the glue stiffens. Normally 10-12 minutes depending on room temperature.

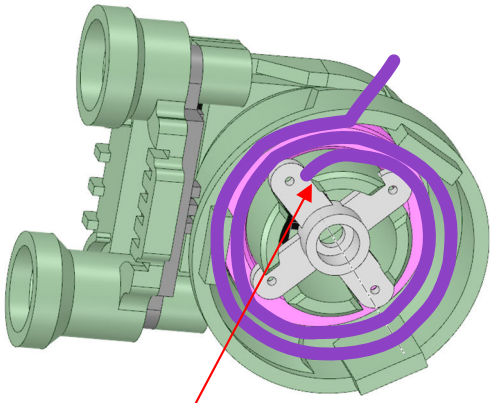
Head VL53L0X LTOF Wiring

Using the Head Eyelets piece and 2 screws, attach the sensor onto the neck. Then glue the Head Shroud into the neck on the Upper plate.

Once the glue has set, connect 5 wires to a 6-pin socket strip, as shown; allowing for a minimum length of 200 mm. Solder the connections, then plug this onto the VL53L1X device whilst feeding the wires down through the neck aperture. The wire length aims to ensure you have sufficient.

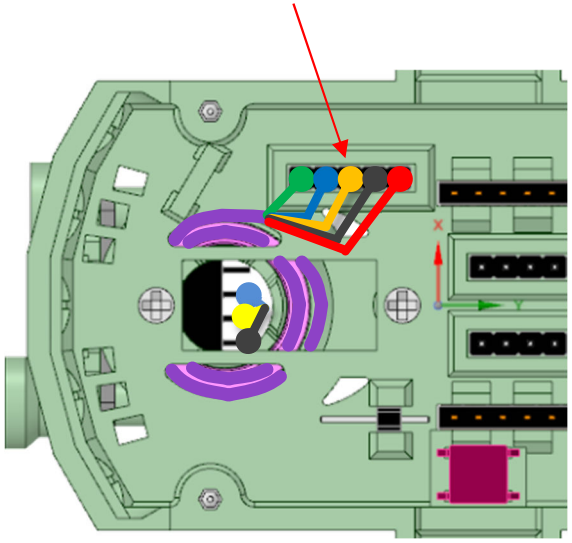


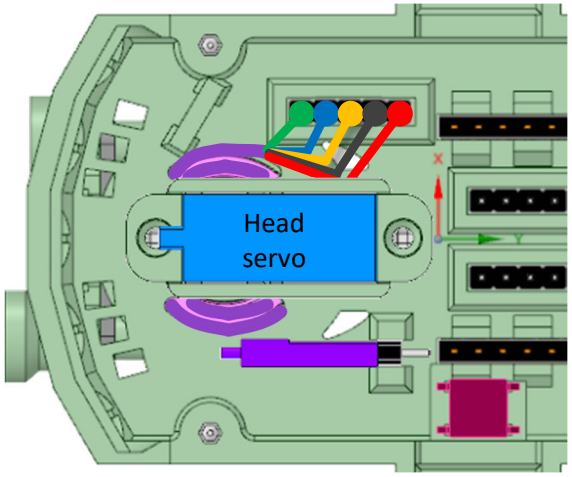




The 5 wires exit the neck here, above the servos drive leaver, and be wrapped twice clockwise around the neck, before exiting through the upper plate aperture.

With the 5 wires wrapped round the neck and exiting the Upper plate as shown, insert the servo with the cross leaver attached, and screw it into position. Then terminate the 5 wire wrap wires as shown. Only solder once tested.





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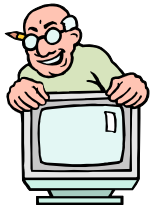
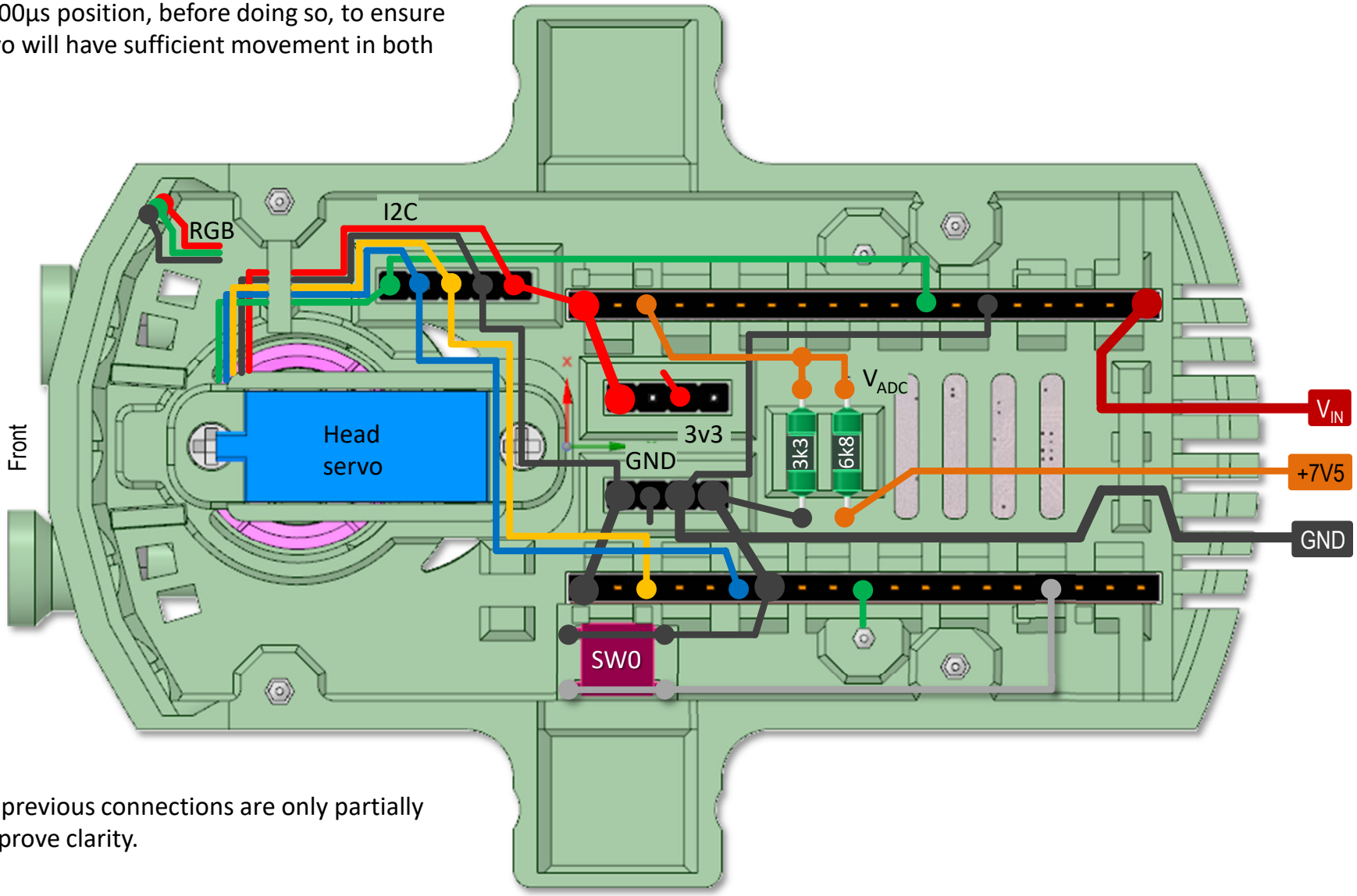
Head VL53L0X LTOF Wiring



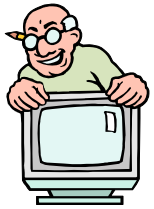
The 5 wires from the VL53L0X sensor are terminated on the 5-pin strip as shown.

Carefully fit the head servo, with its cross leaver arm set in the 1500µs position, before doing so, to ensure that the servo will have sufficient movement in both directions.



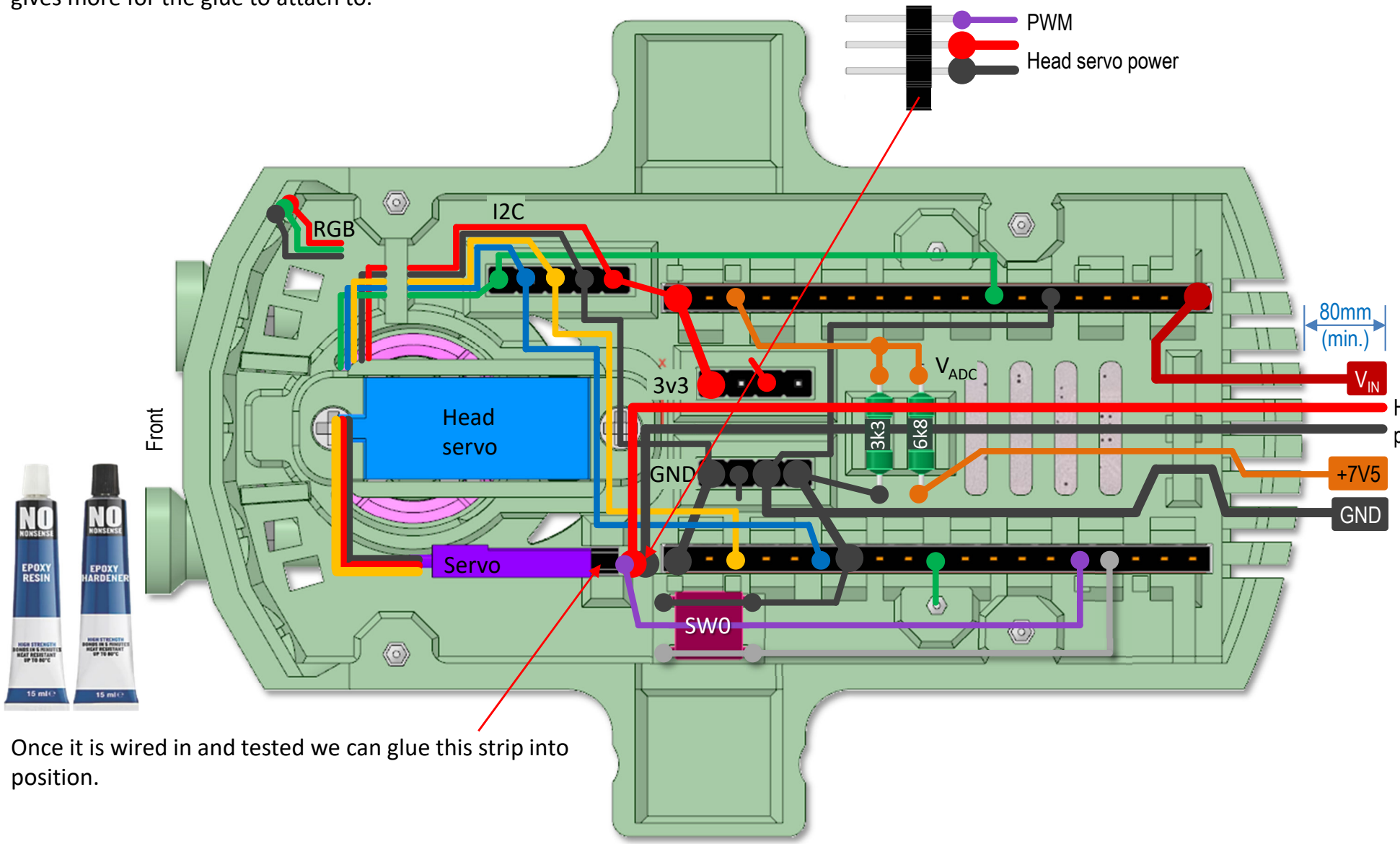
Some of the previous connections are only partially shown to improve clarity.

