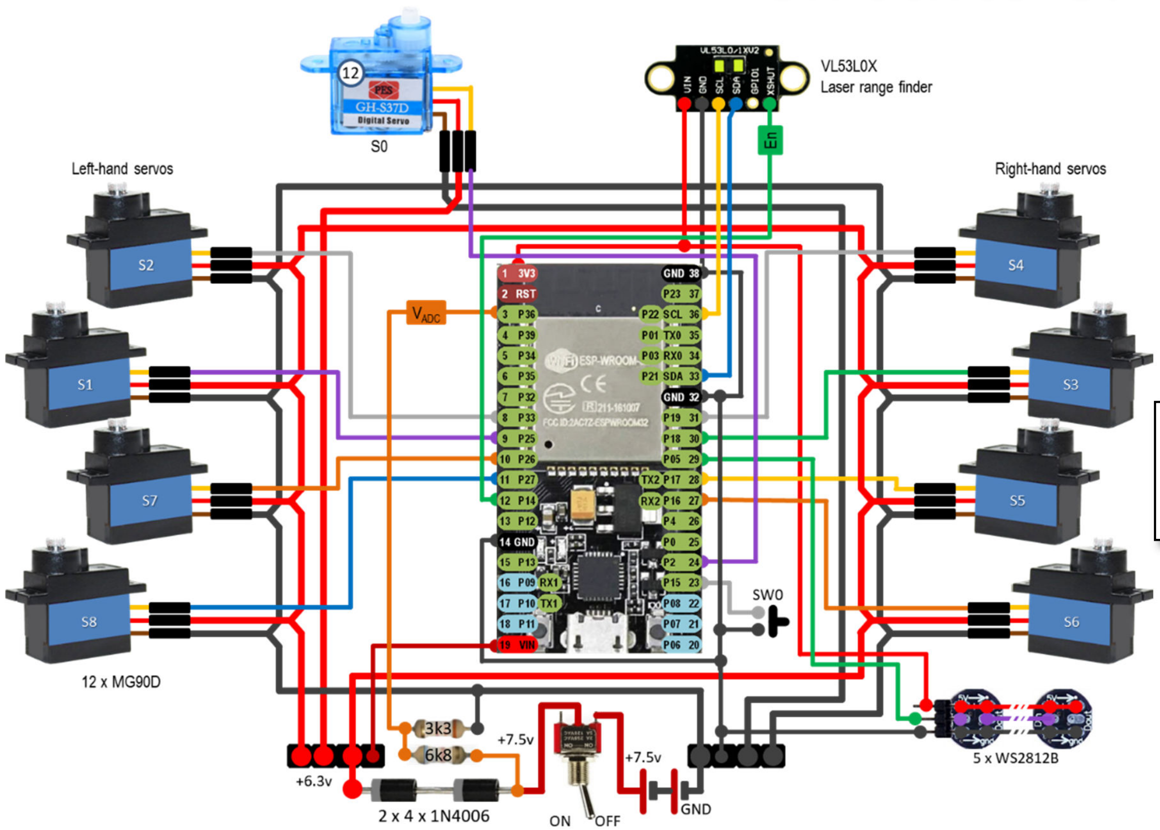
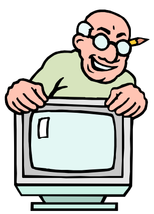
QuadAuto (ESP32)

Circuits & Wiring





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

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Hand Tools:

Recommended:

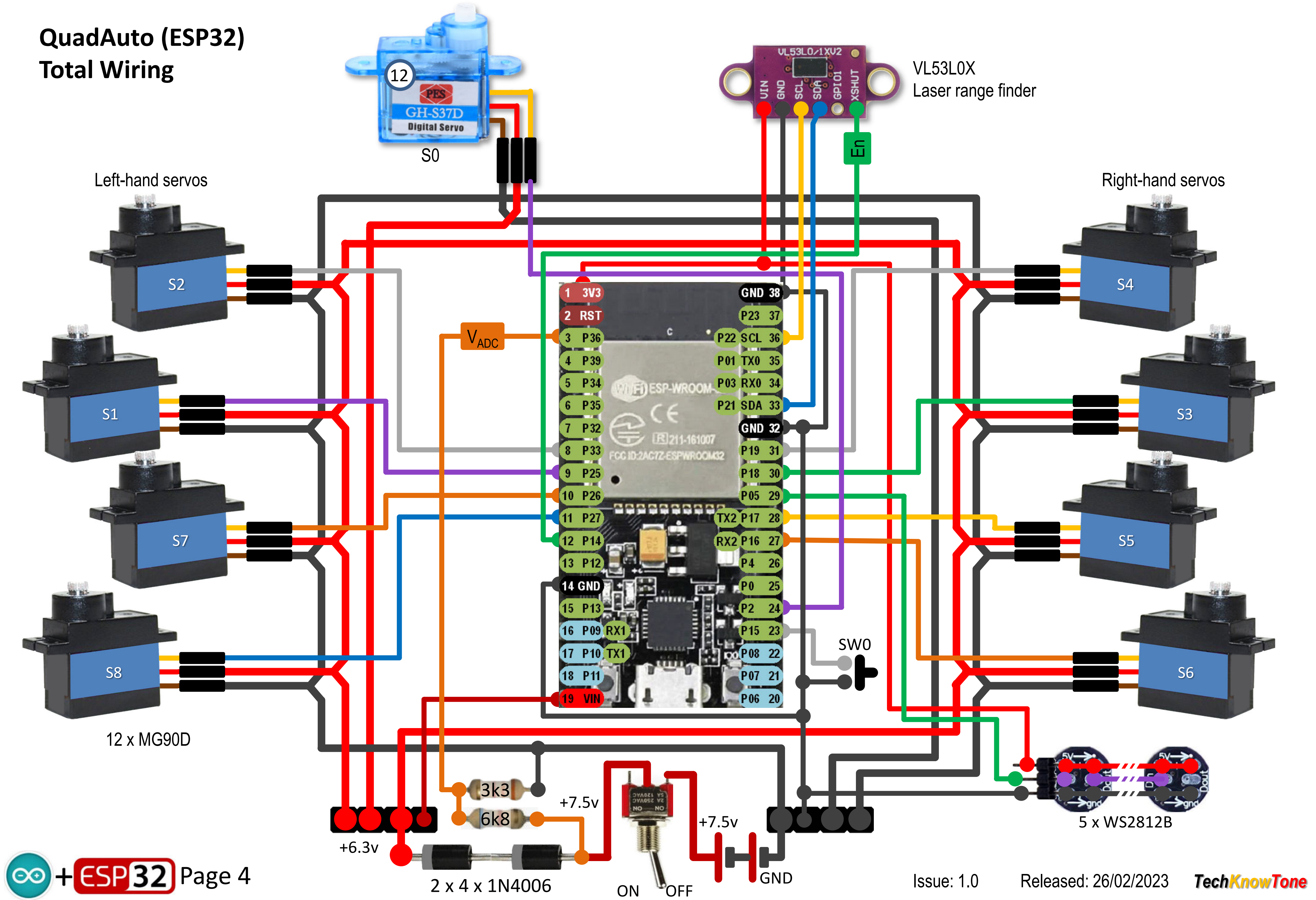
- Fine Nosed Pliers
- Side Cutters
- 1.5 mm Drill
- 2.0 mm Drill
- 4.0 mm Drill
- Needle Files
- Screwdrivers
- Craft Knife

Note: Not all items are shown here.

Tools & Materials:

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

QuadAuto (ESP32)
Total Wiring



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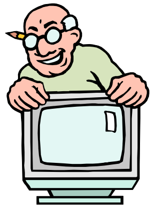
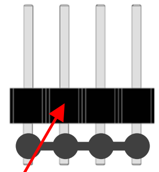
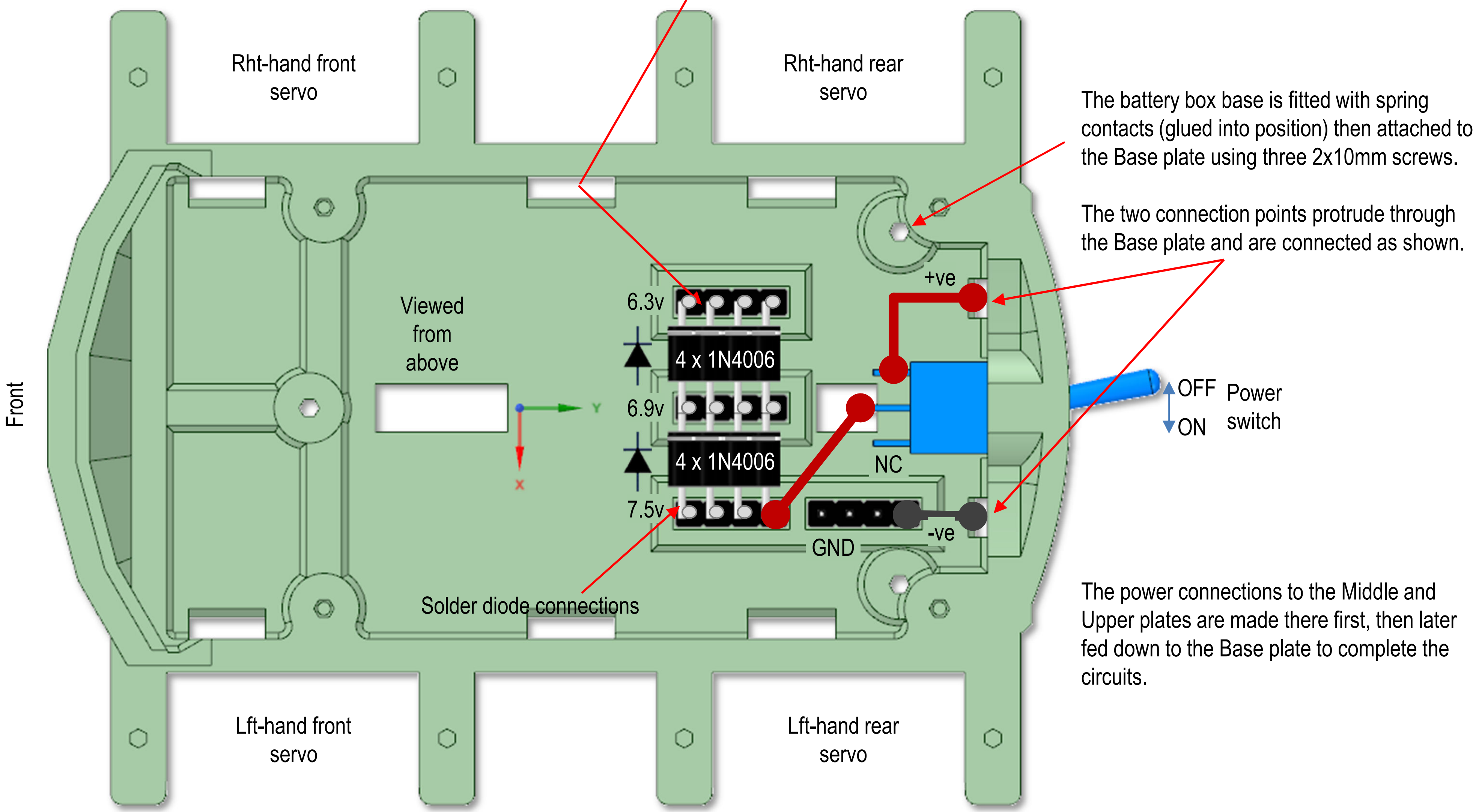
Base Plate Wiring

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

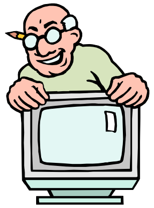


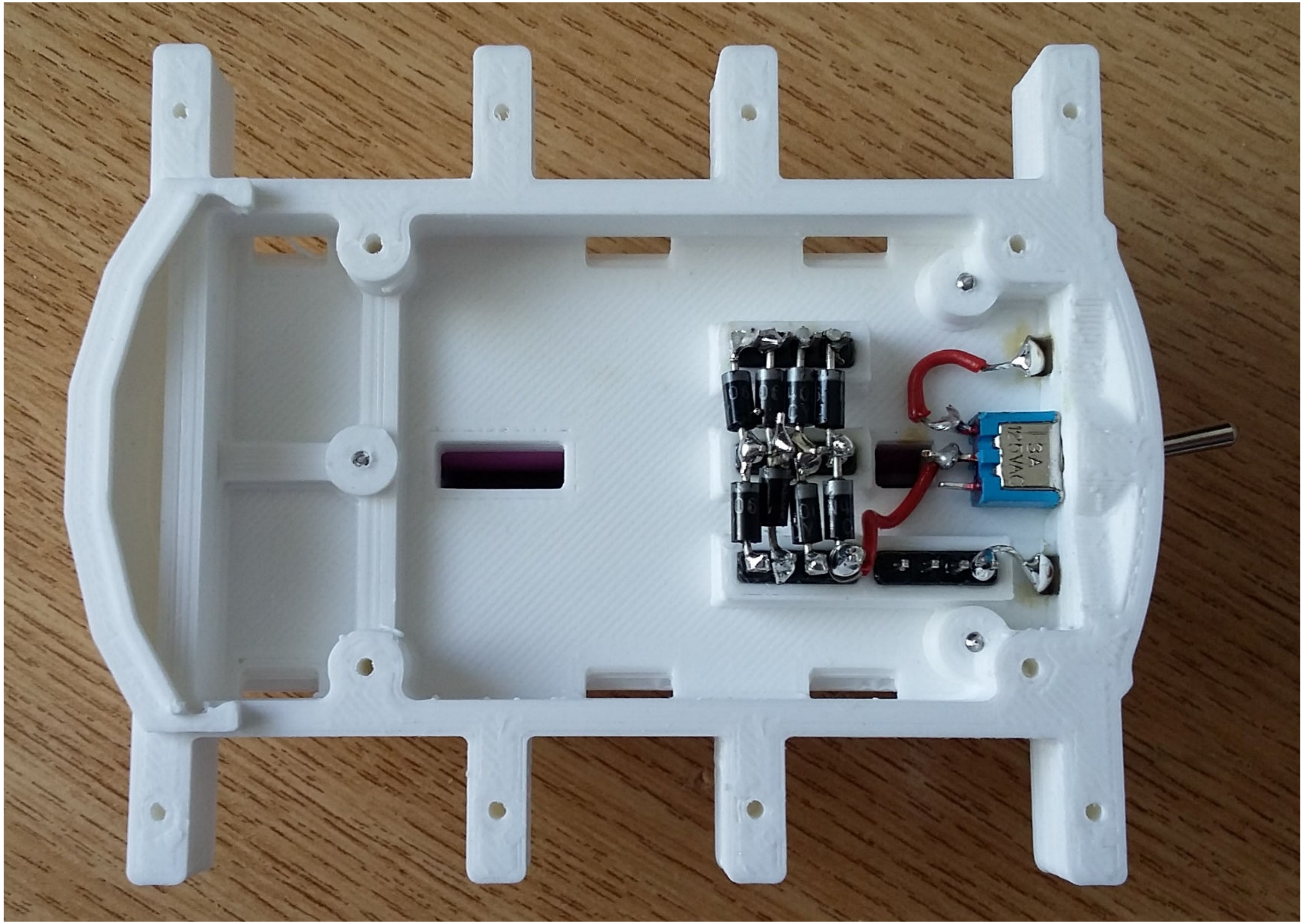




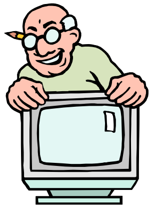
Base Plate Wiring

Your Base plate connections should look something like this.



