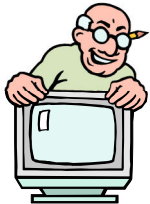
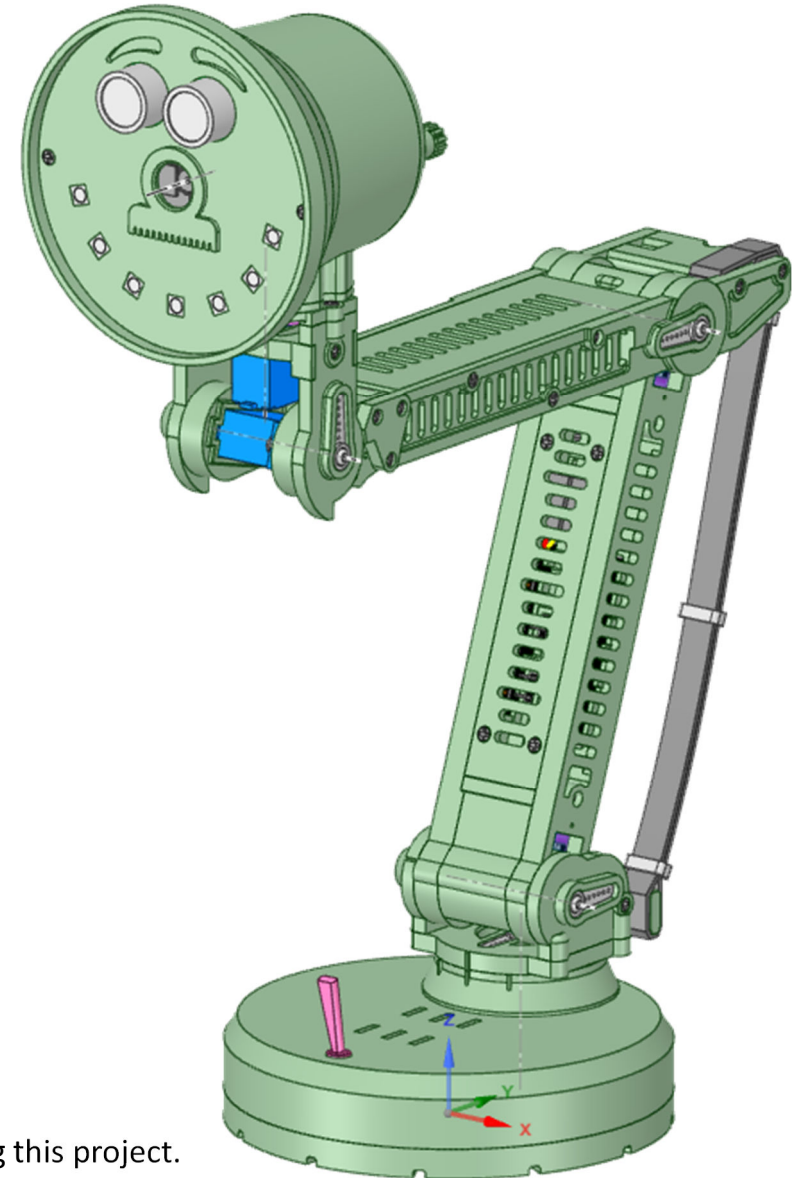
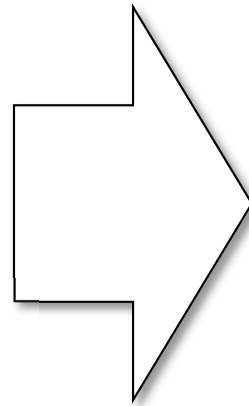
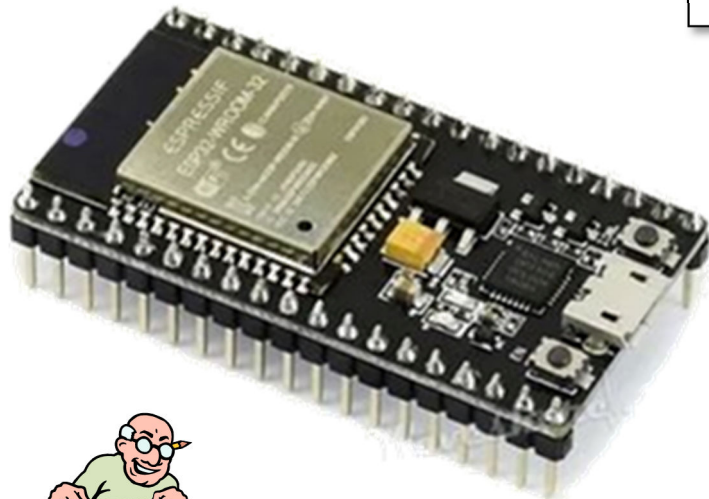
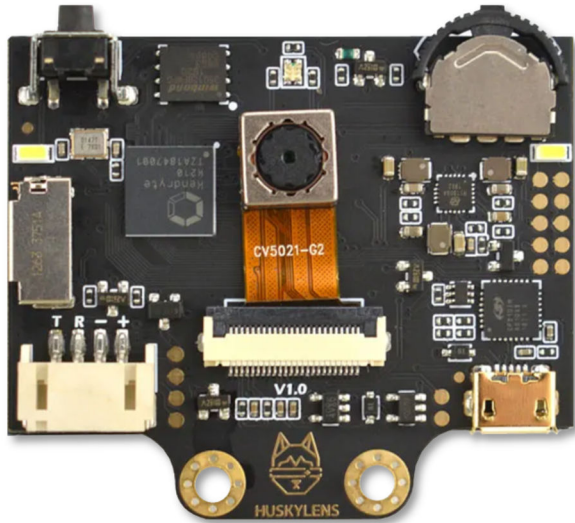


Project PIX_{Ai}R Lamp

Circuits & Wiring



Read through this documentation completely 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 needed are shown here.

Some printed components act as aids and gauges. Use them.

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

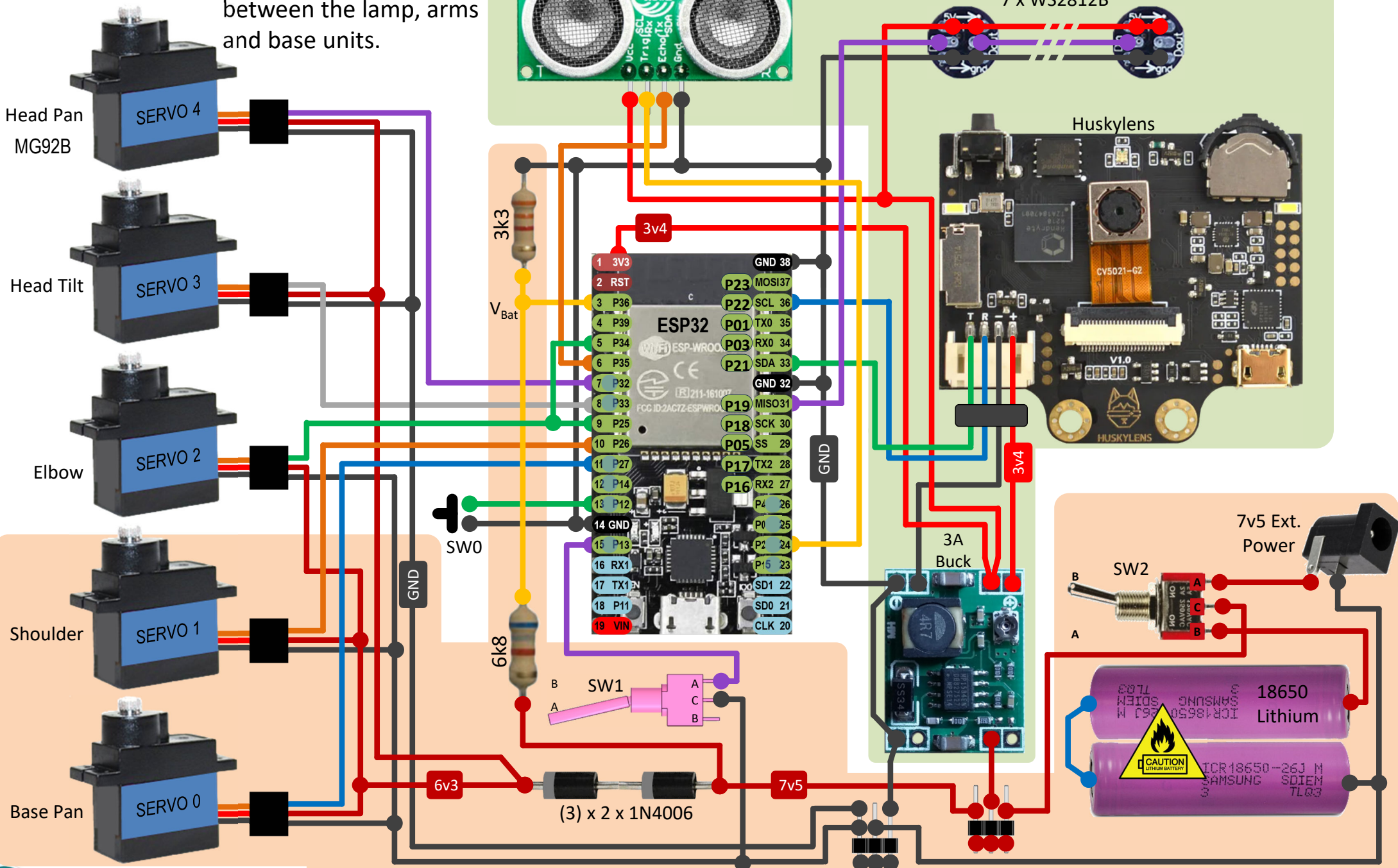
24 AWG stranded wire (red, black & yellow)

Multimeter



Total Wiring

The wiring is distributed between the lamp, arms and base units.



Base Unit Wiring - complete

The base of the lamp houses the 18650 batteries and some of the electronics, like the 1N4006 diode pack, and the voltage sensing resistor network.

In order to reduce weight and strain on servos, the design aims to keep as many components as possible in the lower part of the project.

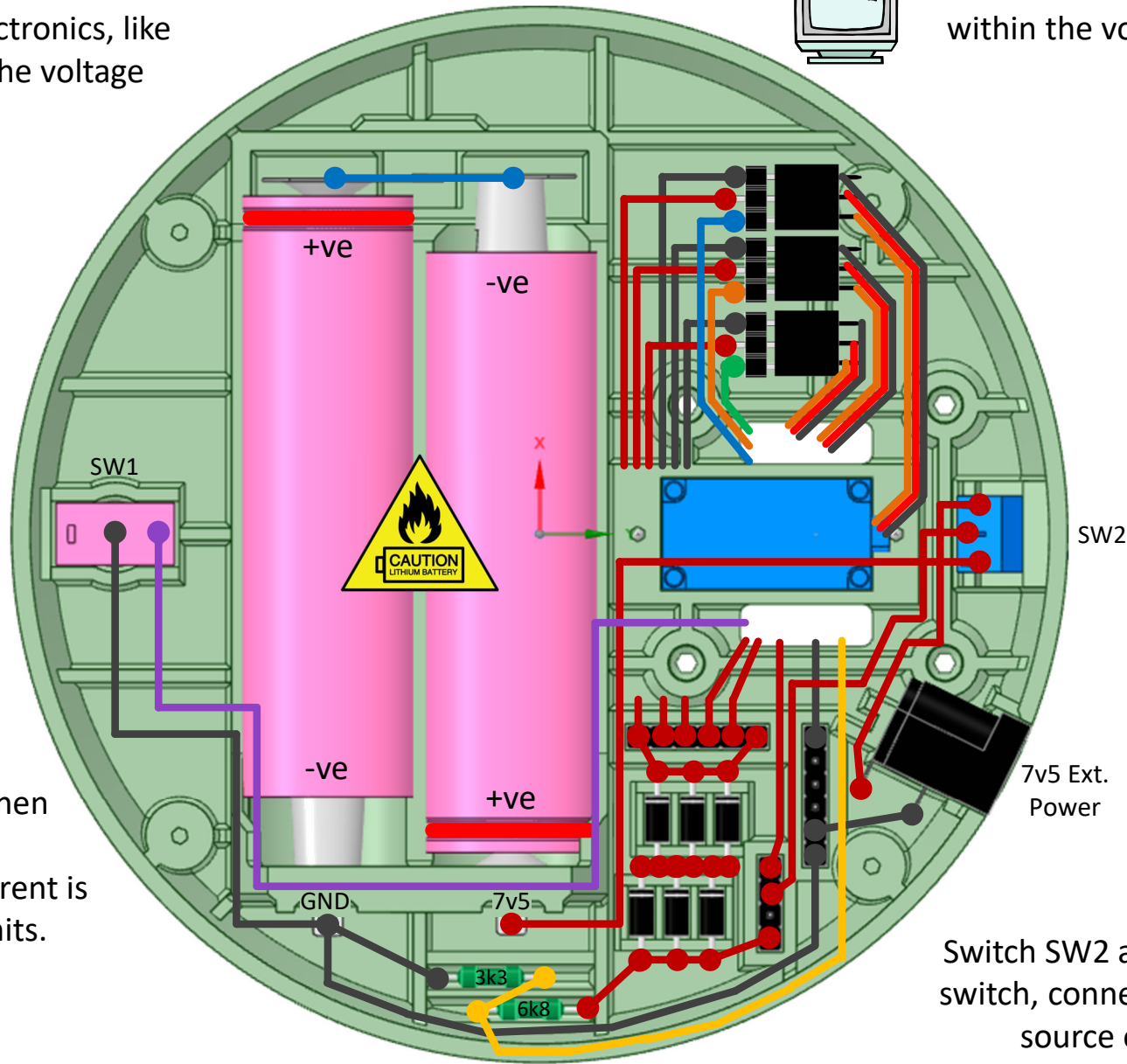


Take care when wiring this project as it does not incorporate any form of circuit protections, should a s/c fault occur, and there is a lot of stored energy in the 18650 Lithium batteries.