Head servo Wiring



We now attach wires to a 3-pin strip (actually 4-pin), to connect to the servo plug. The unused pin position helps to raise the pin strip off the Upper plate, and gives more for the glue to attach to.

A 4-pin strip, with one end pin removed, is pre-wired as shown, before gluing it into the Upper plate. The head servo plugs onto these pins.

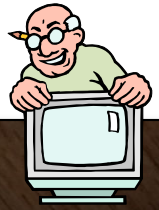


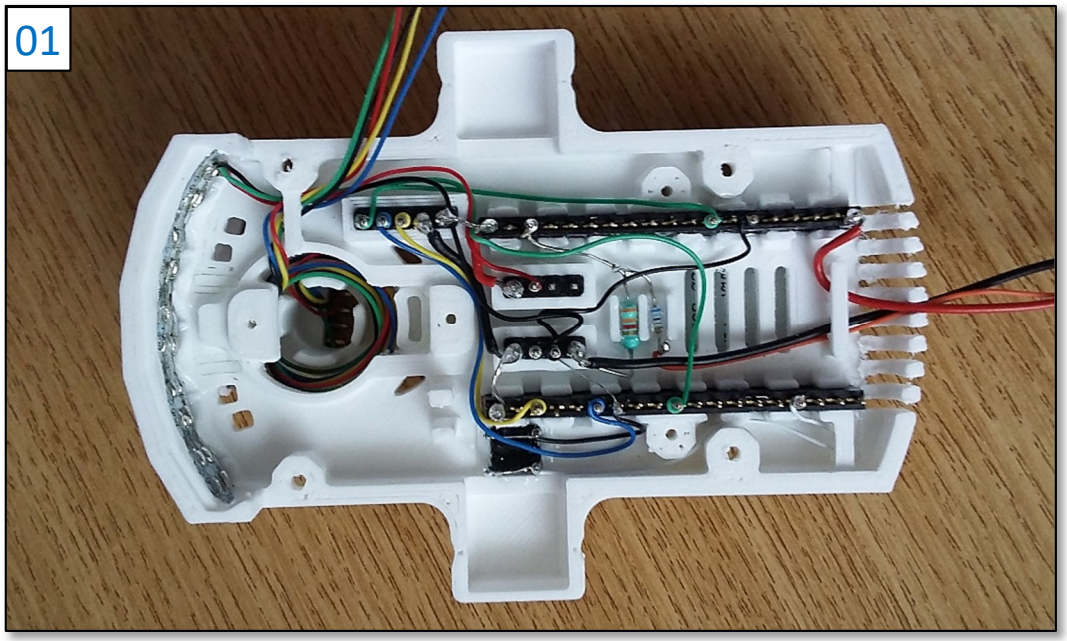
These five wires need to be long enough to reach contact points in the base plate when assembled. 80mm minimum.

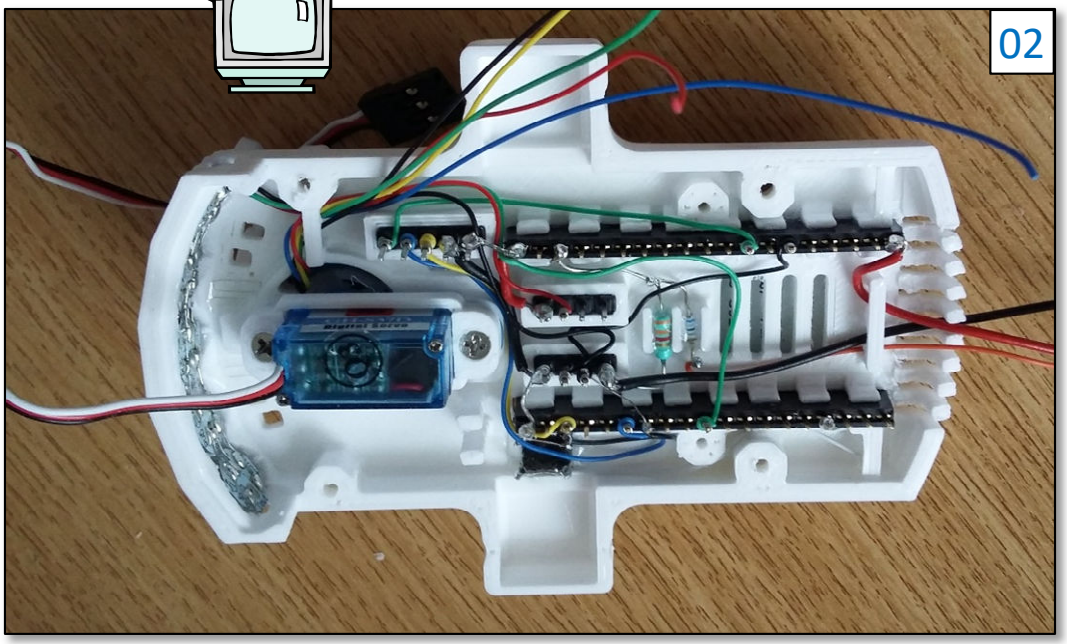
Once it is wired in and tested we can glue this strip into position.

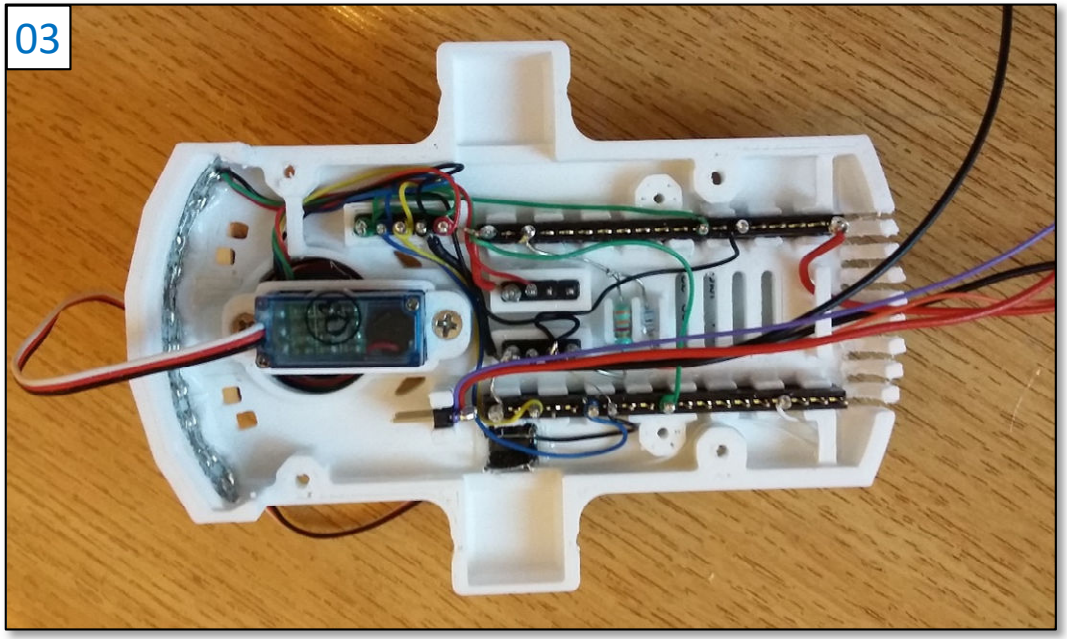
Upper Plate Servo Wiring

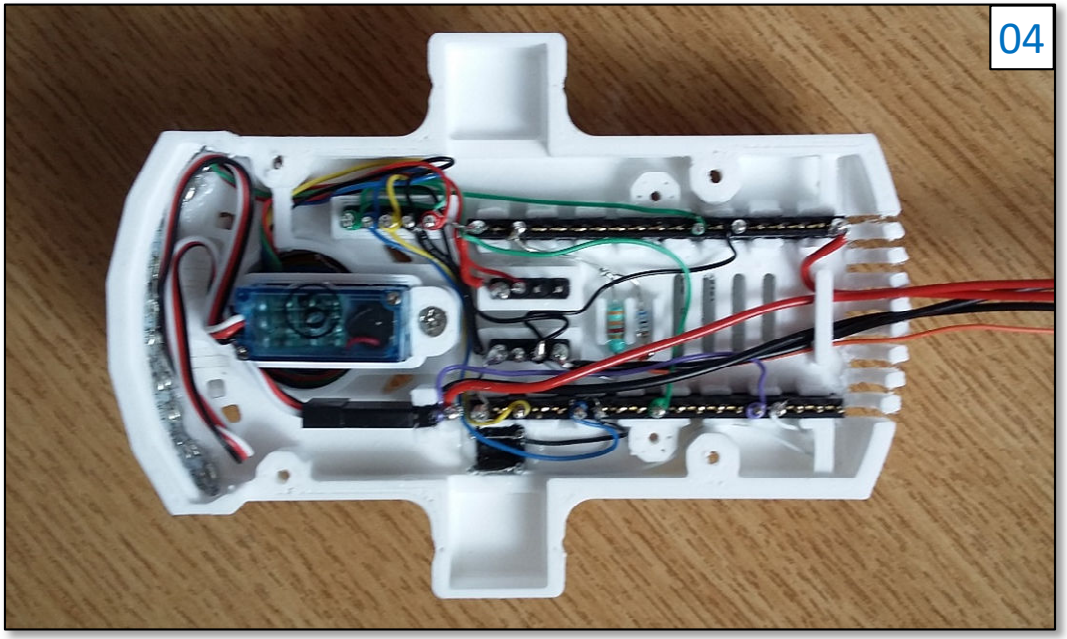
Your Upper plate connections should look like this.