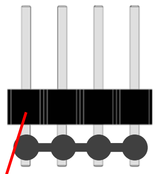


Upper Plate Initial Wiring

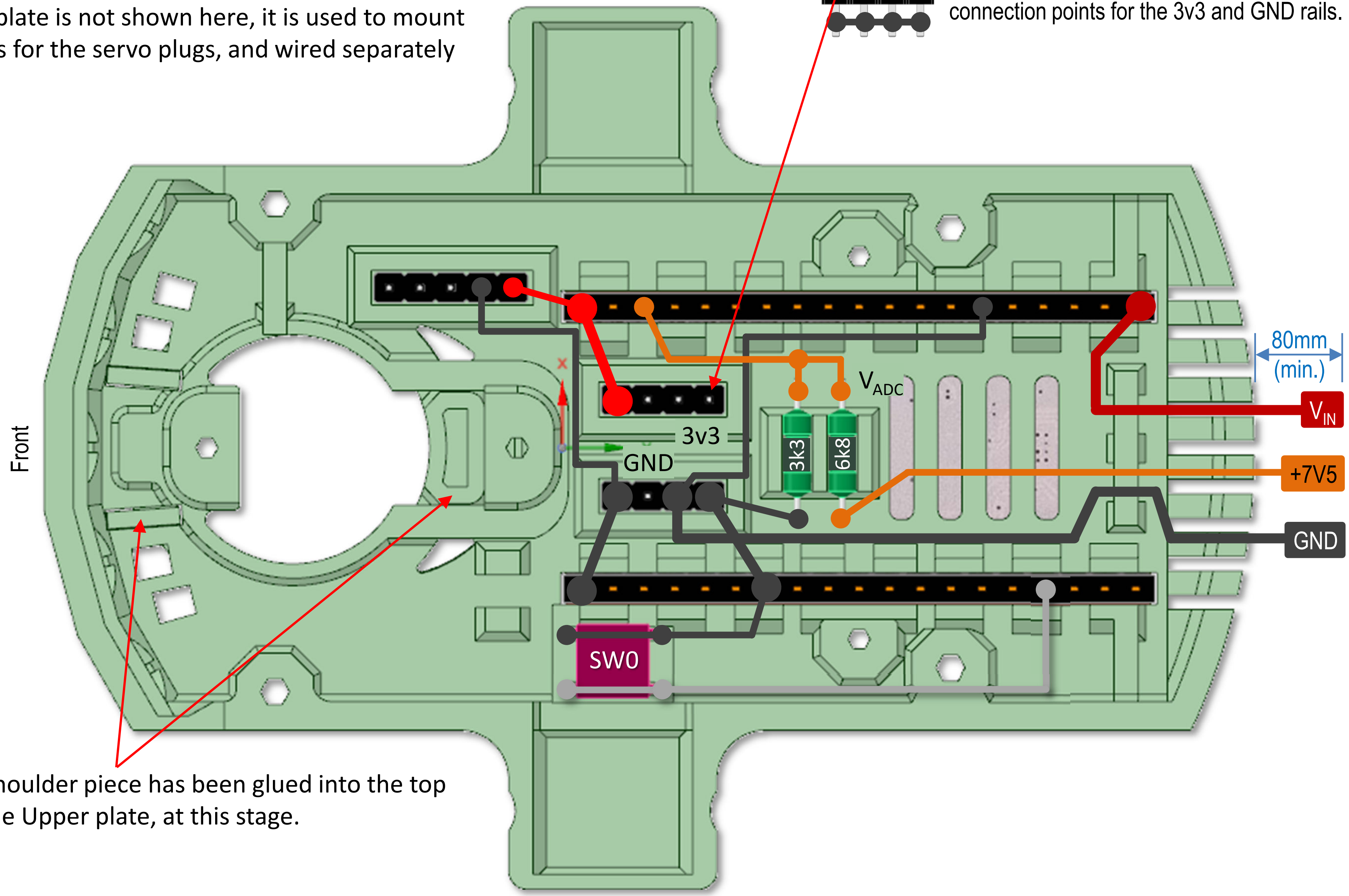


Start by making the power connections to the micro, the battery monitoring resistors network, and button switch SW0. Solder these connections.

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.

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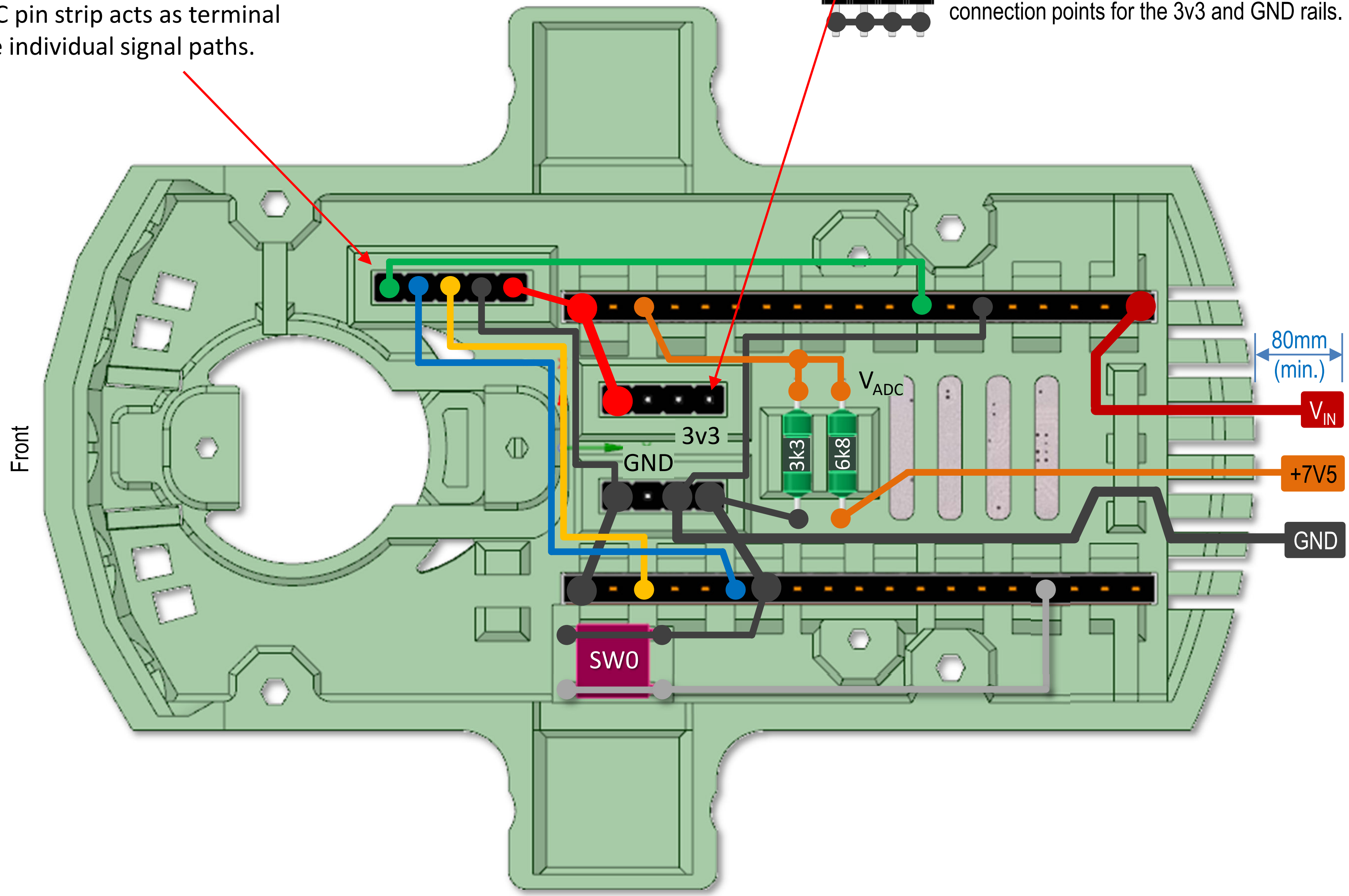
Upper Plate Wiring I2C

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

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.

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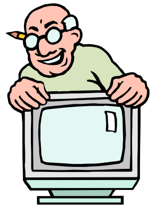
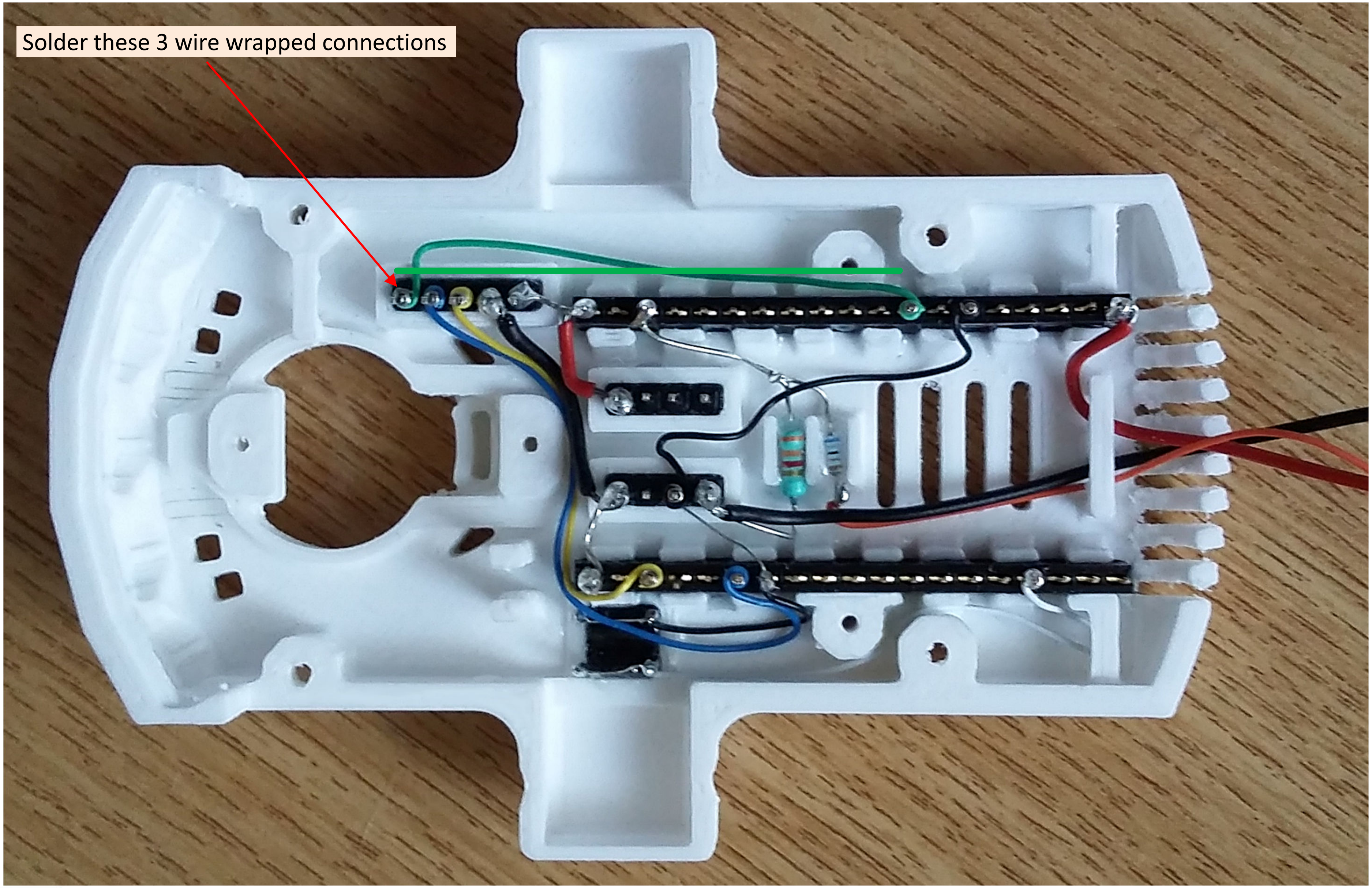
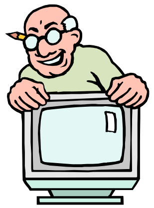
Upper Plate Wiring I2C

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.

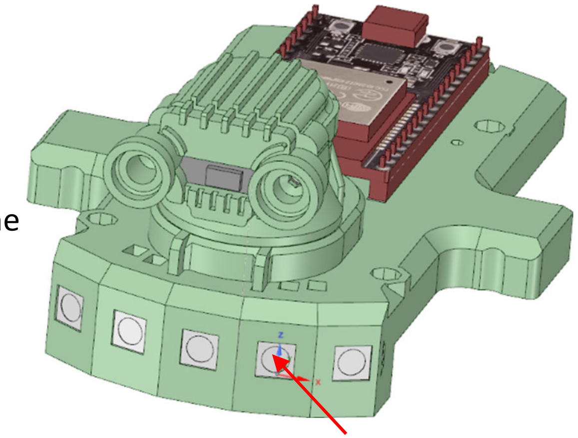
The wires will be of different length, with the green wire being much longer, due to its data loops and the micro connection.

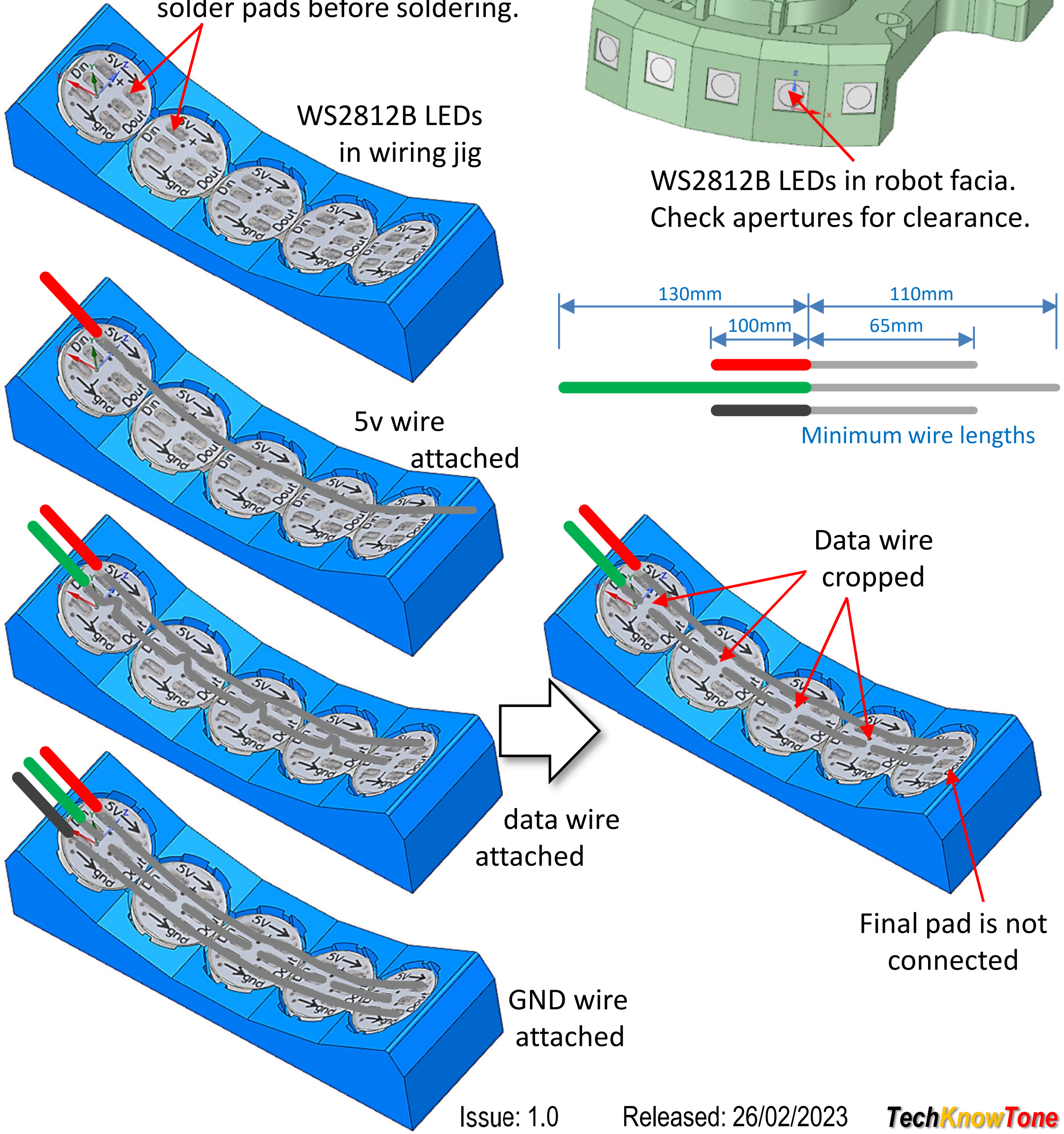
Then solder in the red wire along the 5v pads. The stripped wire needs to exceed the length of the jig, and the insulated portion needs to be able to reach the 5v common pin strip. Crop excess, once soldered onto pads.

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.