Use a good quality charger, when recharging your batteries, to ensure that their charging current is kept within recommended limits.



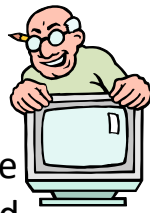
Some of the servo leads are stored within the volume of the base unit.



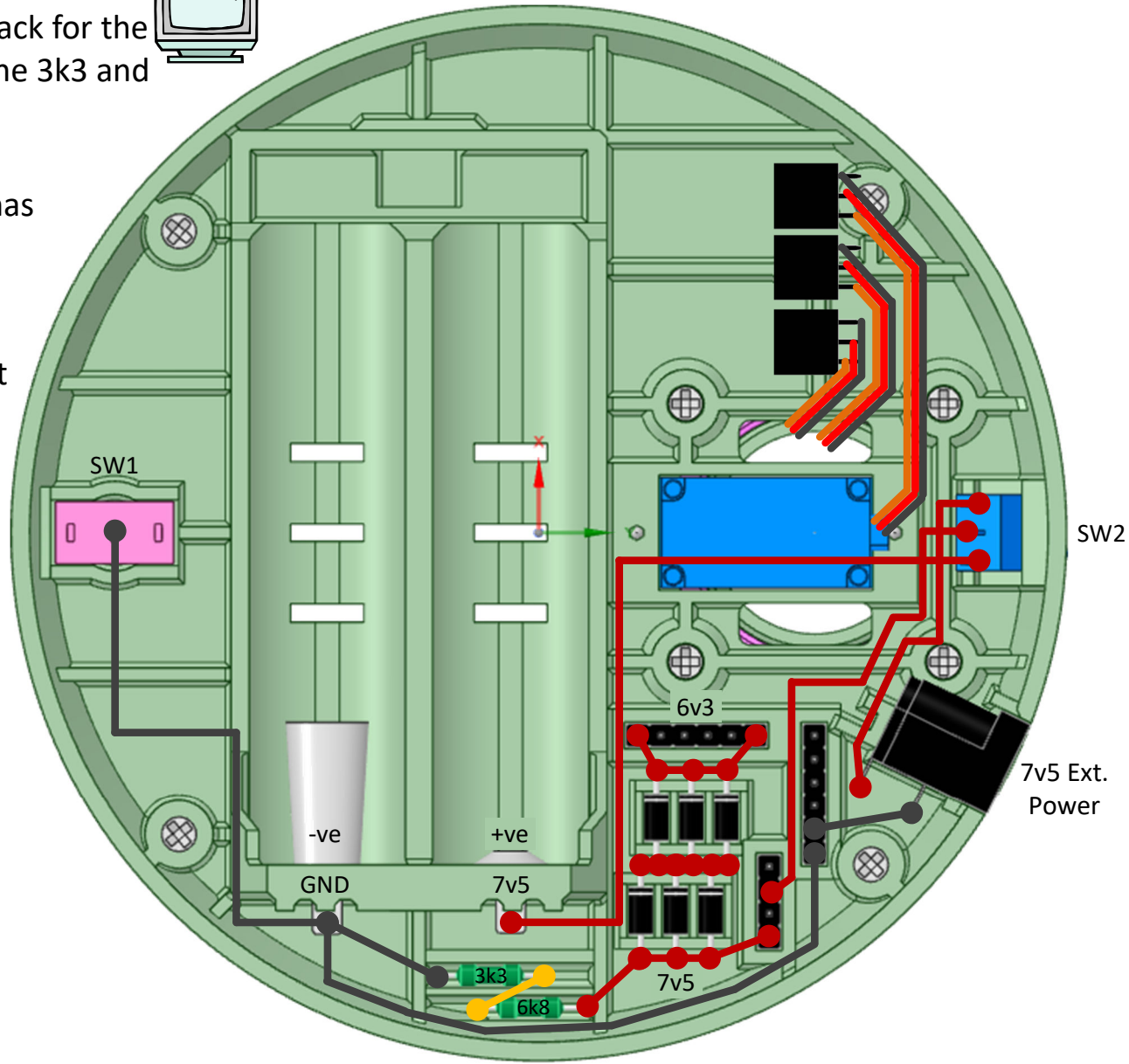
Switch SW2 acts as the main power switch, connecting to either battery source or and external supply.

Base Unit Wiring – Step 1

The 1st step is to wire in the power connections, and the diode stack for the servo feeds. We also wire in the 3k3 and 6k8 resistor network.



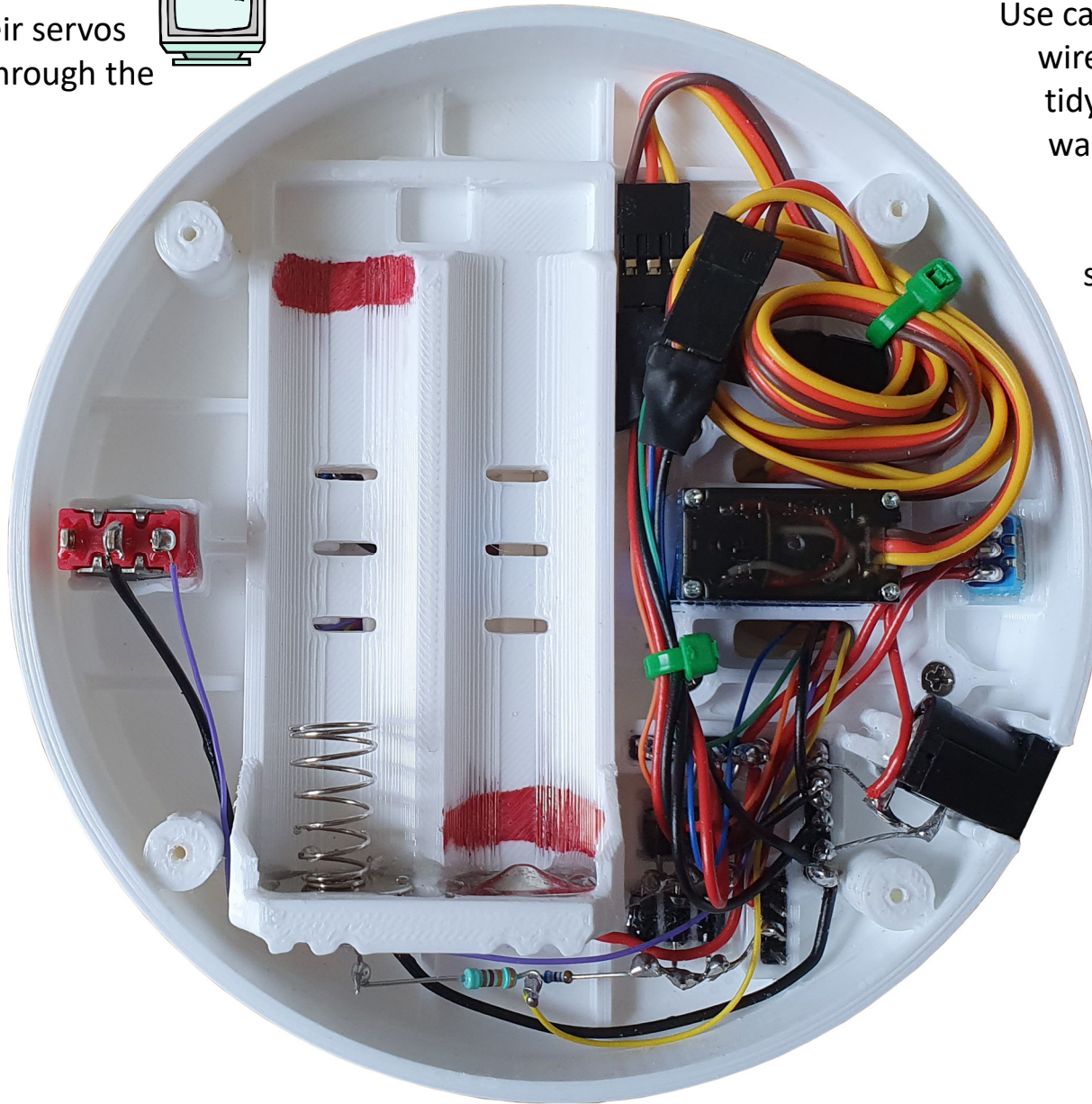
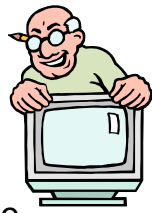
At this point the PIXAR lamp has been assembled, with the exception of the lamp unit, micro plate and voltage regulator board. The base unit is attached to the lower arm.



Base Unit Wiring – Step 1

This is a photo of the wired base unit. At this stage the arms and their servos have been attached and fed through the rotary mounting apertures.

Note how I have marked the battery polarity, with a red marker pen, to ensure they are inserted the correct way round. There is no circuit protection in this design, so incorrect battery insertion would damage the electronics.



Use cable ties to group the servo wires together and keep them tidy. You do not want them to wander into the battery area.

Don't make the wires too short, as you may need to dismantle the rotary base, should a servo fail in use.

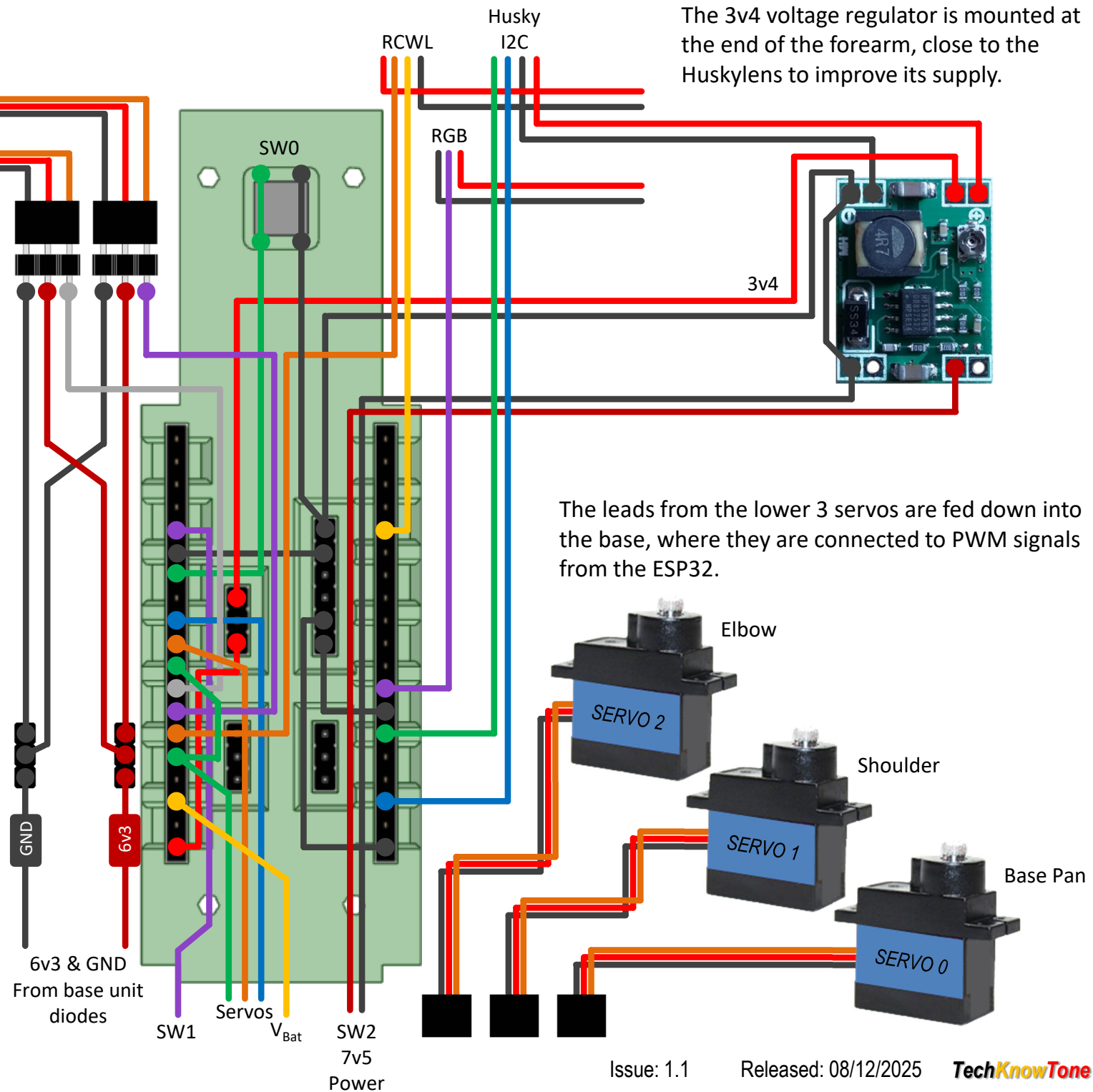
Micro Plate Wiring - complete

The length of the servo leads has influenced the wiring to the Micro Plate and their connection points.



The head servo connectors are insulated with heat shrink sleeving, to prevent s/c.

The GND and 6v3 3-pin strip connections are shown off-board here for clarity.

