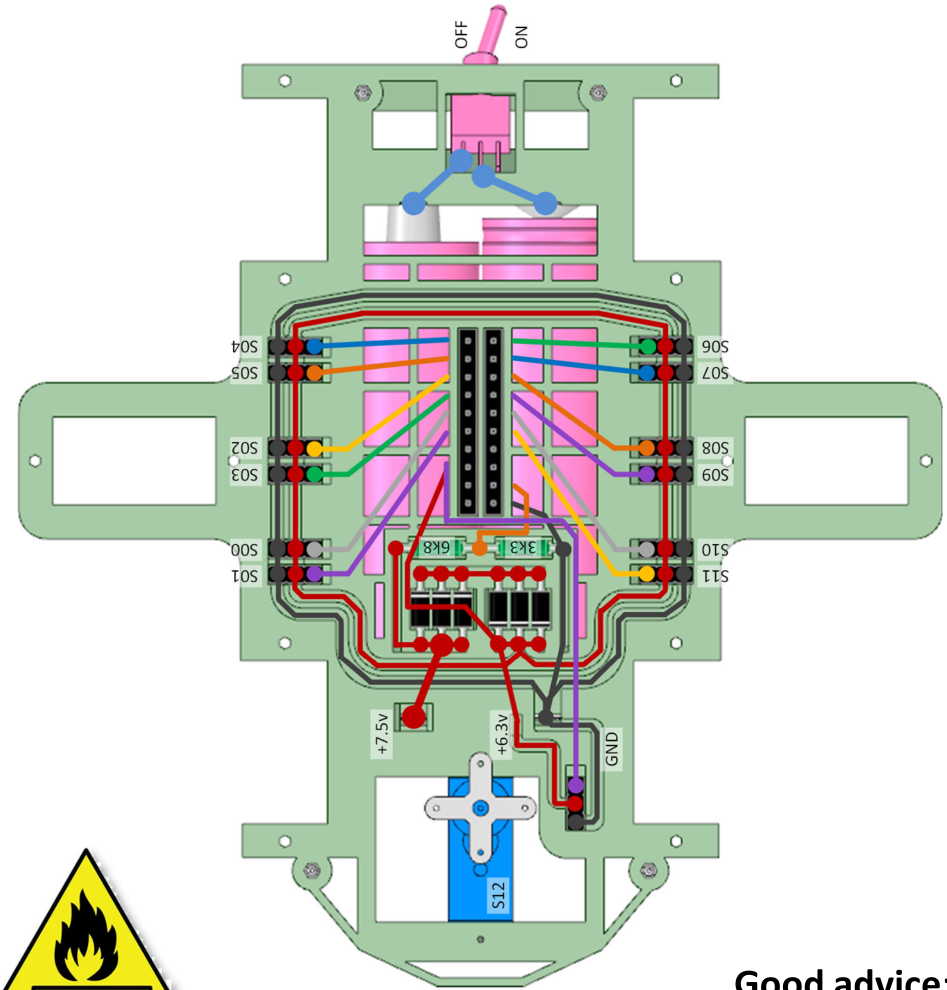
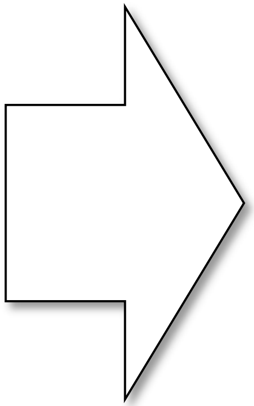
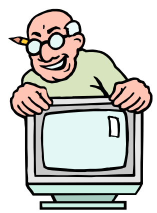
HexBot 2

Circuits & Wiring





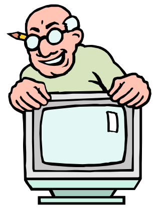
Good advice: read through the whole of this document before attempting this project.



CAUTION LITHIUM BATTERY

+ ESP32

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:

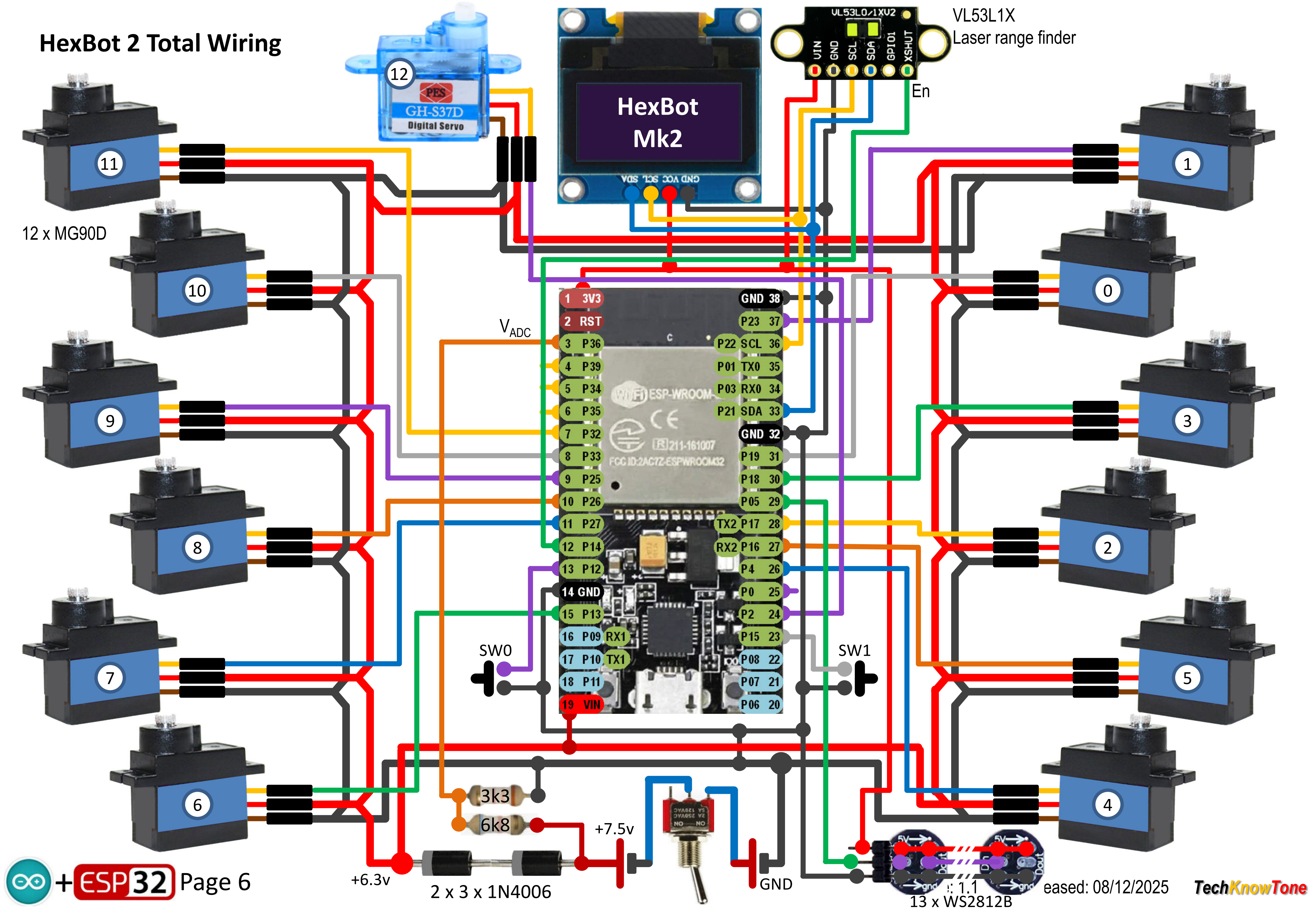
Temperature controlled iron
Solder flux
Resin cored solder
Hot melt glue gun {optional)
2-part epoxy resin glue
Screw drivers
Tweezers
Wire wrapping tool
Wire wrapping wire 30 AWG
24 AWG stranded wire (red, black & yellow)
Multimeter

Special Tools

Hot air gun for heat shrink sleeving
Ratchet crimping tool + 2.54mm female connectors

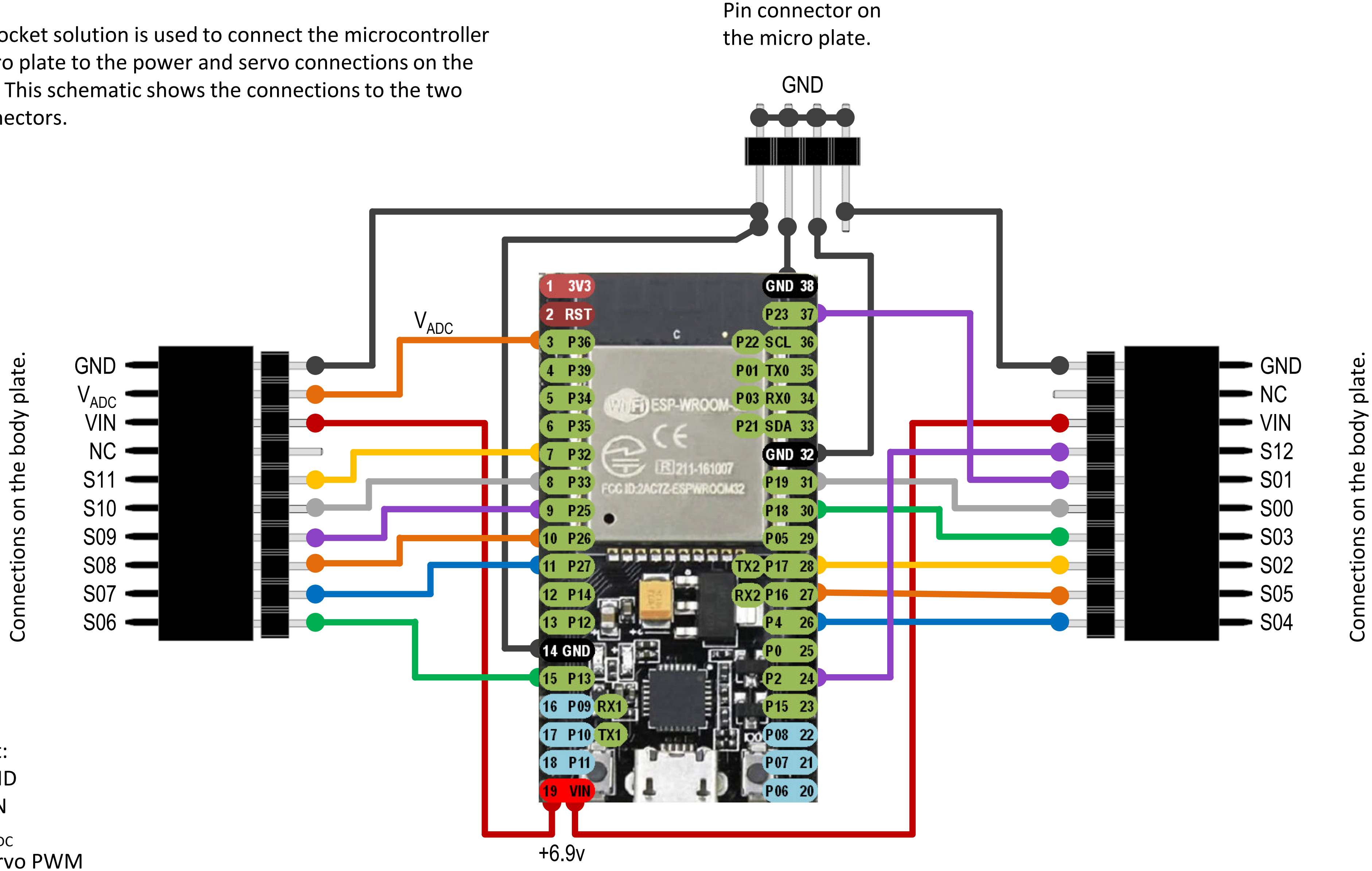
Watch videos on the internet to learn how to best use this tool, <u>before</u> attempting to shorten the servo leads.

HexBot 2 Total Wiring



HexdBot 2 Control Wiring

A pin and socket solution is used to connect the microcontroller on the micro plate to the power and servo connections on the body plate. This schematic shows the connections to the two 10 pin connectors.

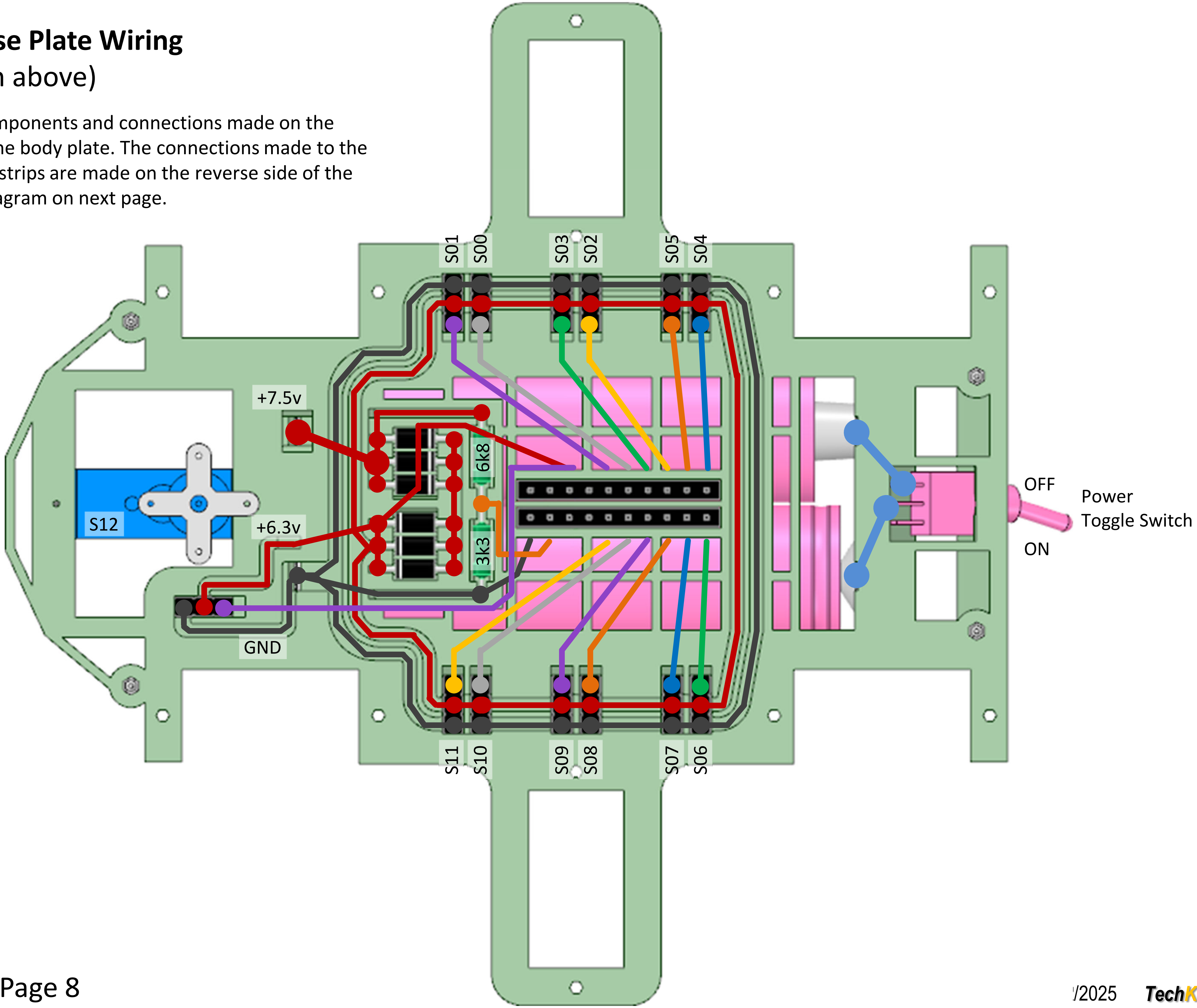


Pin count:

2	GND
2	VIN
1	V_{ADC}
13	Servo PWM

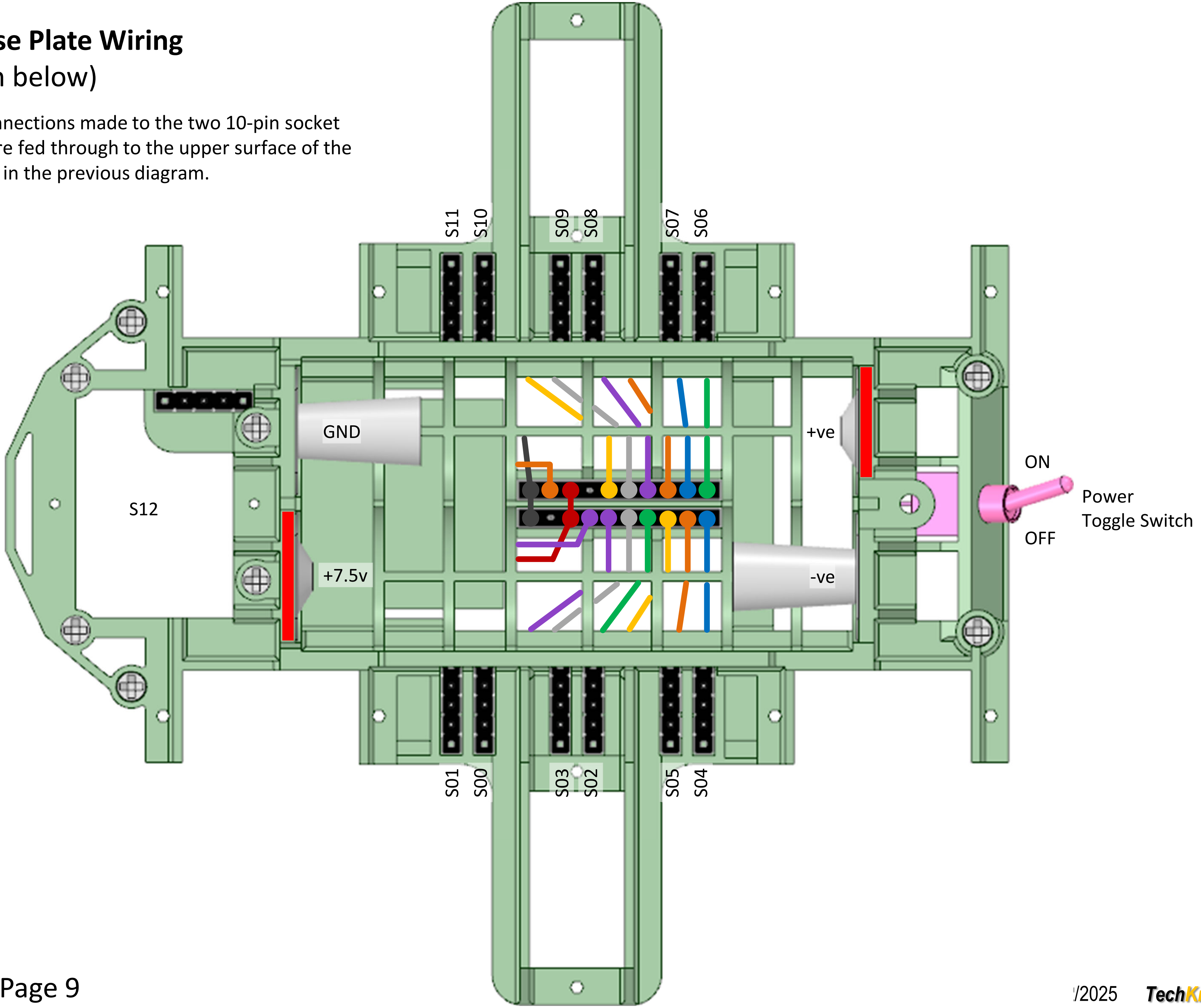
HexBot 2 Base Plate Wiring
(viewed from above)

This shows the components and connections made on the upper surface of the body plate. The connections made to the two 10-pin socket strips are made on the reverse side of the body plate. See diagram on next page.