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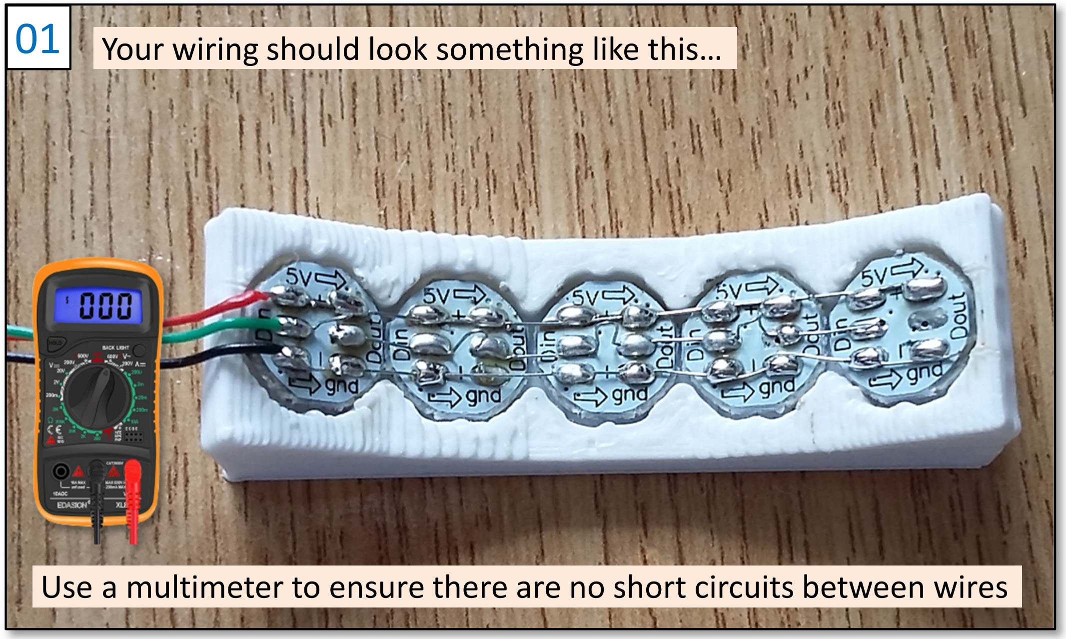
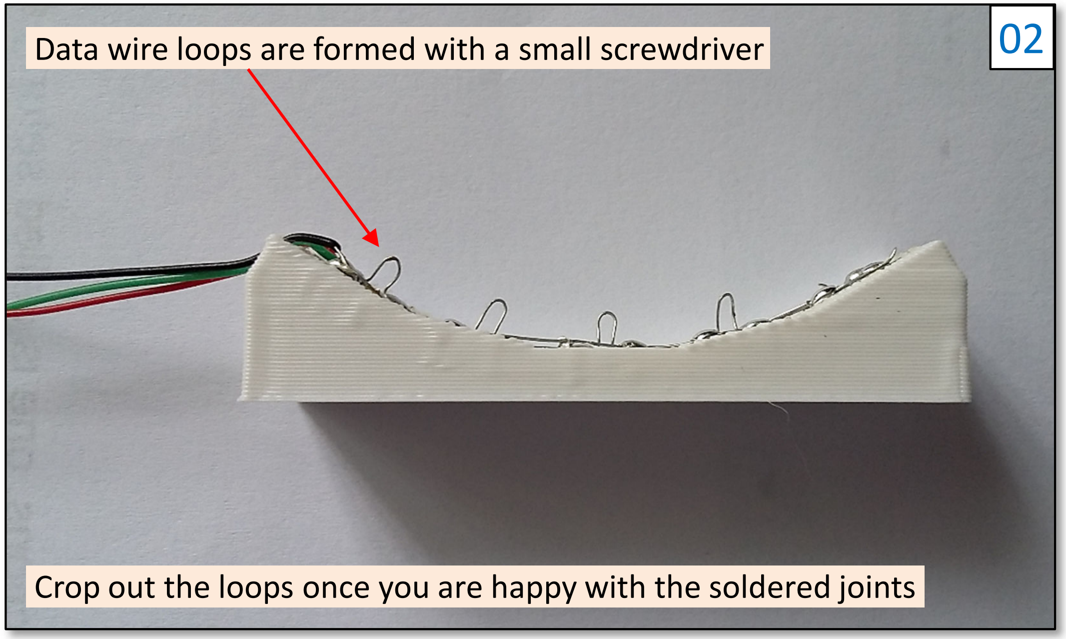
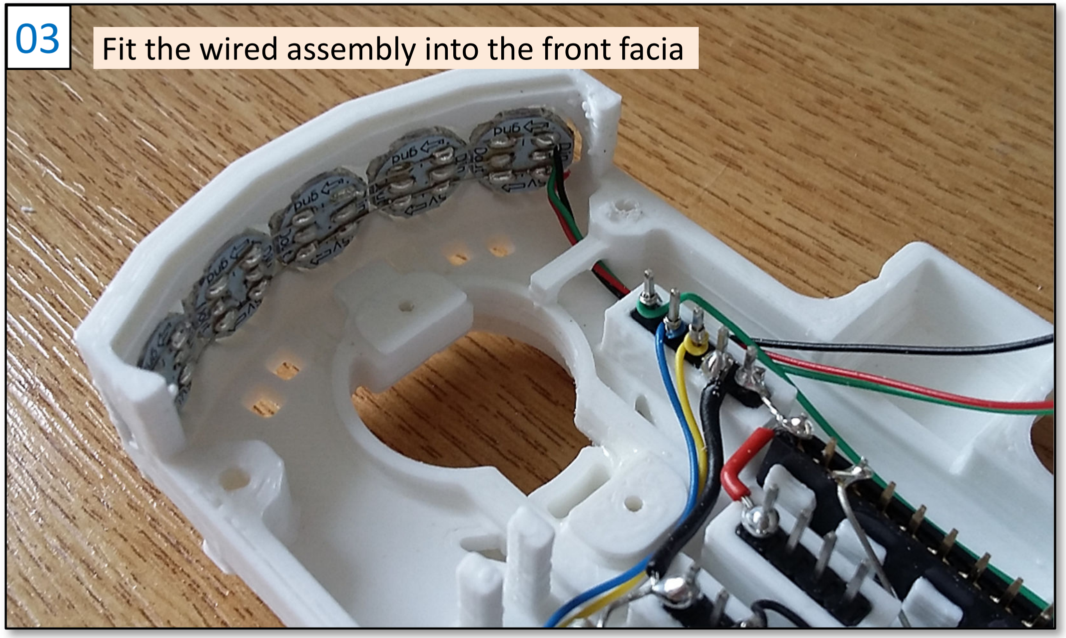
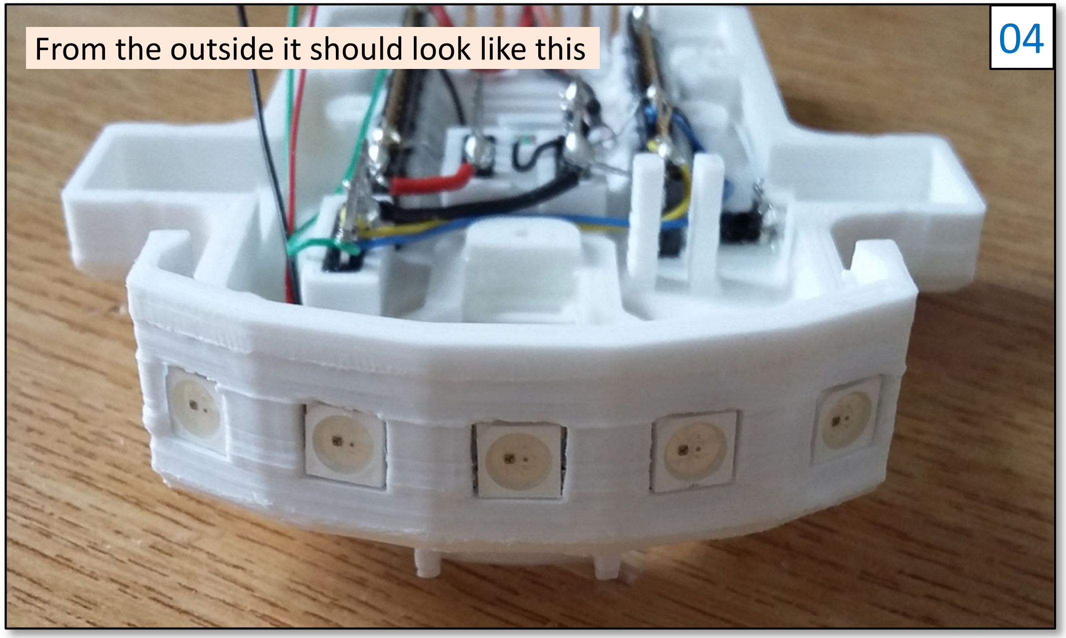
WS2812B RGB strip Wiring

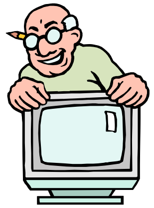






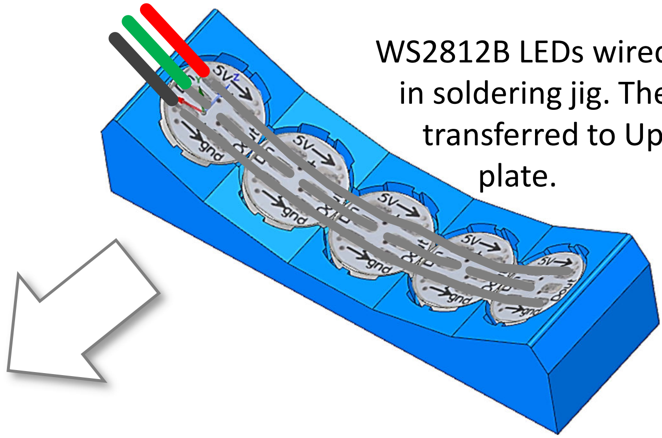


Upper Plate WS2812B Wiring

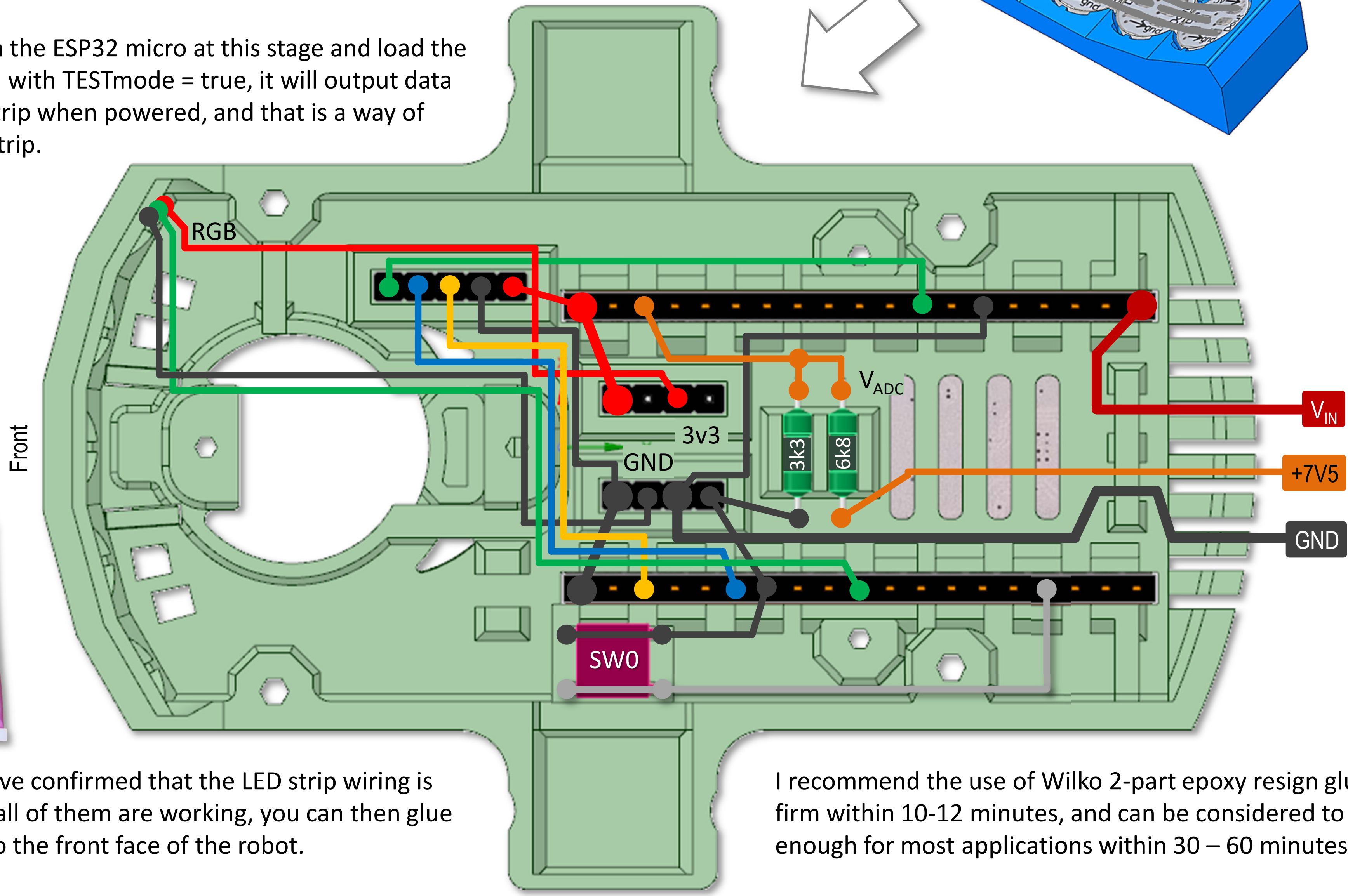


Now we carefully transfer the wired WS2812B LEDs from the soldering jig, into the front face of the Upper plate. From that position we run and terminate the three wire connections.

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.



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

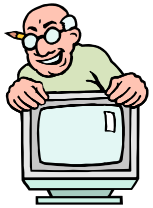


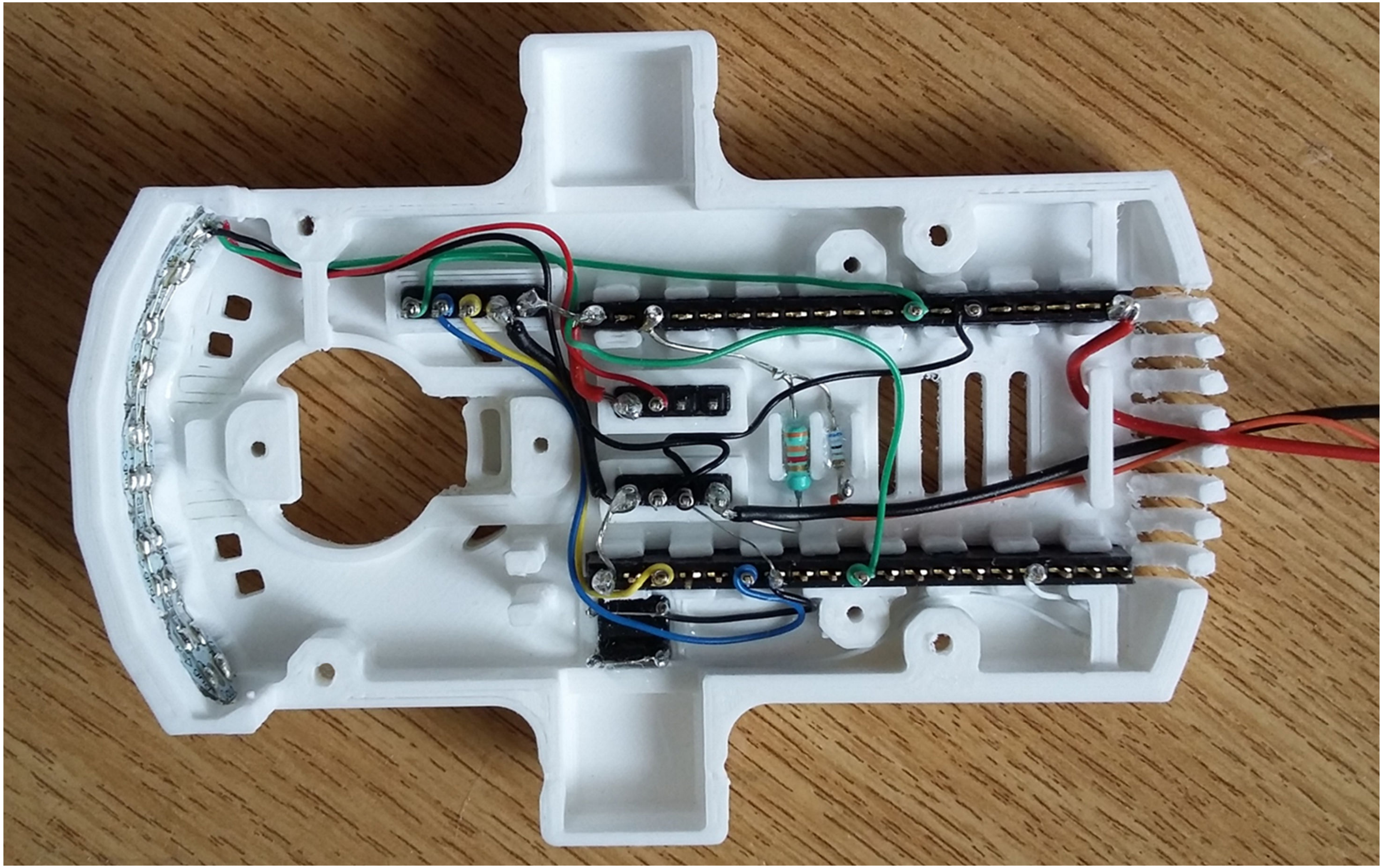
Once you have confirmed that the LED strip wiring is correct and all of them are working, you can then glue the LEDs into the front face of the robot.

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..

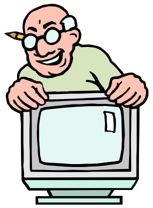
Upper Plate WS2812B Wiring

Your Upper plate connections should now look like this.