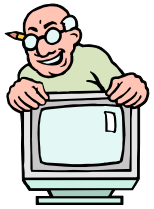






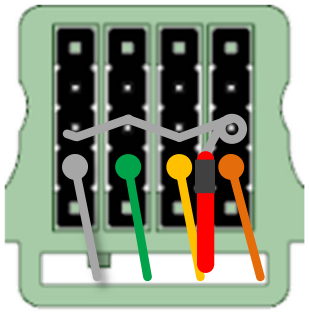


Middle Plate Wiring

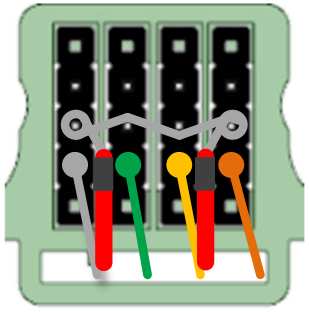


The servo Vcc and GND wire loops work like a ring main, acting to improve current distribution in the servo power wiring.

Having soldered the wire wrapped connections, connect the power leads. Shrink sleaving is used to prevent the wire from melting back.



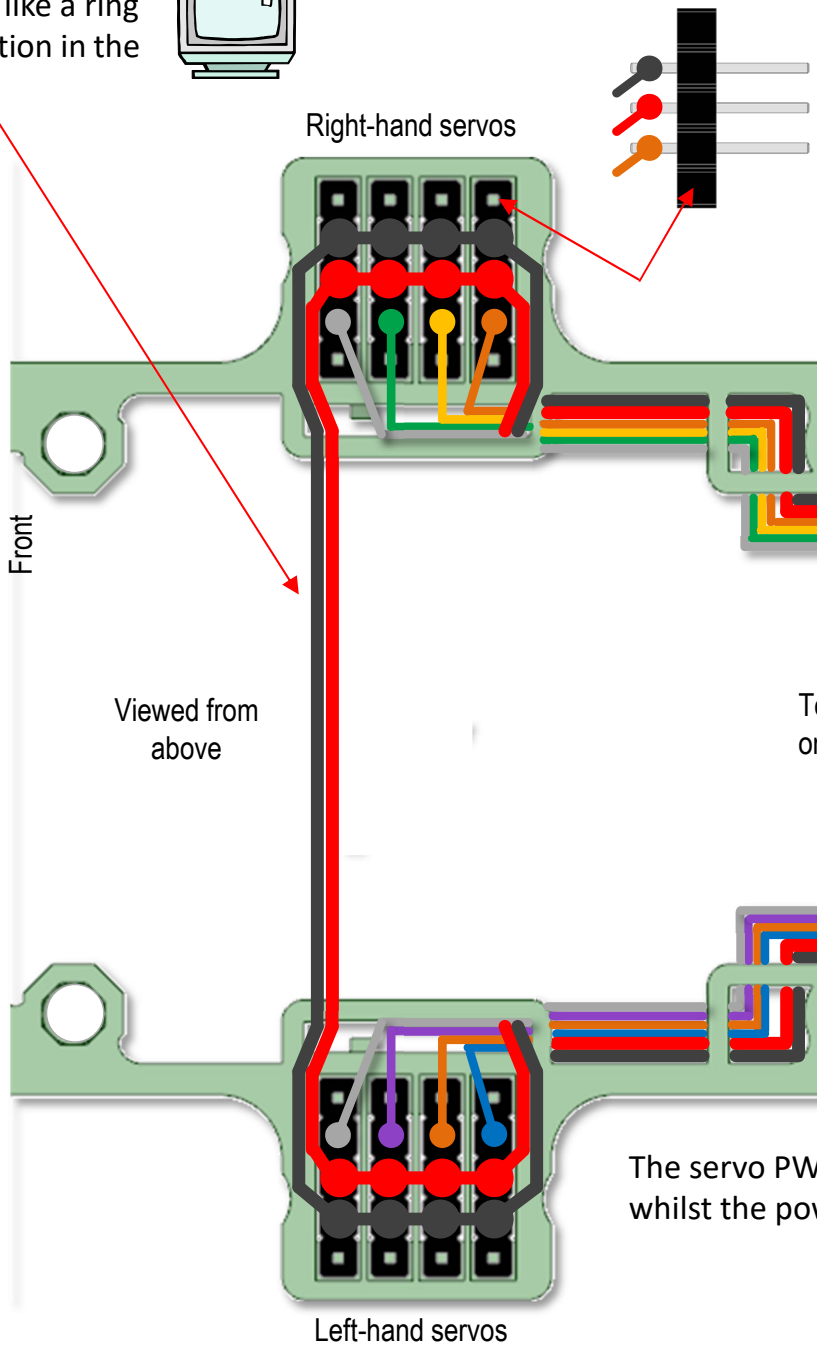
Use the first wire to link all 4 pins, then make the second connection at the other end. Take care soldering, and check for shorts at each stage.



Repeat this process for the GND wire to complete the task.

Servo 5-pin strips have their end pins removed, making them 3-pin, with the modified end pieces being used as glued supports. Ensure that the glue has set before wiring.

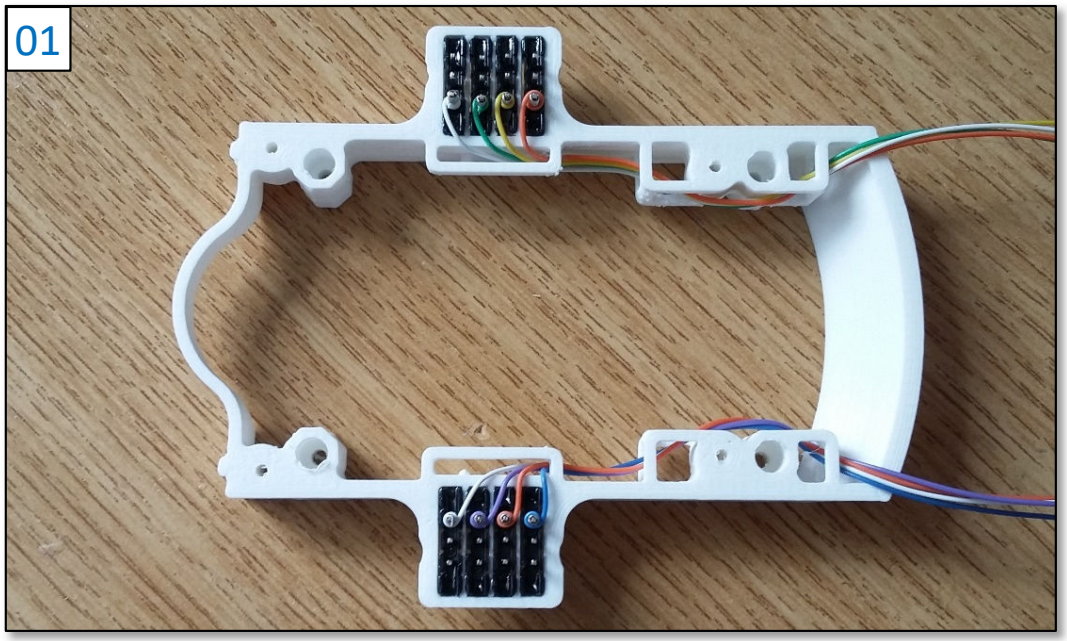
Start by wire wrapping the PWM pins, ensuring that there is sufficient length to reach the ESP32 pins on the upper plate. Solder those connections, then solder in the power wires. Use wire lengths of at least 220mm.