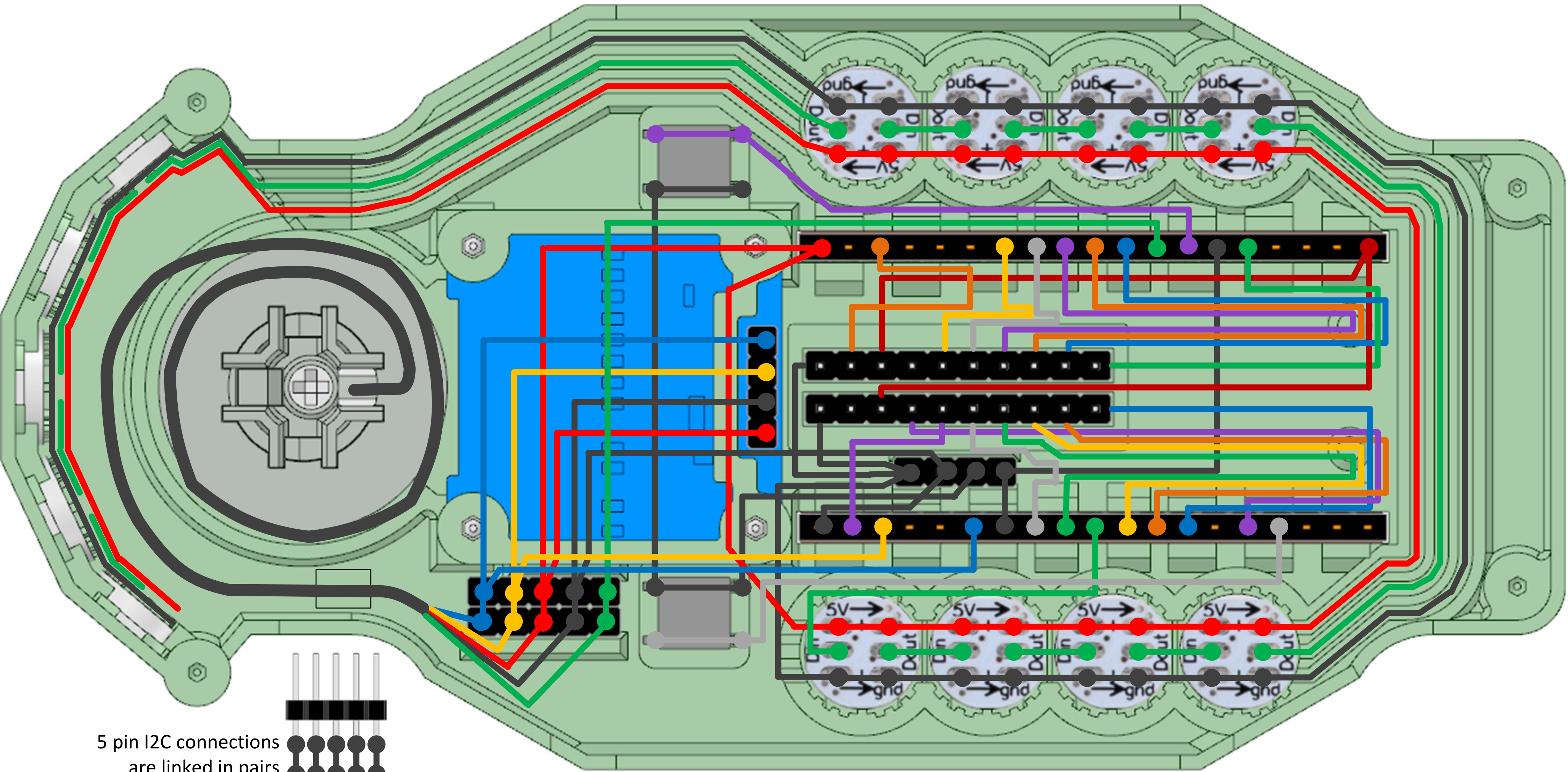
HexBot 2 Base Plate Wiring
(viewed from below)

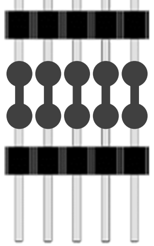
This shows the connections made to the two 10-pin socket strips. The wires are fed through to the upper surface of the body plate, shown in the previous diagram.



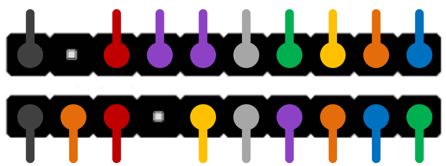
HexBot 2 Micro Plate Wiring
(viewed from below)

Note that the wiring for the centre floating 20 pin connector are longer than shown in some cases, and all are looped back towards the rear of the robot. This gives the floating connector scope for movement, and makes it much easier to insert this pin connector into the base plate sockets during final assembly. See photos to follow.

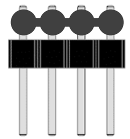




5 pin I2C connections are linked in pairs before gluing in

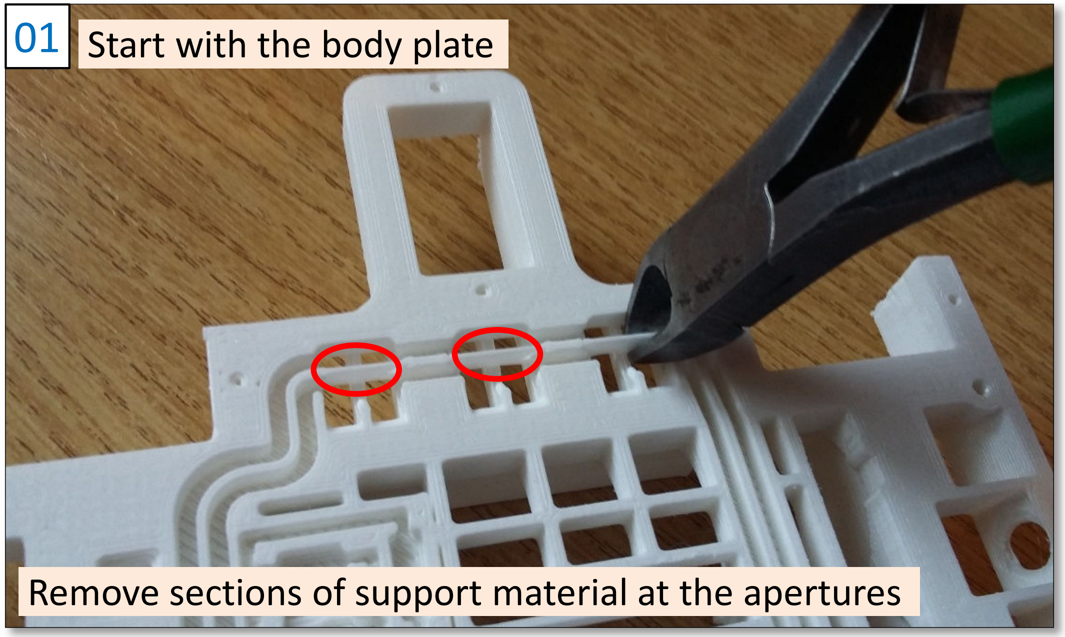


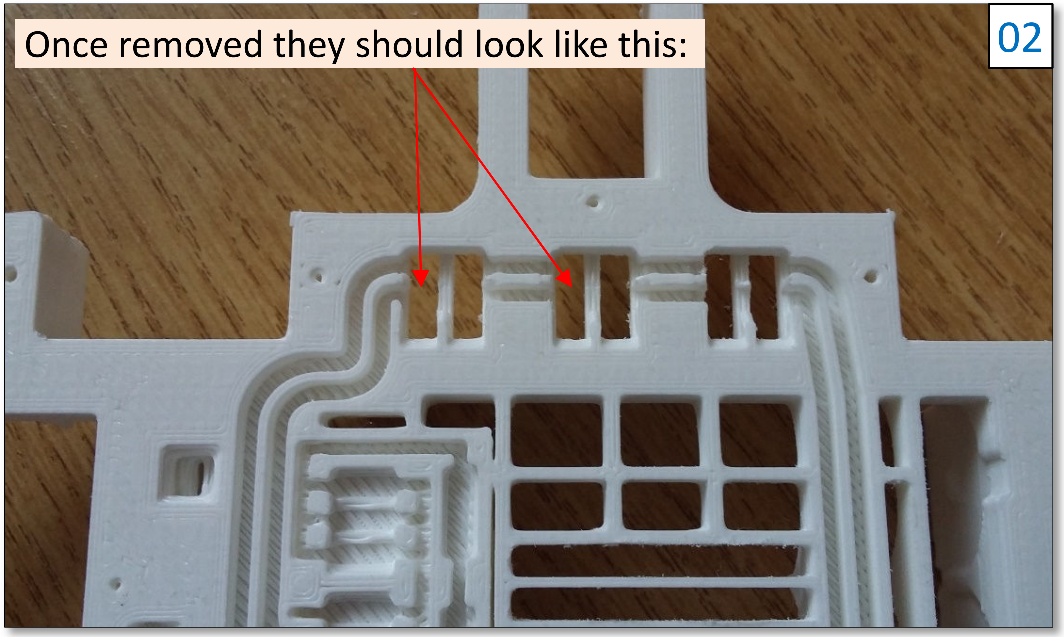
20 pin floating pin strip viewed from above

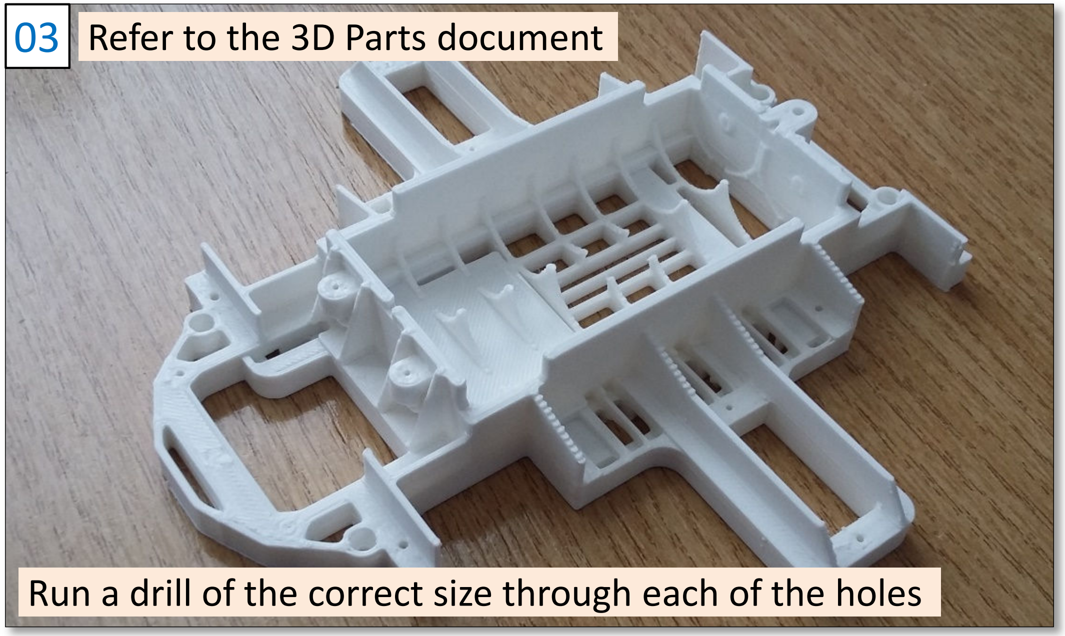


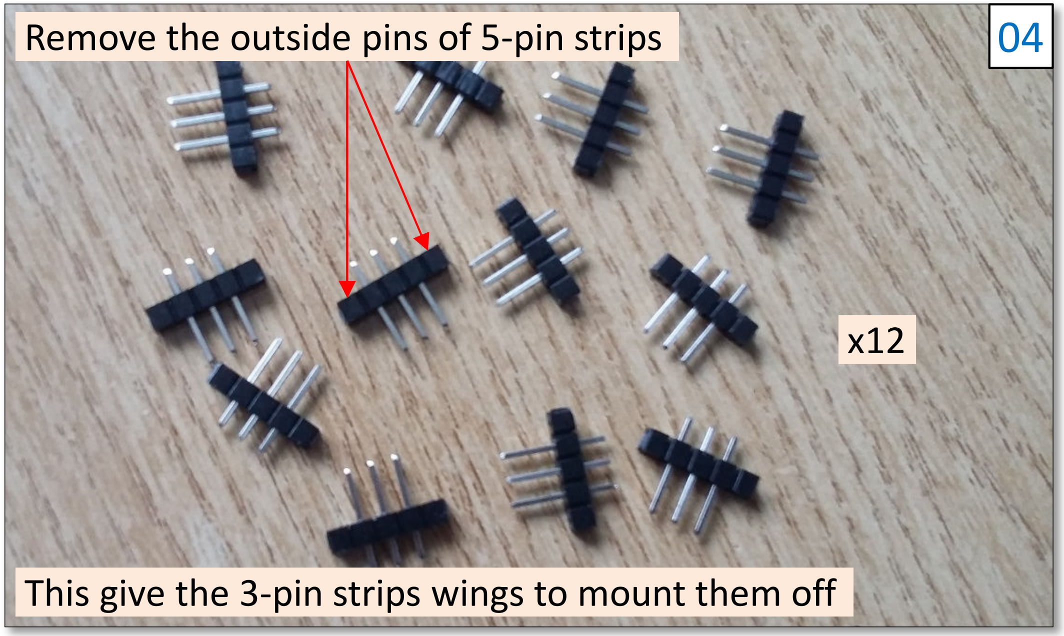
GND pins are linked together before gluing in