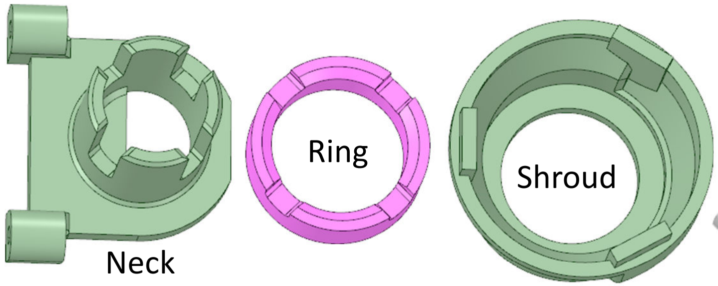
Head assembly

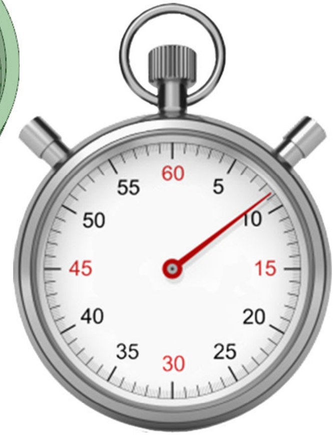


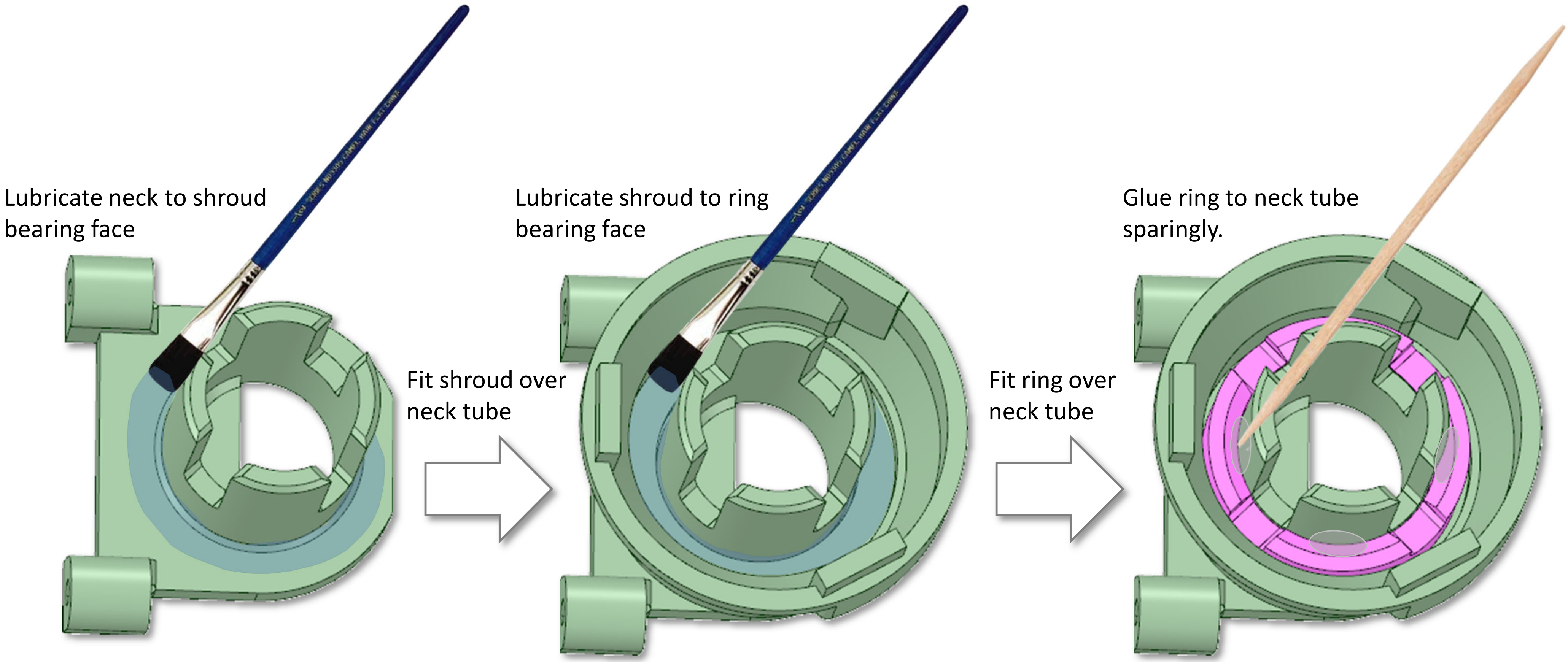
The neck is held into the shroud piece by a retaining ring, which is glued onto the neck tube.

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.

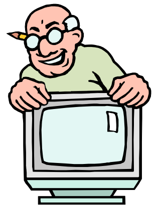






Allow the glue to go firm, then carefully rotate the neck within the shroud, to ensure that it is not glued also. Leaving the tooth pick on the mixing card gives a good indication as to when the glue stiffens. Normally 10-12 minutes depending on room temperature.

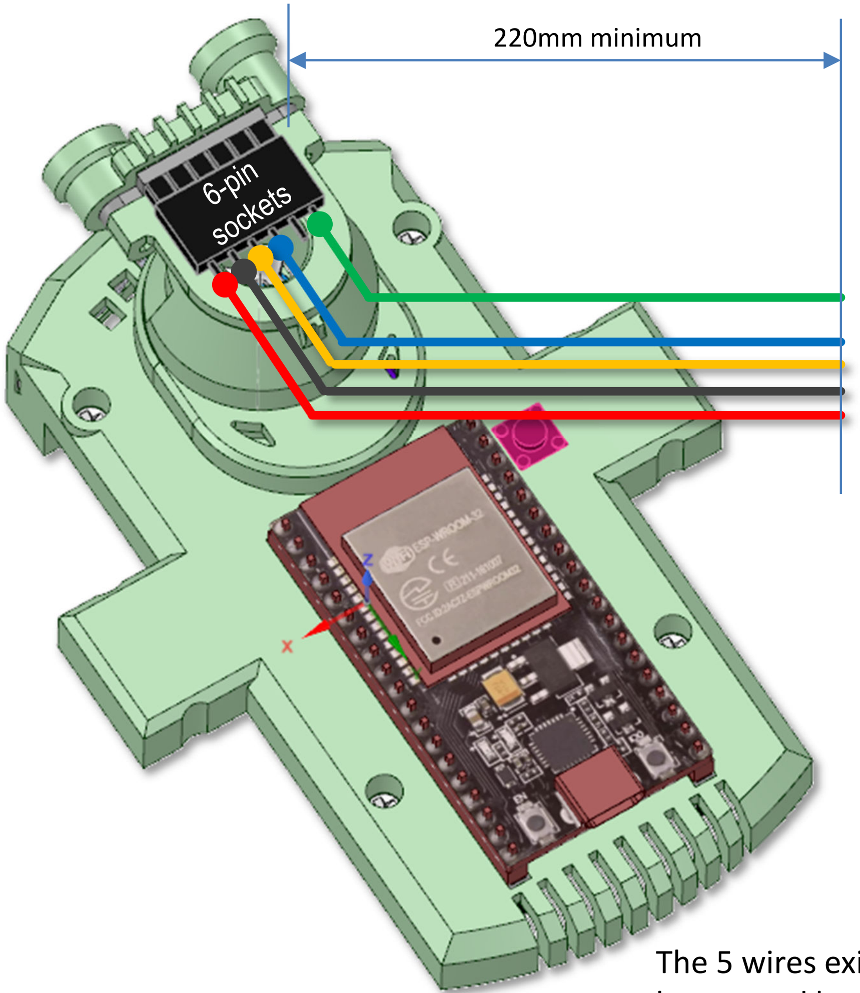
Head VL53L0X LTOF Wiring

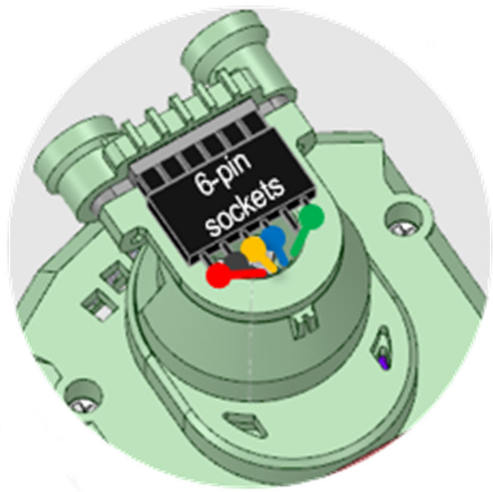


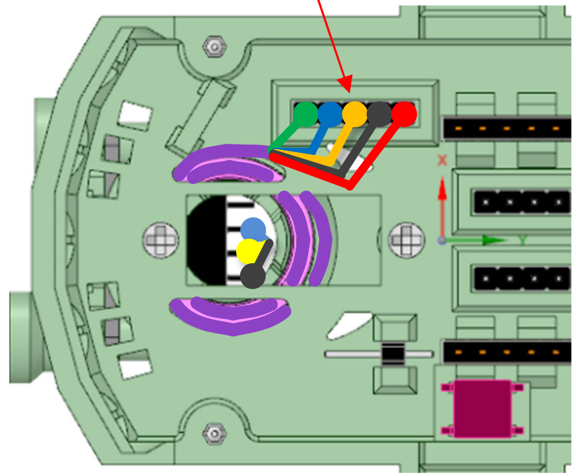
Using the Head Eyelets piece and 2 screws, attach the sensor onto the neck. Then glue the Head Shroud into the neck on the Upper plate.

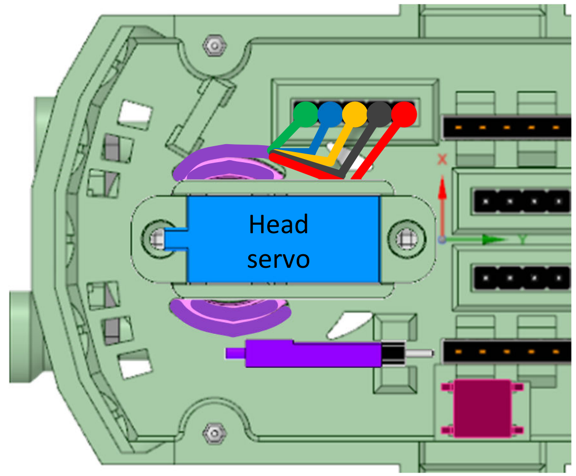
Once the glue has set, connect 5 wires to a 6-pin socket strip, as shown; allowing for a minimum length of 200 mm. Solder the connections, then plug this onto the VL53L1X device whilst feeding the wires down through the neck aperture. The wire length aims to ensure you have sufficient.

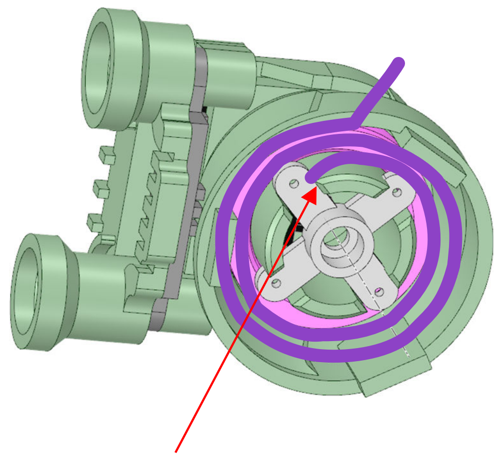
With the 5 wires wrapped round the neck and exiting the Upper plate as shown, insert the servo with the cross leaver attached, and screw it into position. Then terminate the 5 wire wrap wires as shown. Only solder once tested.





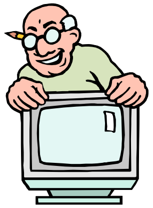






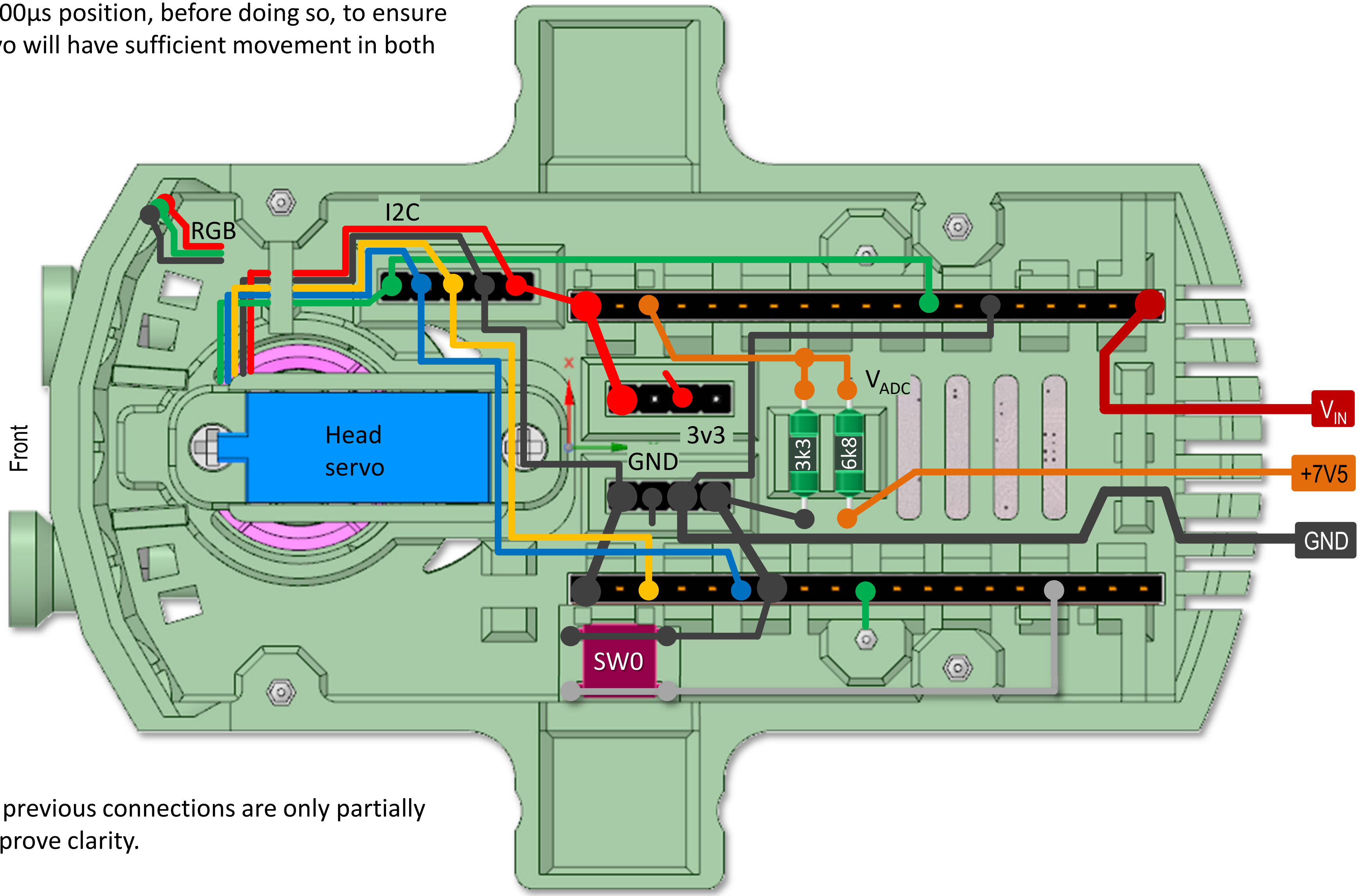
The 5 wires exit the neck here, above the servos drive leaver, and be wrapped twice clockwise around the neck, before exiting through the upper plate aperture.

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.