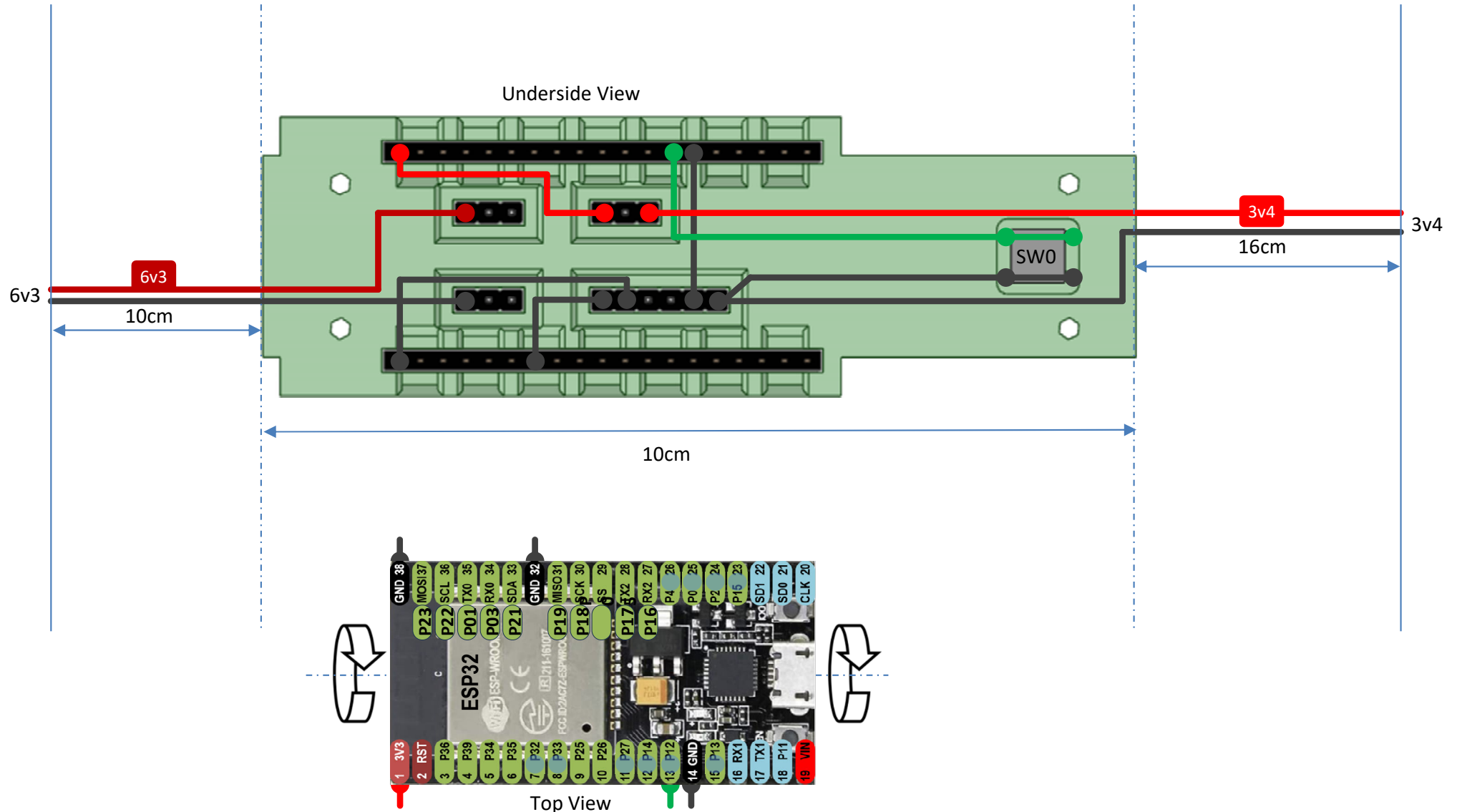


The 3v4 voltage regulator is mounted at the end of the forearm, close to the Huskylens to improve its supply.

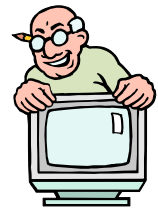
The leads from the lower 3 servos are fed down into the base, where they are connected to PWM signals from the ESP32.

Micro Plate Wiring – Step 2

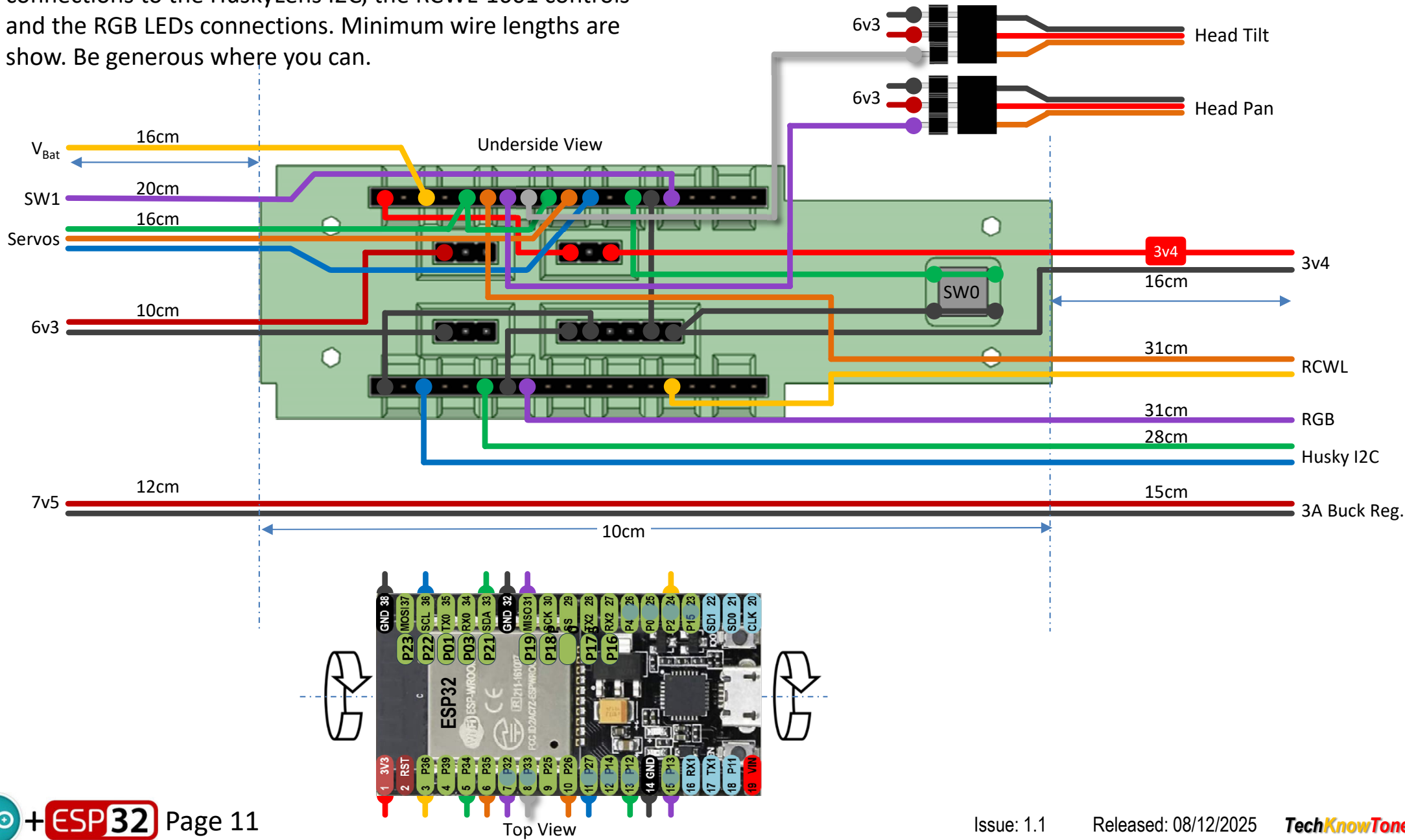
Here we start by wiring in the power connections, to the pin strips, and then the button switch, SW0. Wire lengths are estimated from the edge of the board, which itself is 10cm long. Be generous, you can always cut off any excess.



Micro Plate Wiring – Step 3

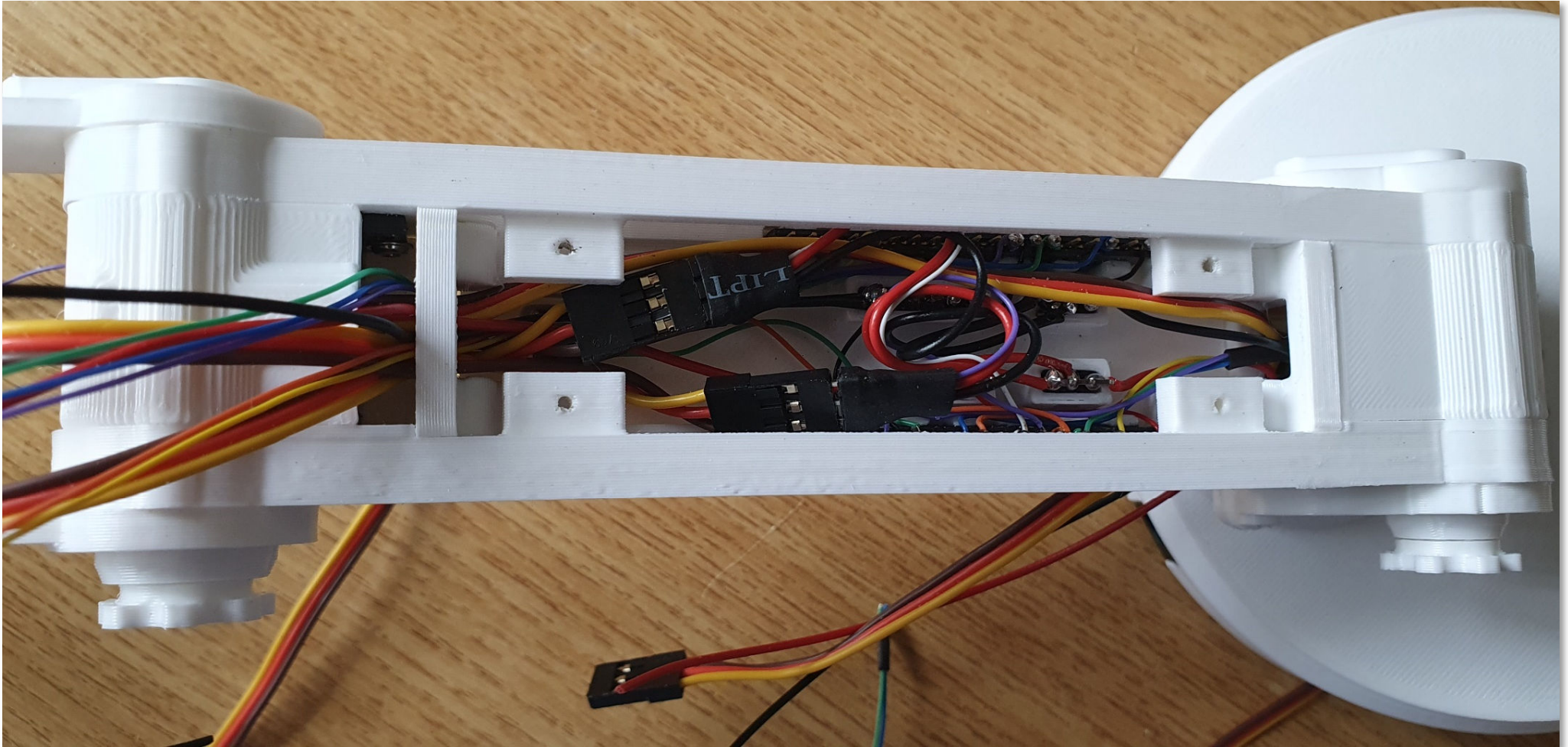


The we attach pin strips for the pan and tilt servos. We feed through wires for the 3A voltage regulator, and provide connections to the HuskyLens I2C, the RCWL-1601 controls and the RGB LEDs connections. Minimum wire lengths are show. Be generous where you can.



Micro Plate Wiring – Step 4

In this view the microplate has been mounted on the rear of the lower arm, and we are looking into the lower arm from the front. This shows you how the servo wires from the pan/tilt lamp are connected, and how wires are routed to the lamp(left) and the base (right).

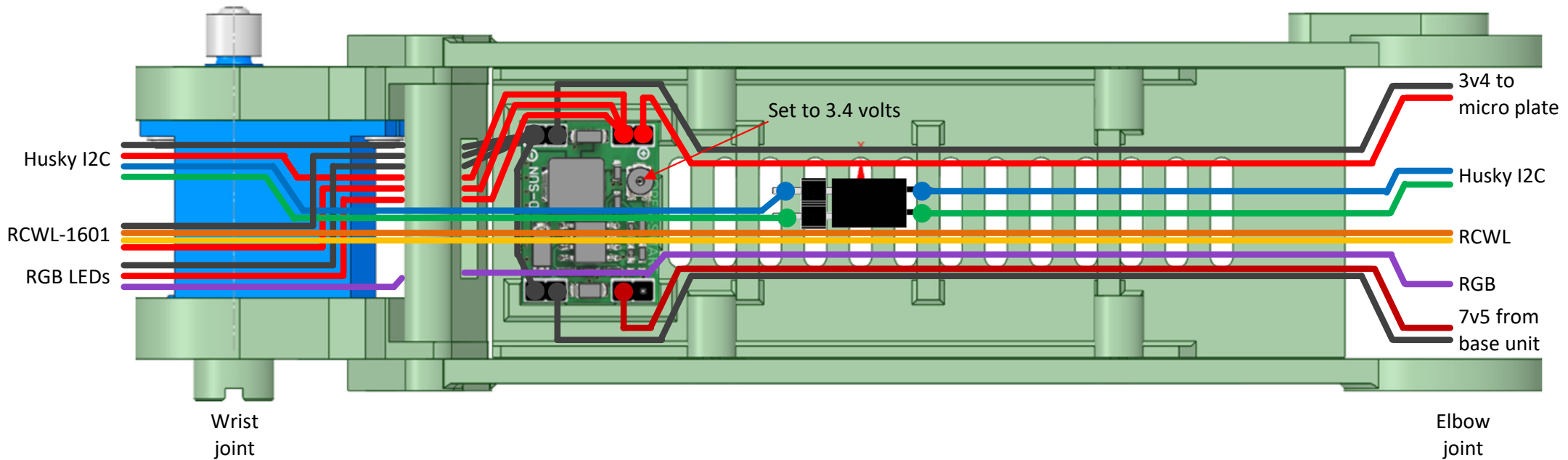


Micro Plate Wiring – Step 4

Then we mount the voltage regulator on the forearm cover plate, and wire to that. Power is fed up from the base to the regulator. From there the regulated 3.4v output is fed back to the micro plate, and onto the HuskyLens camera and face plate components.