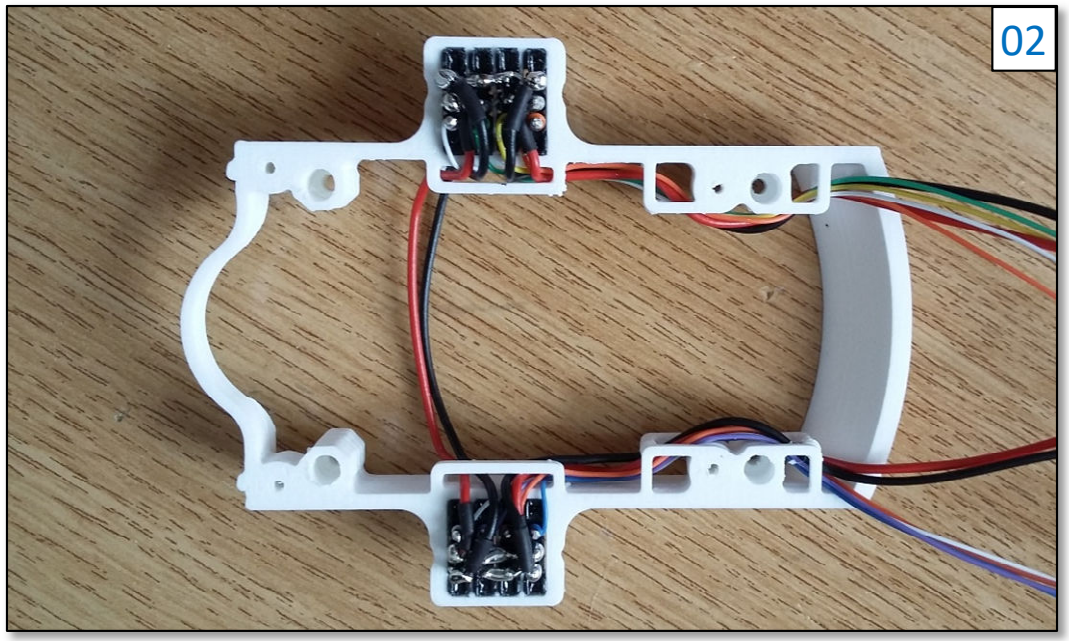


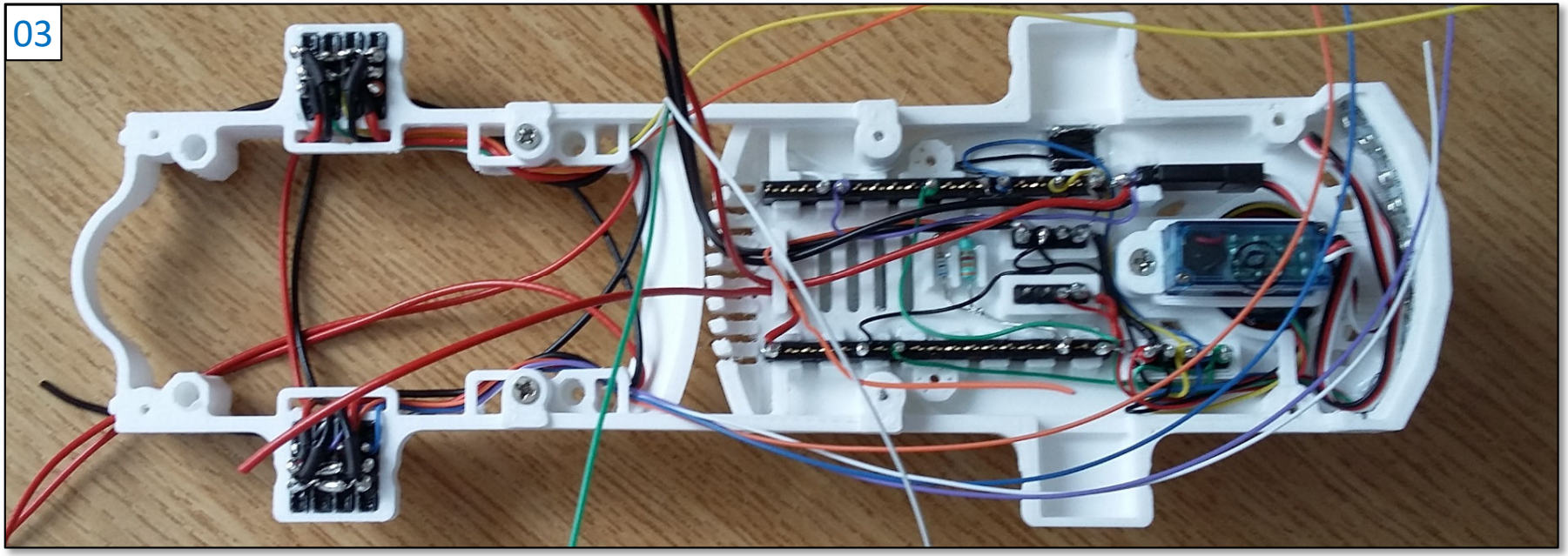
The servo PWM signals are wired to the ESP32 on the upper plate, whilst the power connections go to points on the base plate.

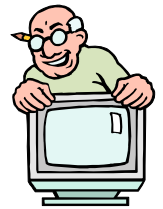
Issue: 1.1 Released: 20/10/2025 TechKnowTone

Wiring Sequence









You can now use the custom support bars to connect the Middle plate to the Upper plate. This will make the wiring of the servo connections much simple to do.

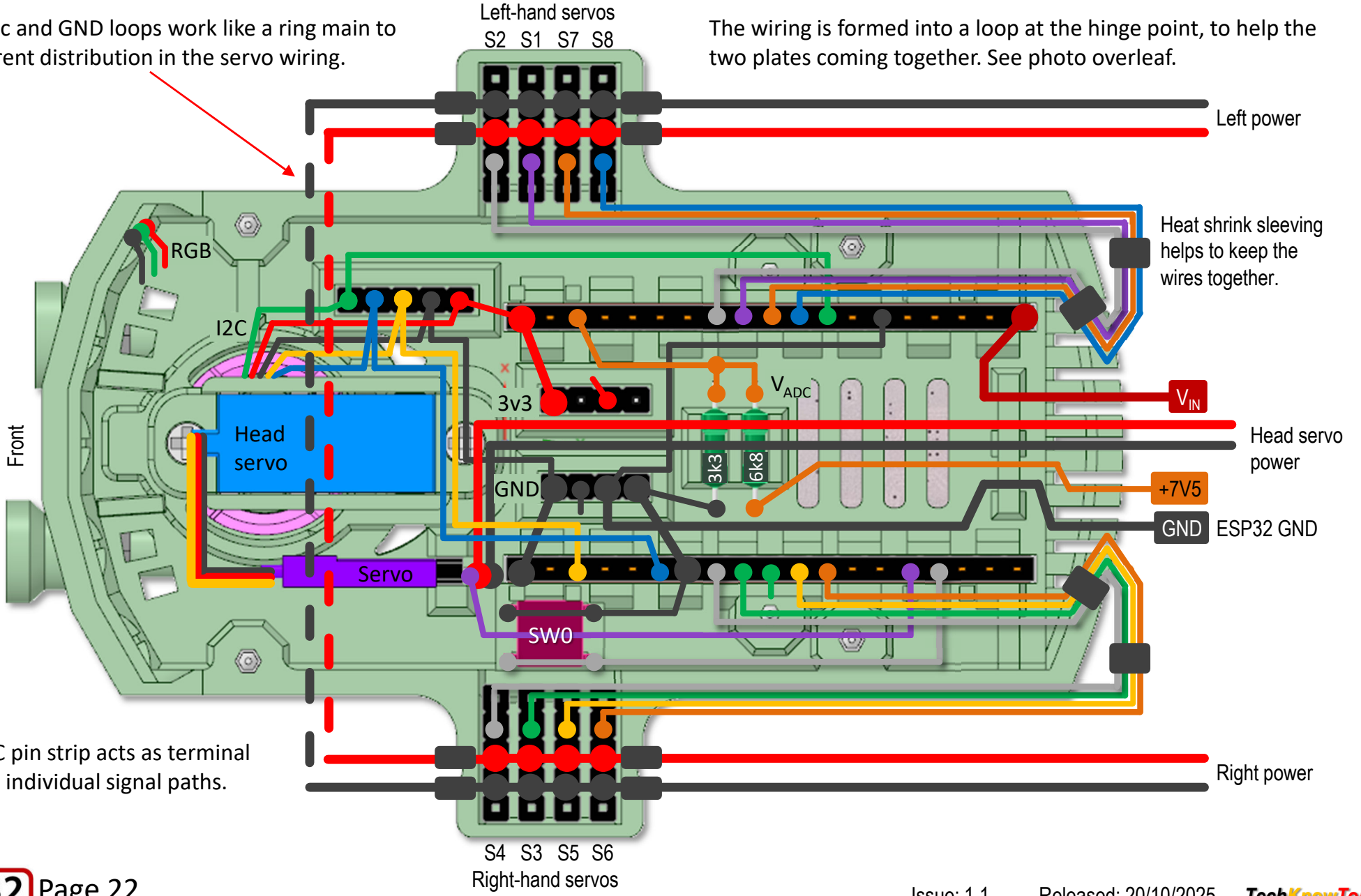
Upper/Middle Plate Wiring

Middle plate is not shown here, but is used to mount the pin strips for the servo plugs, which are shown.

The servo Vcc and GND loops work like a ring main to improve current distribution in the servo wiring.

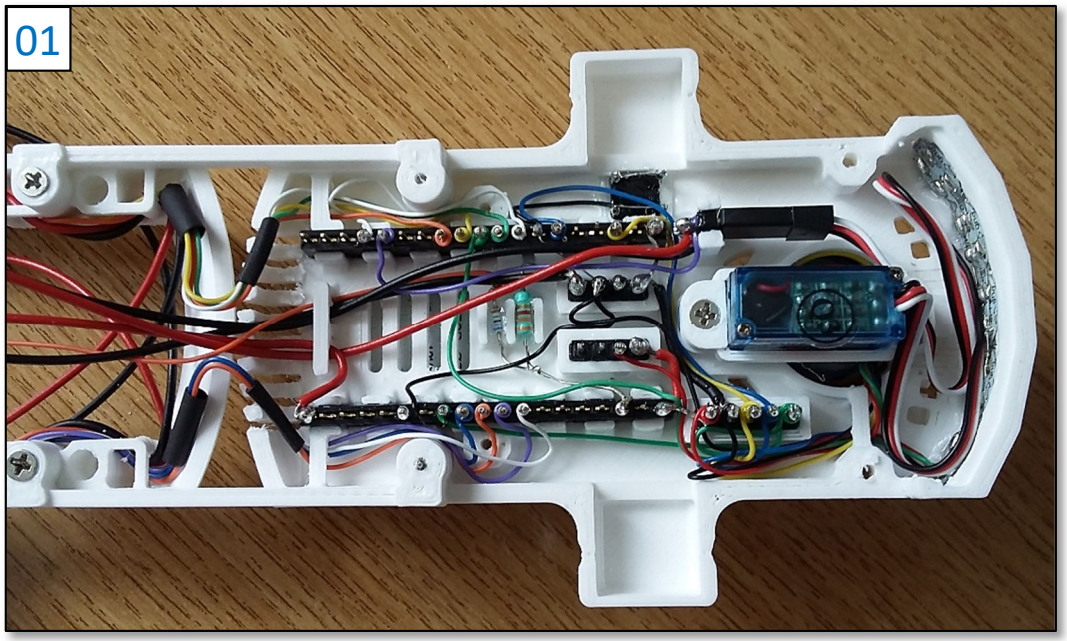
Use the custom brackets, that are designed to tie the Upper plate to the Middle plate whilst wiring.