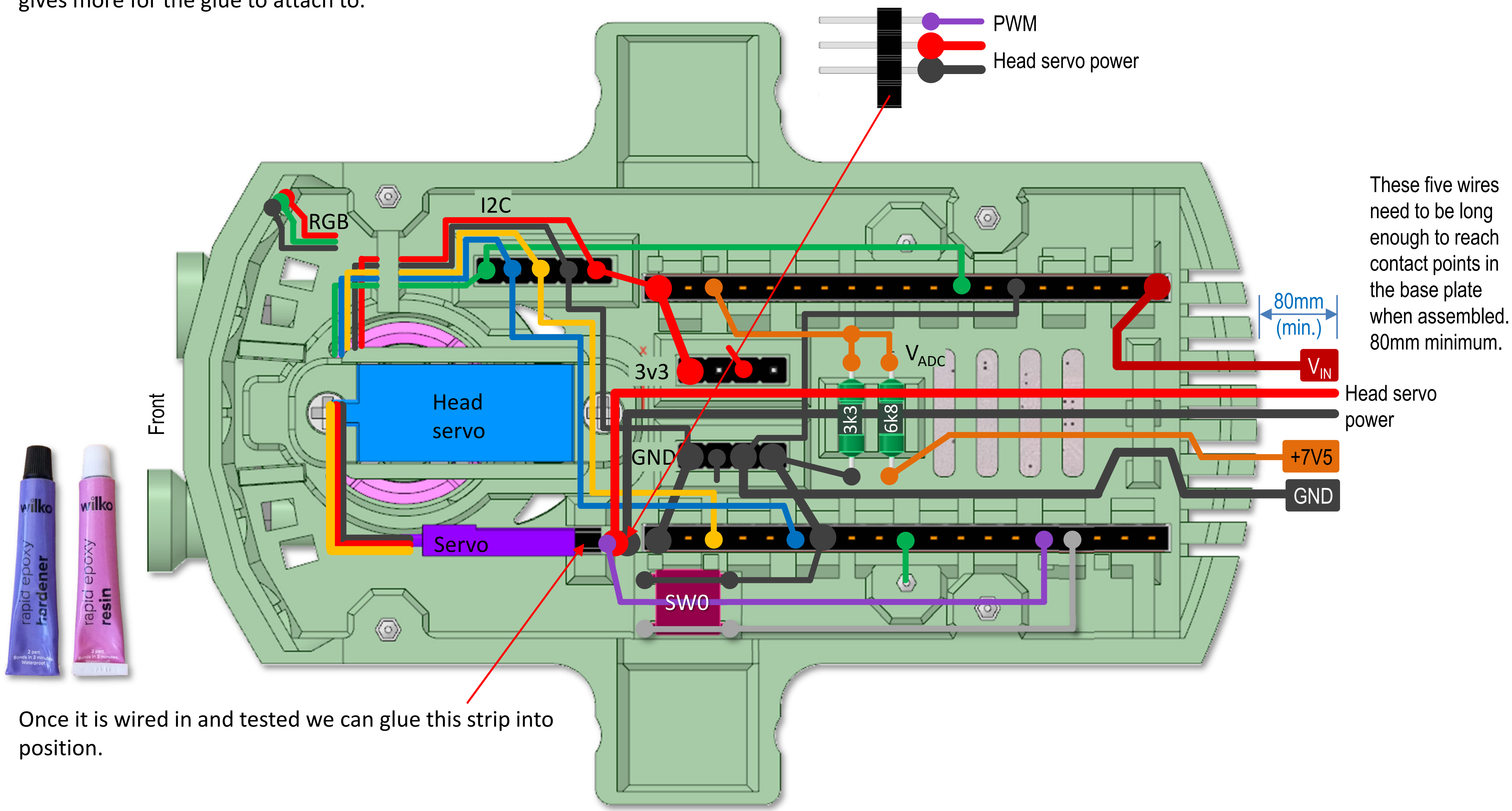


Some of the previous connections are only partially shown to improve clarity.

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.



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

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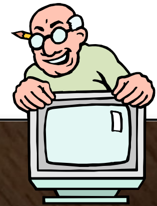
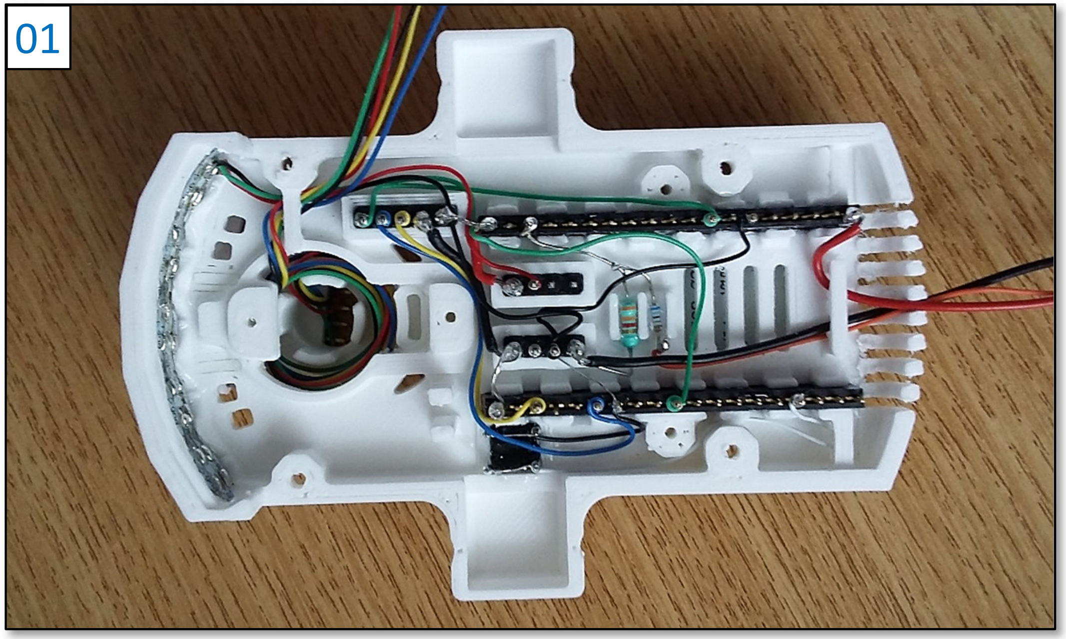
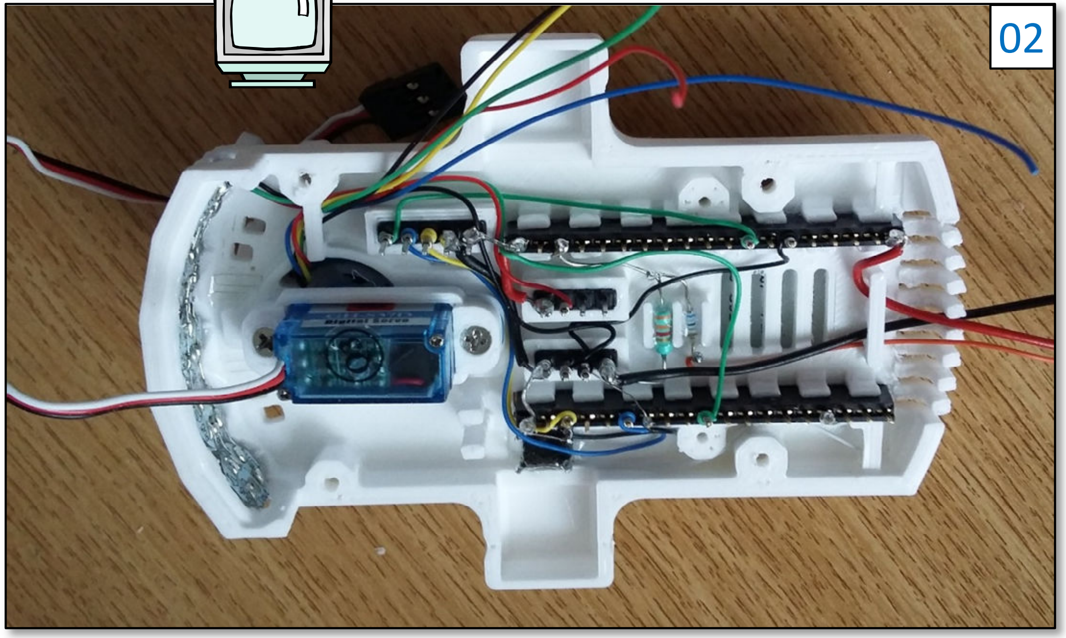
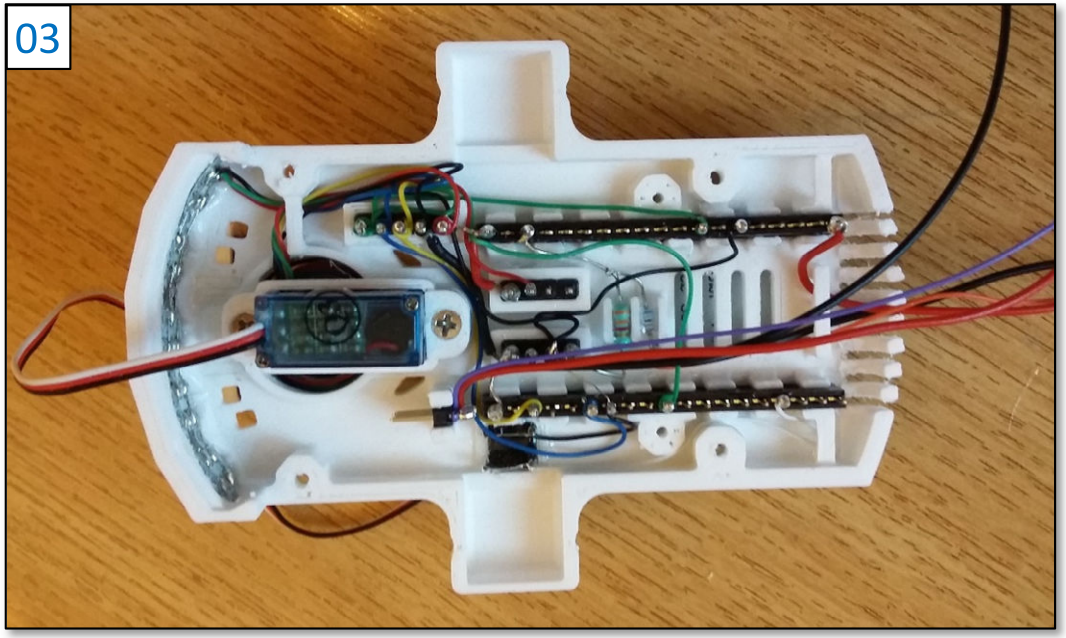
Upper Plate Servo Wiring

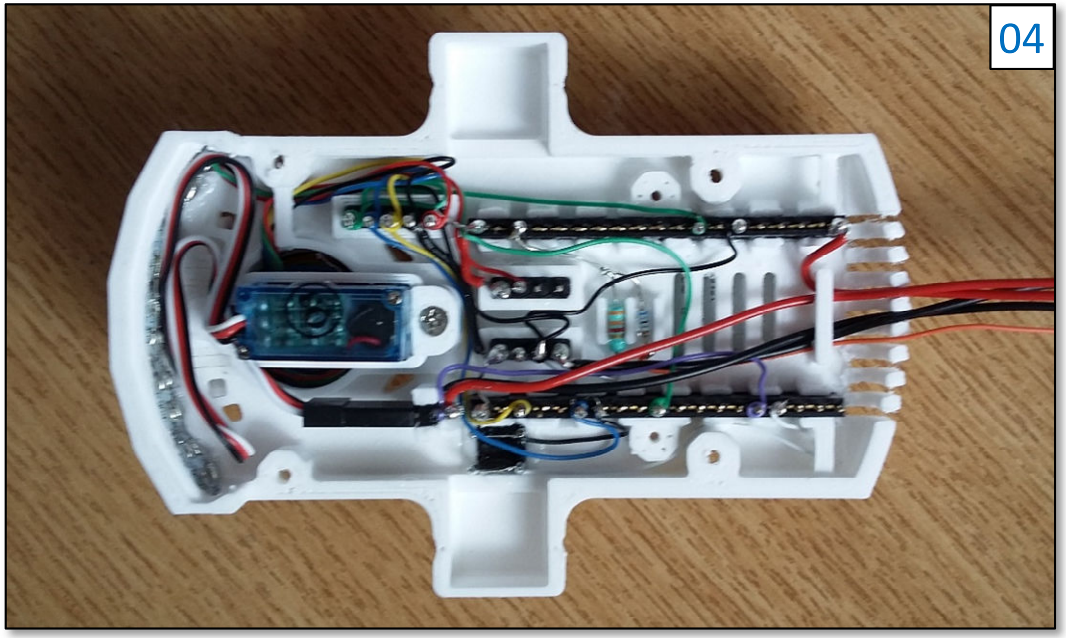
Your Upper plate connections should look like this.



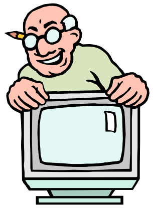








Middle Plate Wiring

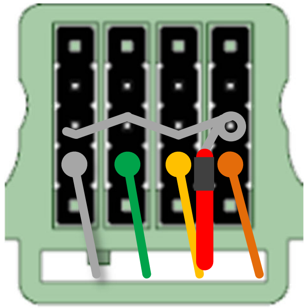


The servo Vcc and GND wire loops work like a ring main, acting to improve current distribution in the servo power wiring.

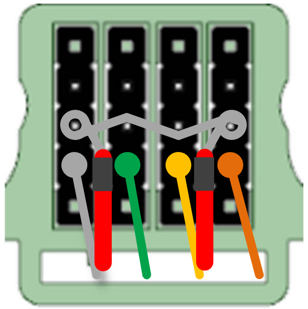
Servo 5-pin strips have their end pins removed, making them 3-pin, with the modified end pieces being used as glued supports. Ensure that the glue has set before wiring.

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.

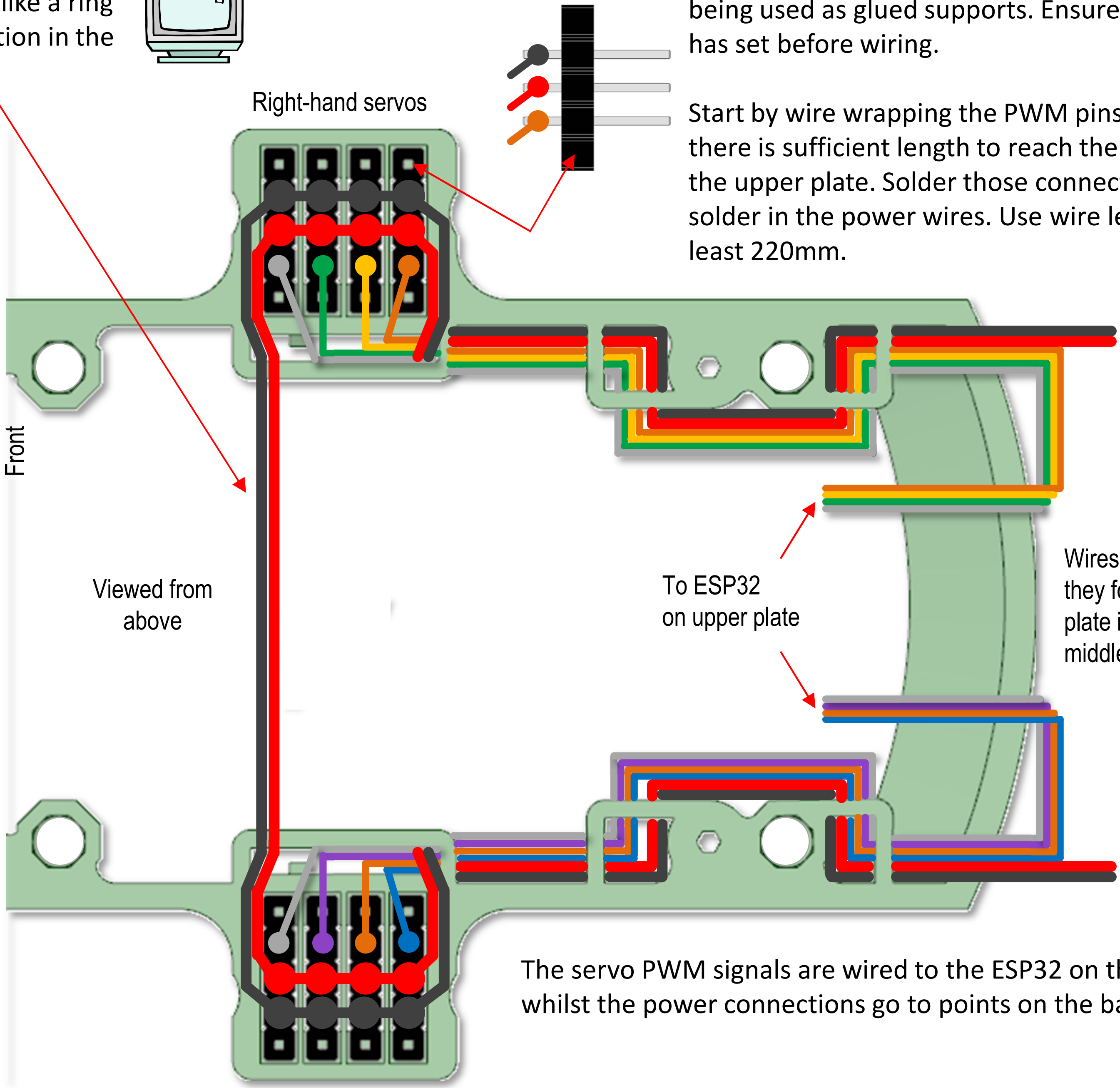
Having soldered the wire wrapped connections, connect the power leads. Shrink sleaving is used to prevent the wire from melting back.



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.