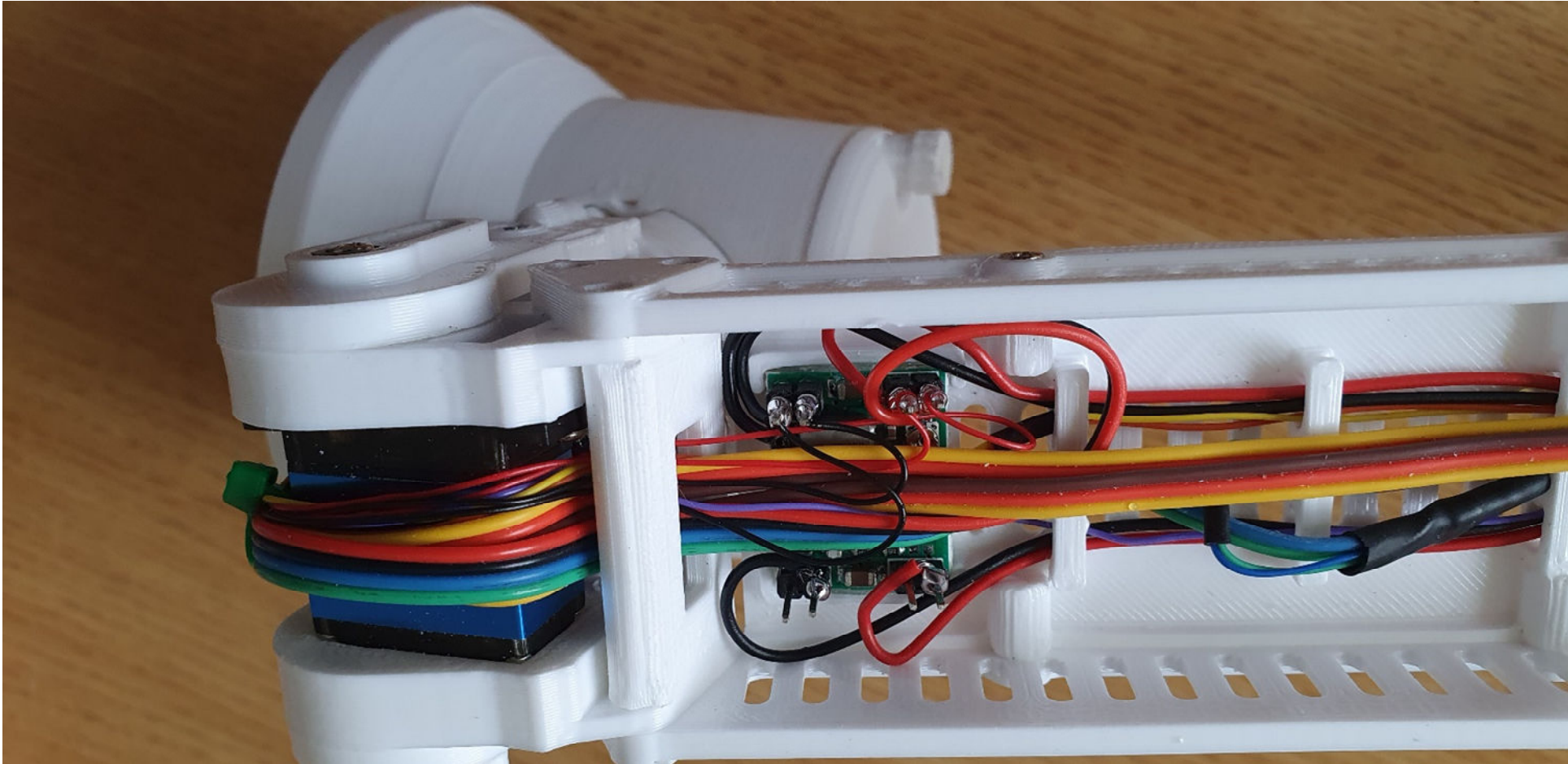
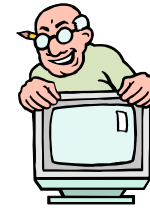


The pan and tilt servo leads pass through this area, and onto the micro plate.



Micro Plate Wiring – Step 4

This image shows the connections made to the 3.4v voltage regulator, and the feedthrough of the servo wires, I2C and RGB LED connections.

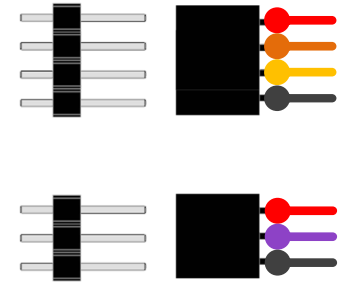
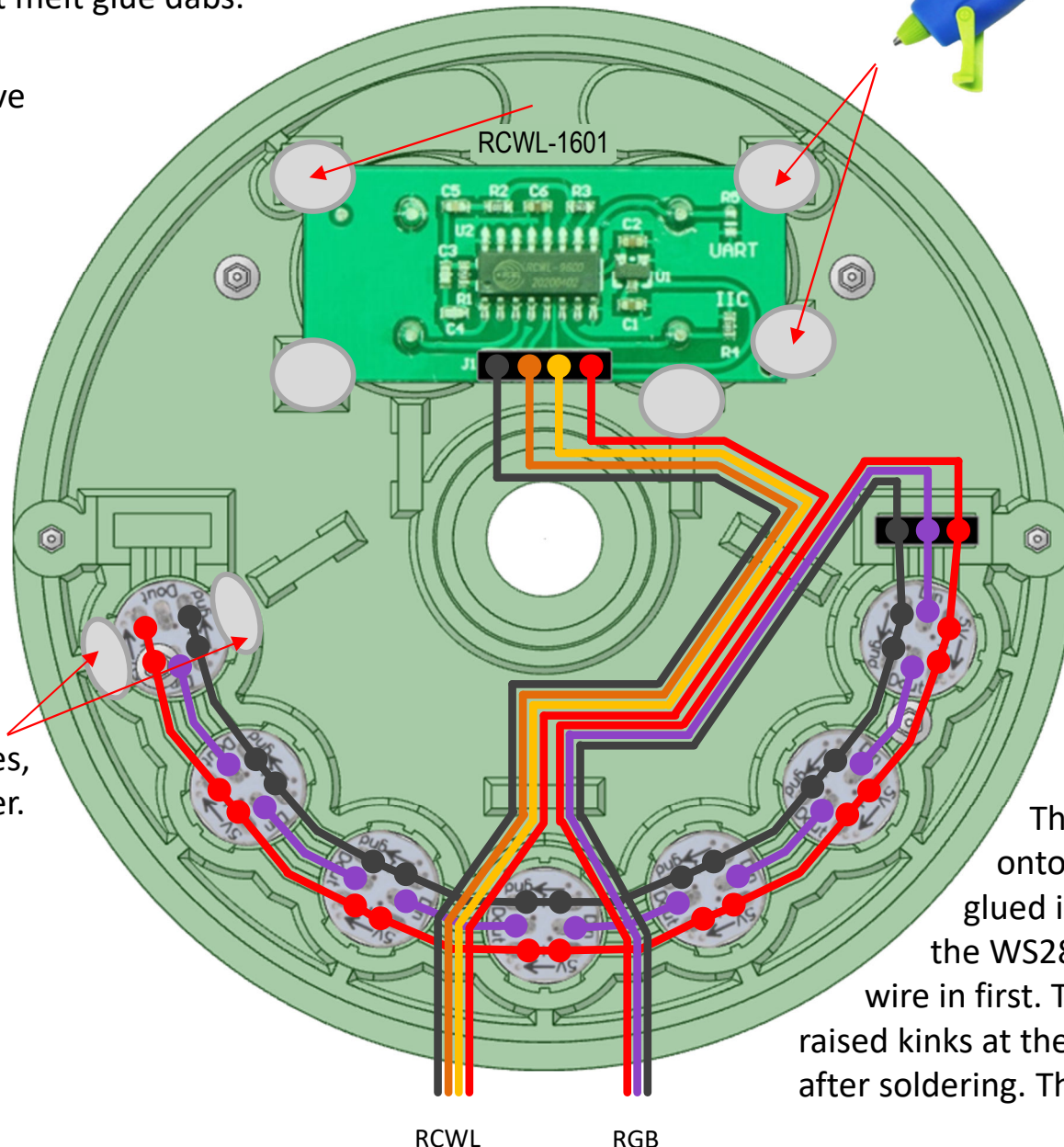


Face Plate Wiring

The four bent pins on the RCWL-1601 sensor are first straightened, and cropped, to normal length, before the board is glued into position, using hot melt glue dabs.

This makes it possible to remove the sensor at a later date, if needed.

The seven WS2812B chips are glued into the face plate, using small dabs of glue at their edges, before wiring the chips together.

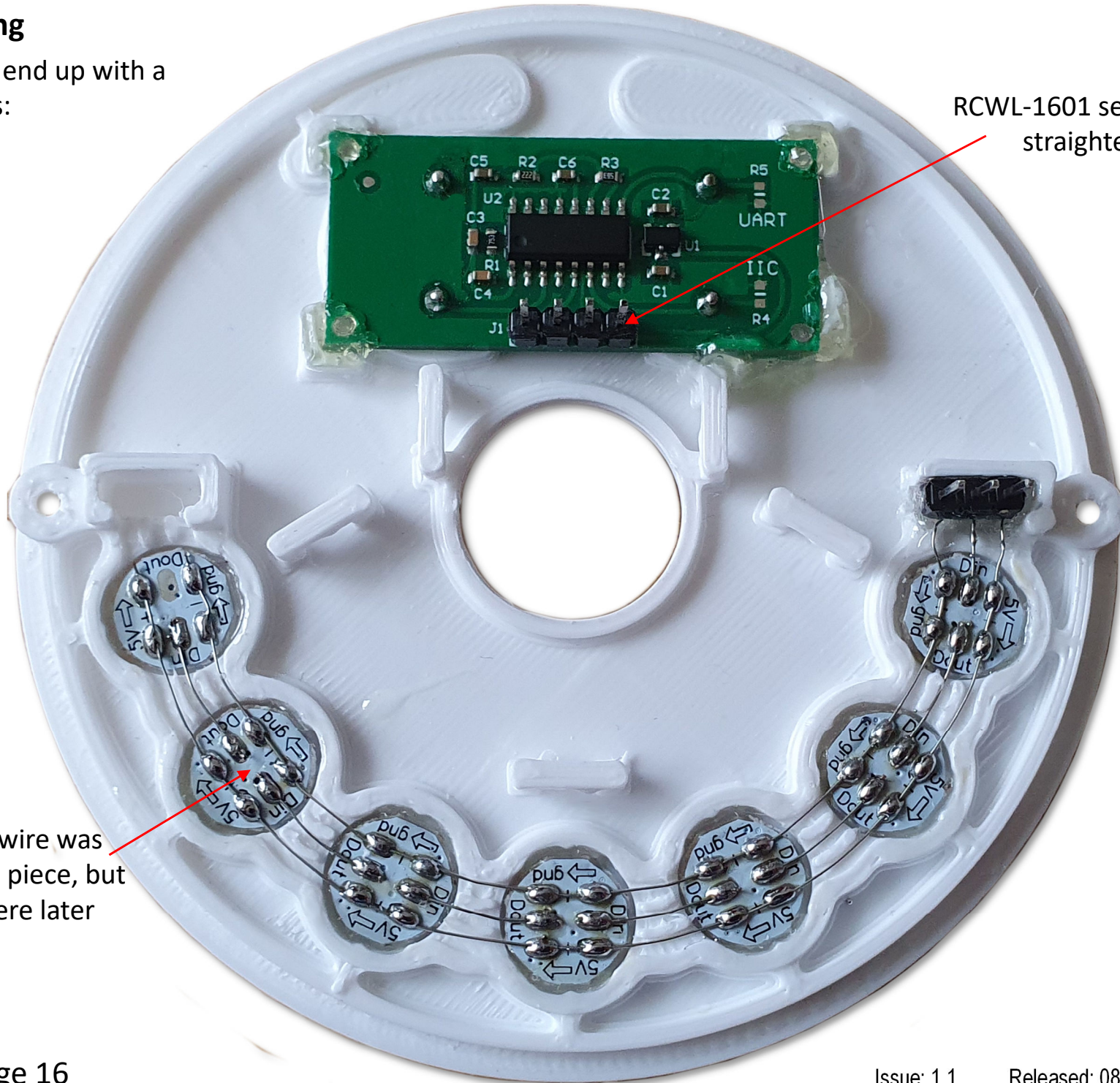


The RGB wires are wrapped onto the 3-pin strip, solder and glued in place before soldering onto the WS2812B chips. Solder the GND wire in first. Then the data wire, with raised kinks at the chip centre points. Cropped after soldering. Then finally the +ve wire.