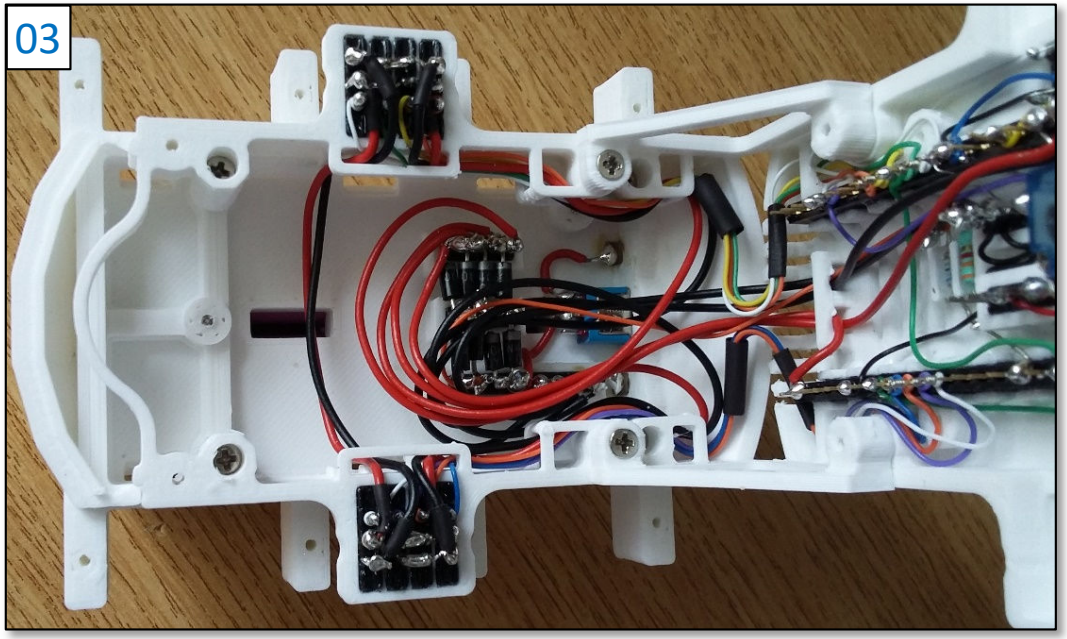
The wiring is formed into a loop at the hinge point, to help the two plates coming together. See photo overleaf.

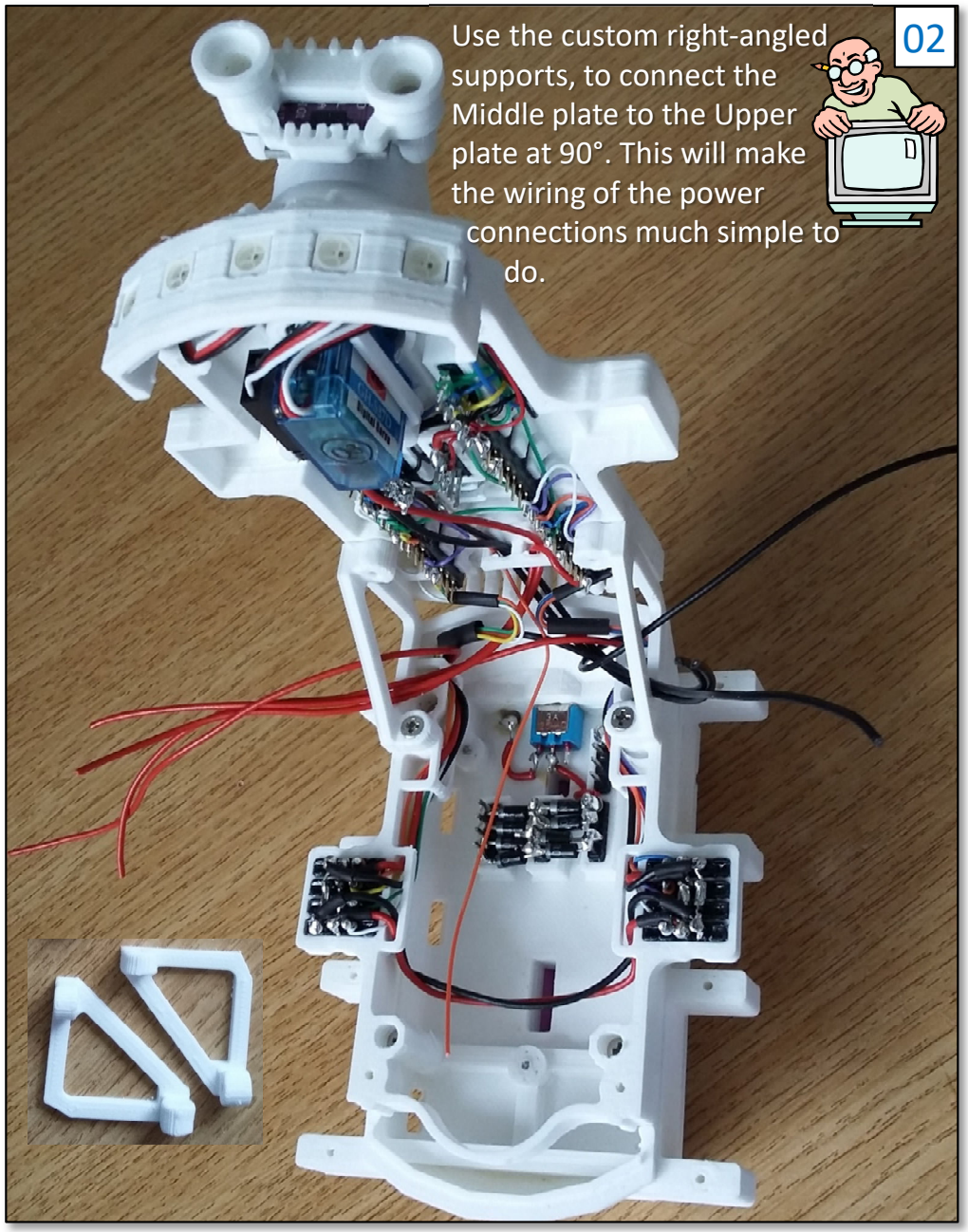


The 5-pin I2C pin strip acts as terminal posts for the individual signal paths.

Wiring Sequence

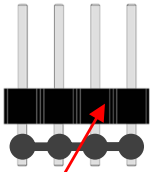






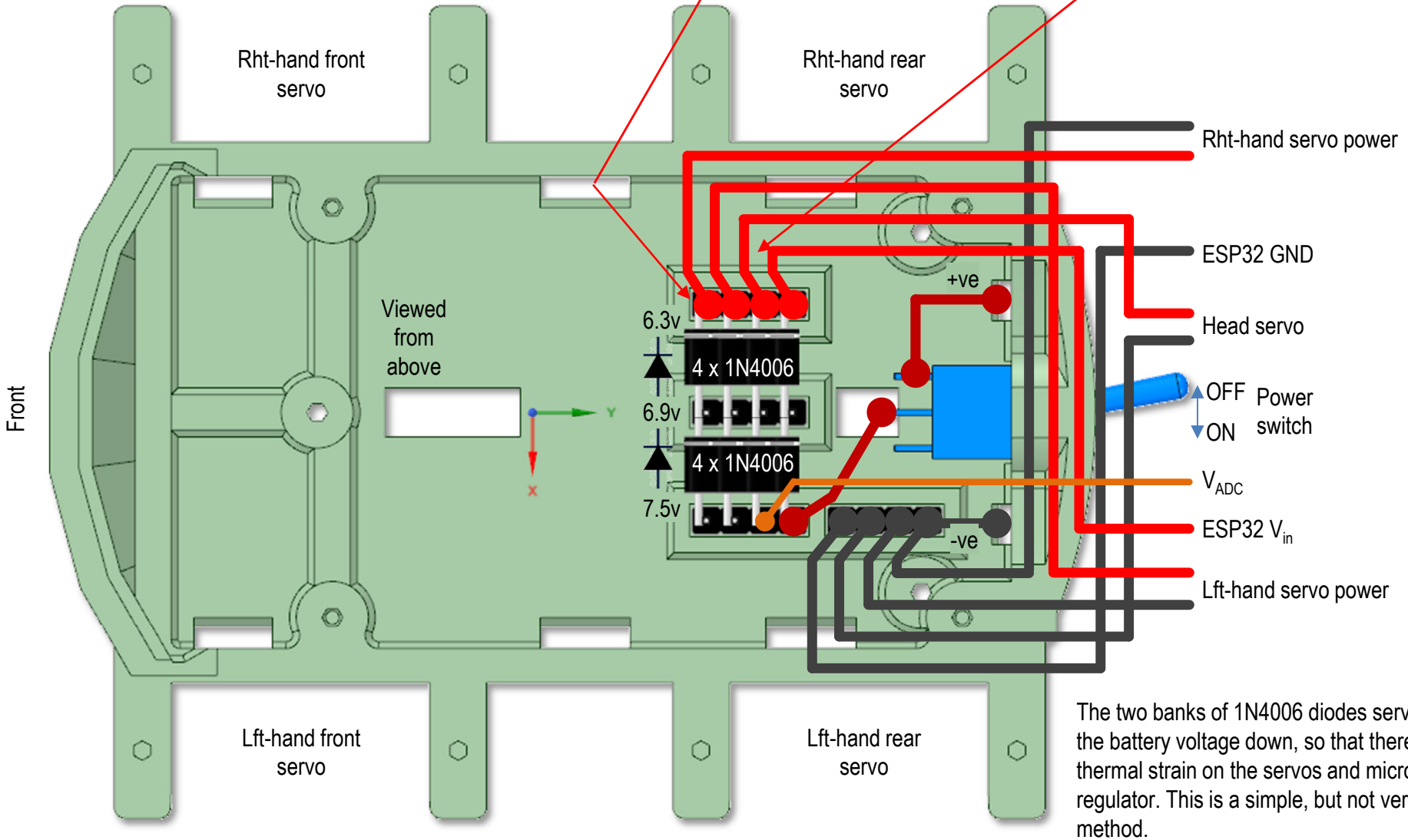
Base Plate Wiring

The Base plate connects to the battery case and distributes power connections to both the Middle (servo) and Upper (micro) plates.