Wiring Sequence

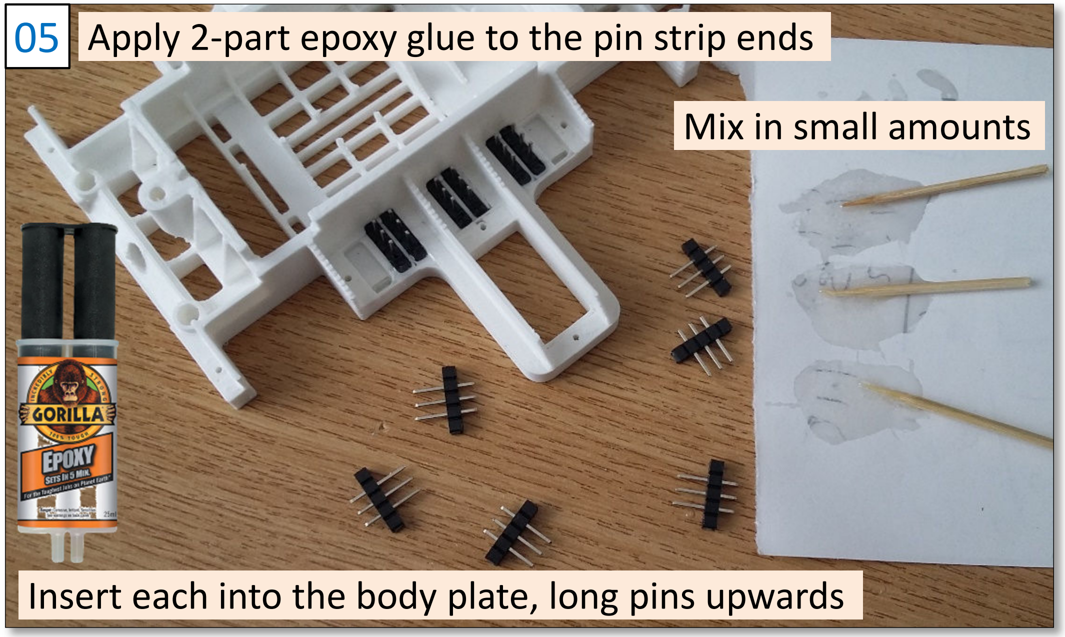


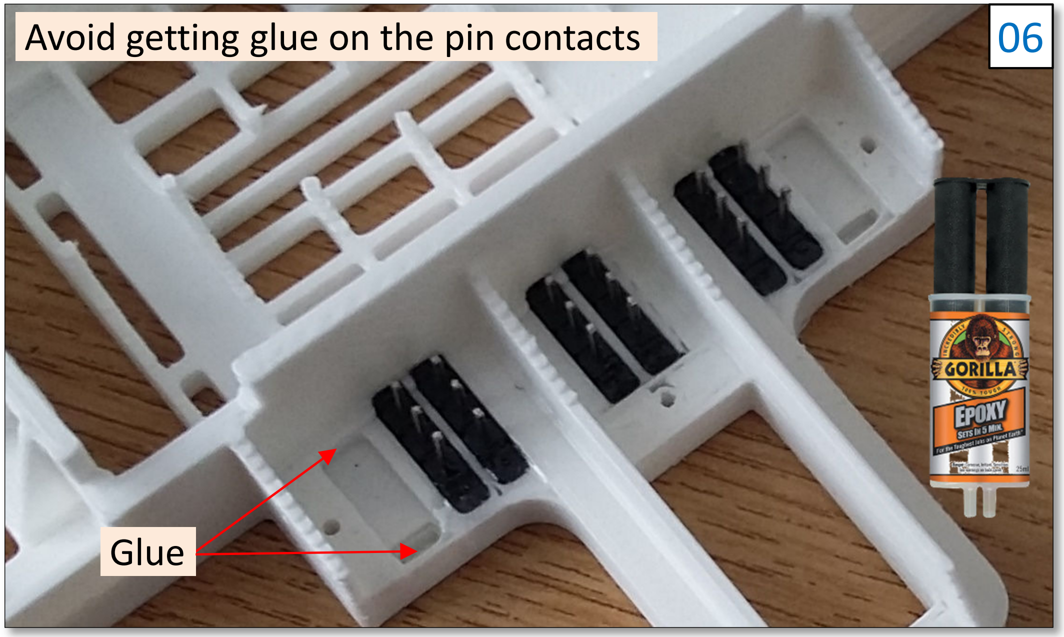


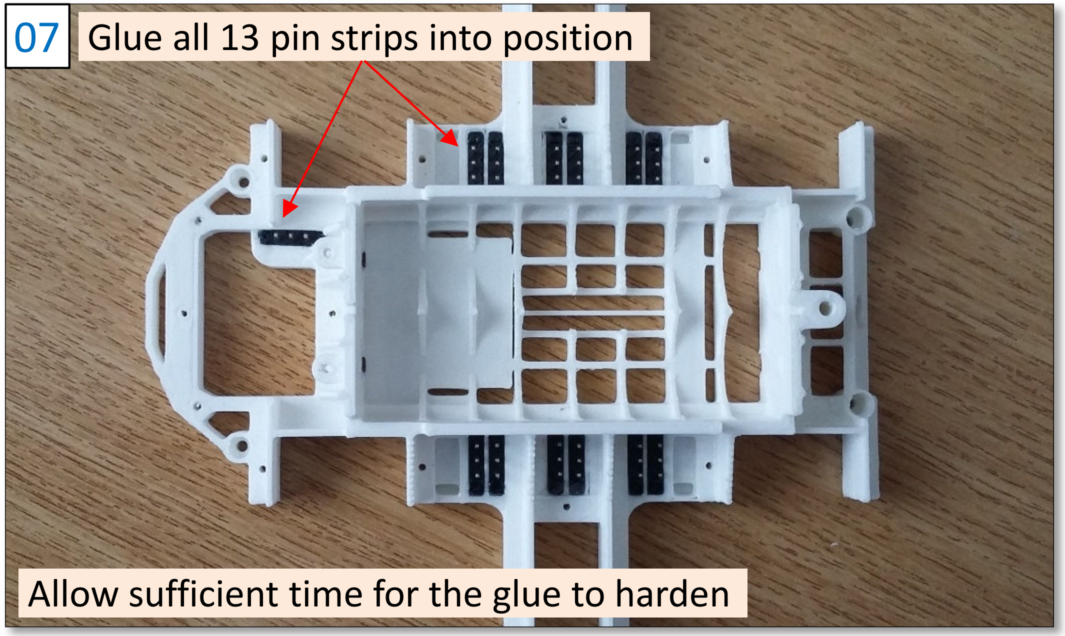


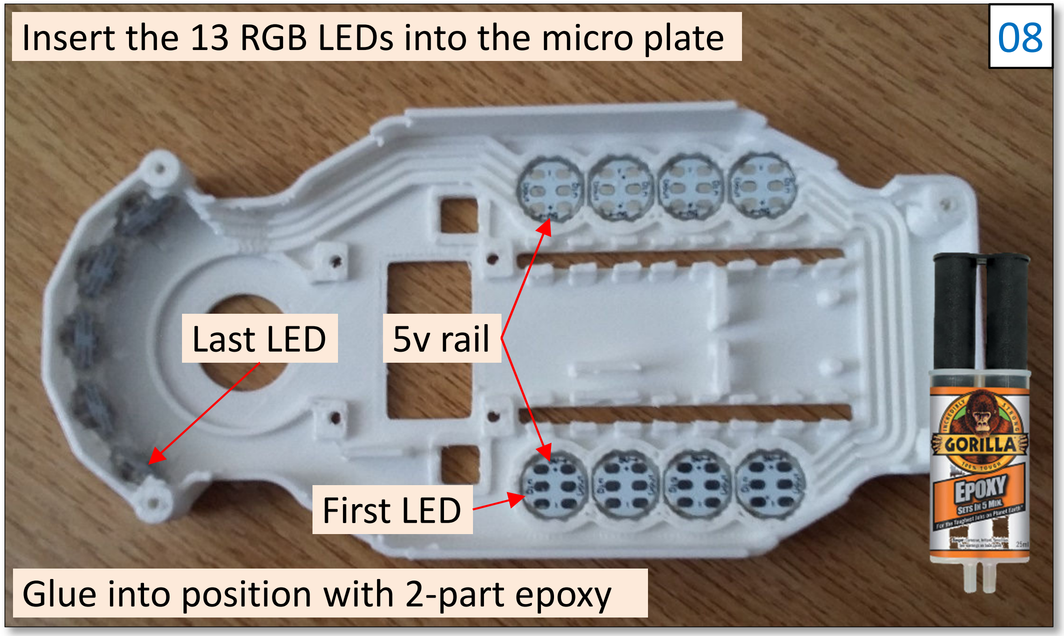


Wiring Sequence



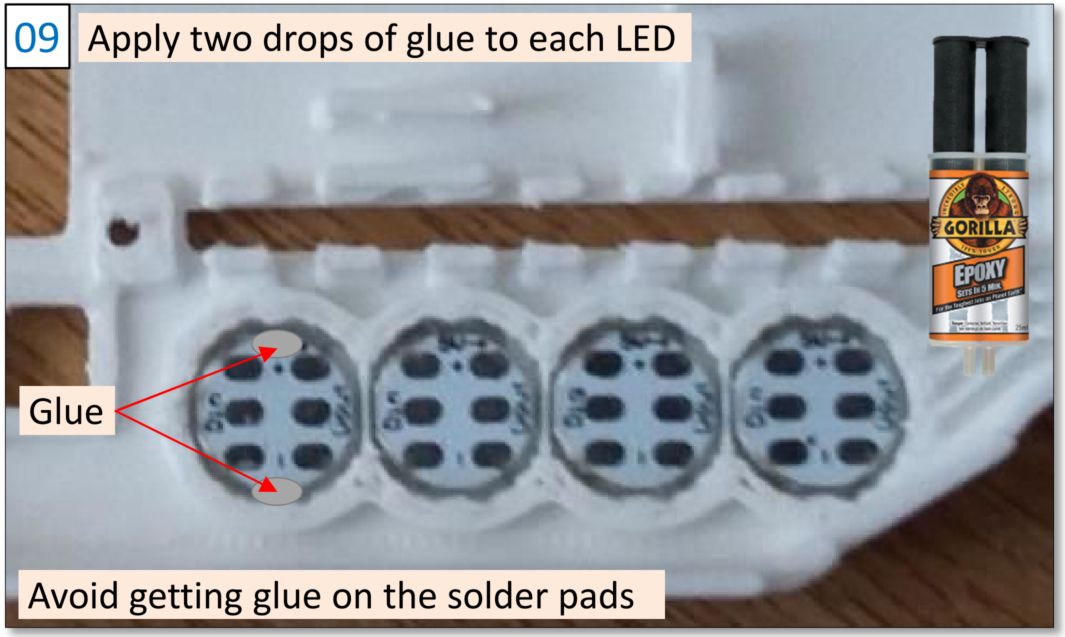






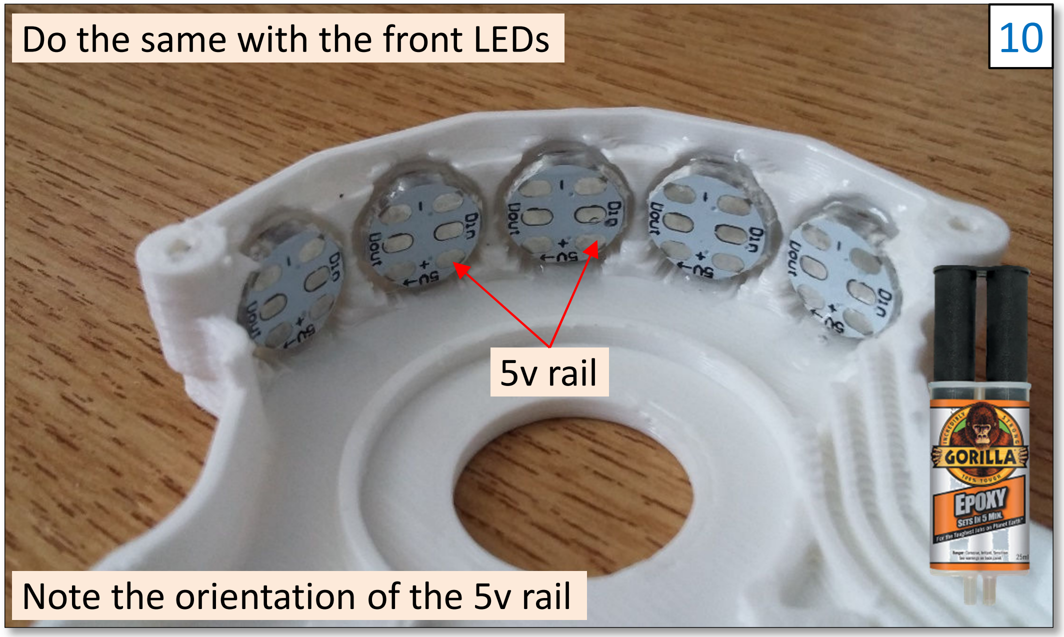
Wiring Sequence

09 Apply two drops of glue to each LED



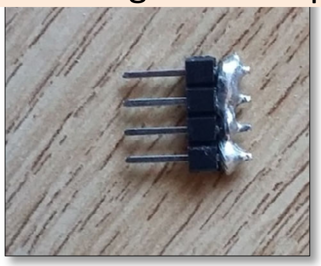
Avoid getting glue on the solder pads

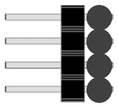
10 Do the same with the front LEDs



Note the orientation of the 5v rail

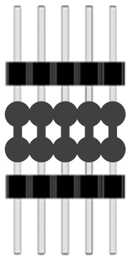
11 Wire together the pins of the 4-pin strip





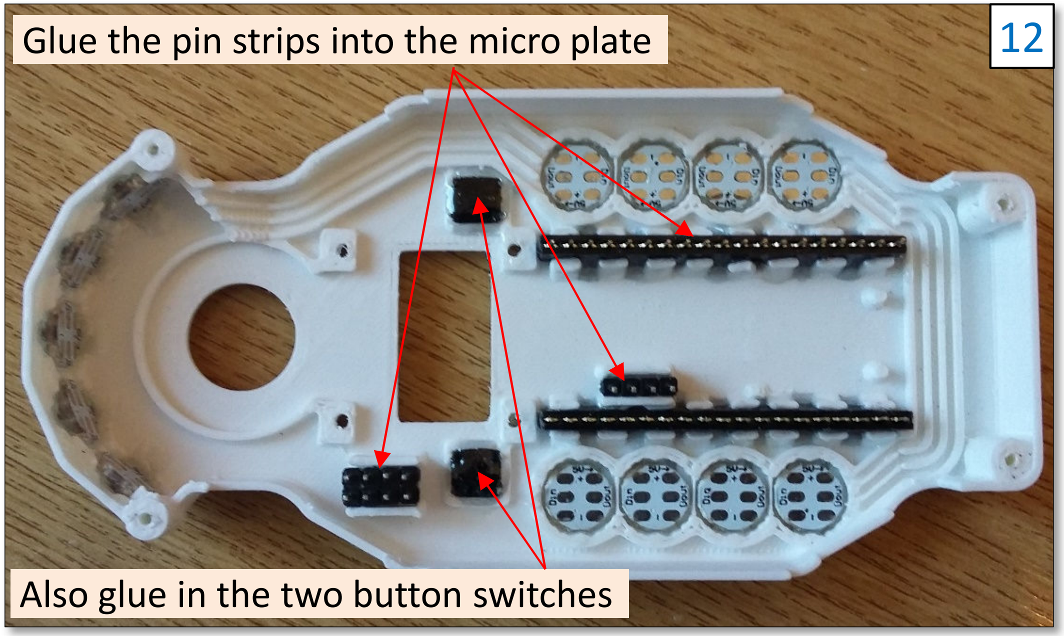
This is the common GND connection point

This is the I2C connection point



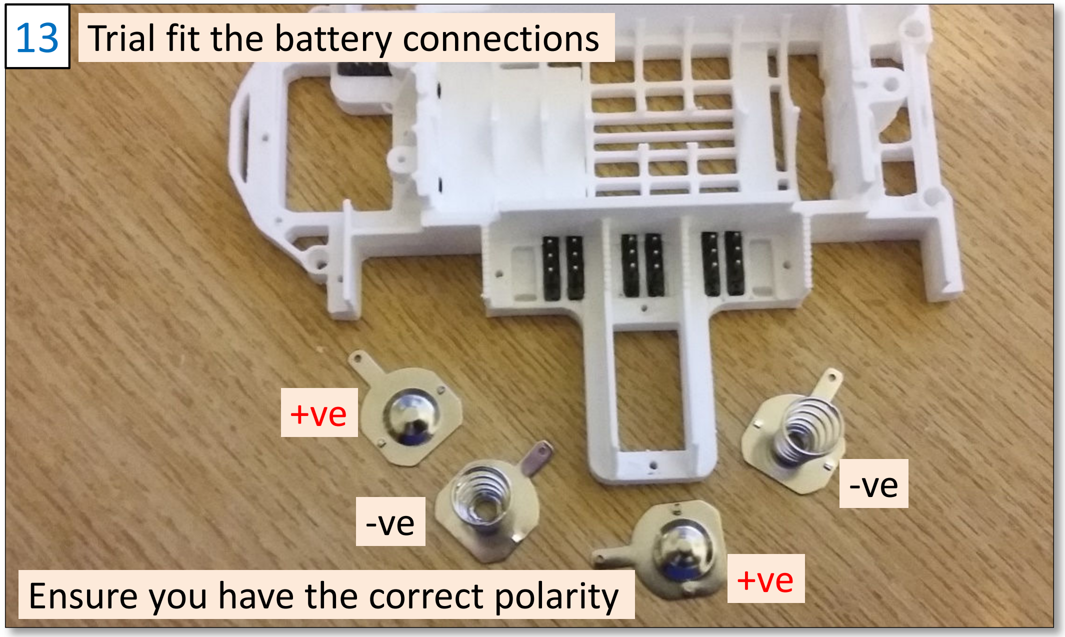
Wire together pairs of the 2 x 4-pin strip

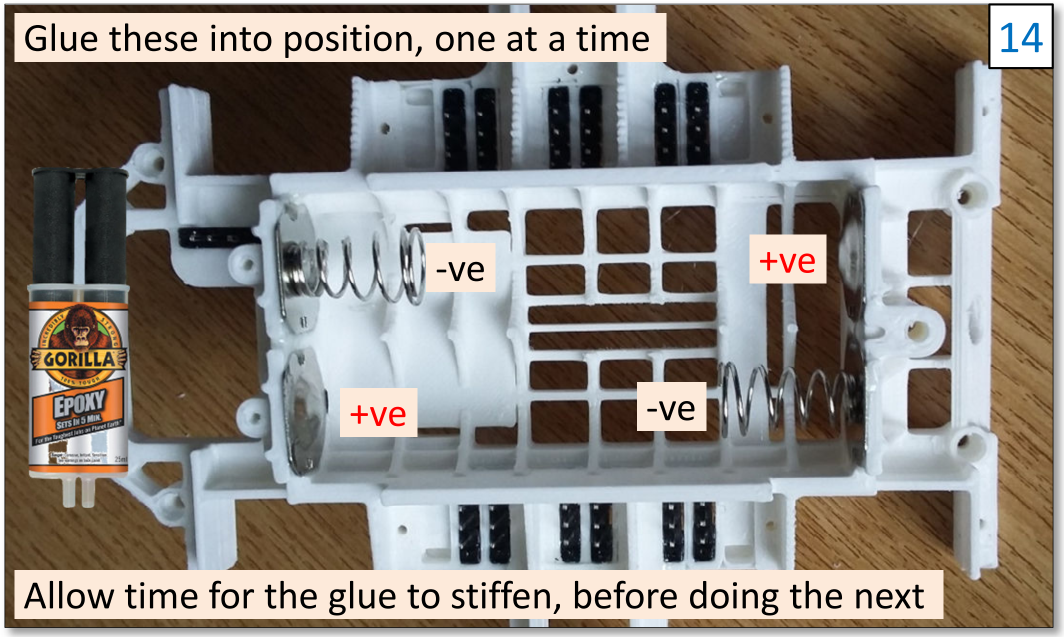
12 Glue the pin strips into the micro plate