Face Plate Wiring

You should aim to end up with a face panel like this:



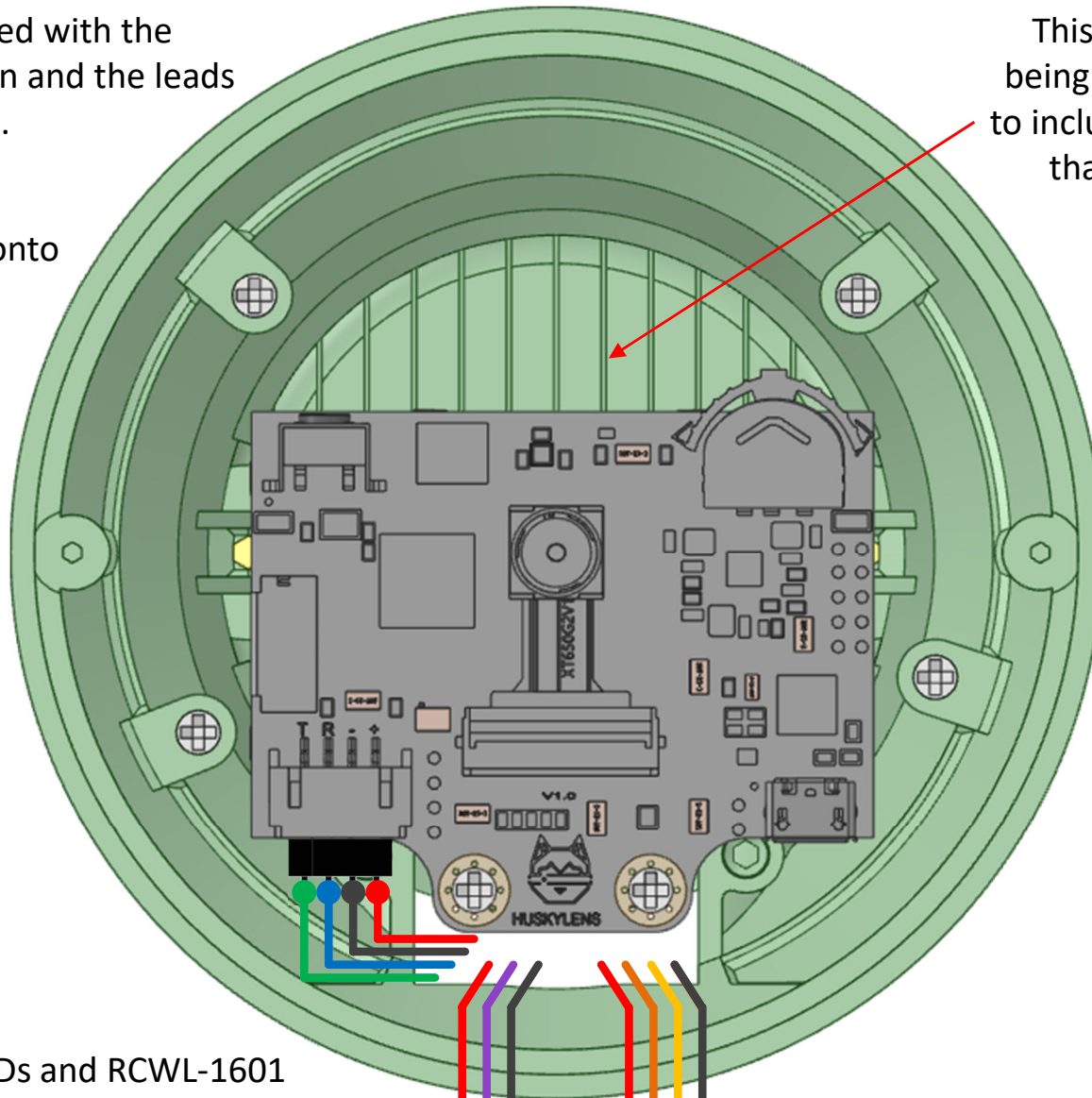
RCWL-1601 sensor with
straightened pins.

See how the data wire was
soldered in as one piece,
but with kinks, that were later
cropped out.

Huskylens Wiring

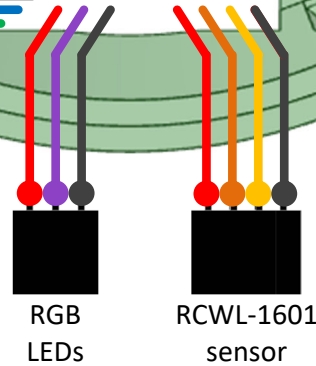
The four pins connector, supplied with the HuskyLens camera, is plugged in and the leads fed through the rotary junction.

They are then cropped to the correct length, to be soldered onto the voltage regulator.



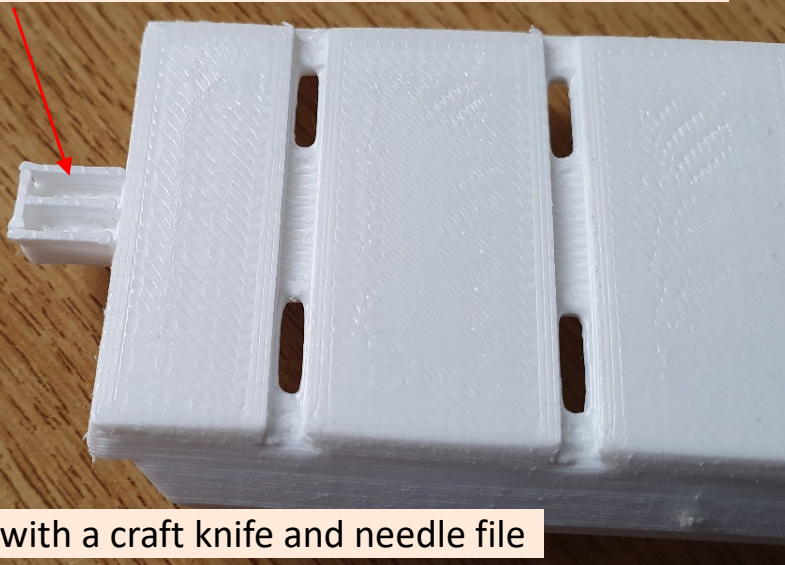
This shows the lamp rear cover as being solid, but it was later decided to include a rectangular aperture, so that the camera display could be viewed from the rear.

The connections to the RGB LEDs and RCWL-1601 sensor are also brought through this aperture, through the rotary junction and onto the voltage regulator and micro plate connections.

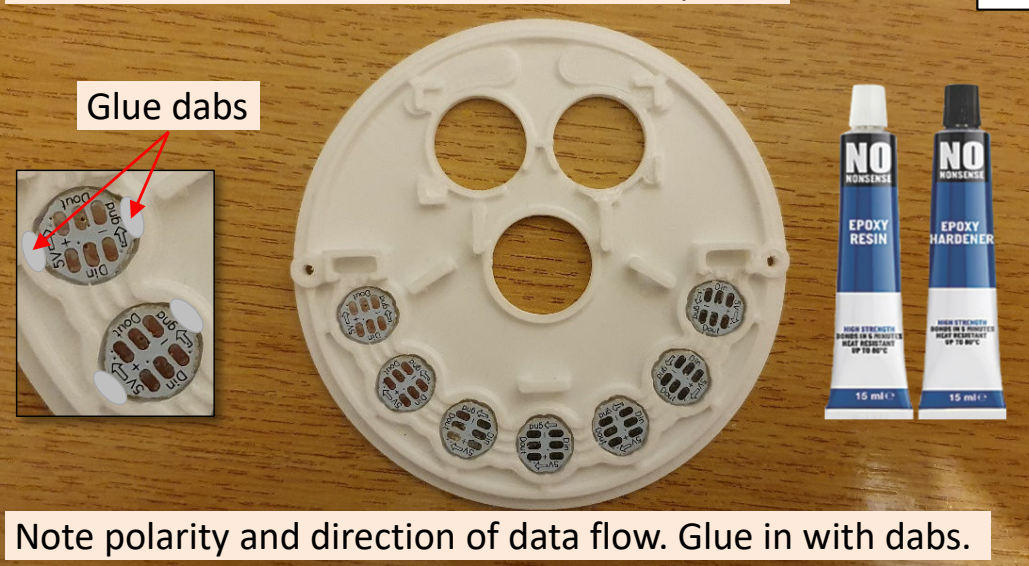


Build Images

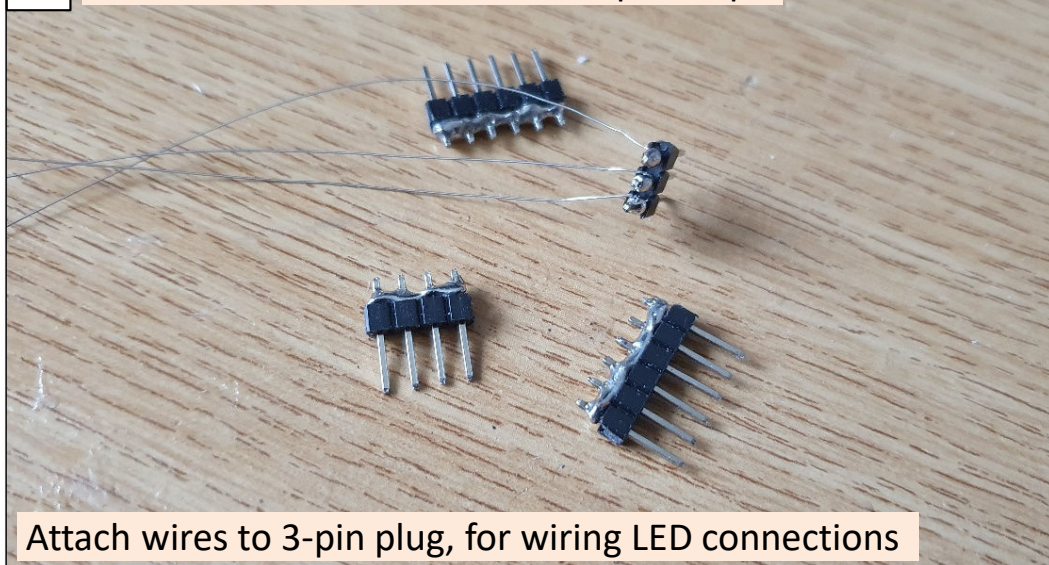
01 Supporting edges are included to make printing easier



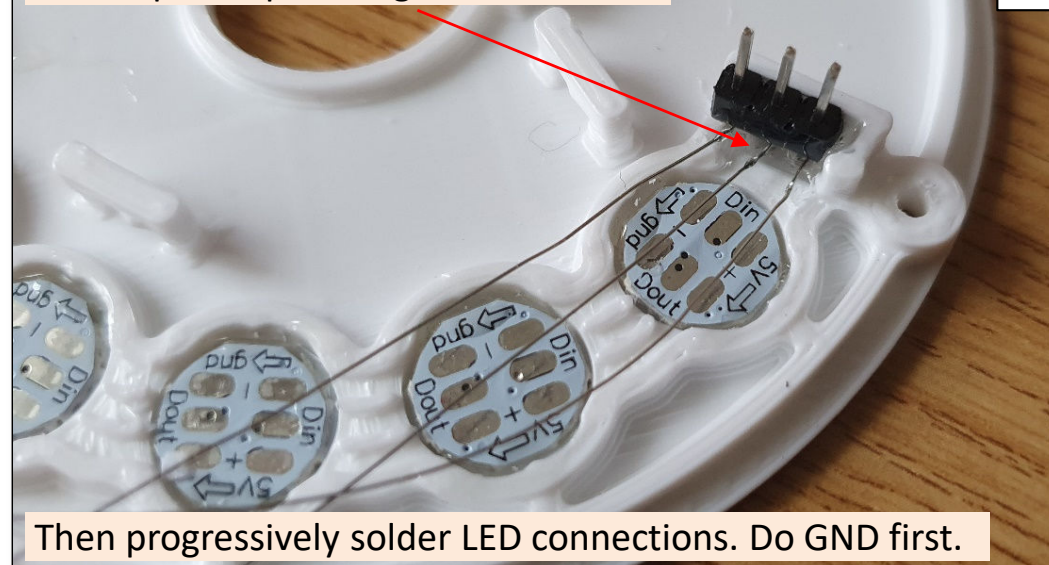
Insert the 7 WS2812B LEDs into the face plate.



03 Solder common connections on pin strips



Glue 3-pin strip into right-hand socket

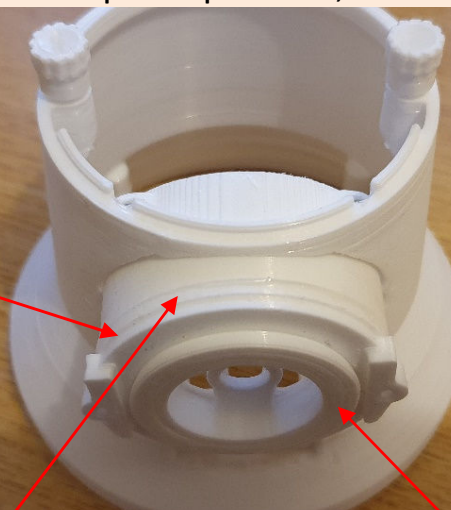


Build Images

05 Assemble the lamp components, with 2x10mm screws.



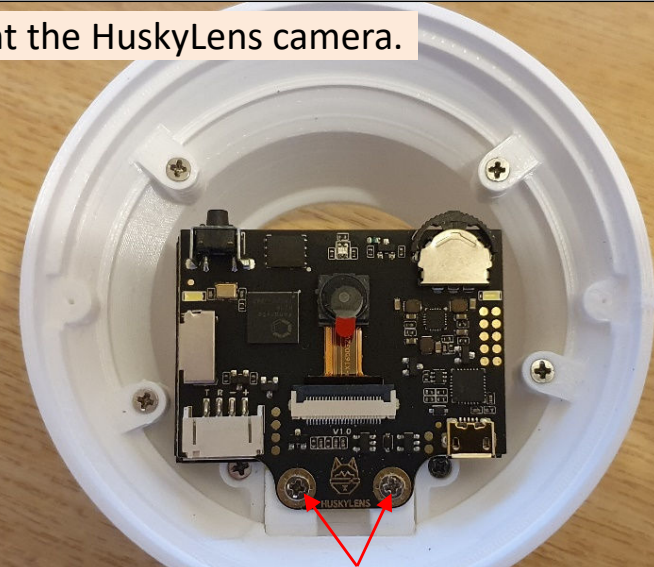
Lubricate faces



Glue on the mounting plate, and then the retaining ring.