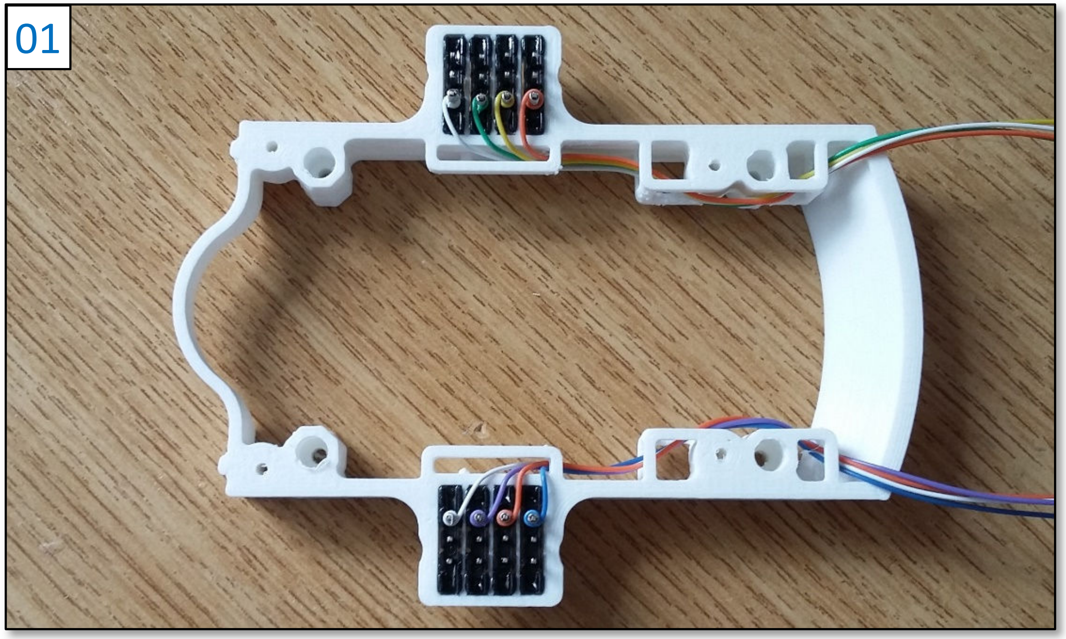


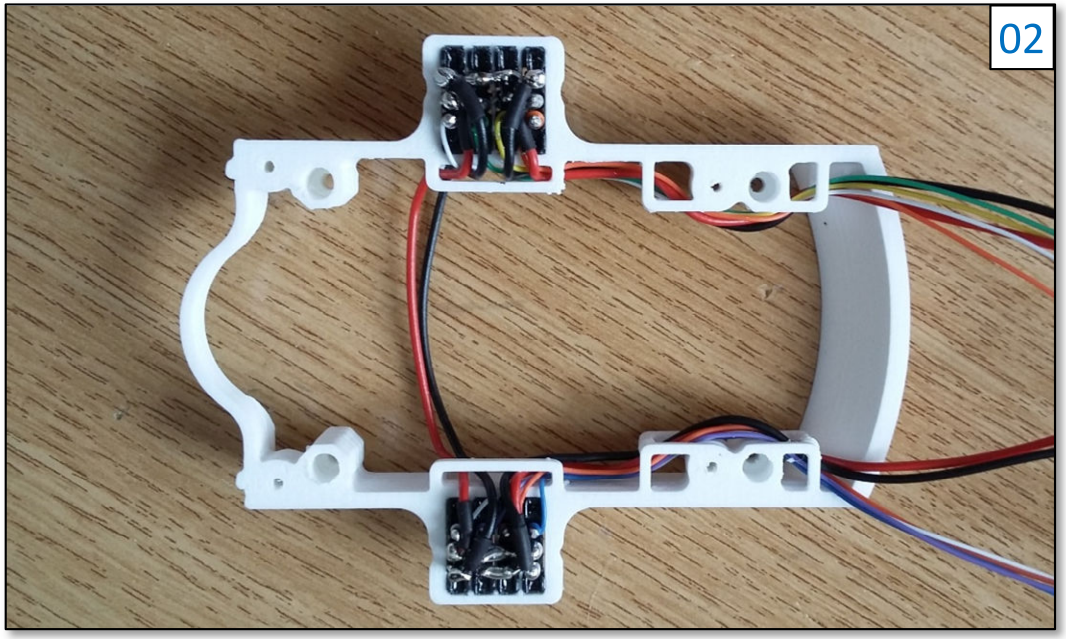
Repeat this process for the GND wire to complete the task.

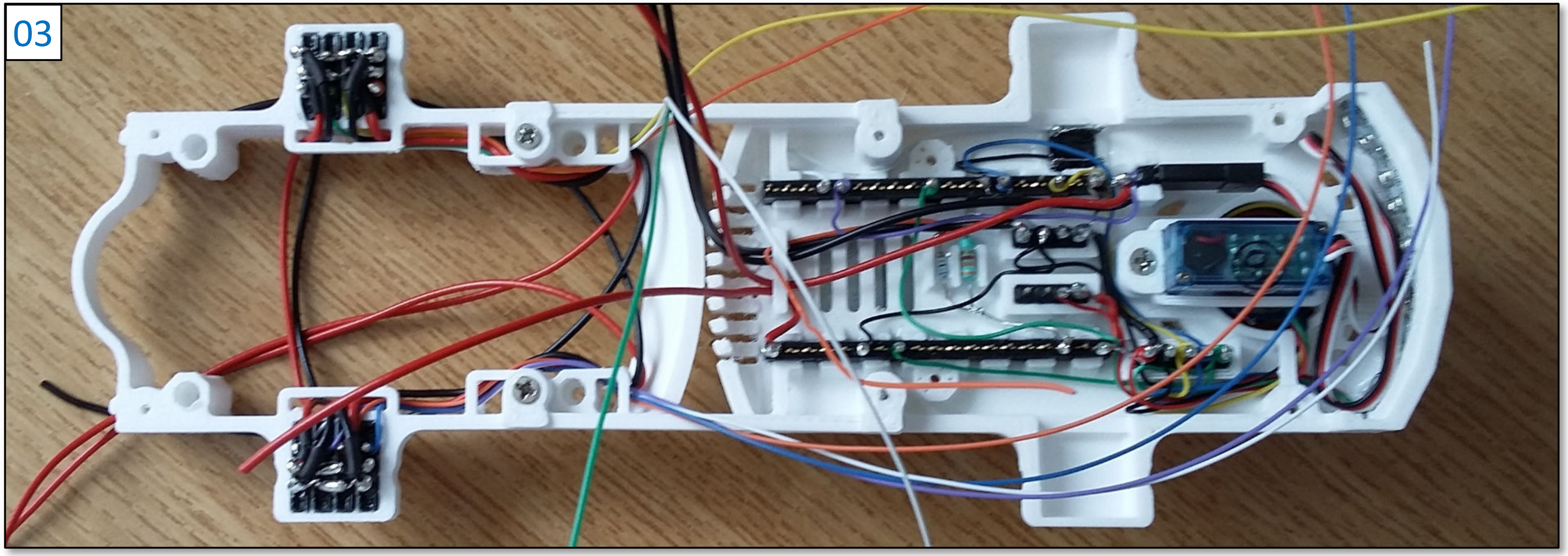


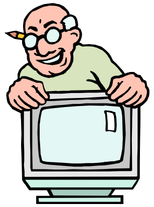
The servo PWM signals are wired to the ESP32 on the upper plate, whilst the power connections go to points on the base plate.

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.

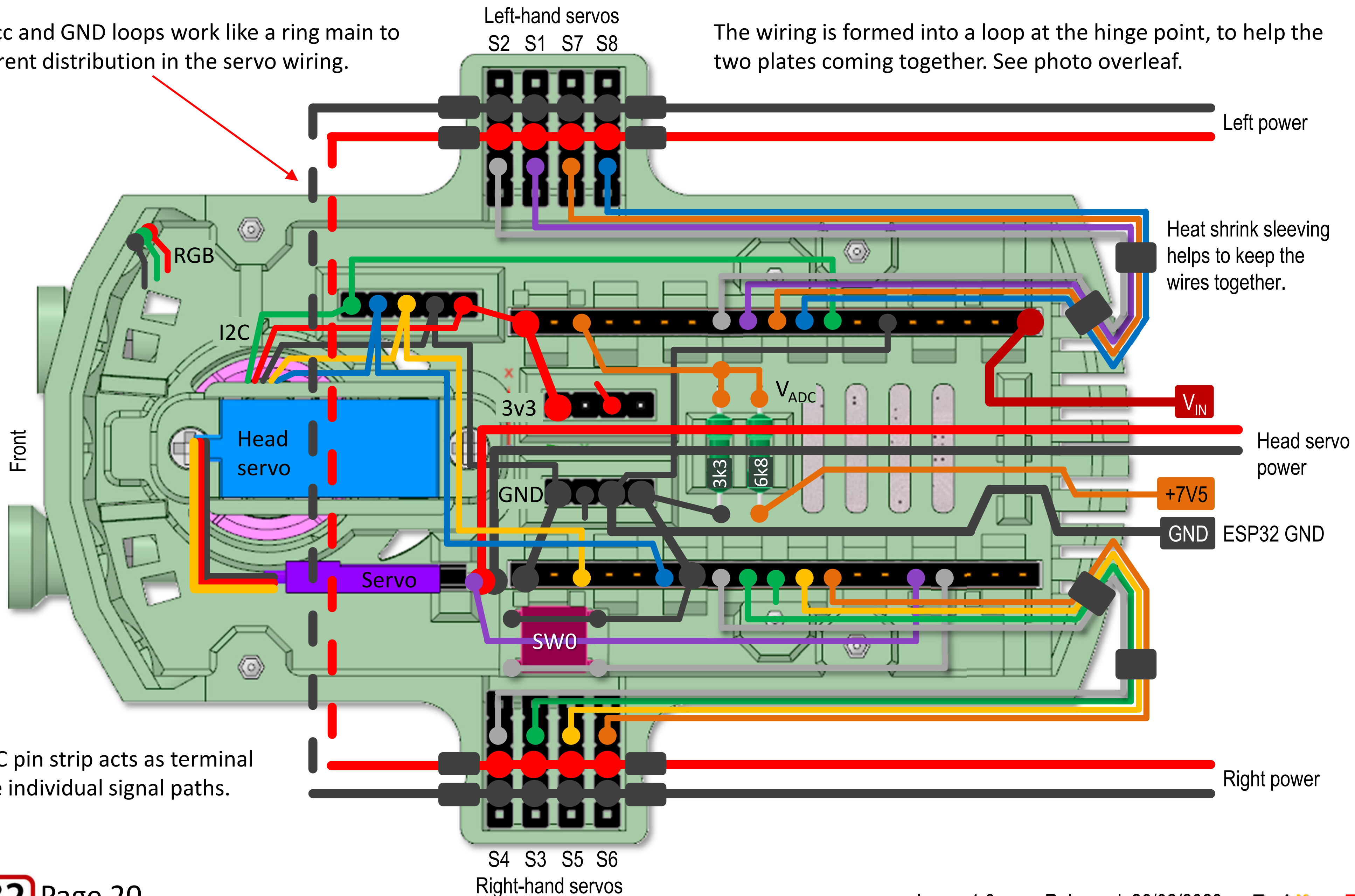
Upper/Middle Plate Wiring

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

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

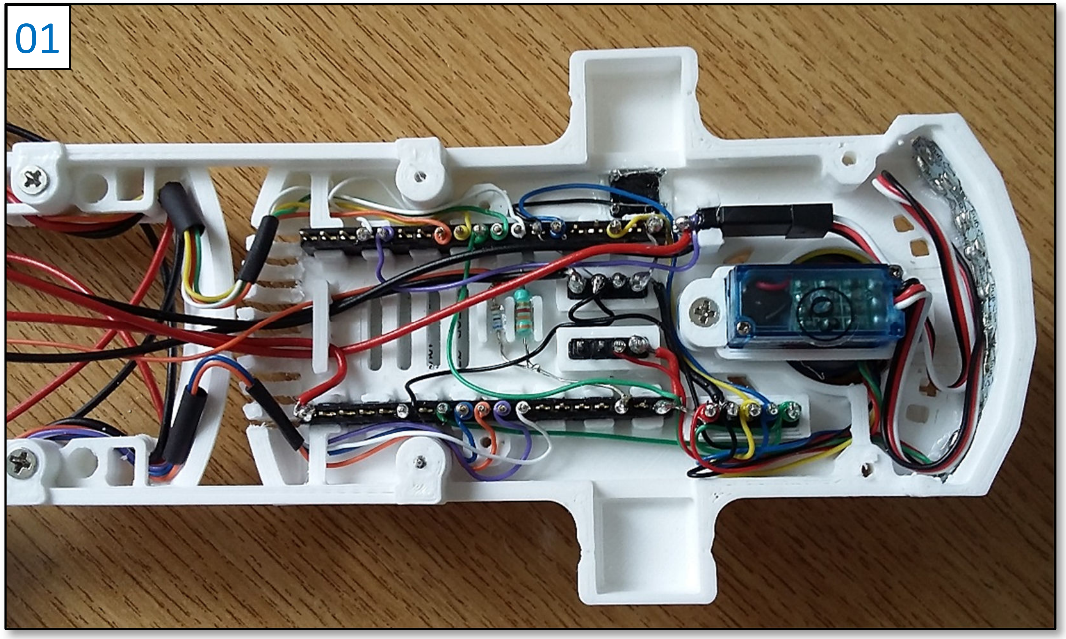
The servo Vcc and GND loops work like a ring main to improve current distribution in the servo wiring.

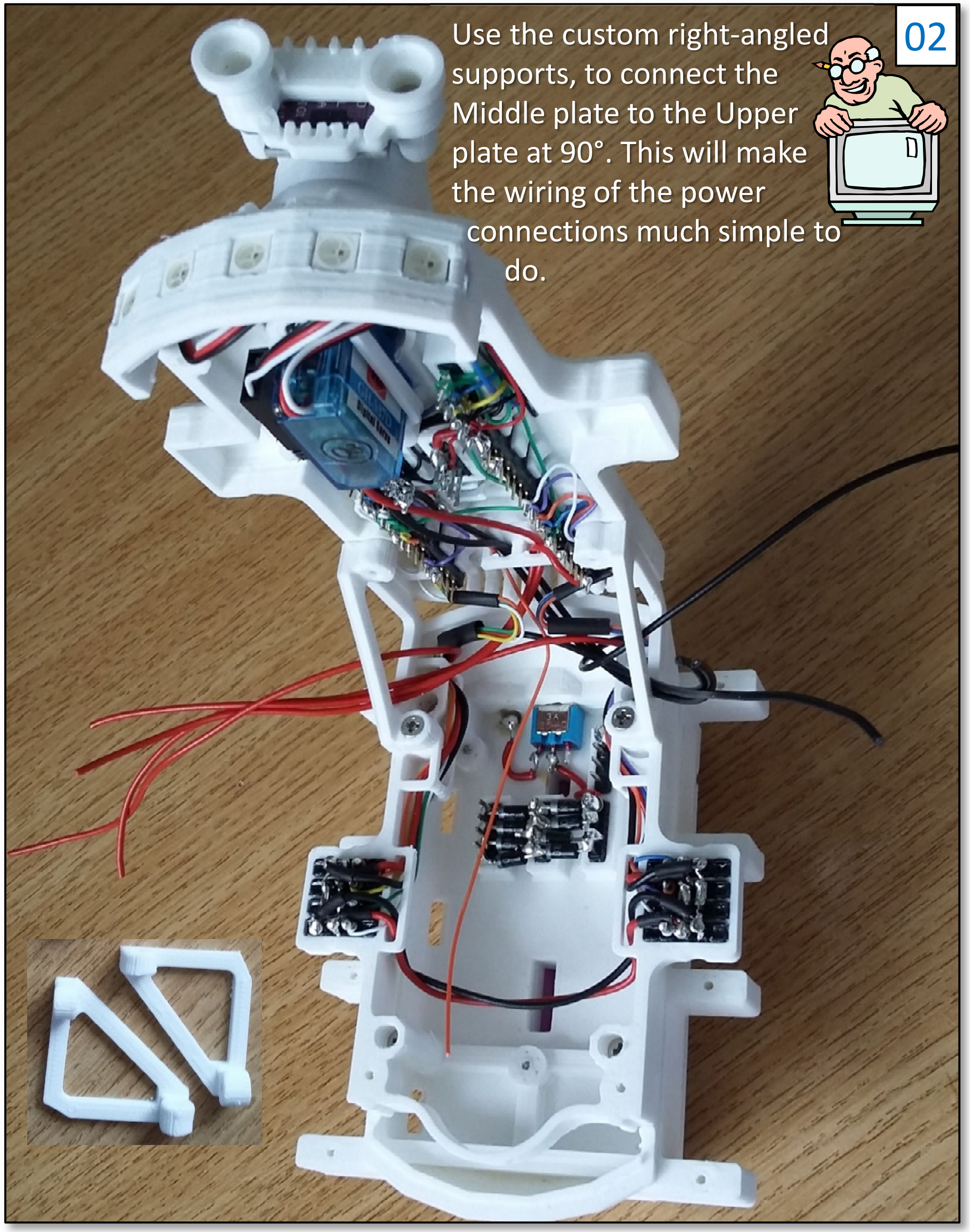
The wiring is formed into a loop at the hinge point, to help the two plates coming together. See photo overleaf.