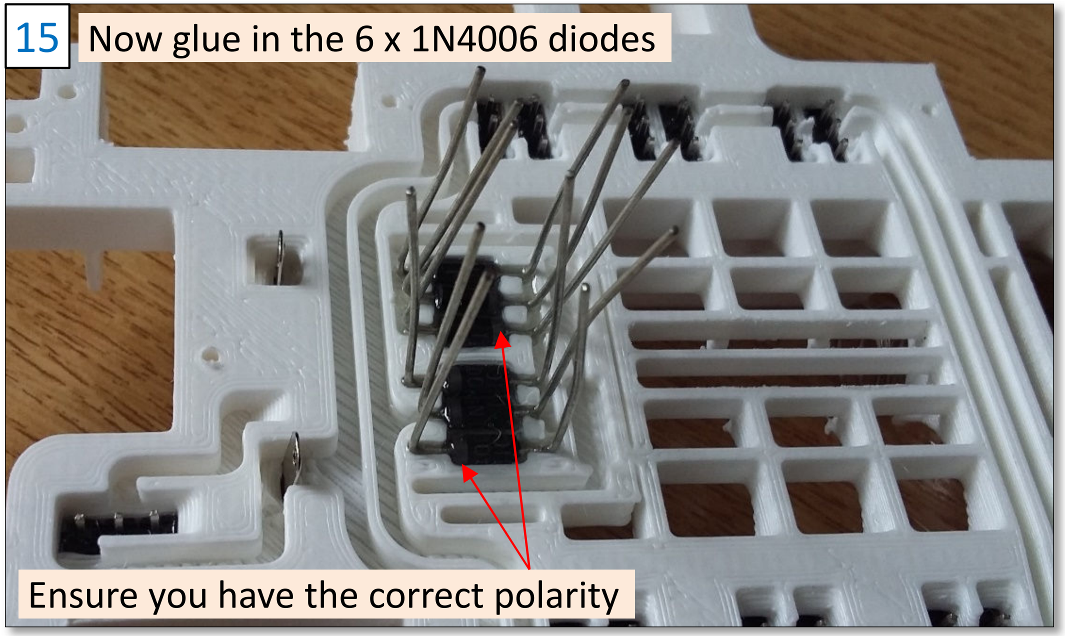


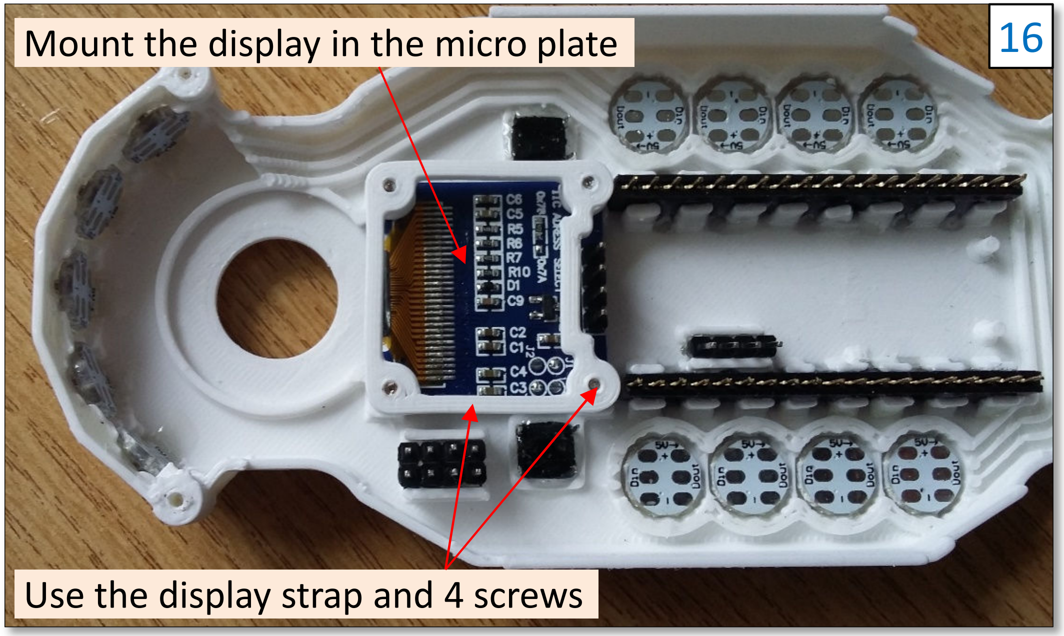
Also glue in the two button switches

Wiring Sequence

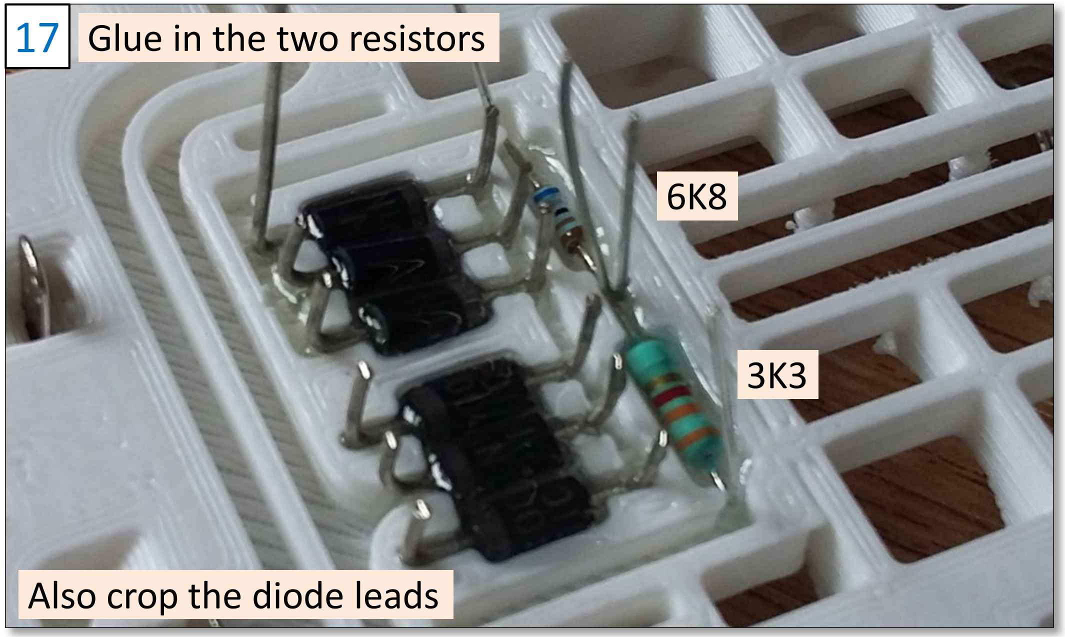


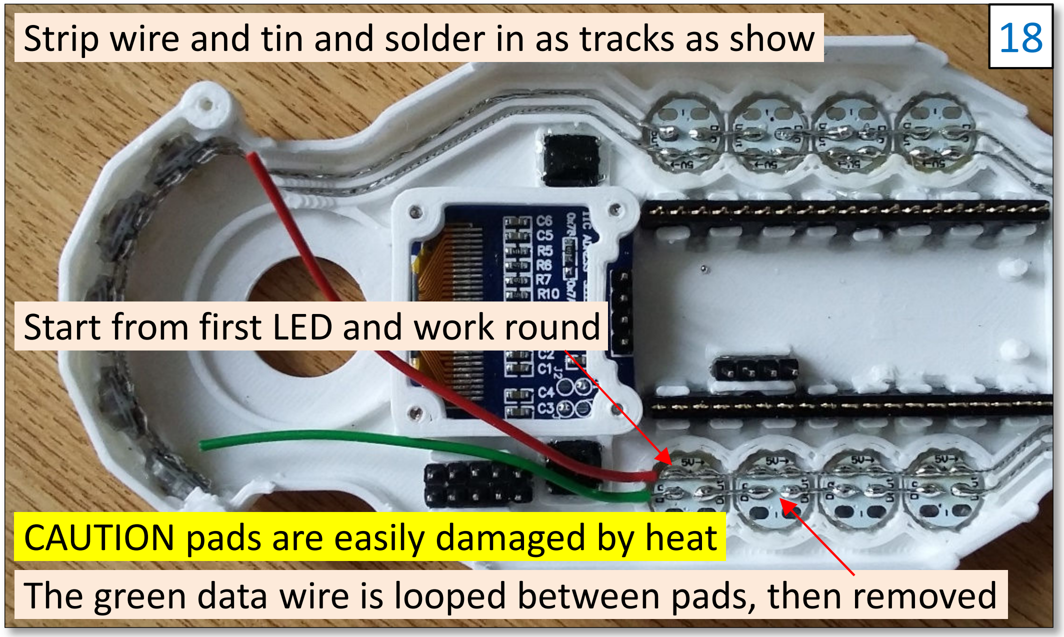


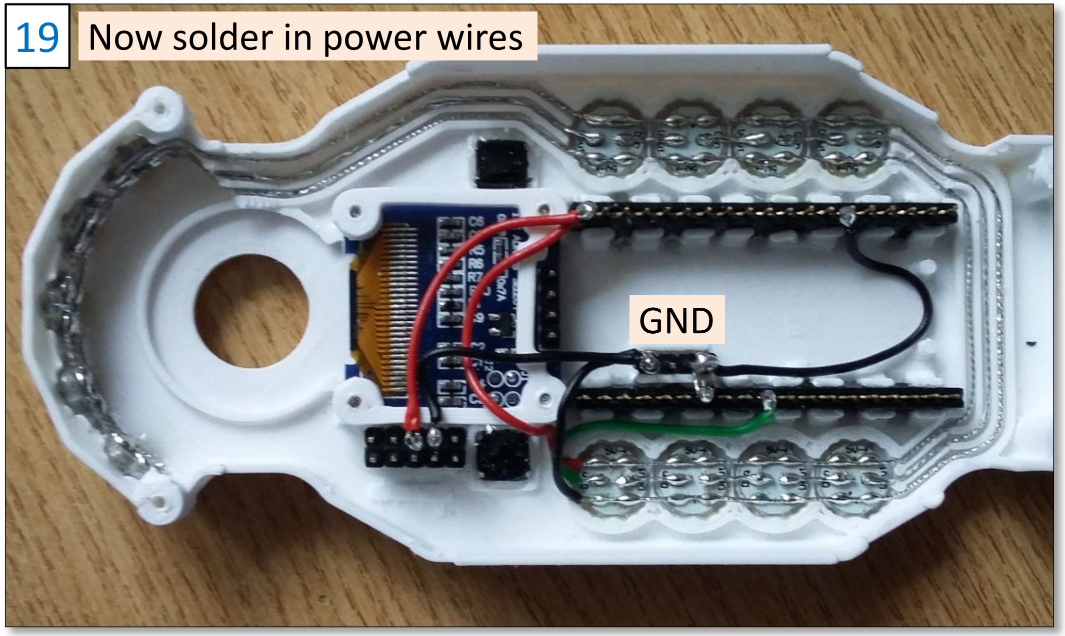


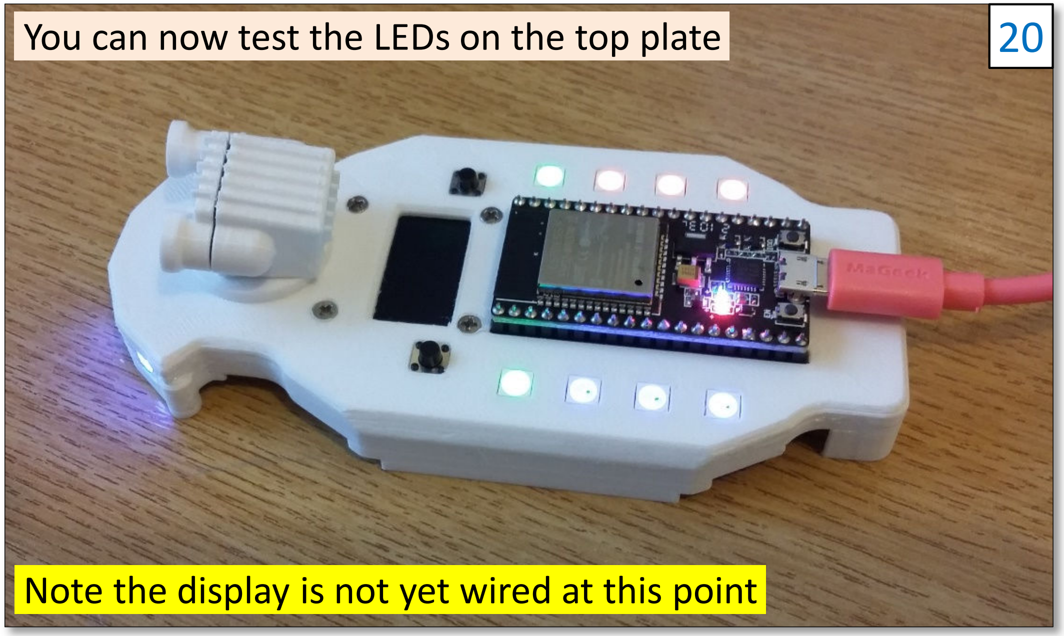


Wiring Sequence

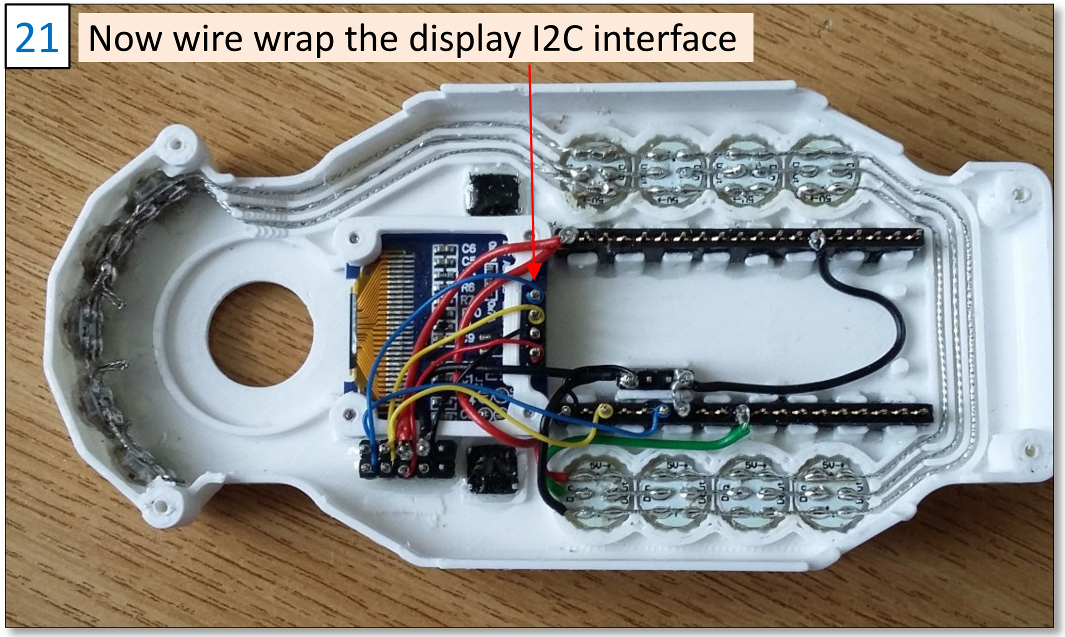


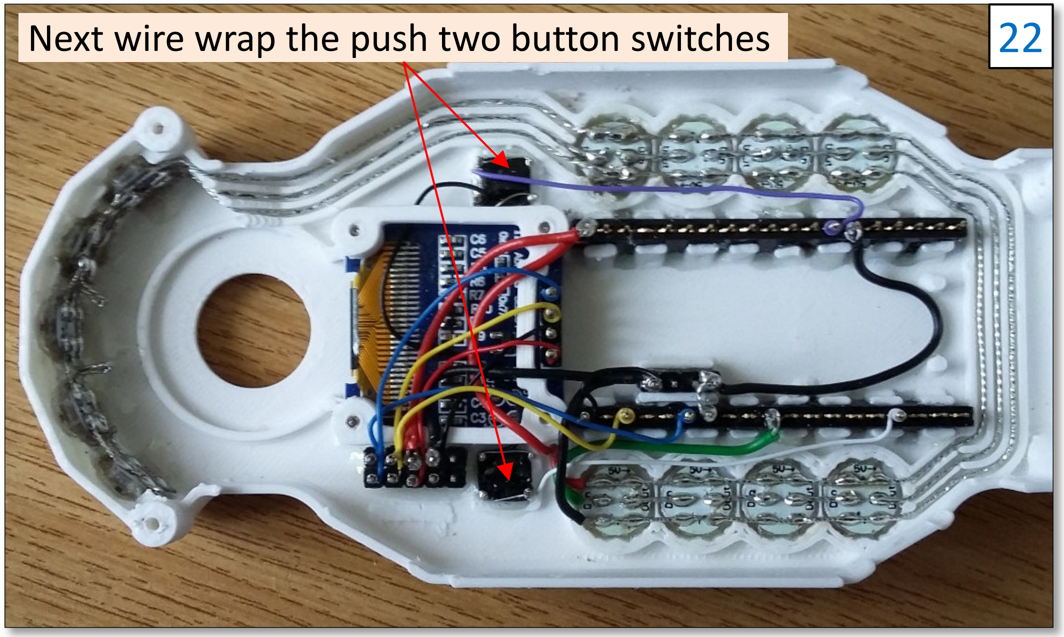


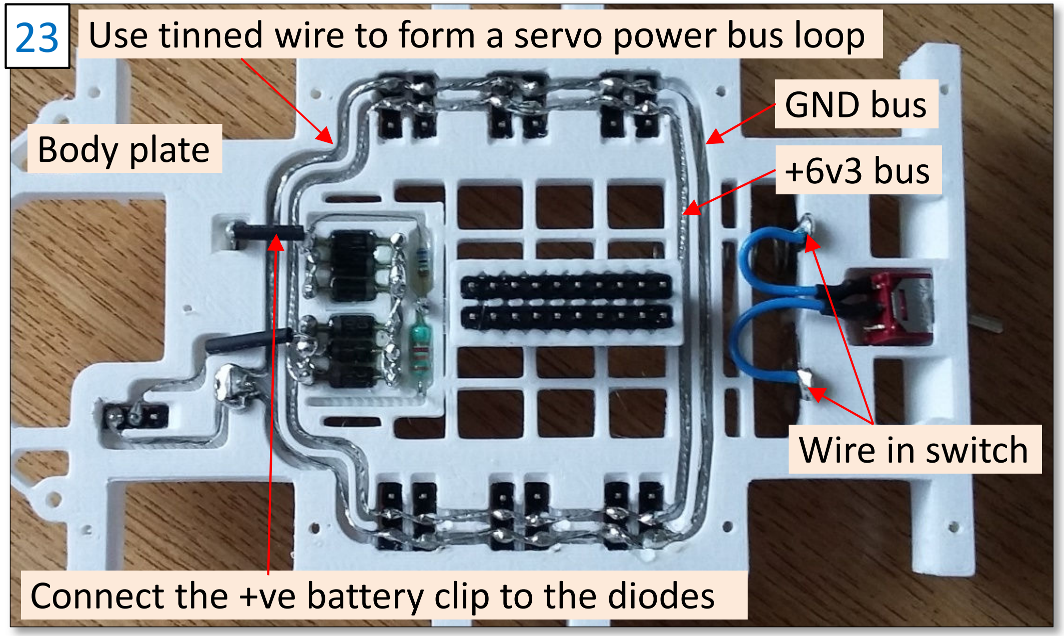




Wiring Sequence

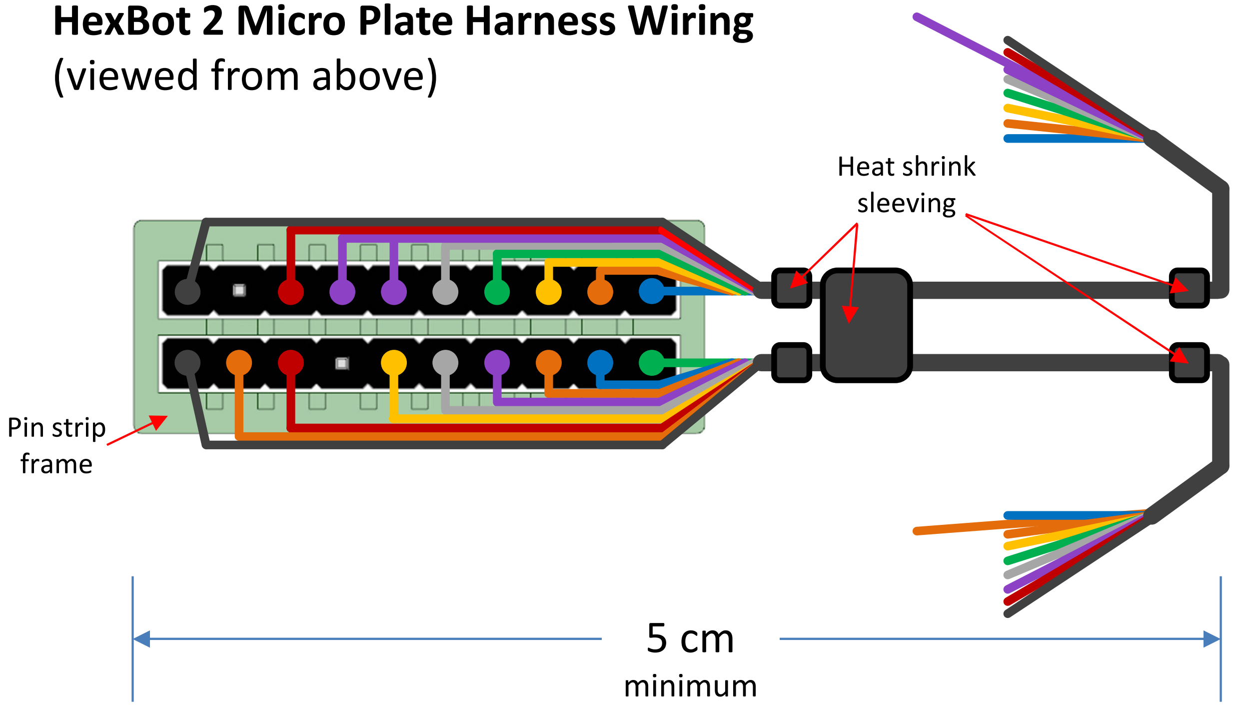






HexBot 2 Micro Plate Harness Wiring

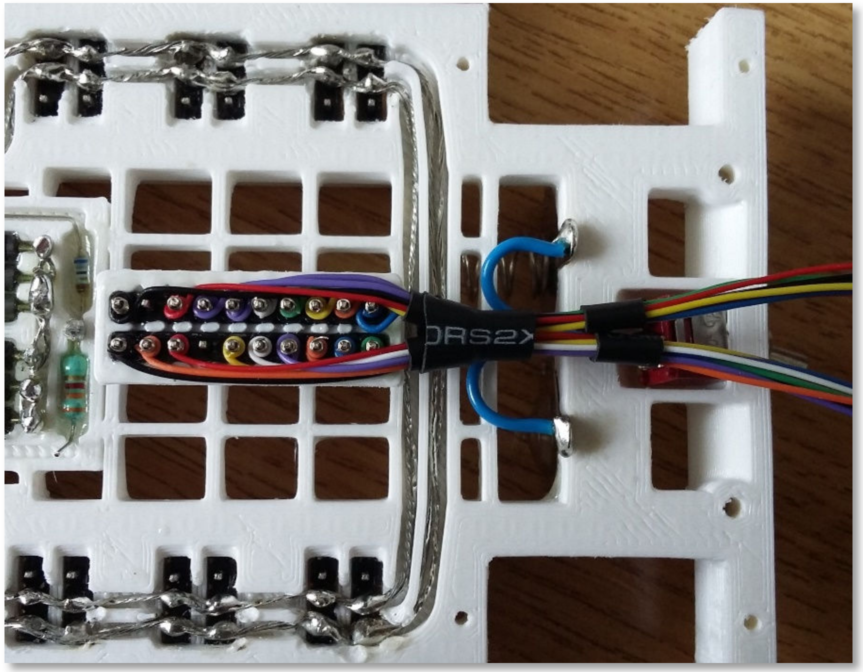
(viewed from above)

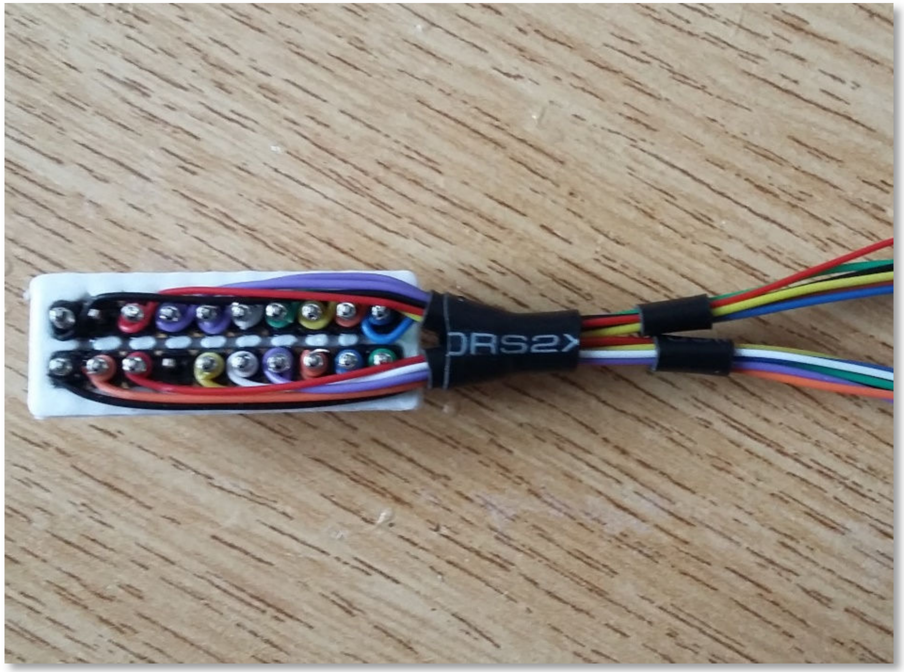


Note: start with 14cm lengths of wire minimum. Make the connections to the two pin strips first; then apply heat shrink sleaving to group the wires together as shown; first as two harnesses then grouped together as one near the pin strip end. Finally wire the free ends to the ESP32 socket strip connectors, as shown in the previous image.

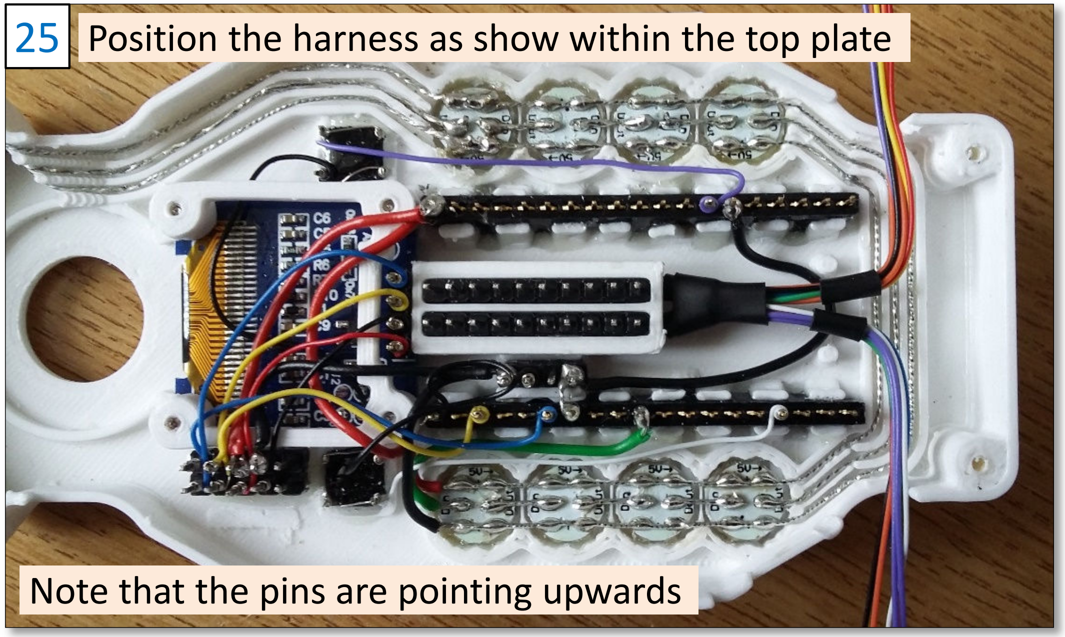
Note: The top pin strip has two purple wires and the lower strip has two orange wires. Make one of the wires longer in each case, or tie a small knot at the end, so that you can identify them when they are bundled together.