4 x 4-pin strips
Pins wired together, then glued into Base plate

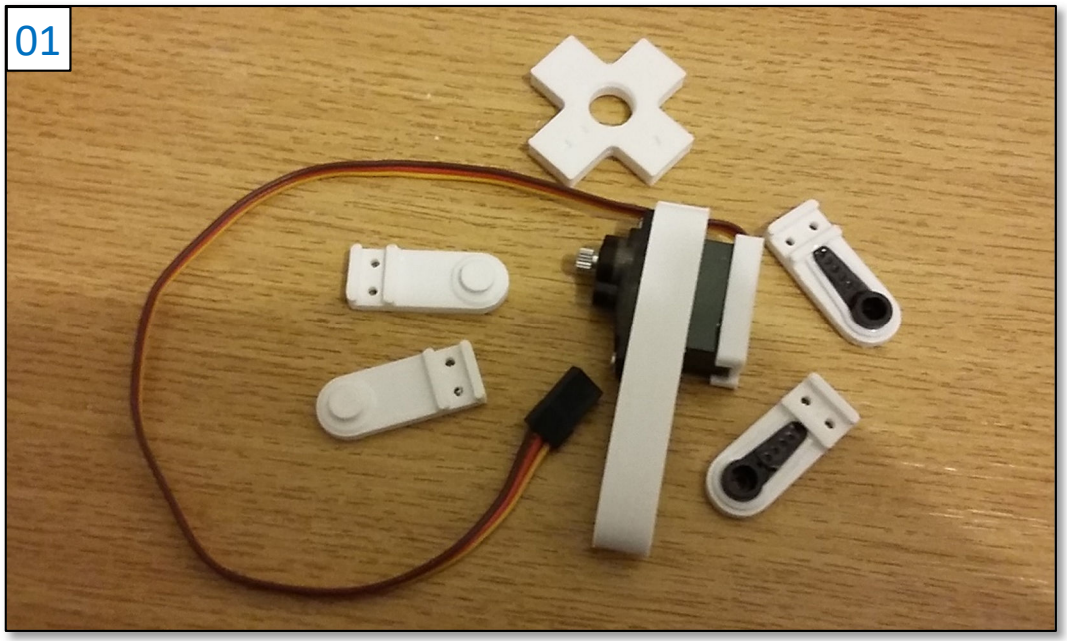
The power wires are looped round and soldered, as if from the front, so that they can move forward a little as the Upper plate is turned over and lowered onto the Base plate.

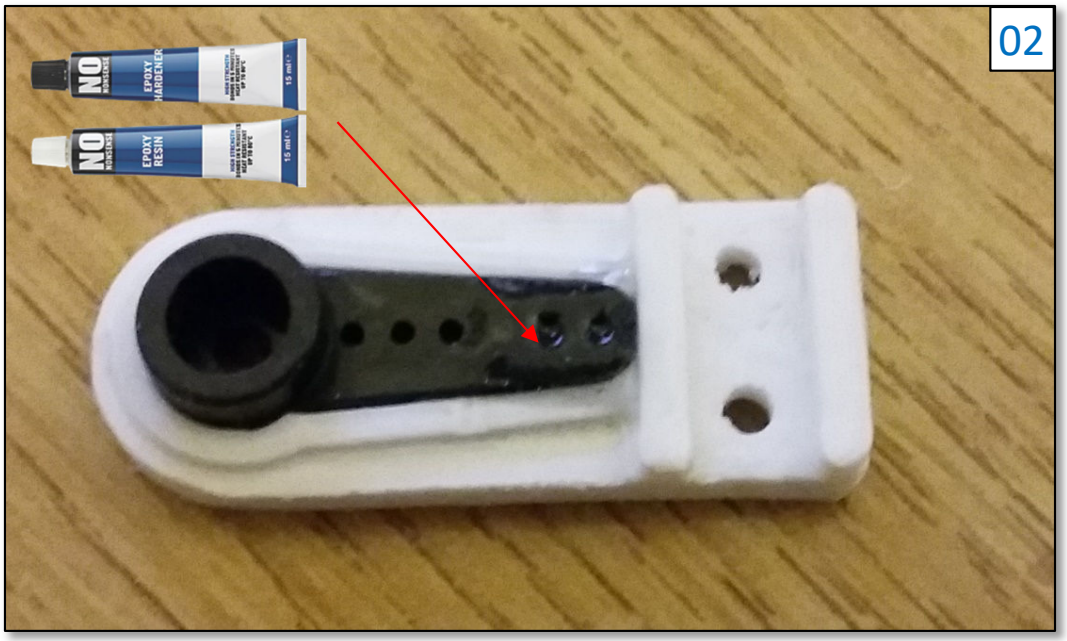


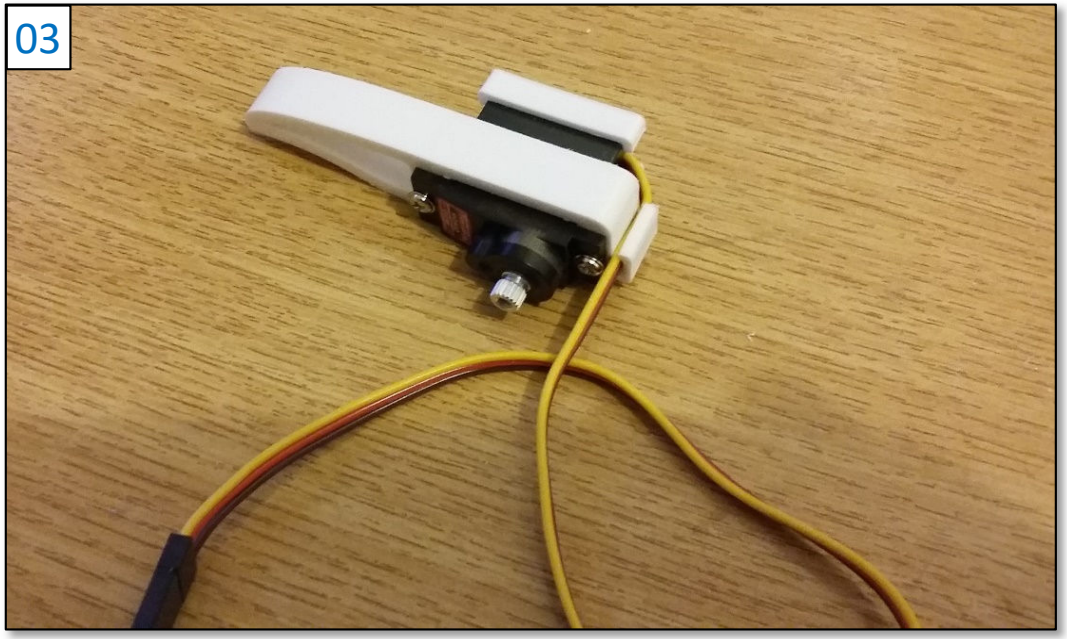
The two banks of 1N4006 diodes serve to drop the battery voltage down, so that there is less thermal strain on the servos and micros 3v3 regulator. This is a simple, but not very efficient method.

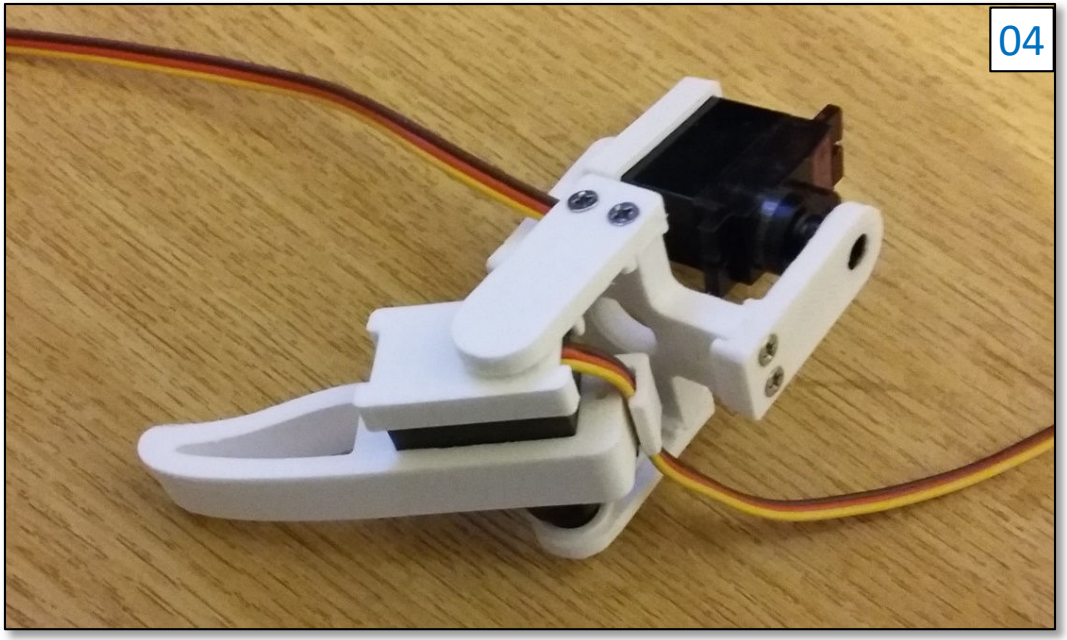
This is how the power connections to the Base plate will be completed.