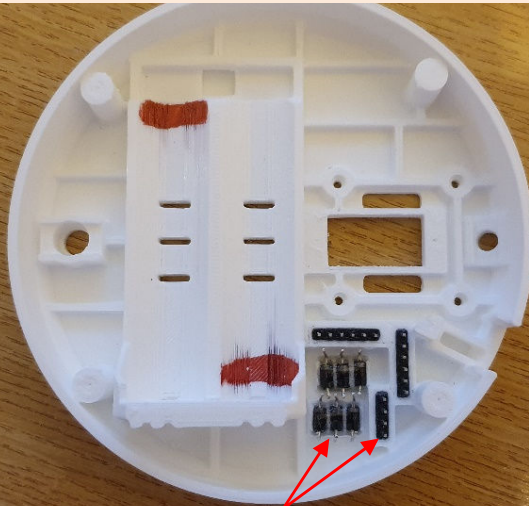
06 Test mount the HuskyLens camera.

06



Use two 2x10mm self-tapping screws for this.

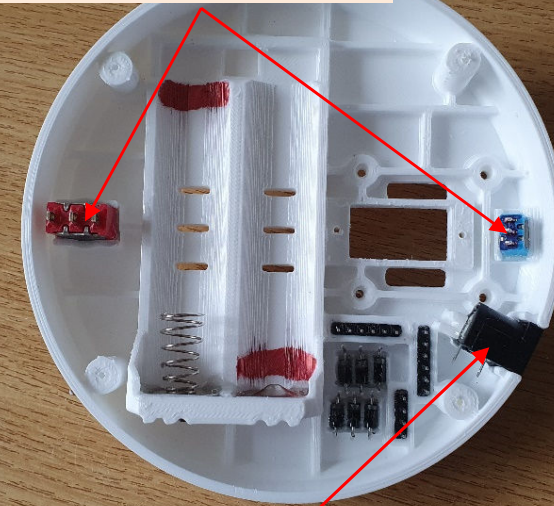
07 Mark the positive locations red in the battery trays.



Glue in place the diodes and the pin strips.

08 Then glue in place the two switches.

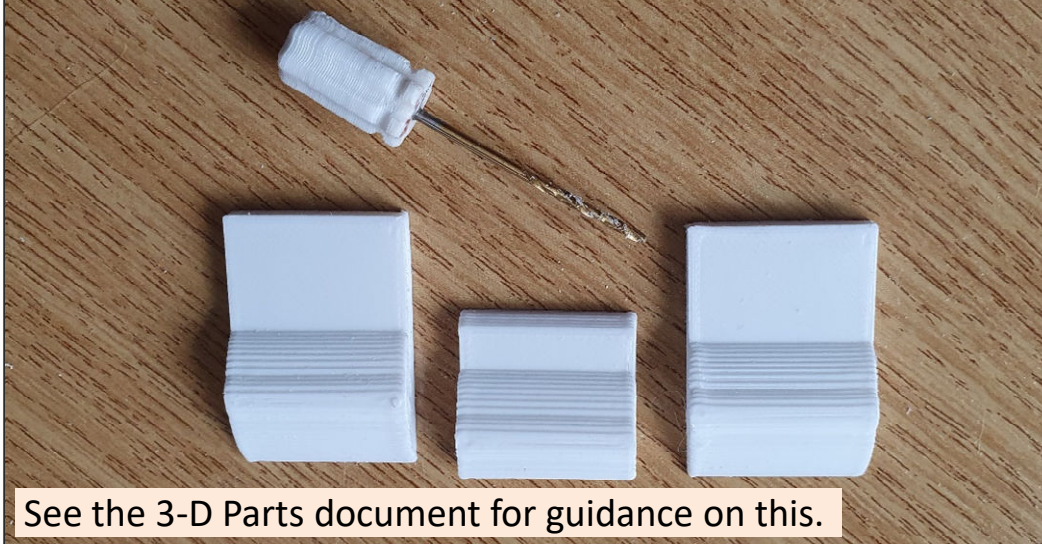
08



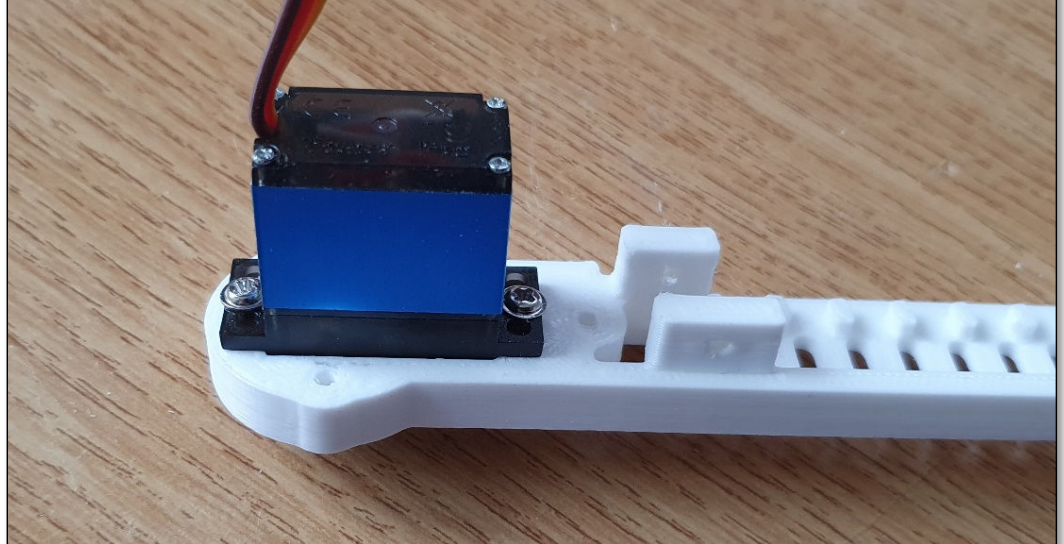
And the 7.5v DC power socket.

Build Images

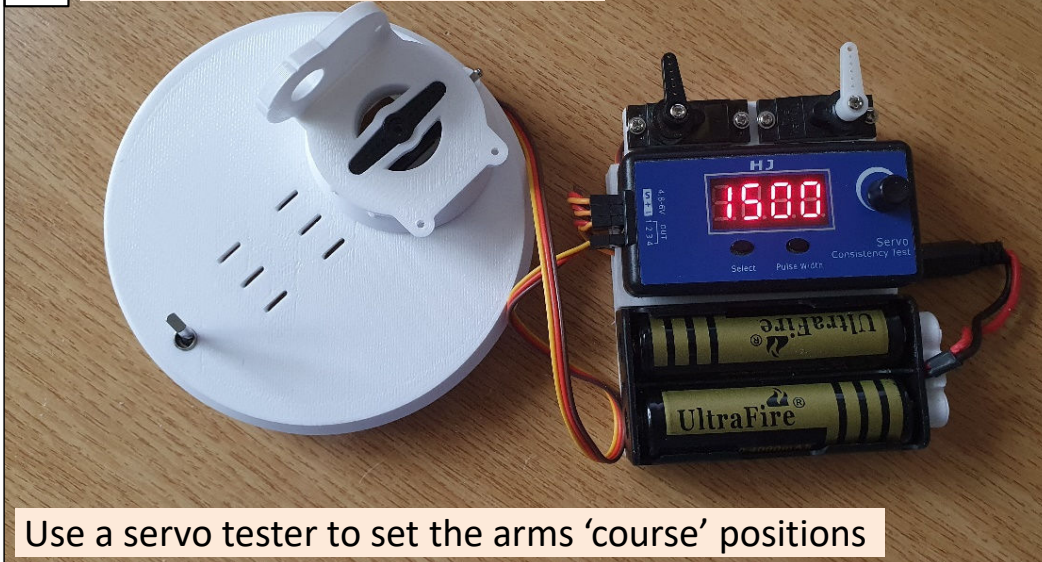
09 Print off the 3-d parts and prepare pilot holes



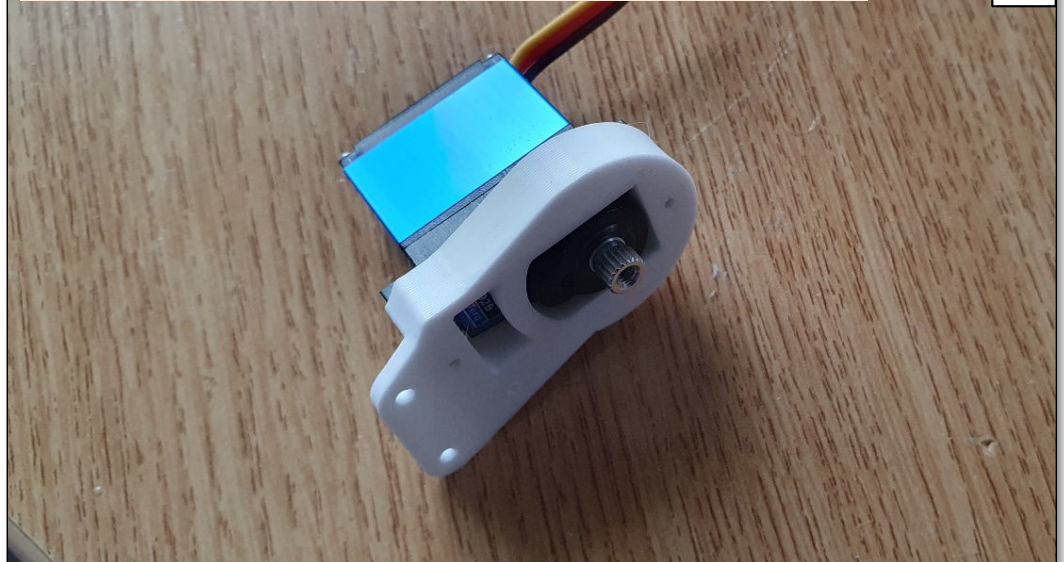
10 Attach the two servos to the lower arm.