Note: Plugging the 20 pin floating pin strips into the sockets on the body plate will help to hold the job whilst you apply the wire wrap wire, and the heat shrink sleaving

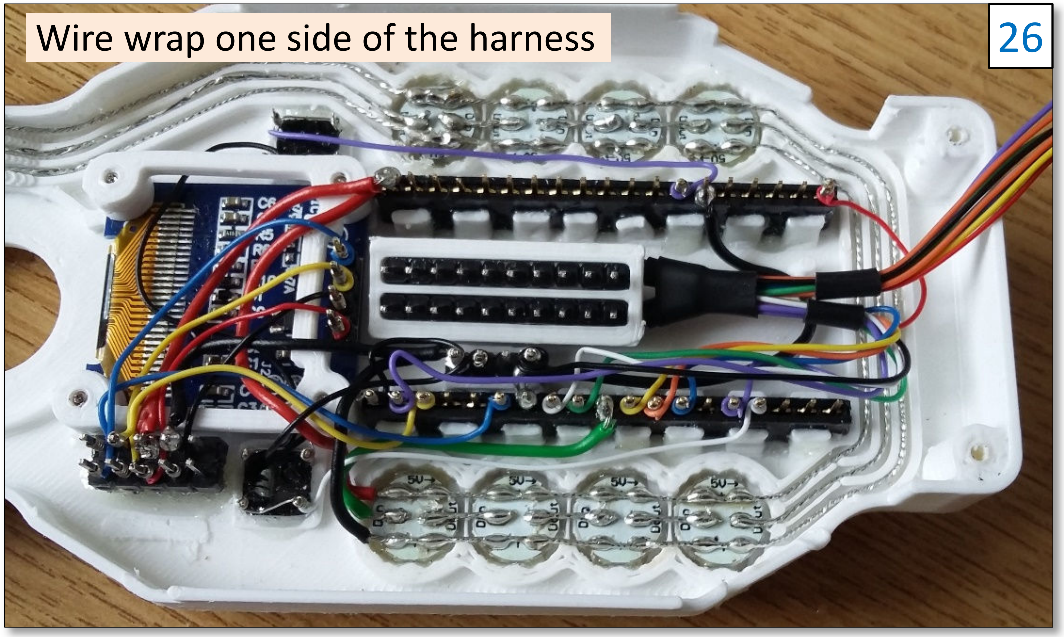


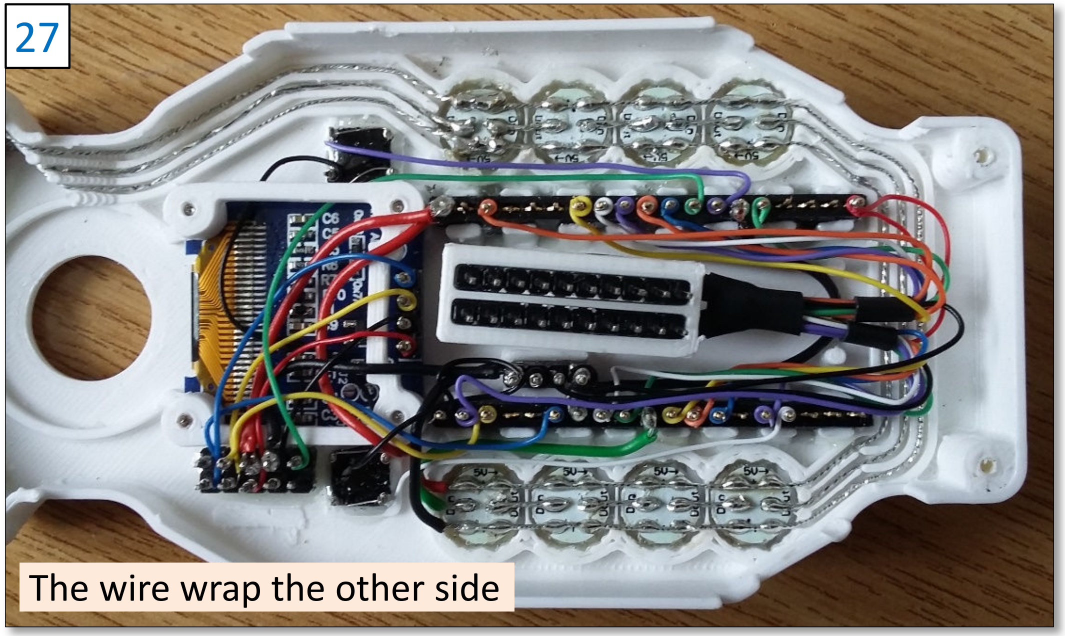


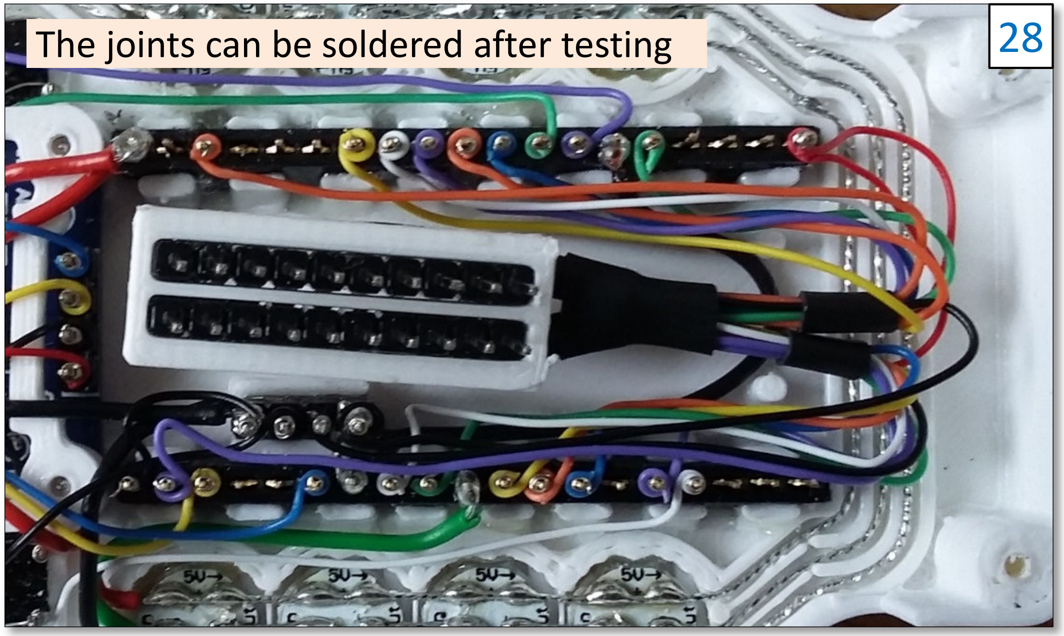
Wiring Sequence


25 Position the harness as show within the top plate

Note that the pins are pointing upwards

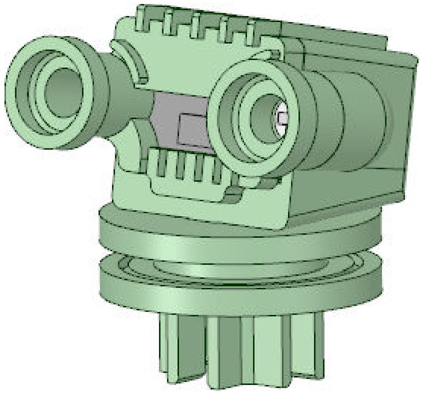

26 Wire wrap one side of the harness

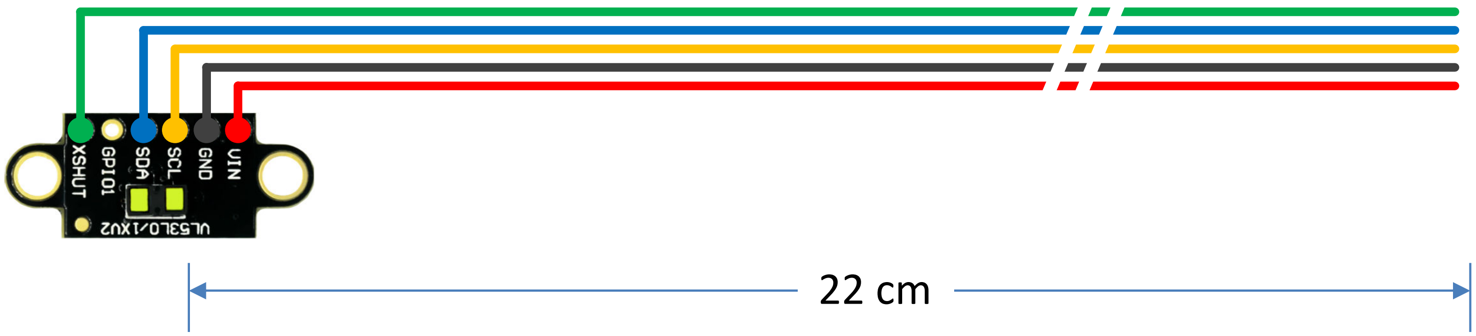

27 The wire wrap the other side


28 The joints can be soldered after testing

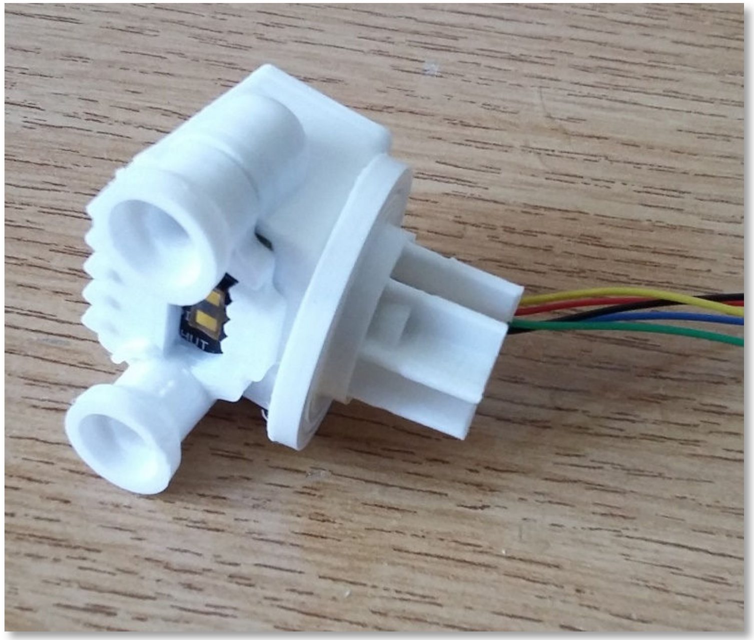
HexBot 2 Head Wiring

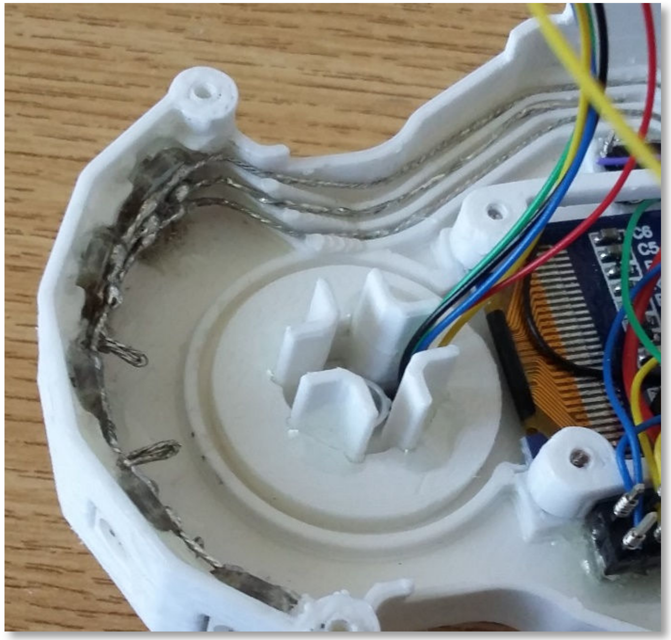
Note: start with 22cm lengths of wire minimum. Make the connections to the pins on the VL53L1X sensor first. Then feed the five wires through the neck aperture before screwing on the eye plate. Then mount the head onto the top face of the micro plate and glue the retaining disc into position from the other side, with the wiring protruding through the neck aperture.