Build Sequence Photos

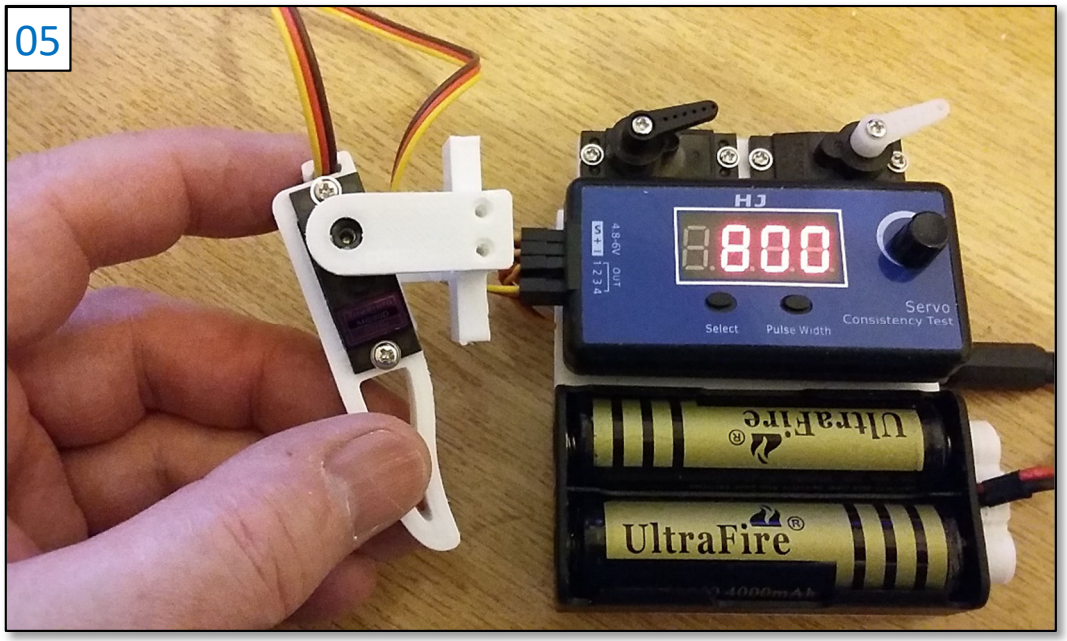


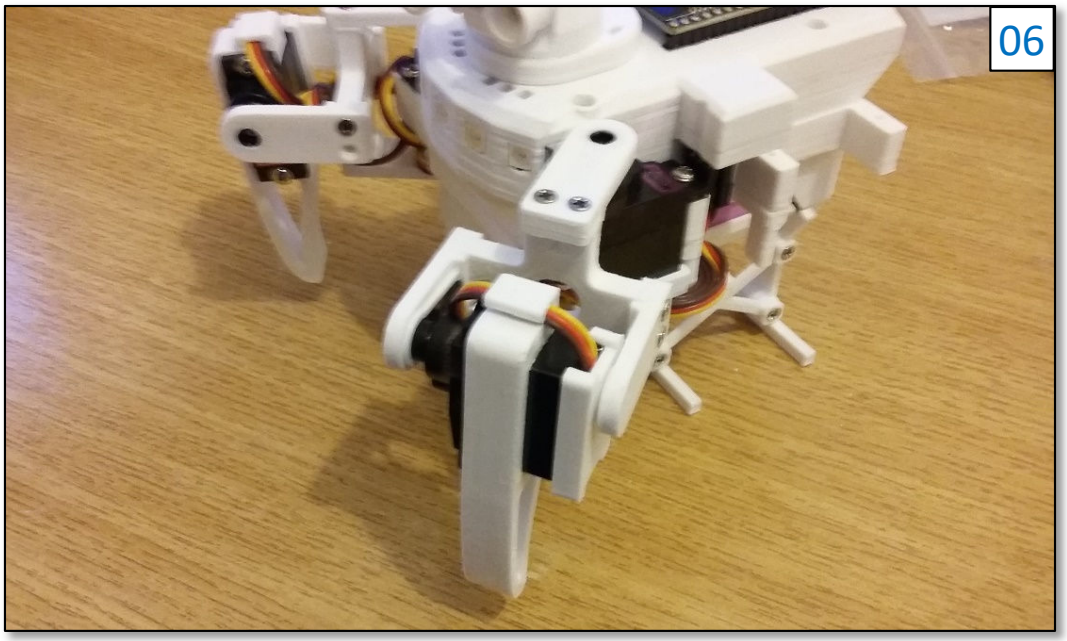


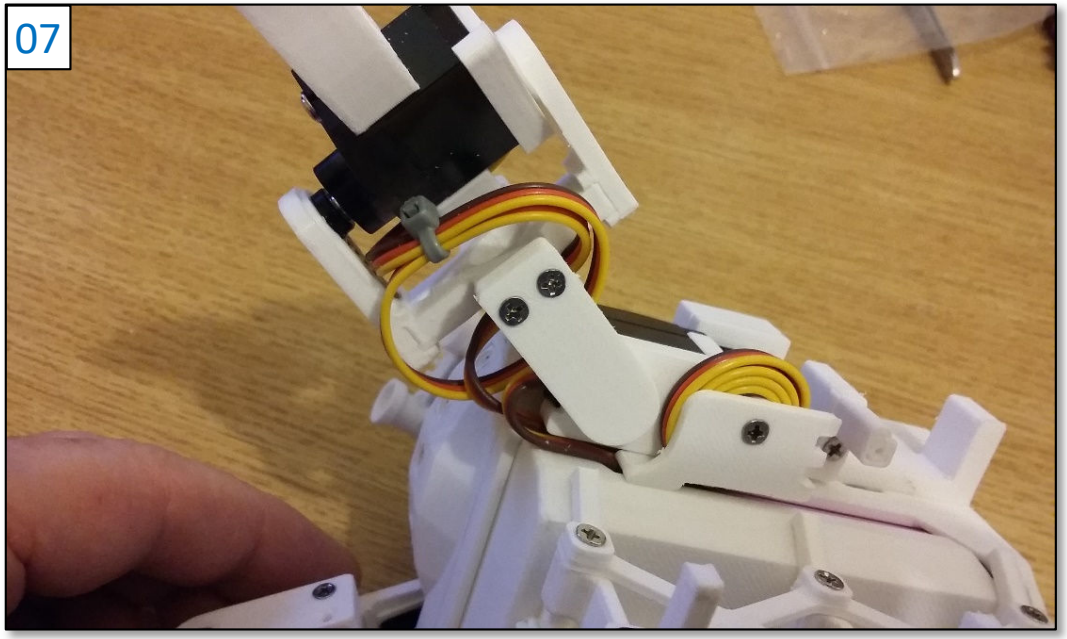


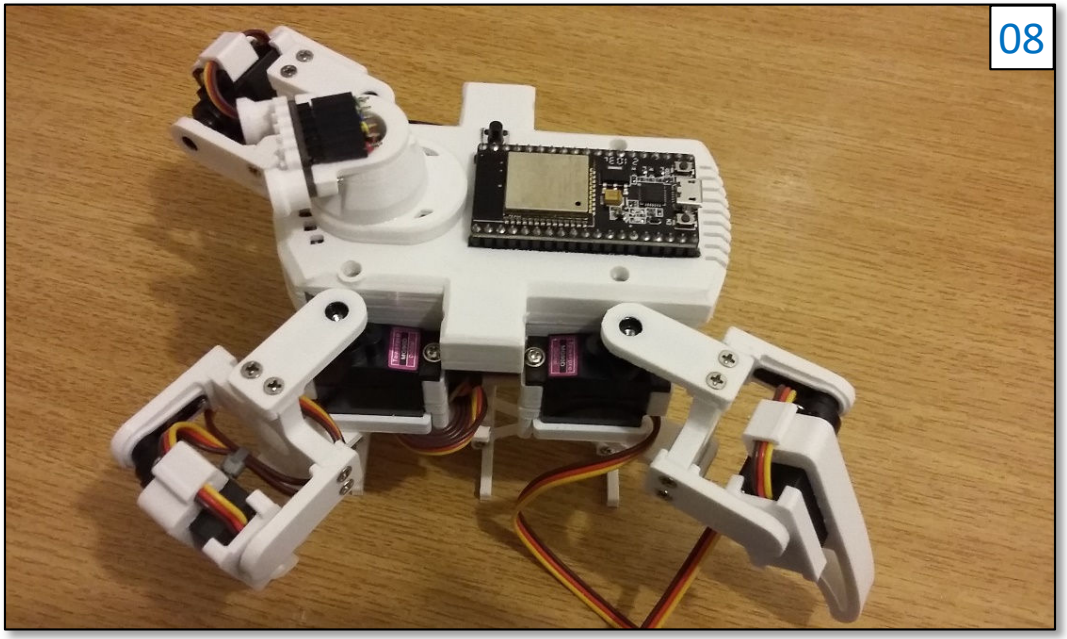


Build Sequence Photos





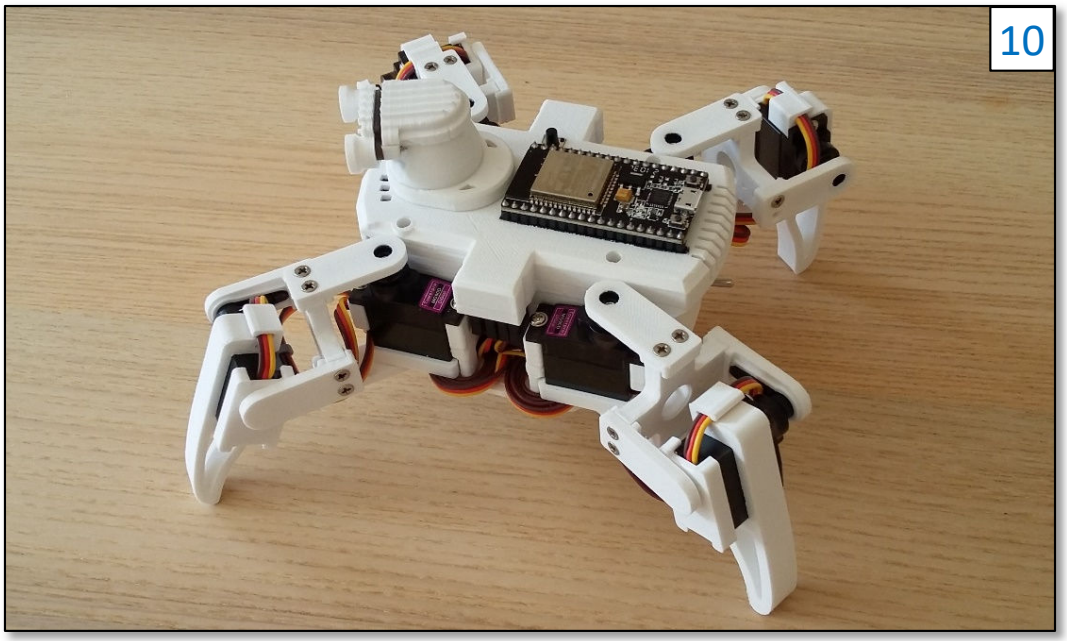




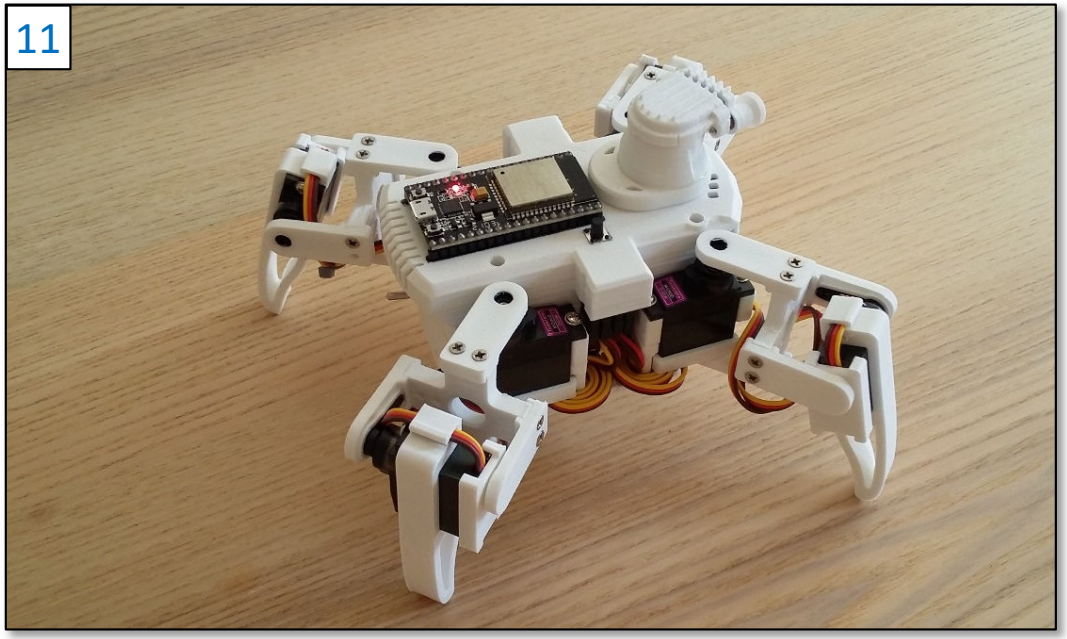
Build Sequence Photos

09

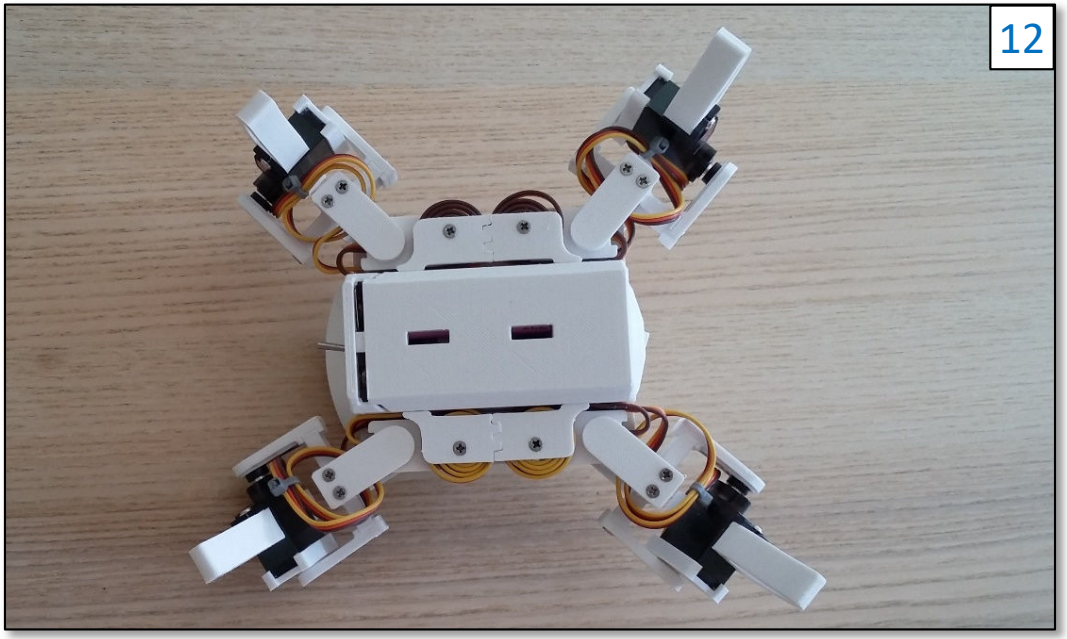
10



11



12



Battery Voltage Calibration

See Lithium discharge curve obtained from the internet. In this analysis the lipo battery consists of two identical batteries connected in series.
Assume fully charged 8.2v battery max voltage is V_{BM} >= 8.4v max (charging)
Set battery warning point at V_{BW} = 7.2v (2 x 3.6v)
Set battery critical point at V_{BC} = 6.6v (2 x3.3v), don't go below this!

The ESP32 is powered via a 3v3 voltage regulator, connected to the 3v3 pin. But the 6k8 supply sampling resistor is connected to source V_{Batt} or Ext. supply.
For ESP32 V_{ADC} == 4095 on 12-bit converter (4095 max).
If we use a 6k8 resistor feeding A0 and a 3k3 resistor to GND, we get a conversion factor of 10.1v == 4095, or 2.47mV/bit, or 405.4 bit/v