11 Refer to the Calibration guide.

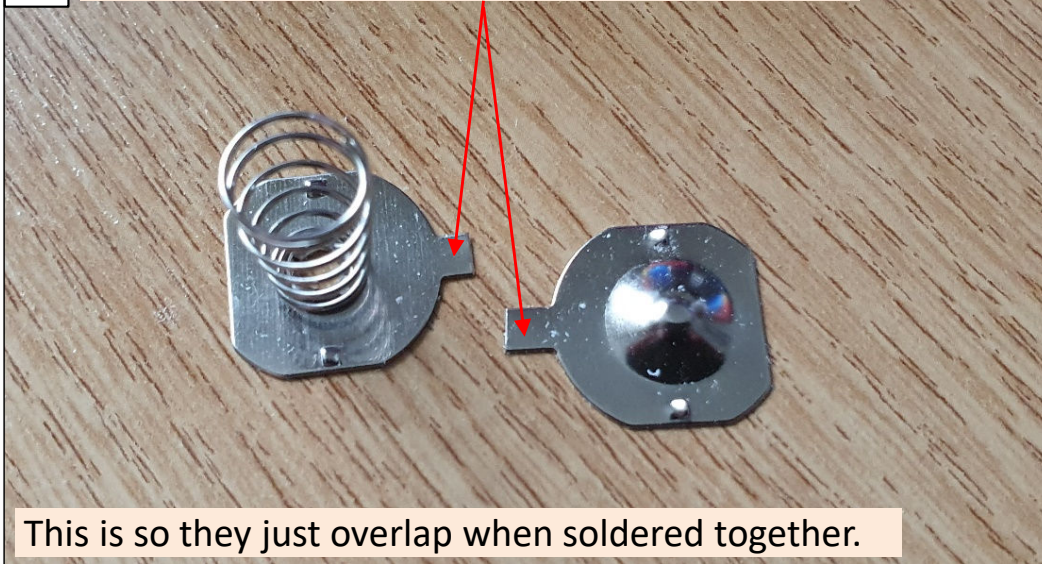


12 Attach the lamp 'Tilt' servo to the mounting plate.

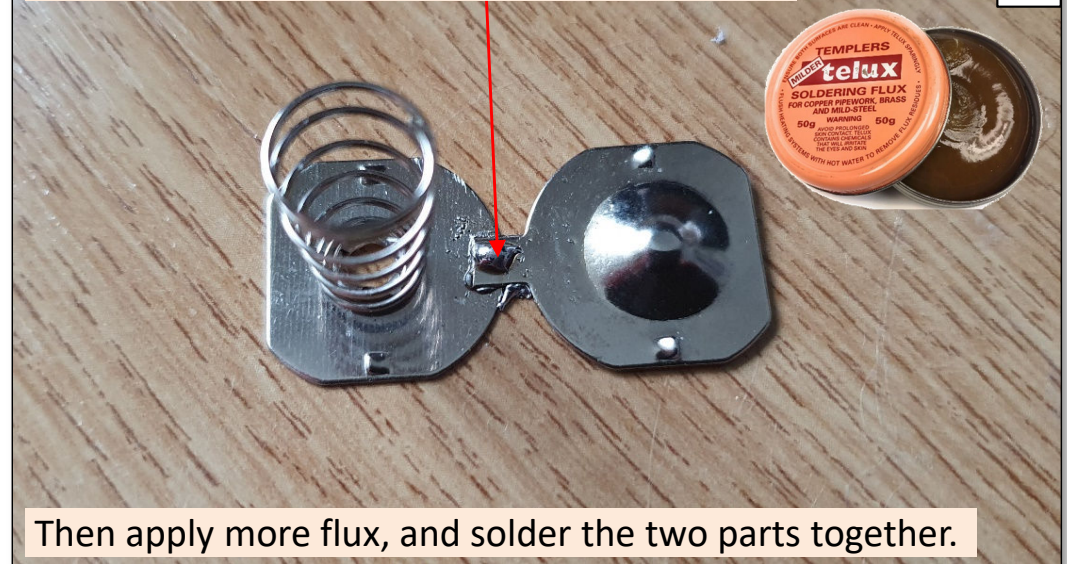


Build Images

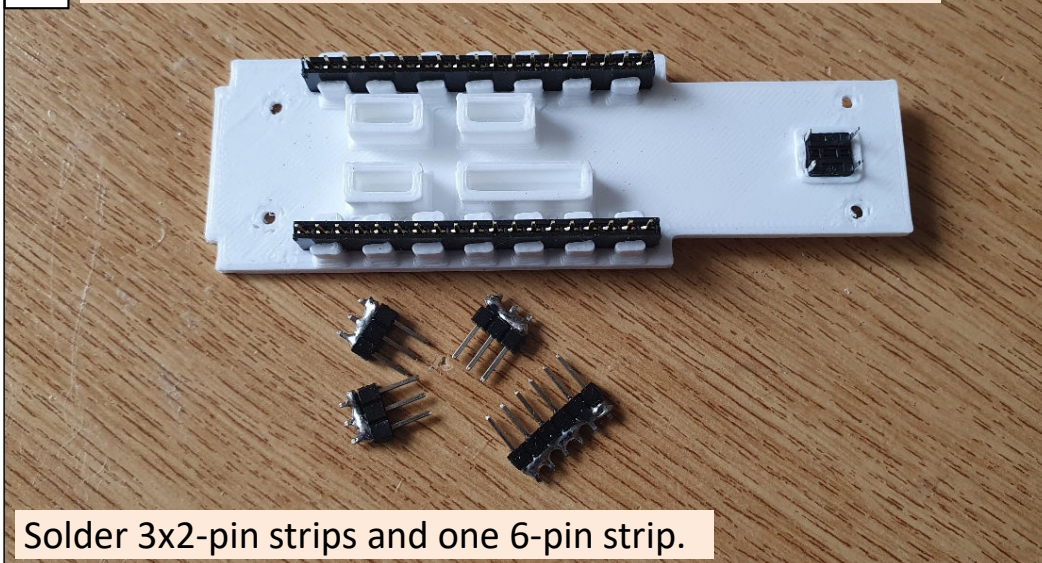
13 Crop one pair of battery connectors as shown.



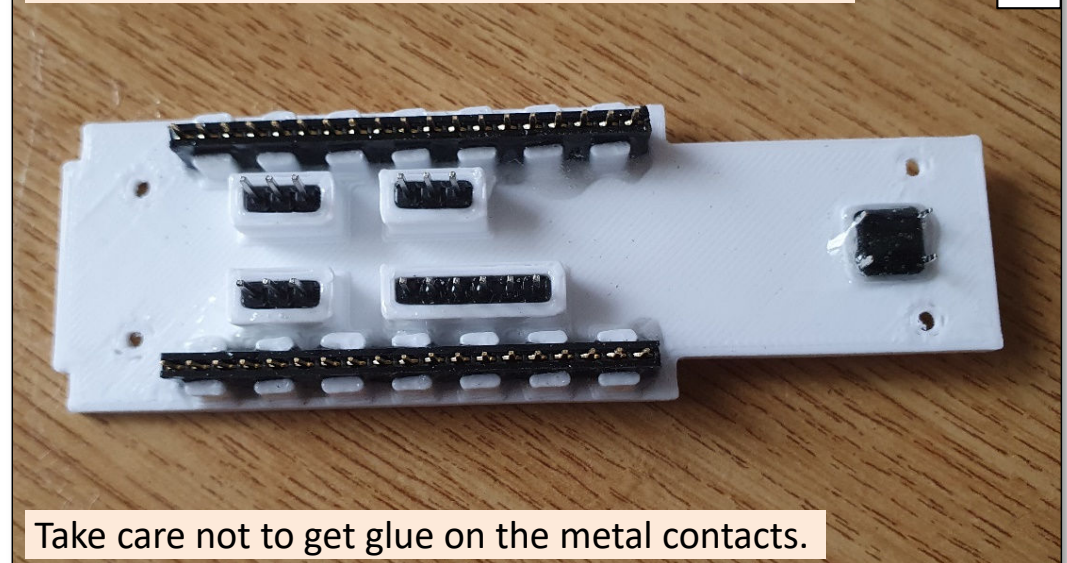
14 Apply flux and pre-solder the ends, then cool.



15 Insert two 19-pin socket strips into the micro plate.

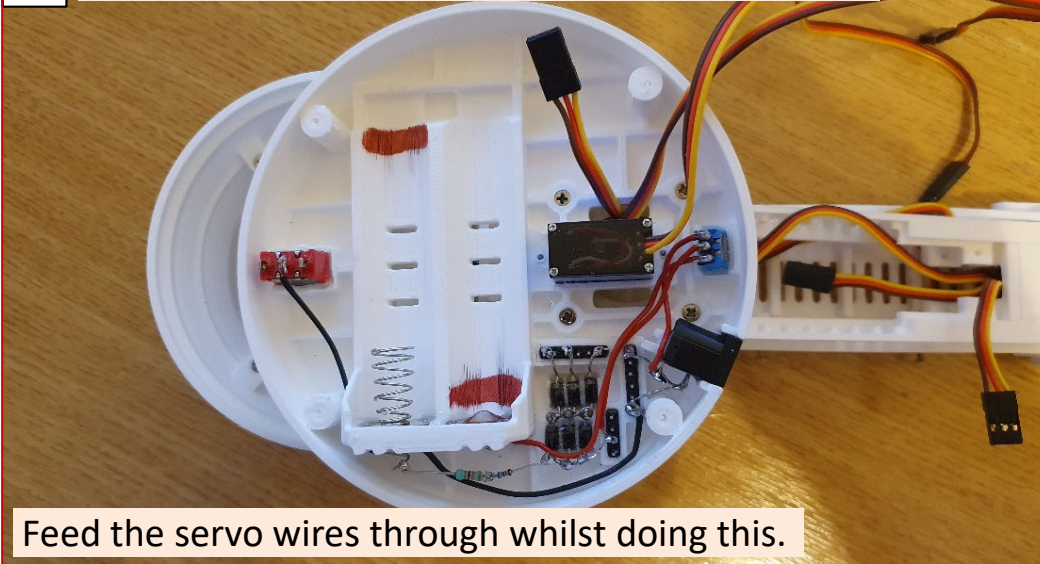


16 Then glue all of these components into the plate.



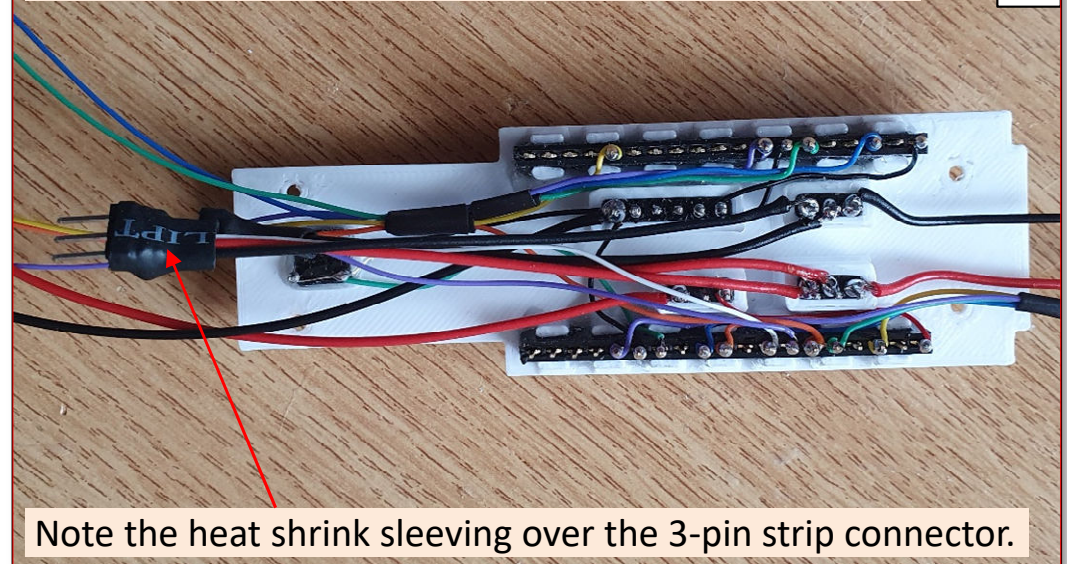
Build Images

17 Attach the lower arm to the base rotary mount.



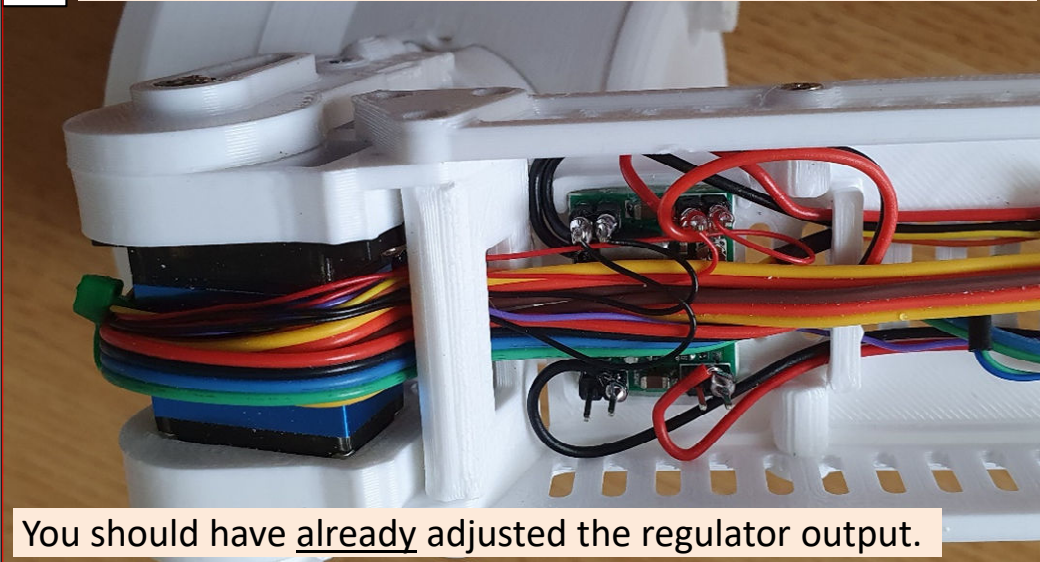
Feed the servo wires through whilst doing this.

18 Wire the micro plate, to the instructions given earlier.



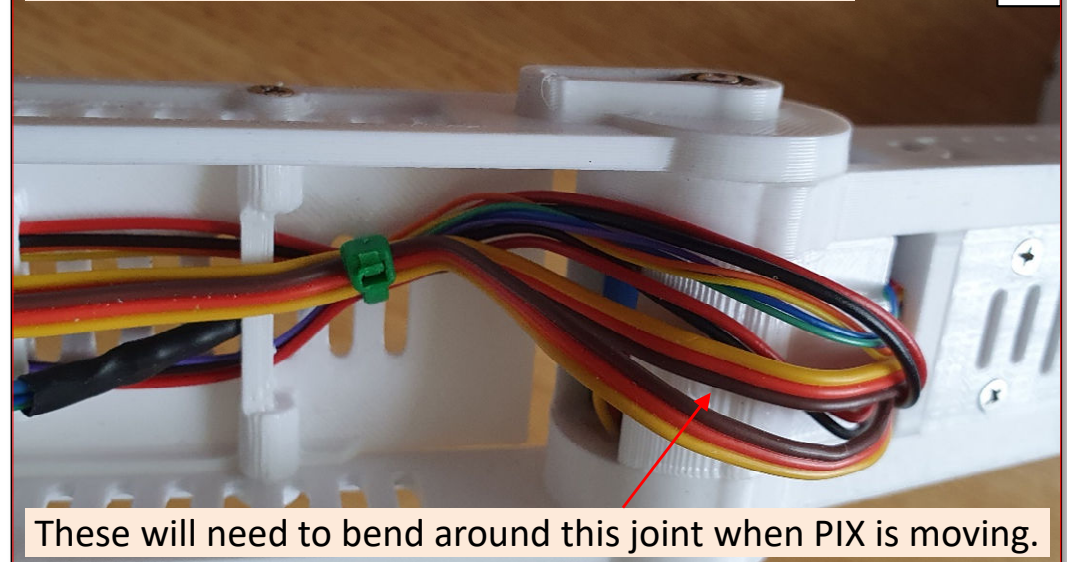
Note the heat shrink sleeving over the 3-pin strip connector.