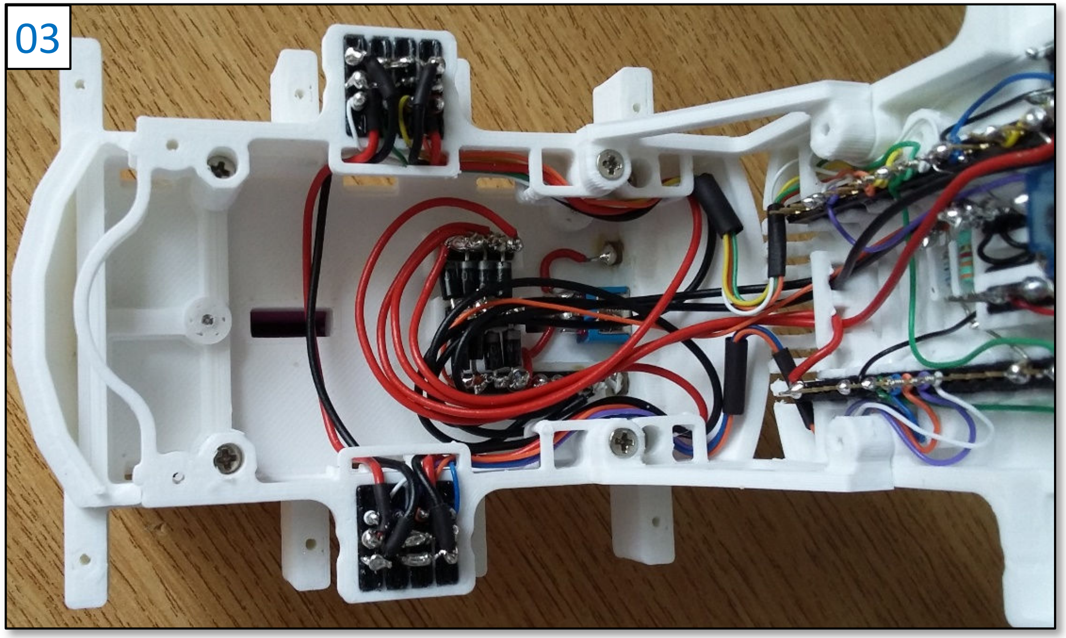


The 5-pin I2C pin strip acts as terminal posts for the individual signal paths.

Wiring Sequence

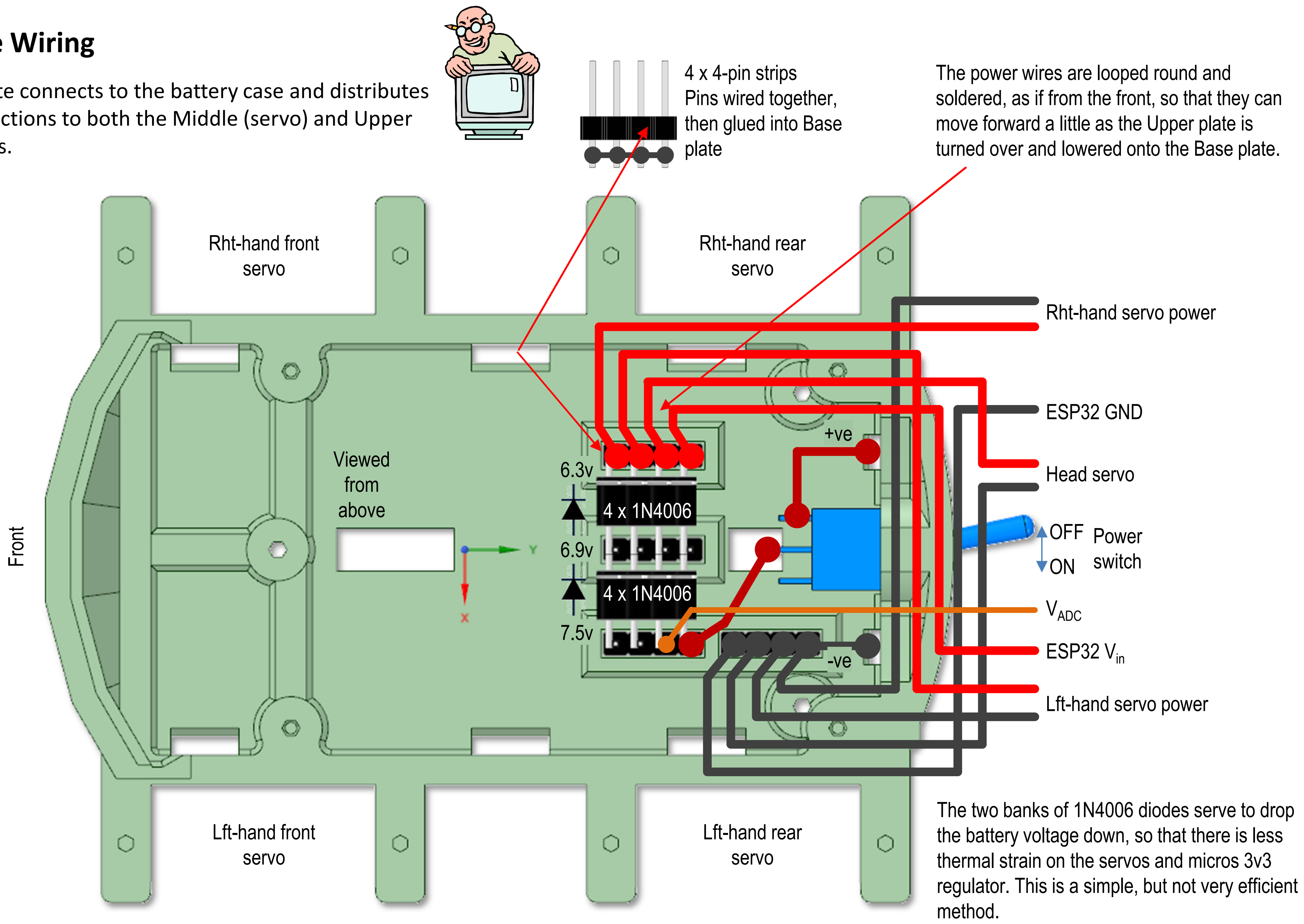






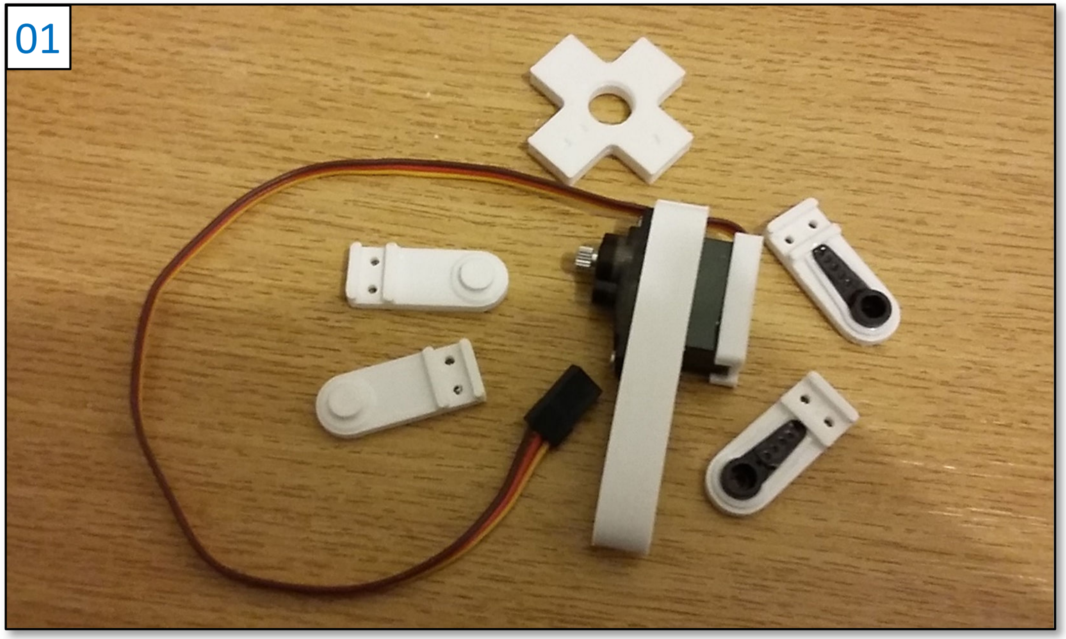
Base Plate Wiring

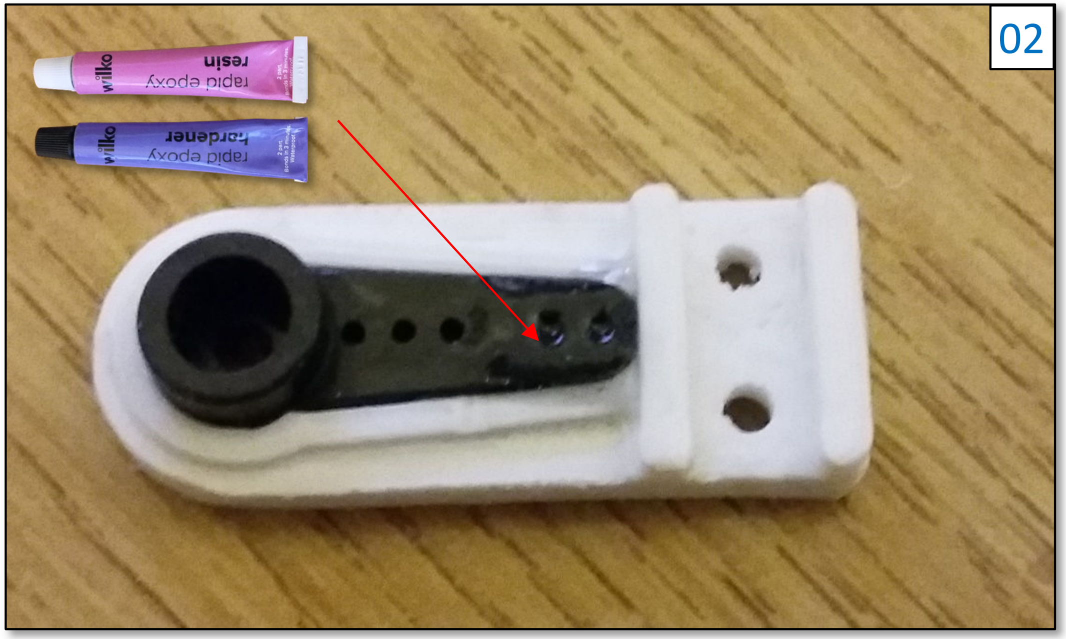
The Base plate connects to the battery case and distributes power connections to both the Middle (servo) and Upper (micro) plates.

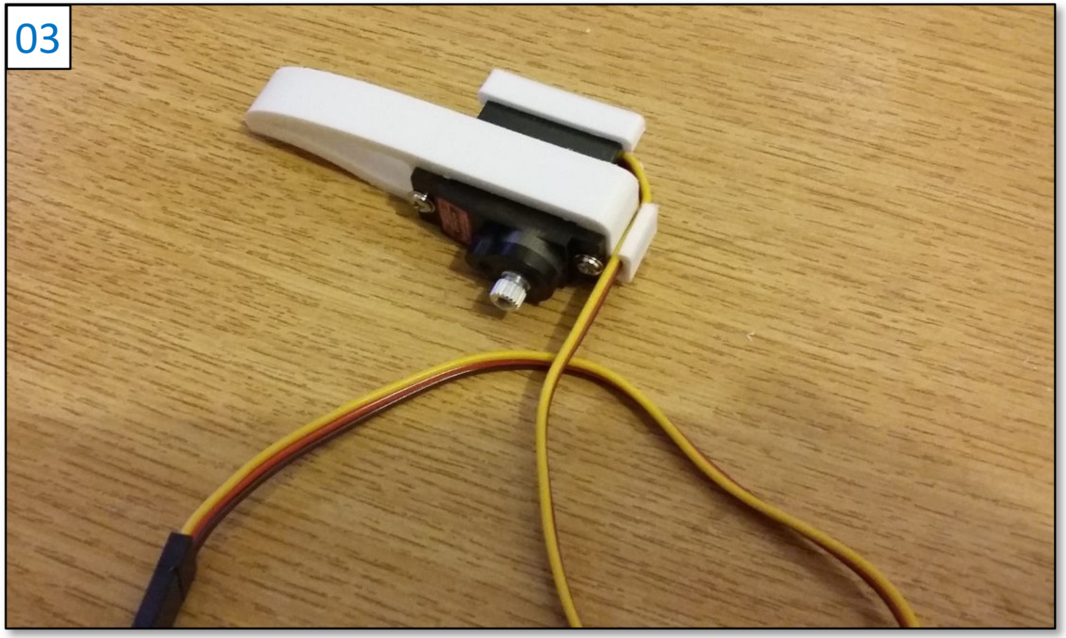


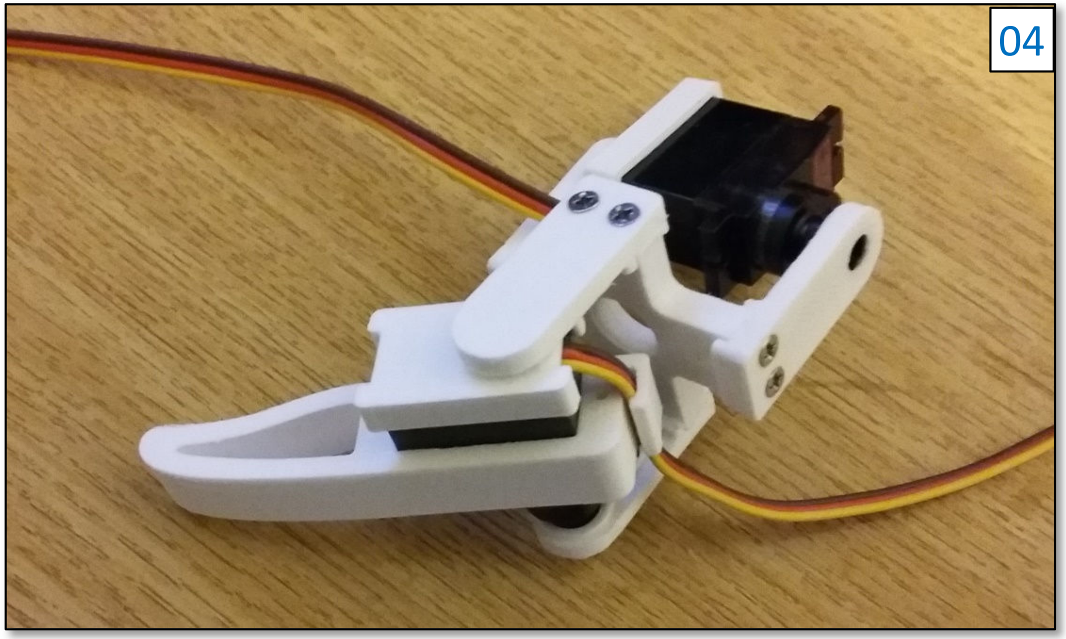
This is how the power connections to the Base plate will be completed.