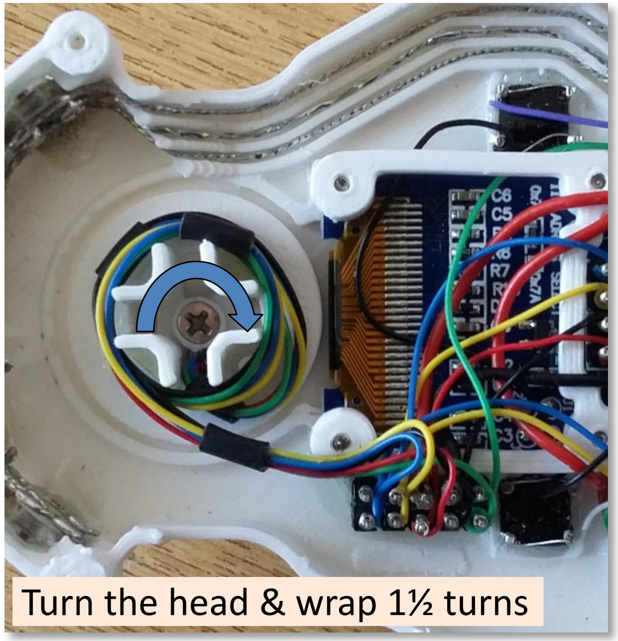




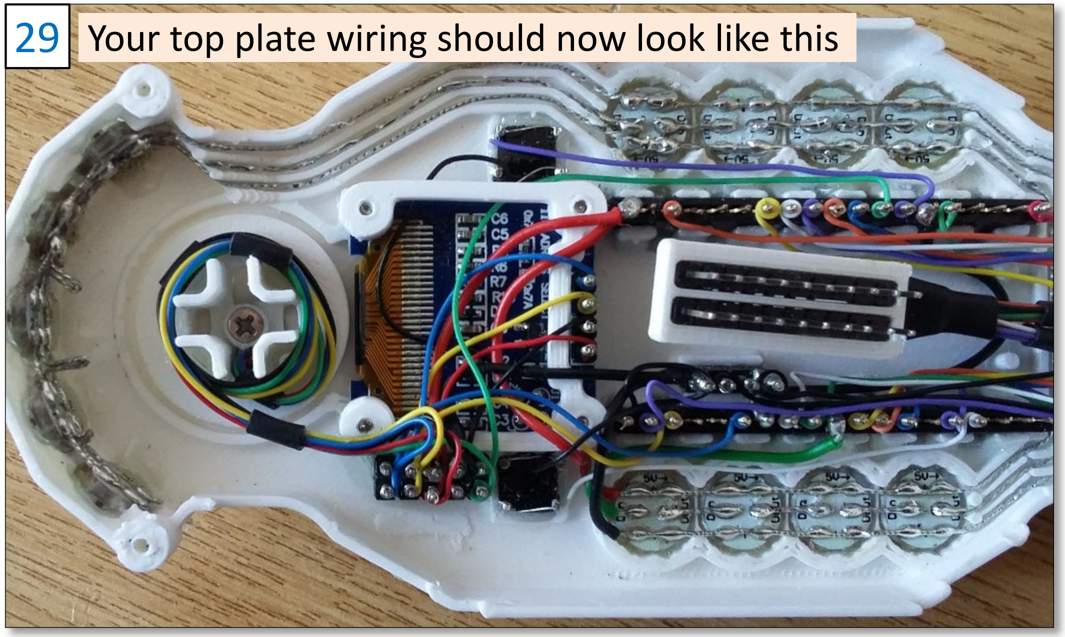
Turn the head 90° to the left, then coil the wires around the neck in an anti-clockwise direction for 1½ turns, as shown below. Then make off the wire wraps to the 4 pin I2C strip. Check that the head can be rotated from left to right without the wire coiling too tightly on the neck. The glue the wire to the vertical supporting post as a tether point.

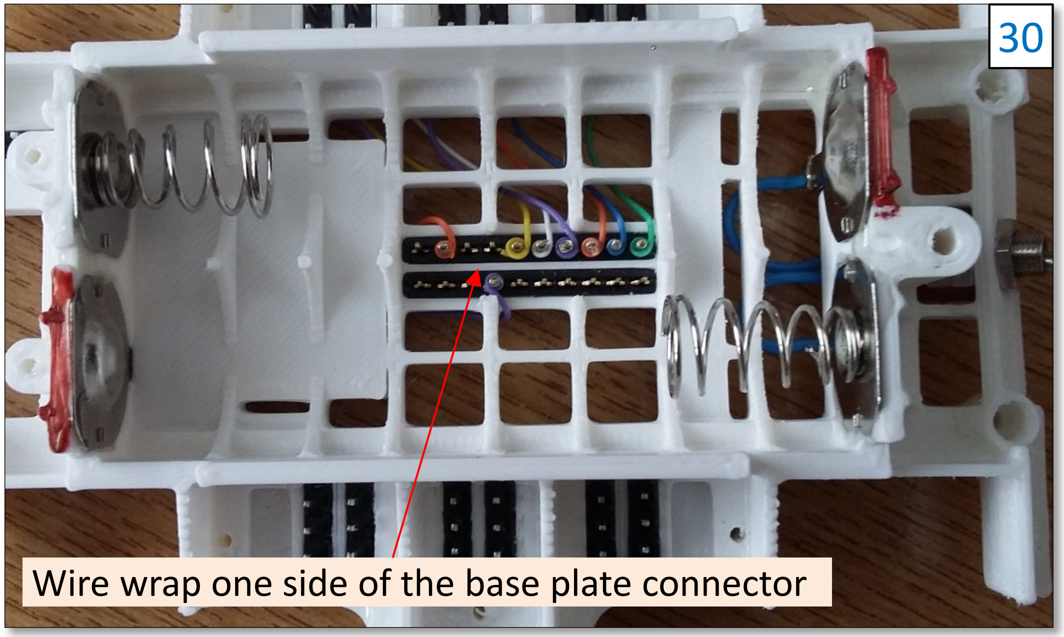


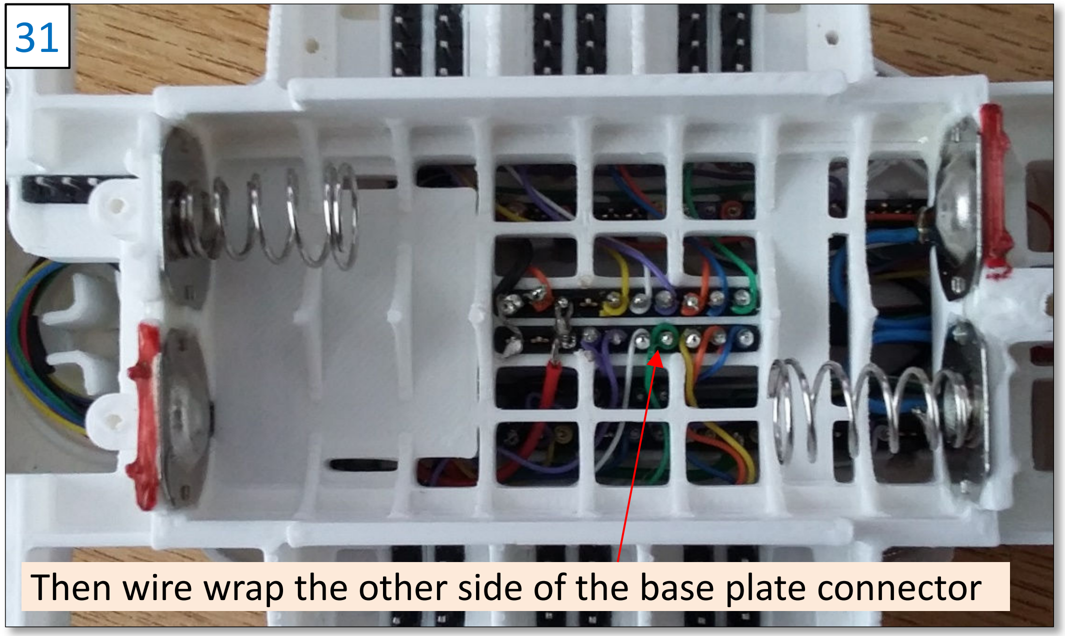


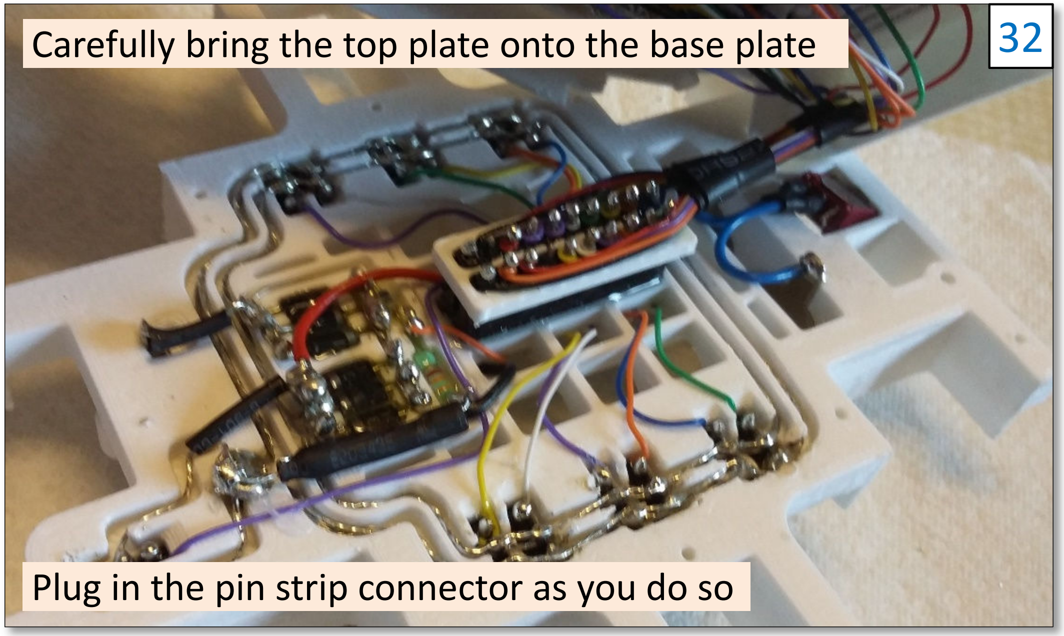


Wiring Sequence


29 Your top plate wiring should now look like this


30 Wire wrap one side of the base plate connector

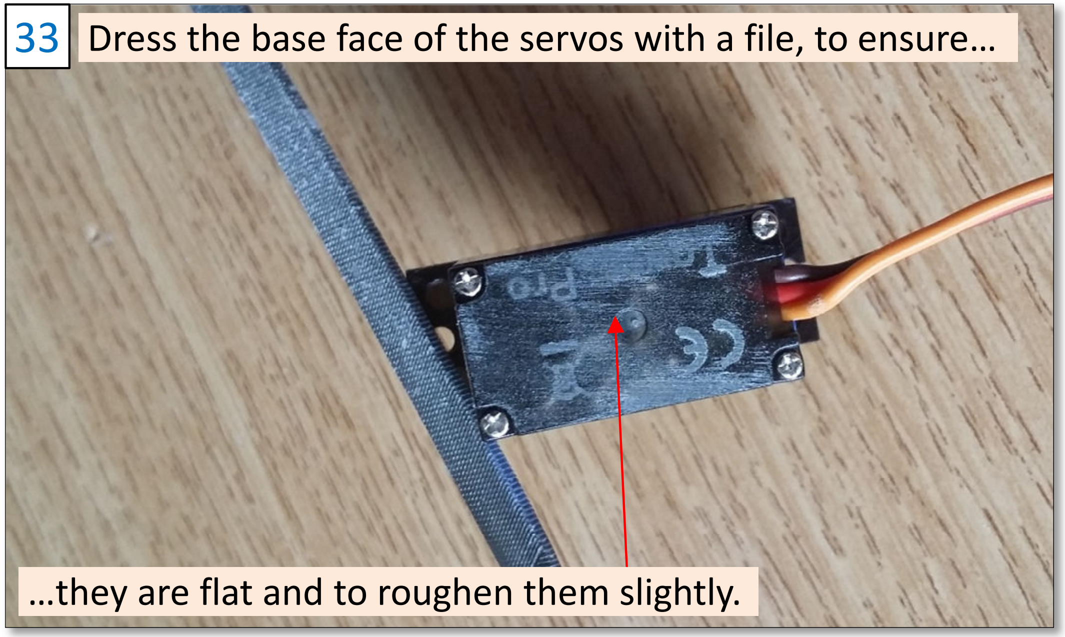

31 Then wire wrap the other side of the base plate connector


32 Carefully bring the top plate onto the base plate

Plug in the pin strip connector as you do so

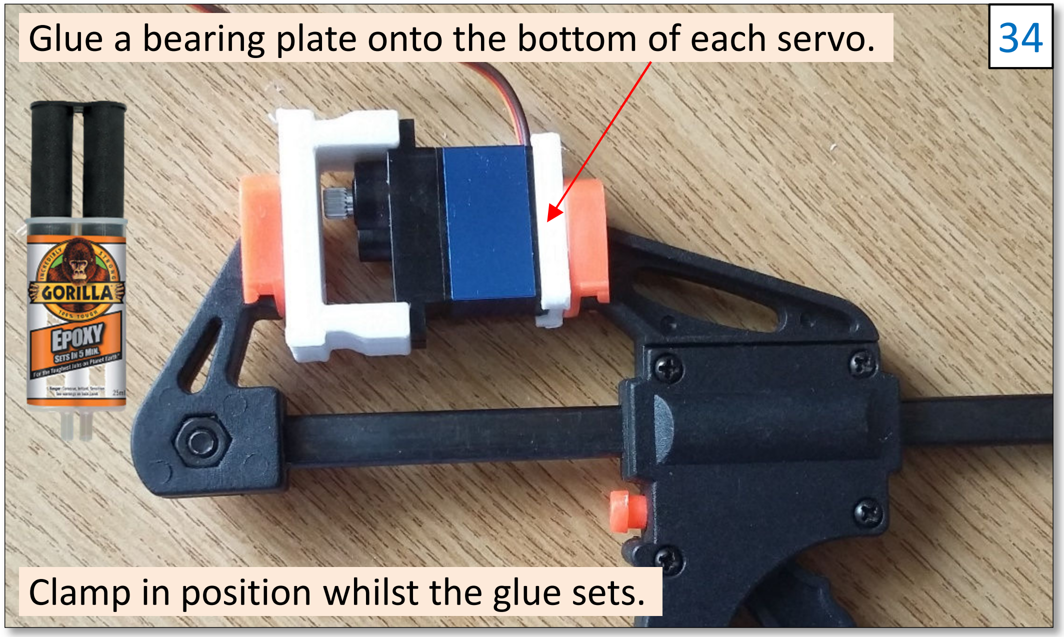
Wiring Sequence

33 Dress the base face of the servos with a file, to ensure...



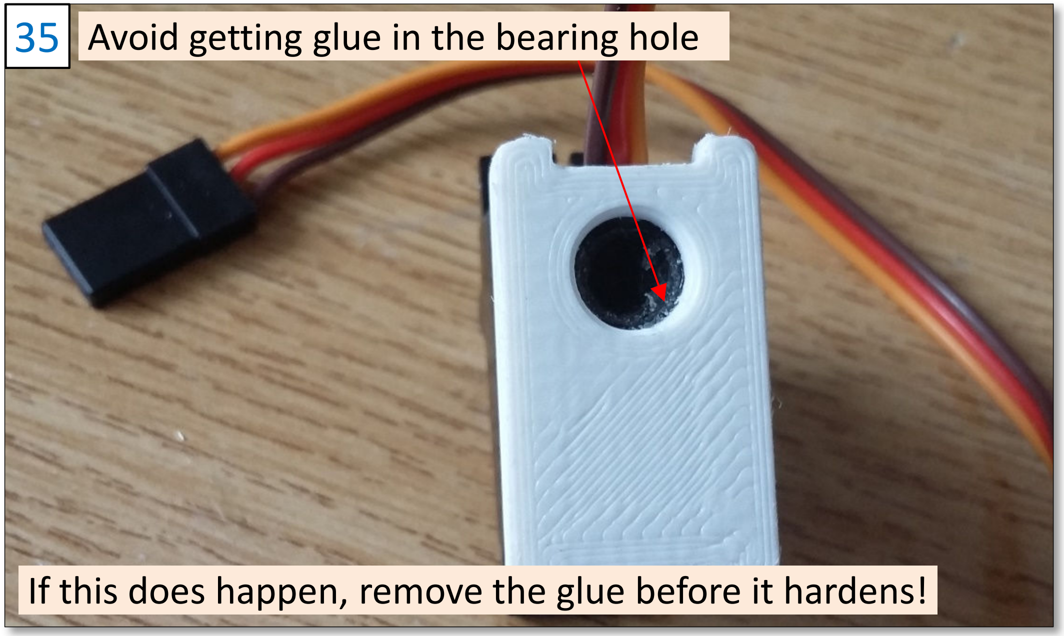
...they are flat and to roughen them slightly.