Place the droid in TEST mode. Using a Multimeter and a variable DC supply, determine the following V_{ADC} values for corresponding threshold voltages:

MAX. O.C V_{OC} = 8.4v, gave A0 = 3295 On V_{ADC} (2 x 4.2v)

MAX: (100%) V_M = 8.2v, gave A0 = 3200 on V_{ADC} (2 x 4.1v)

HIGH: (80%) V_H = 7.8v, gave A0 = 2997 on V_{ADC} (2 x 3.9v)

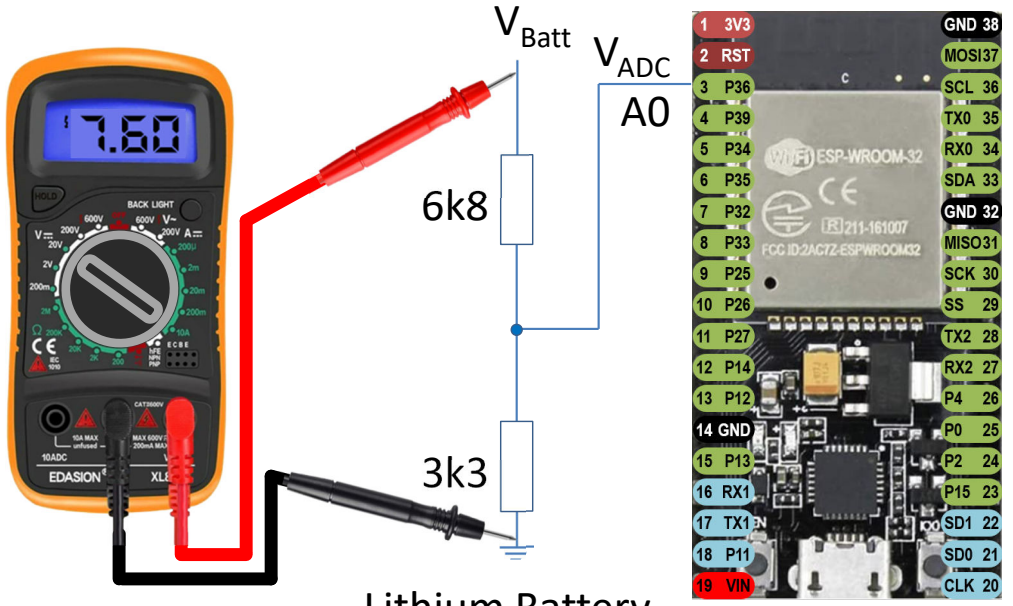
WARNING: (20%) V_{BW} = 7.2v, gives A0 = 2762 on V_{ADC} (2 x 3.6v)

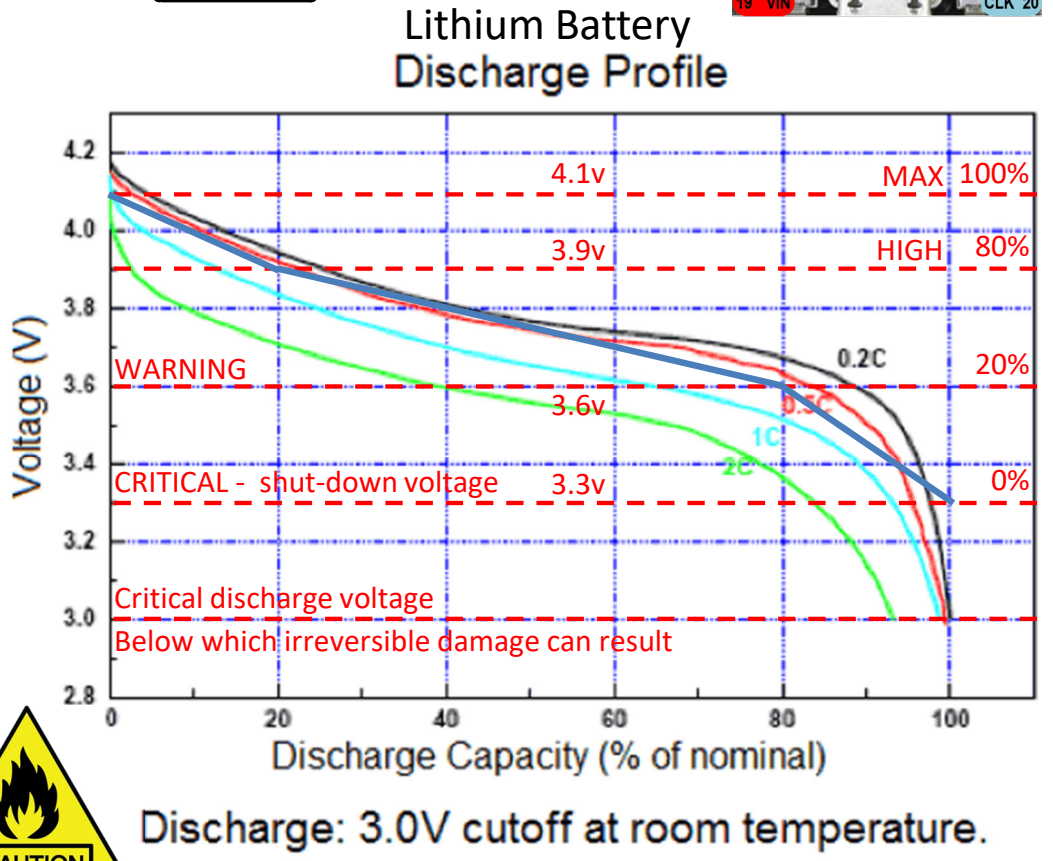
CRITICAL: (0%) V_{BC} = 6.6v, gives A0 = 2513 on V_{ADC} (2 x 3.3v)

The code will sample the battery voltage on power-up to ensure it is sufficient, then at every 40ms interval, calculating an average (1/50) to remove noise. Then converts ADC values to voltage in the getBatV() function.

In the code I have assumed a discharge curve ranging from 8.2v (100%) to 6.6v (0%) capacity, using the blue overlay line shown. The voltage is monitored and used to predict the remaining capacity 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, which limits functions available.





Discharge: 3.0V cutoff at room temperature.