Build Sequence Photos

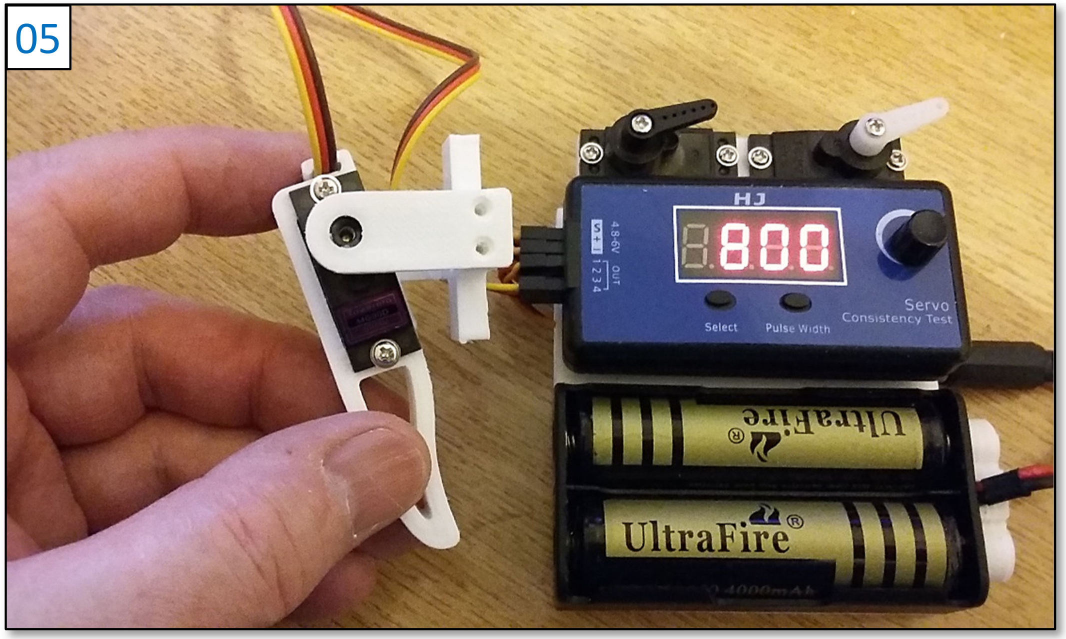


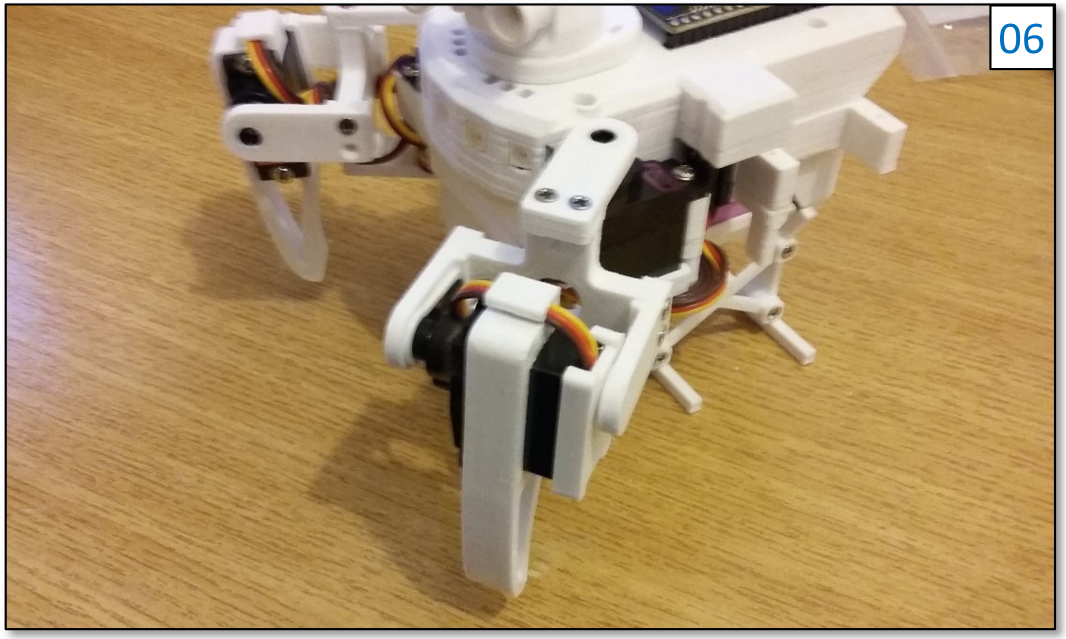


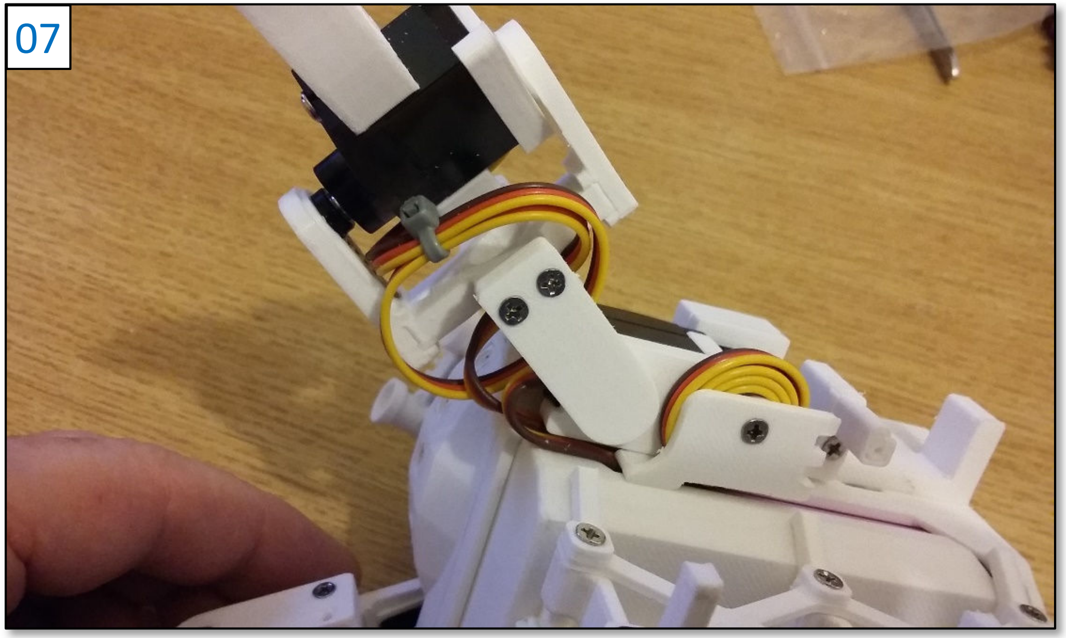


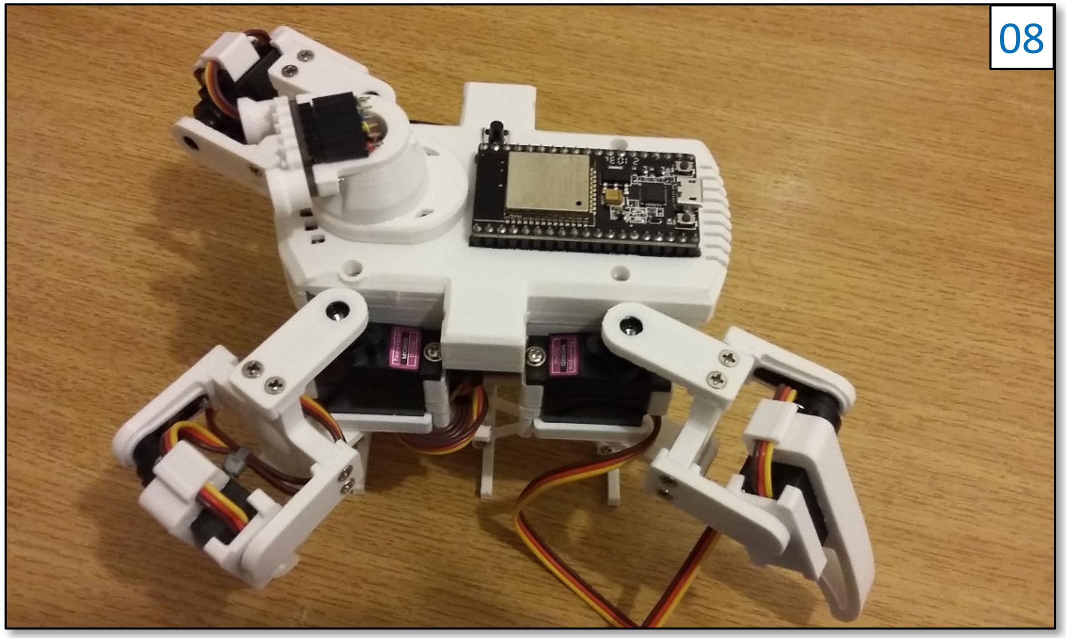


Build Sequence Photos

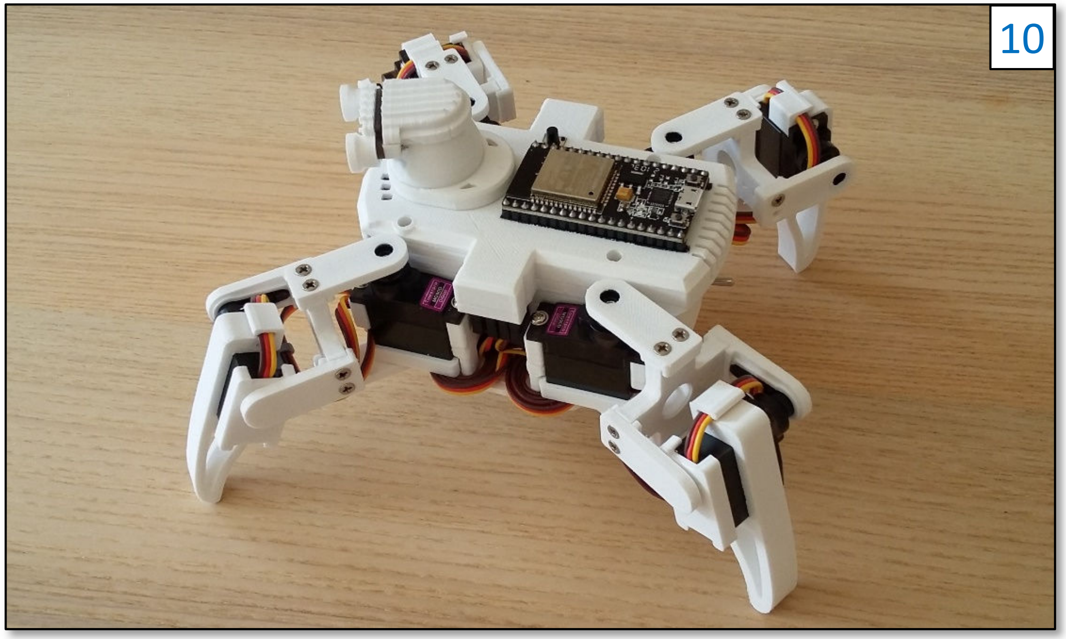


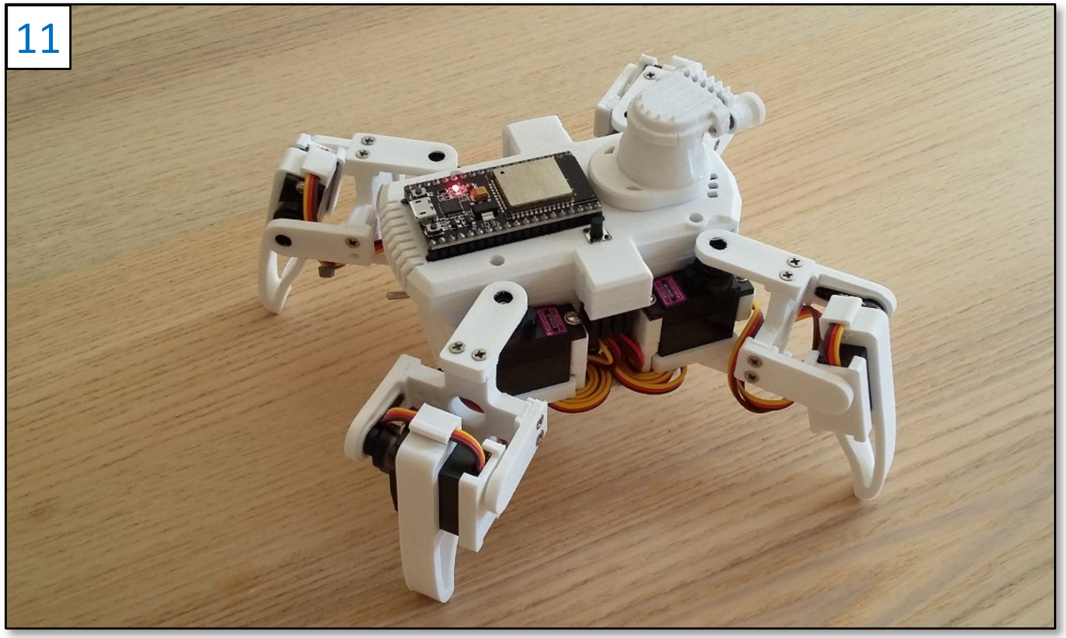


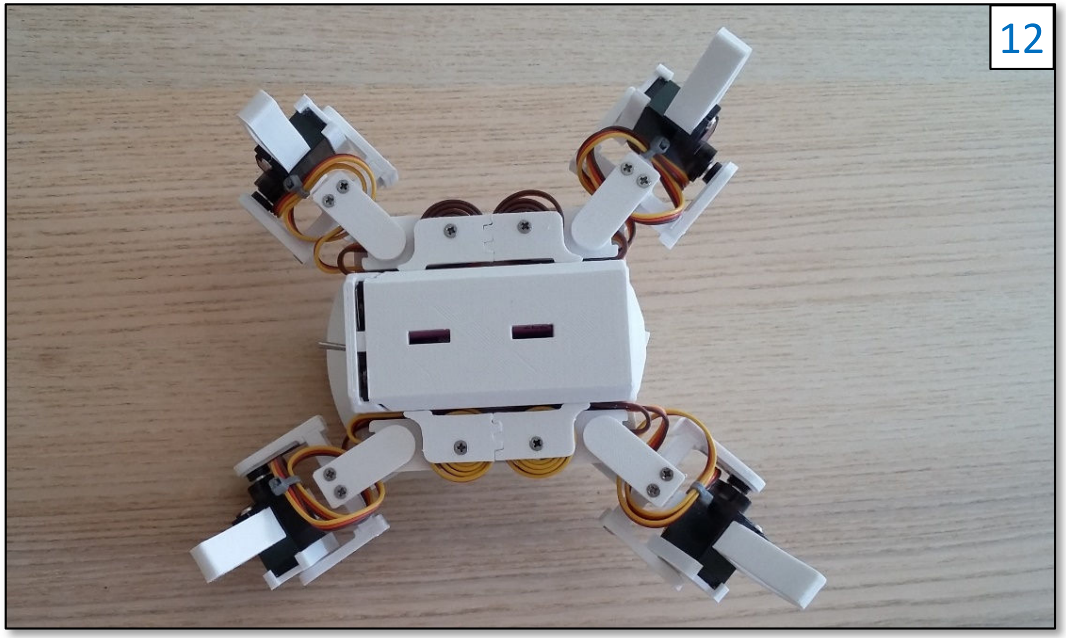




Build Sequence Photos

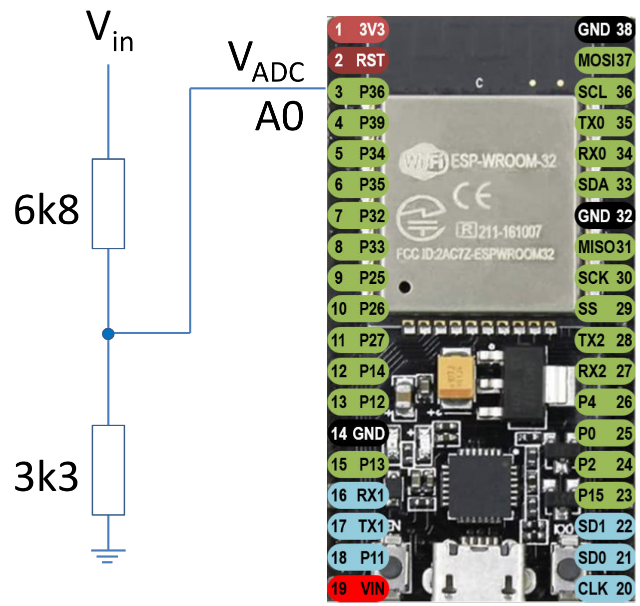






Battery Voltage Health Monitoring

See 18650 discharge curve obtained from the internet. In this analysis both batteries are identical and connected in series,
Assume fully charged batteries max voltage is V_{BM} >= 8.2v max
I measured my rechargeable PP3 at 8.65v when connected and ON.
Set battery warning point at V_B = 7.00v
Set battery critical point at V_{BC} = 6.60v



ESP32 is powered from batteries connected to V_{in}.
3.3v at VADC == 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
Using a Multimeter I determined the conversion factor needed to be reduced to 383.9 to display voltage correctly.

MAX: V_M = 8.2v, gives A0 = 3324 on ADC

WARNING: V_B = 7.0v, gives A0 = 2838on ADC

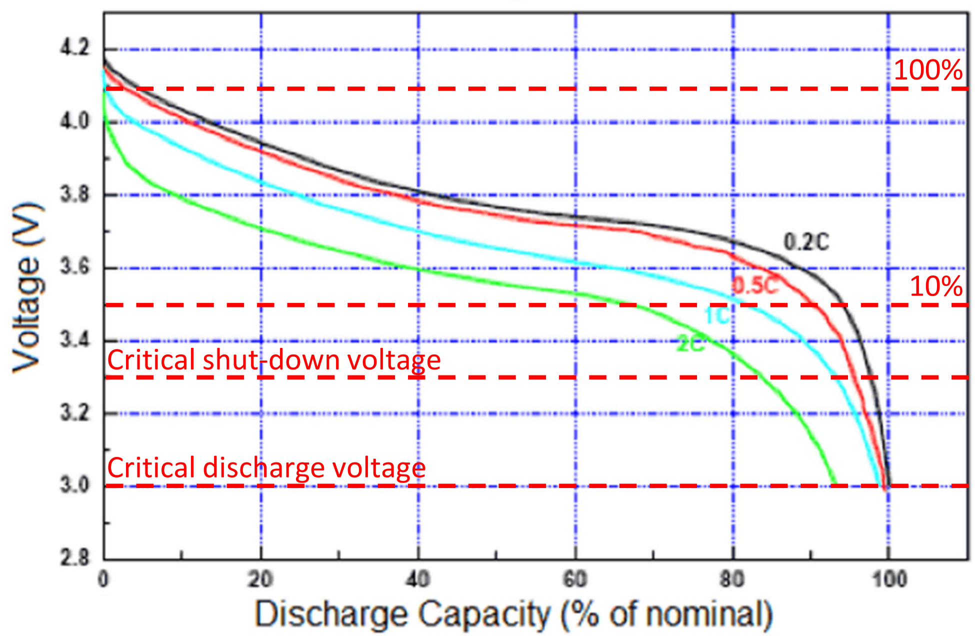
CRITICAL: V_{BC} = 6.6v, gives A0 = 2676 on ADC

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.

Given the relatively light current drawn I have assumed a linear discharge curve ranging from 8.2v (100%) to 6.6v (0%) capacity. The rate of discharge is monitored and used to actively 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.

18650 Lithium Battery
Discharge Profile



Discharge: 3.0V cutoff at room temperature.