34 Glue a bearing plate onto the bottom of each servo.



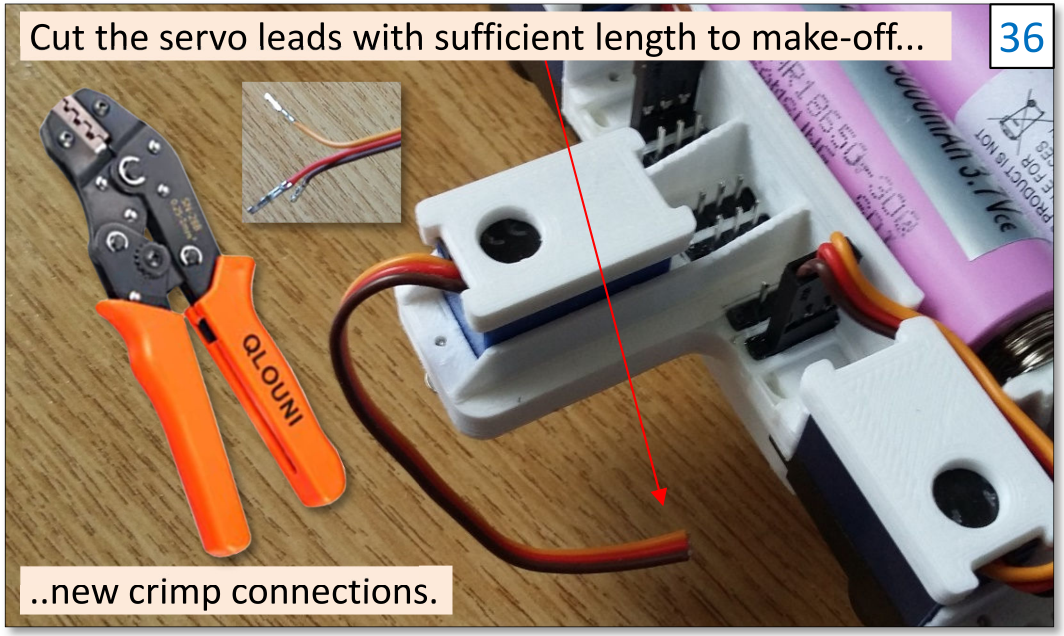
Clamp in position whilst the glue sets.

35 Avoid getting glue in the bearing hole



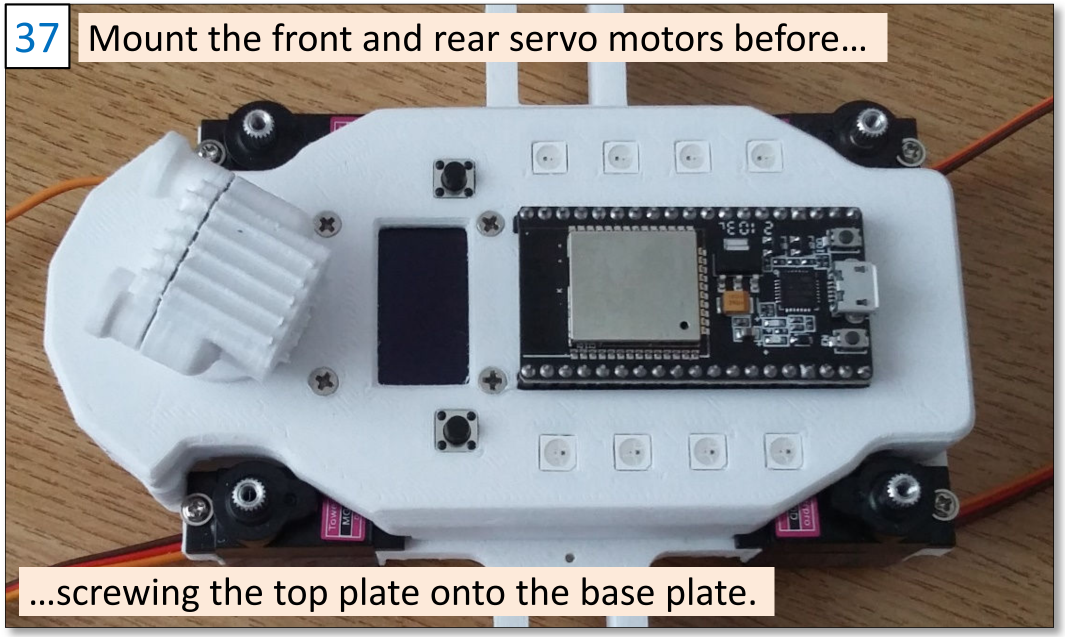
If this does happen, remove the glue before it hardens!

36 Cut the servo leads with sufficient length to make-off...



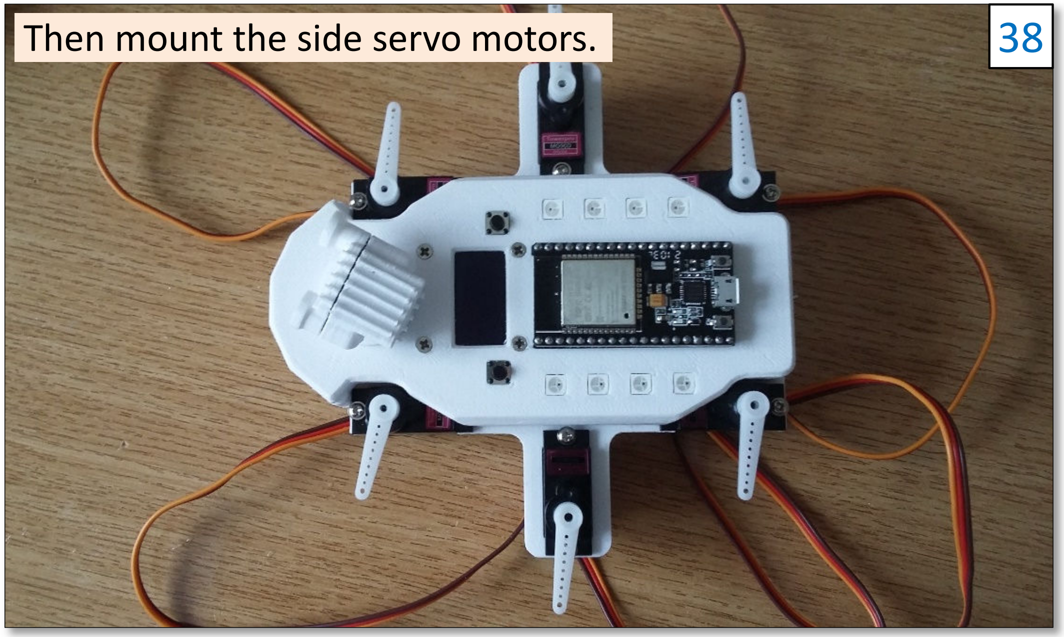
..new crimp connections.

Wiring Sequence

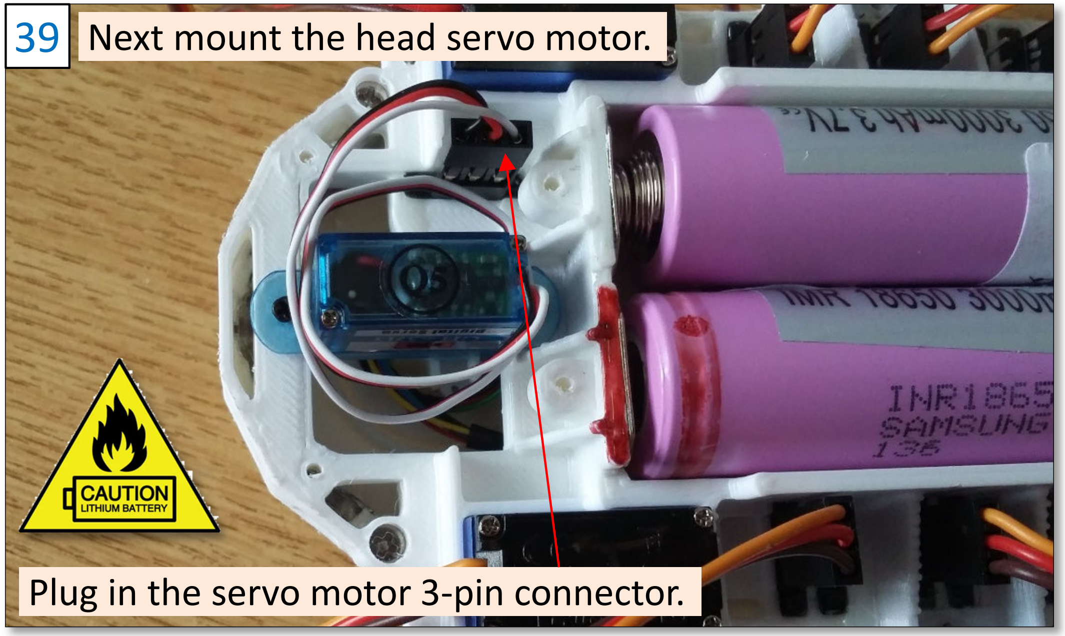


37 Mount the front and rear servo motors before…

…screwing the top plate onto the base plate.

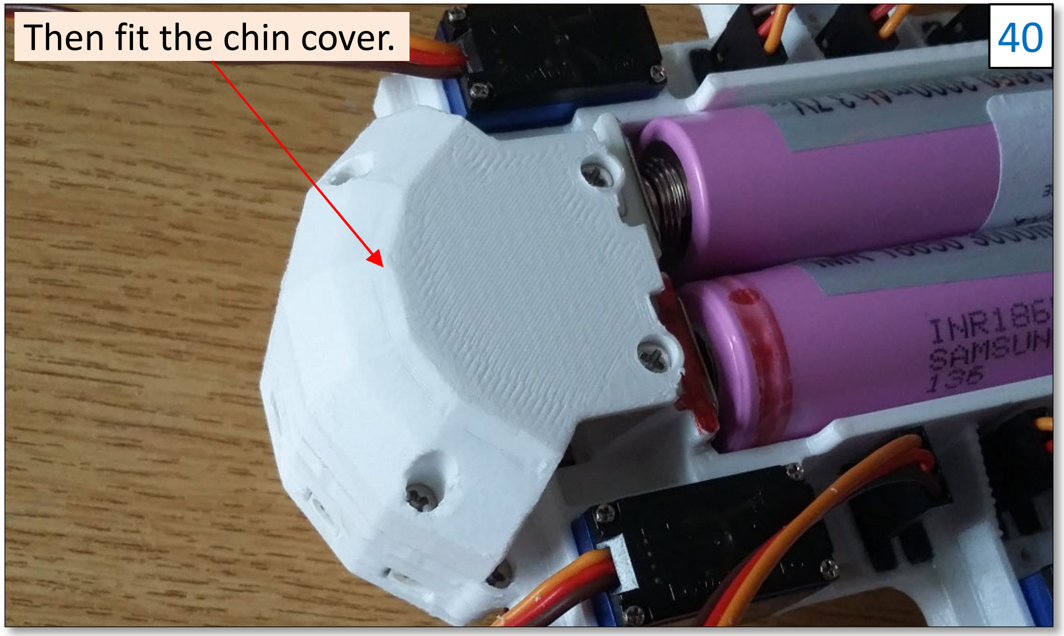


38 Then mount the side servo motors.



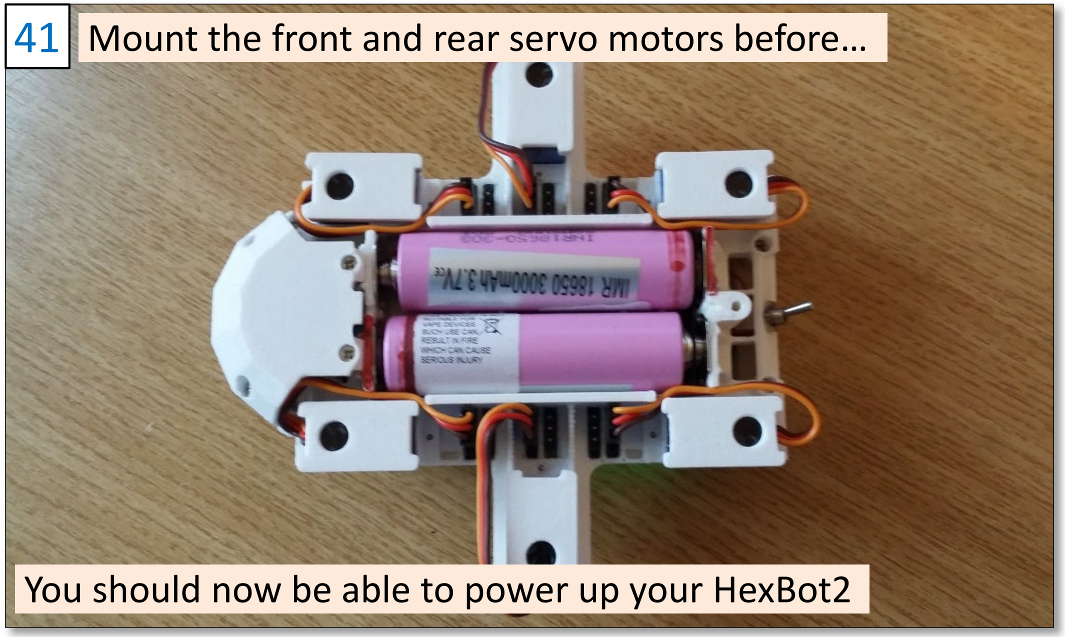
39 Next mount the head servo motor.

Plug in the servo motor 3-pin connector.



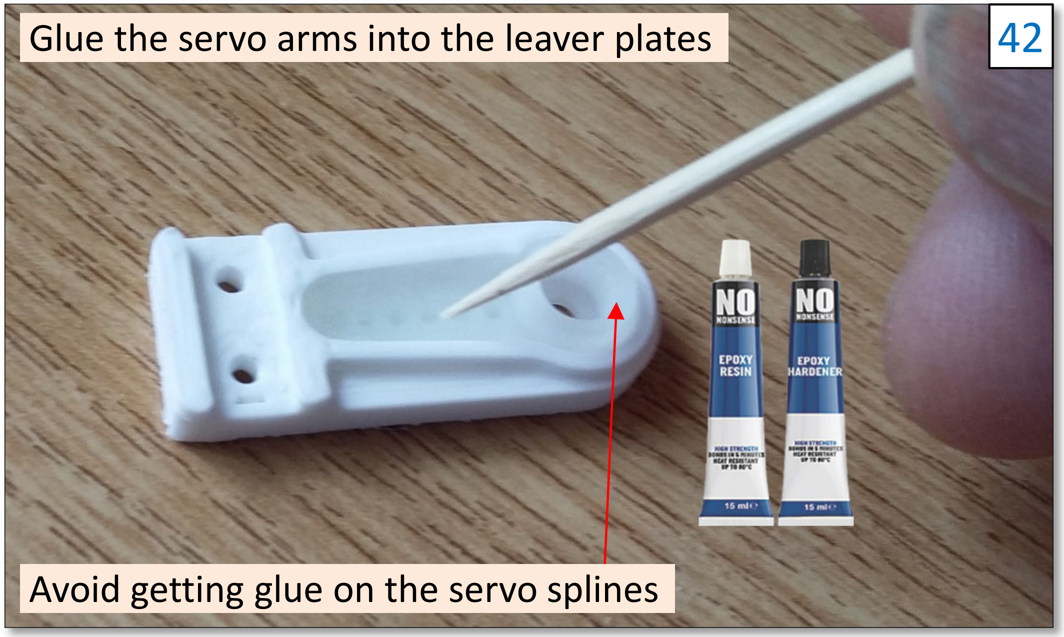
40 Then fit the chin cover.

Wiring Sequence



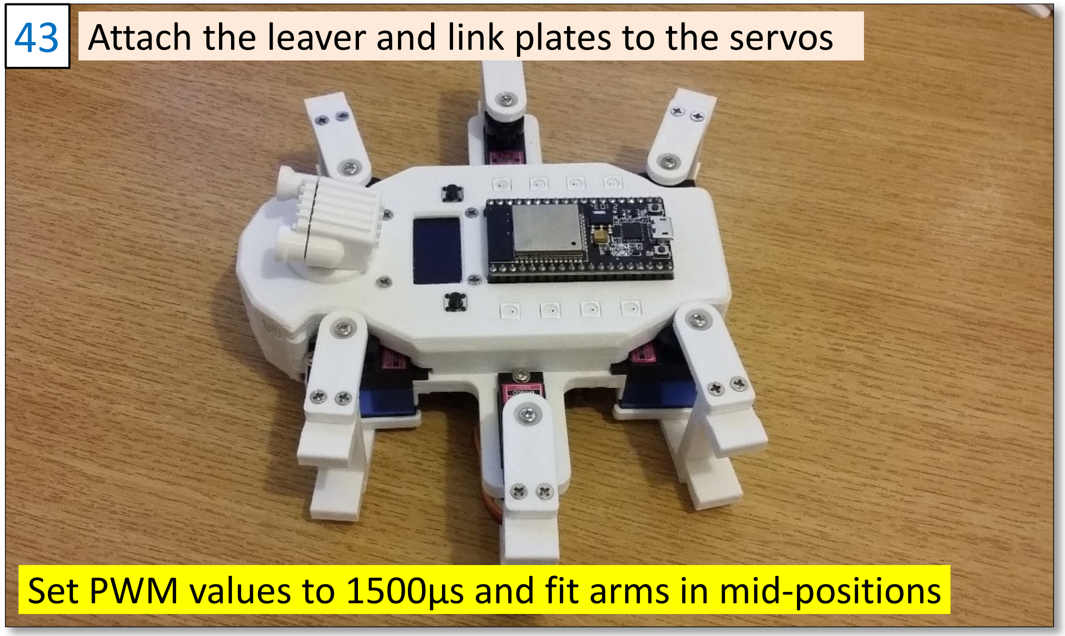
41 Mount the front and rear servo motors before…

You should now be able to power up your HexBot2



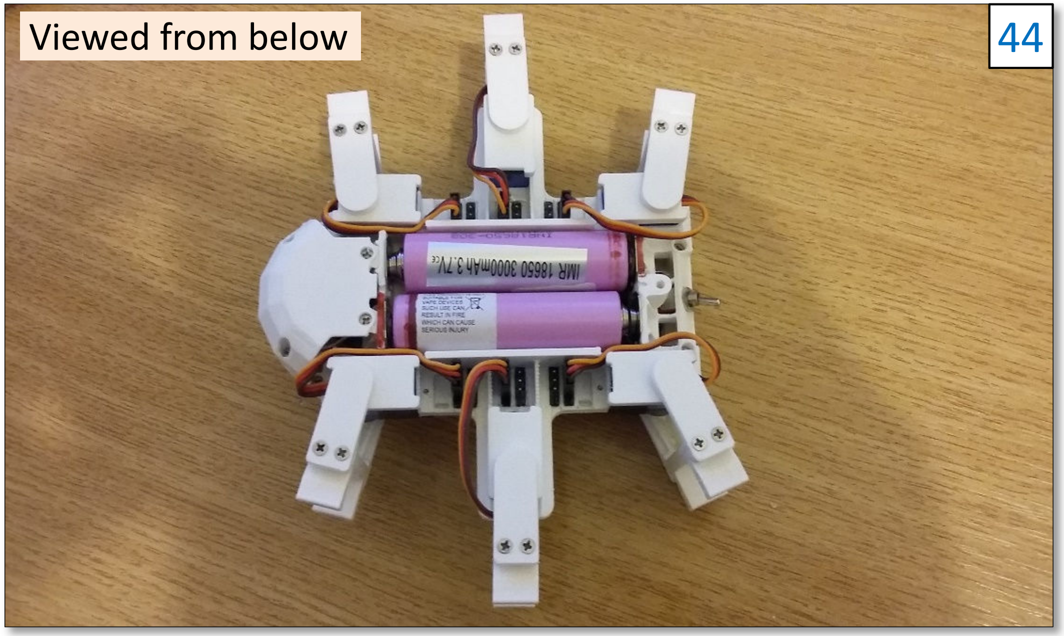
42 Glue the servo arms into the leaver plates

Avoid getting glue on the servo splines



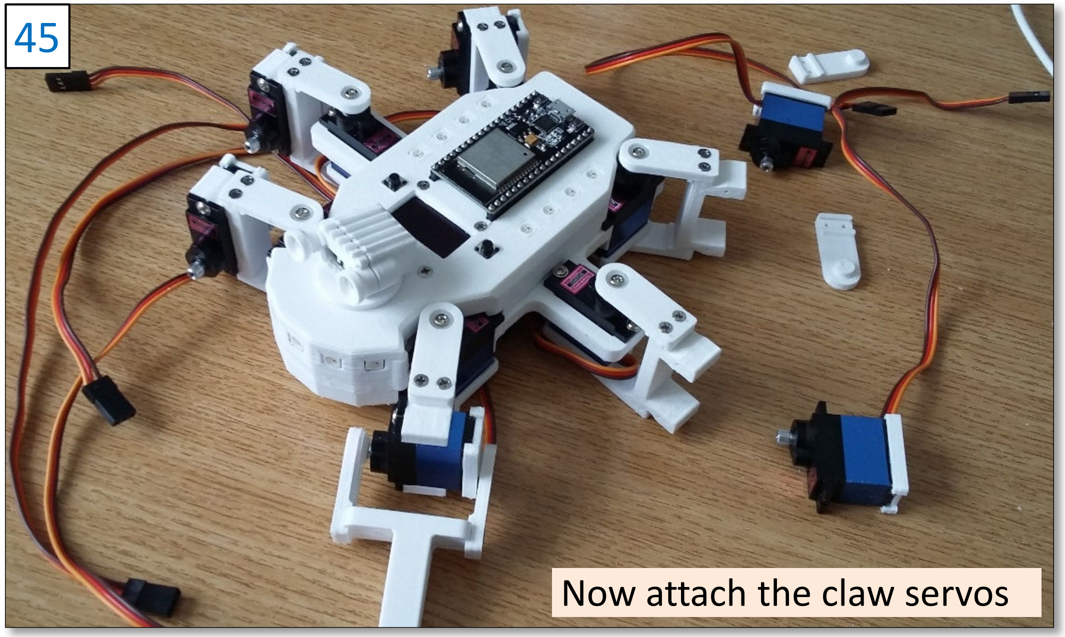
43 Attach the leaver and link plates to the servos

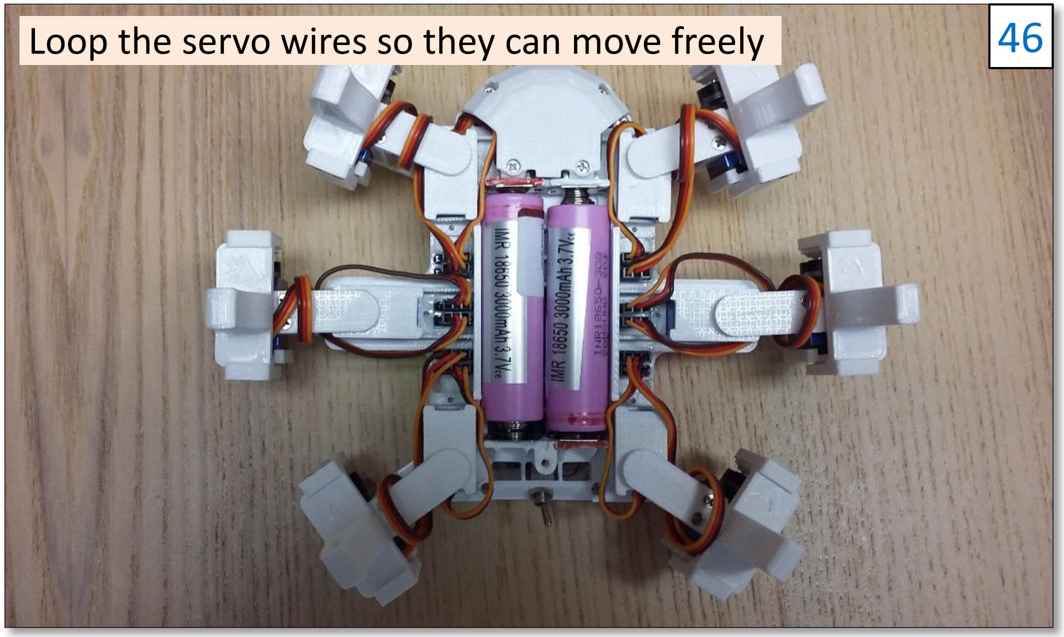
Set PWM values to 1500µs and fit arms in mid-positions

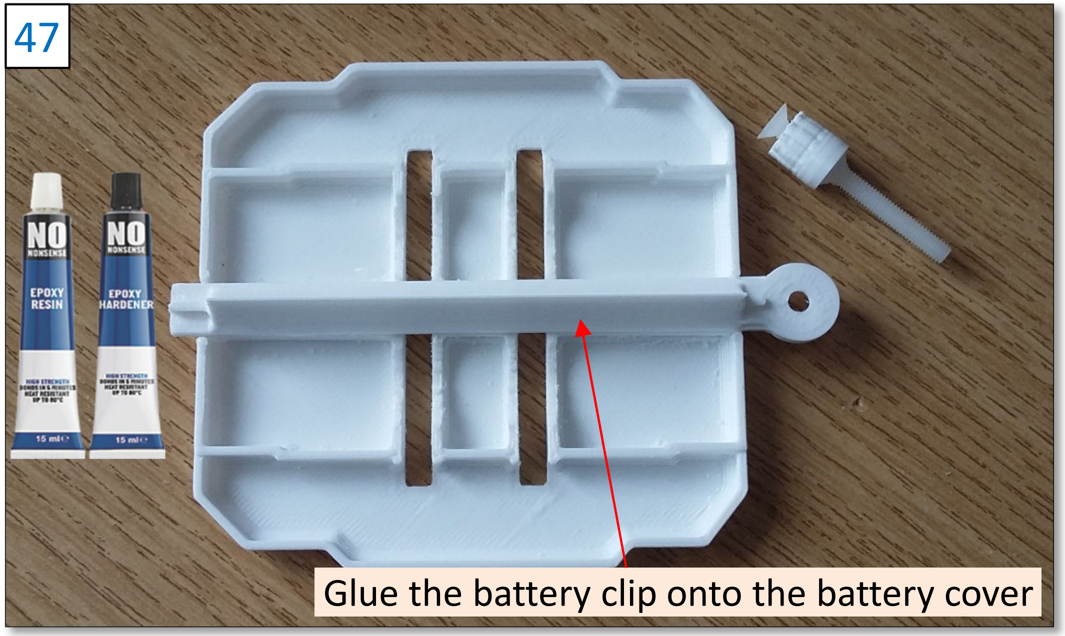


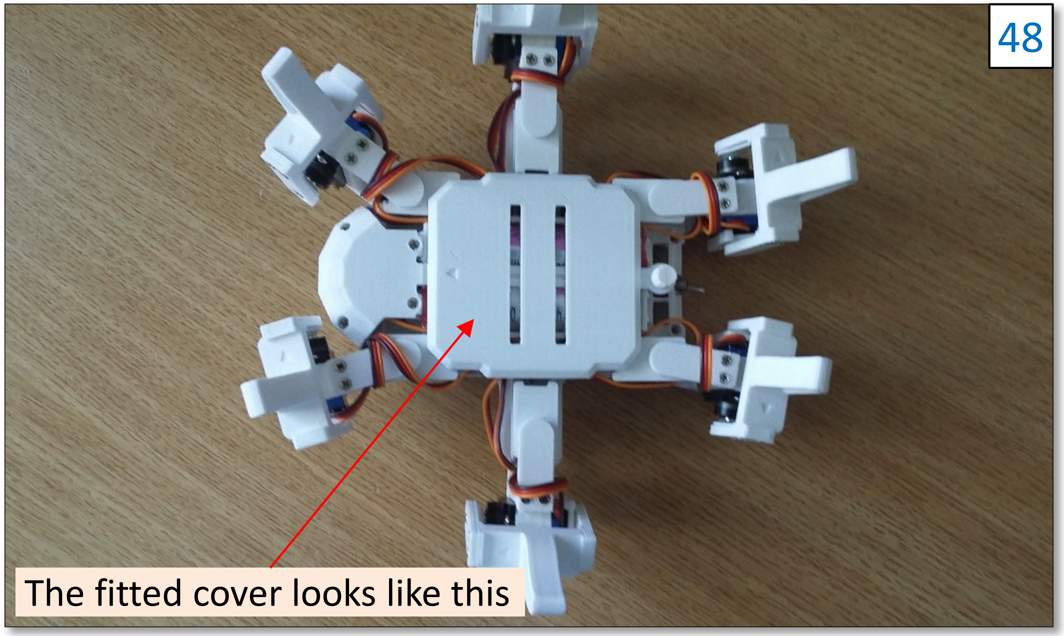
44 Viewed from below

Wiring Sequence









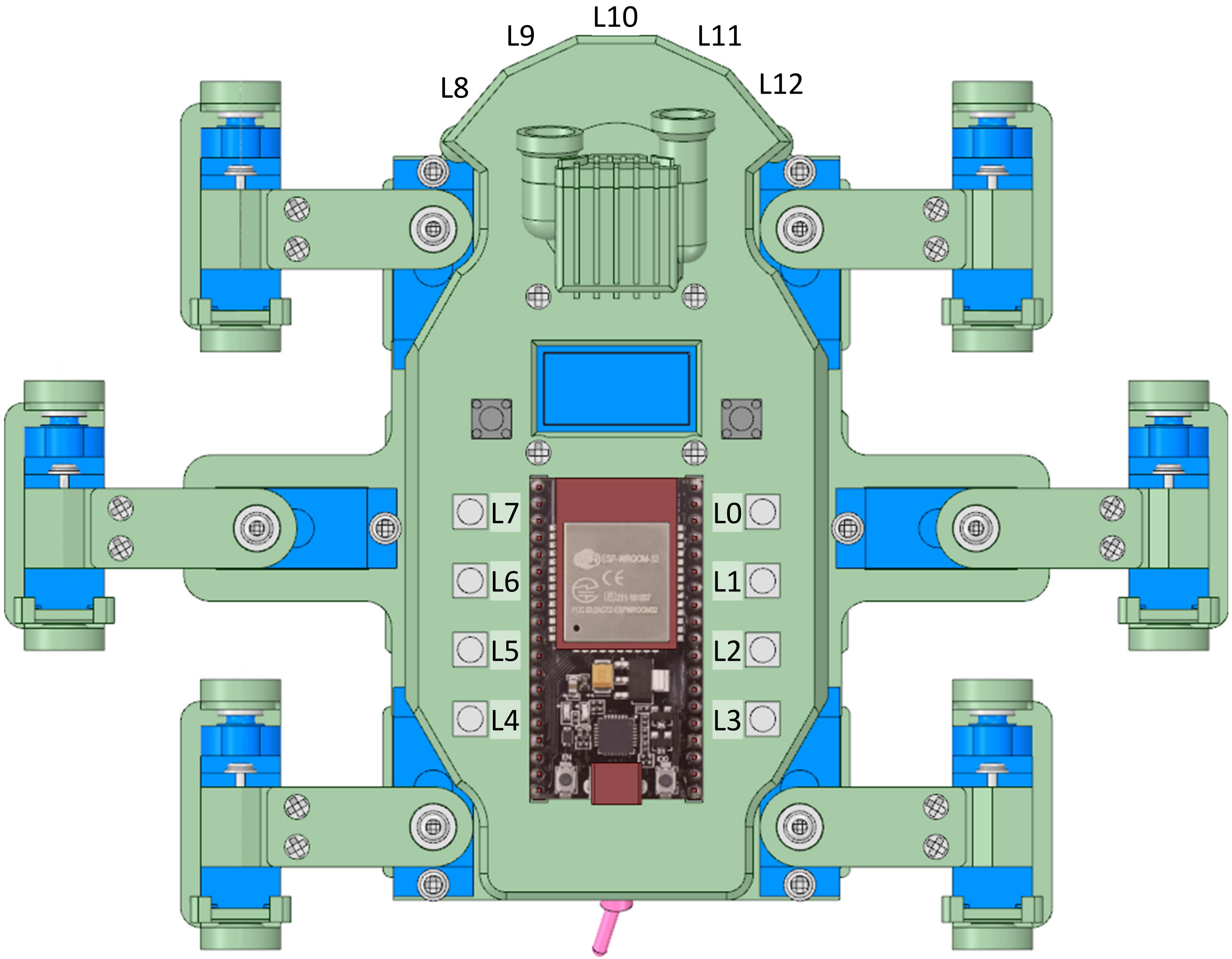
Wiring Sequence

49

The build process is now complete

50

RGB LED assignments



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 or 404.85
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 = 3148 on ADC (V_M* 383.9)

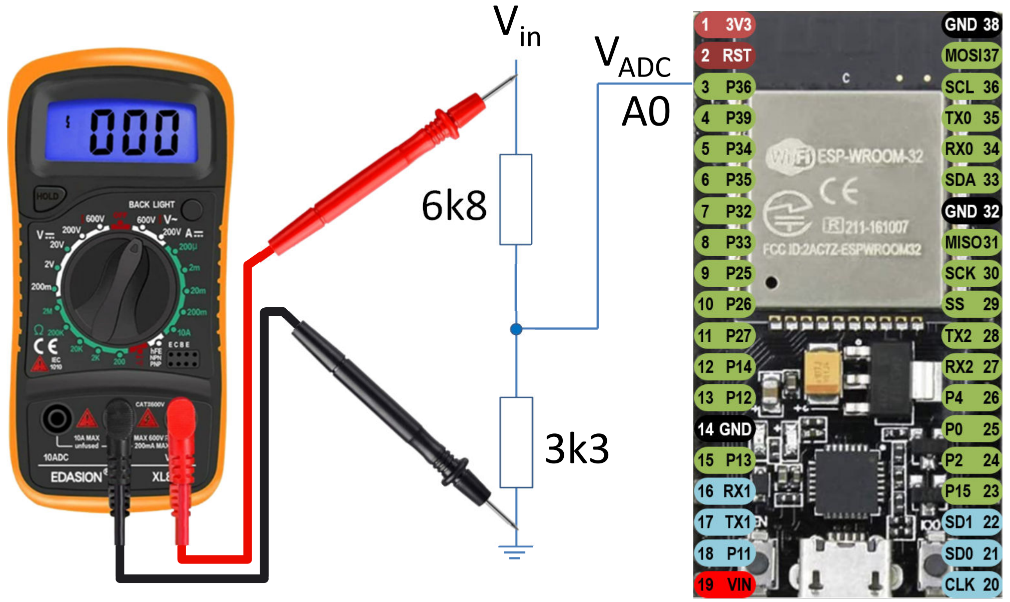
WARNING: V_B = 7.0v, gives A0 = 2687on ADC (V_B* 383.9)

CRITICAL: V_{BC} = 6.6v, gives A0 = 2534 on ADC (V_{BC}* 383.9)

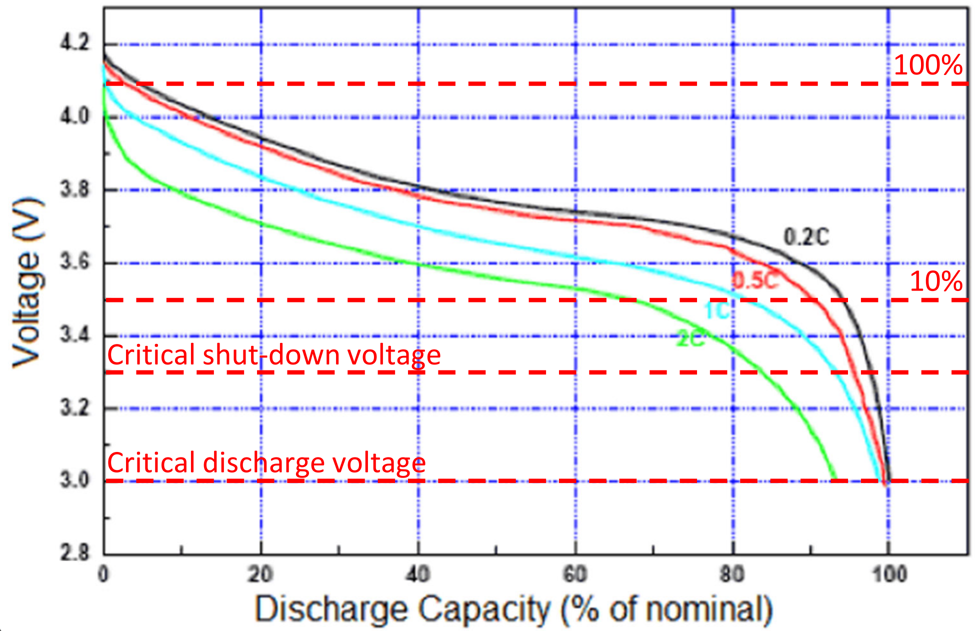
The code will sample the battery voltage on power-up to ensure it is sufficient, then at every 40ms interval, calculating an average (1/20) to remove noise.

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.