19 Wire up the power connections first to the 3.4v regulator.



You should have already adjusted the regulator output.

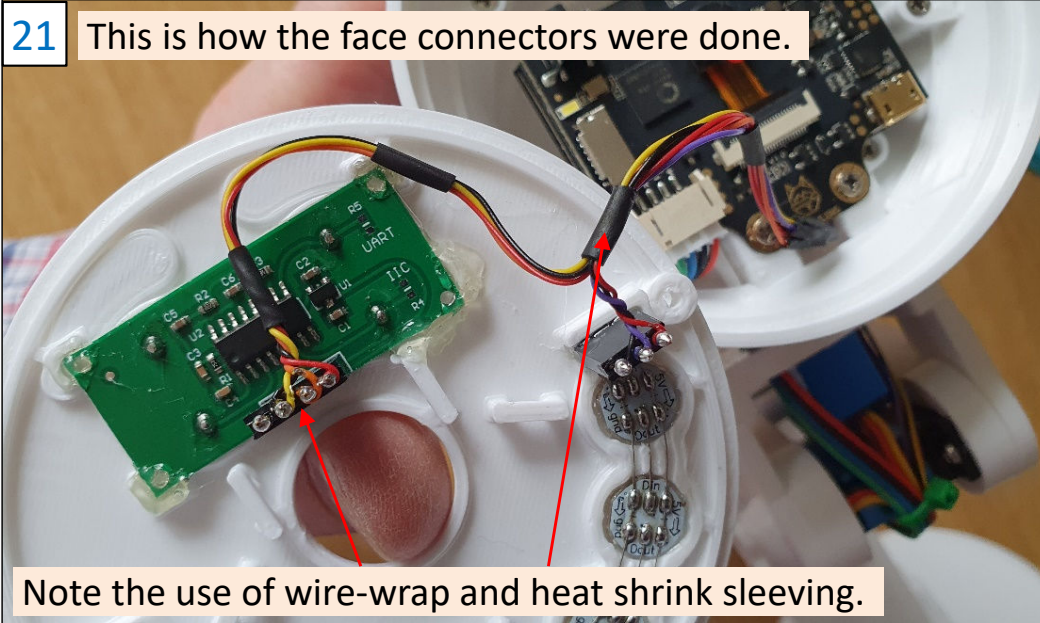
20 At the other end of the forearm, group the wires.



These will need to bend around this joint when PIX is moving.

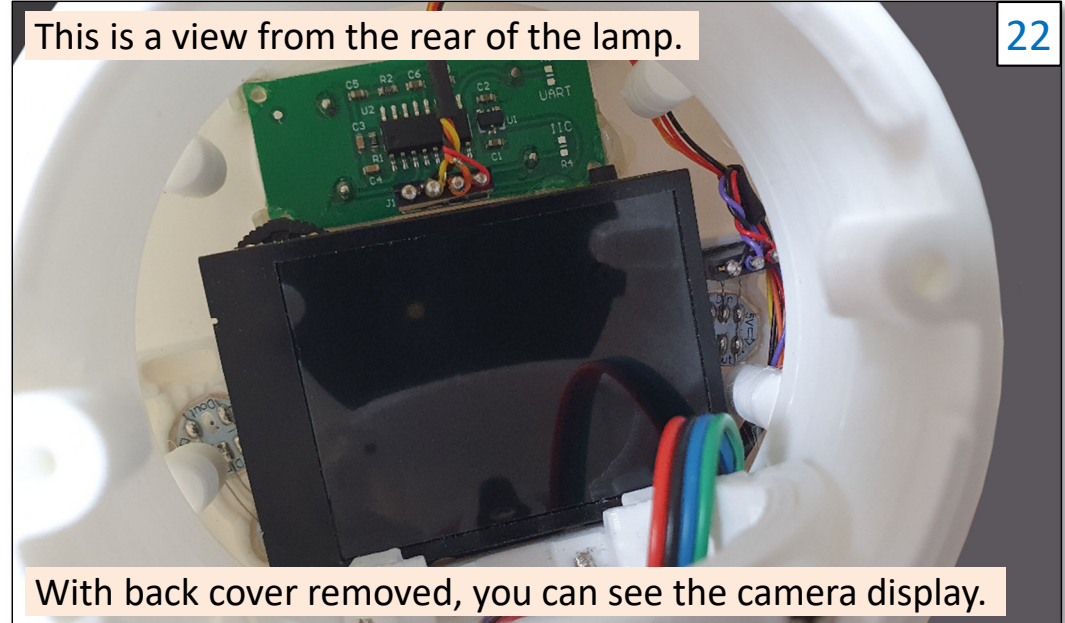
Build Images

21 This is how the face connectors were done.



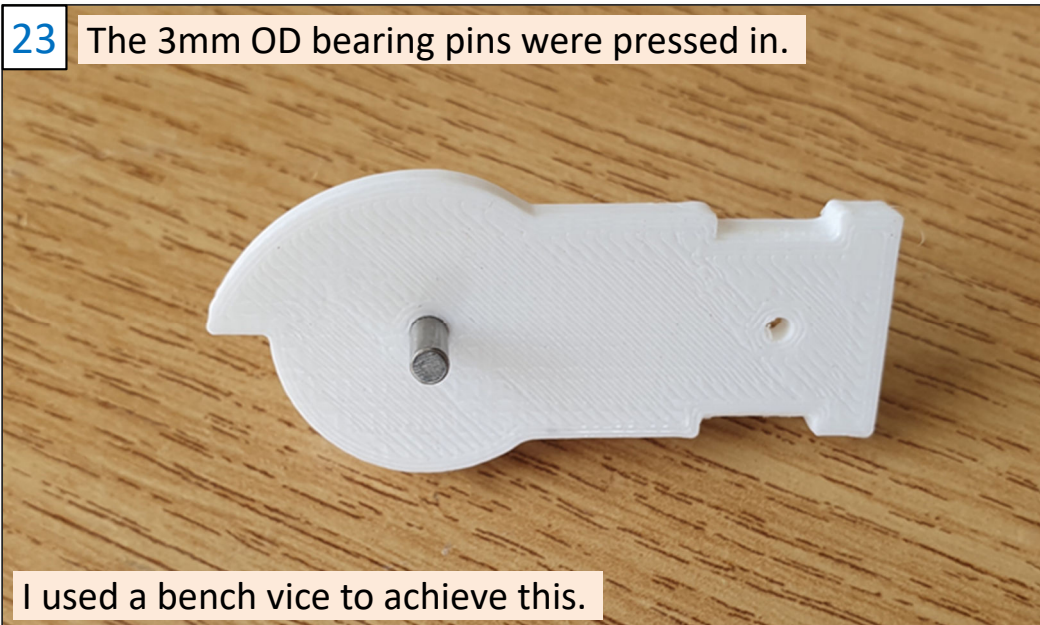
Note the use of wire-wrap and heat shrink sleeving.

22 This is a view from the rear of the lamp.



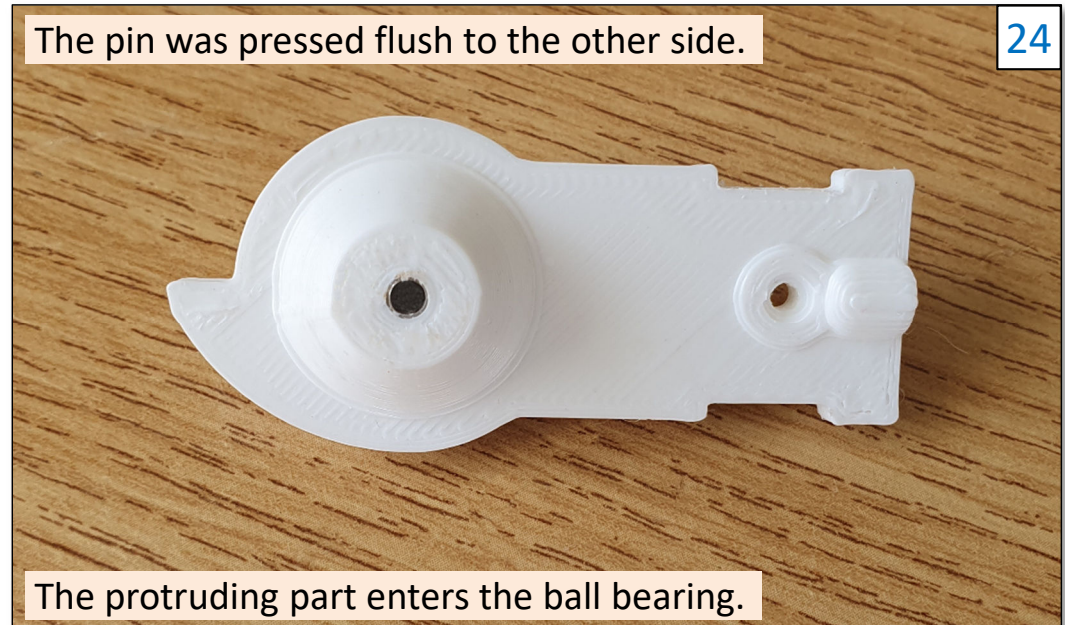
With back cover removed, you can see the camera display.

23 The 3mm OD bearing pins were pressed in.



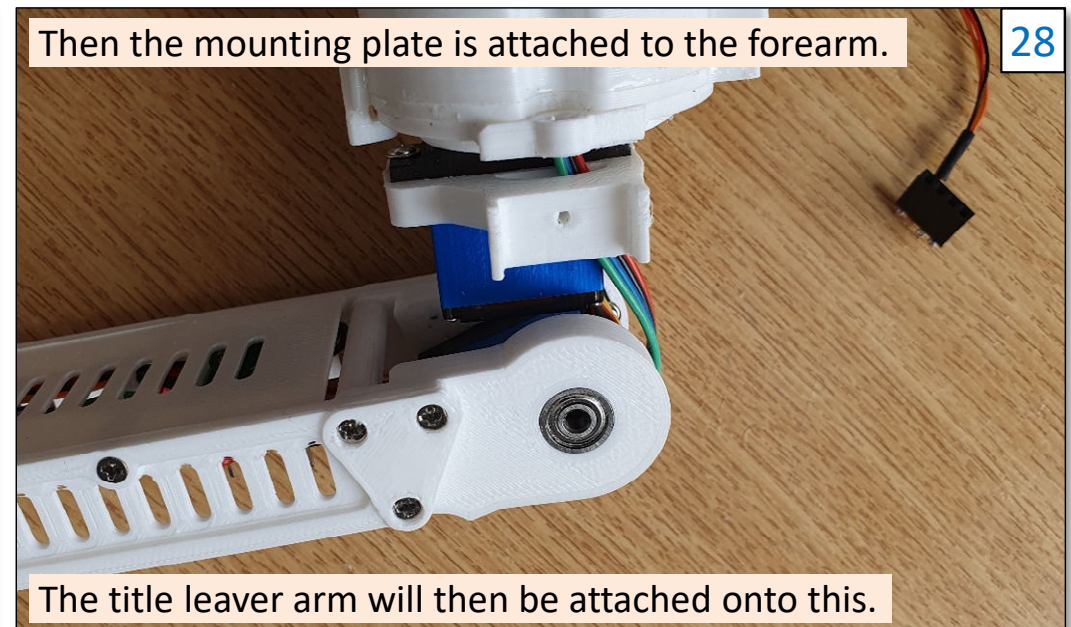
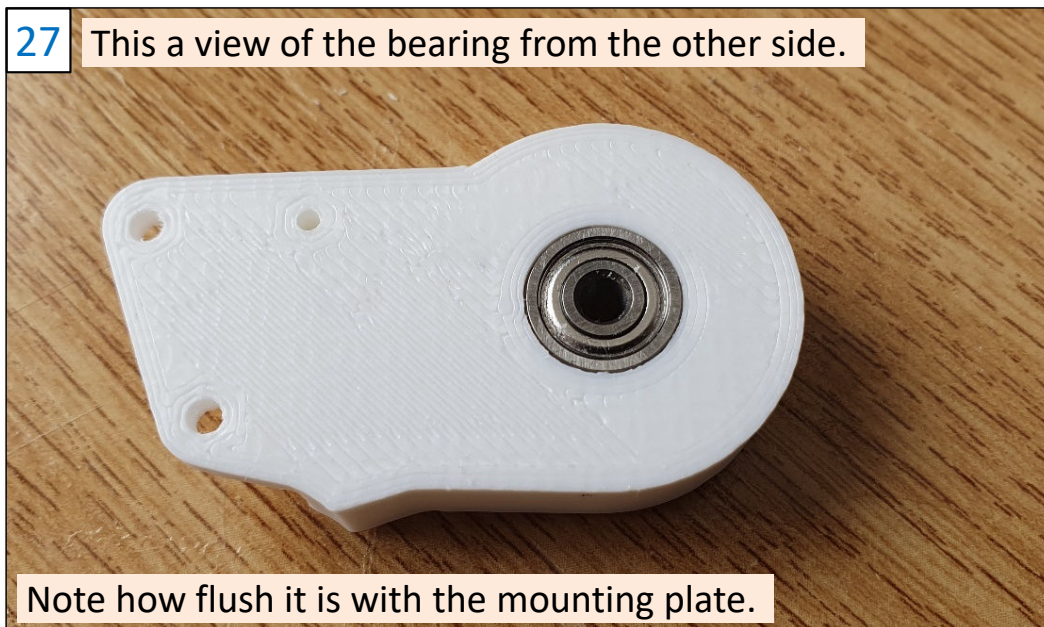
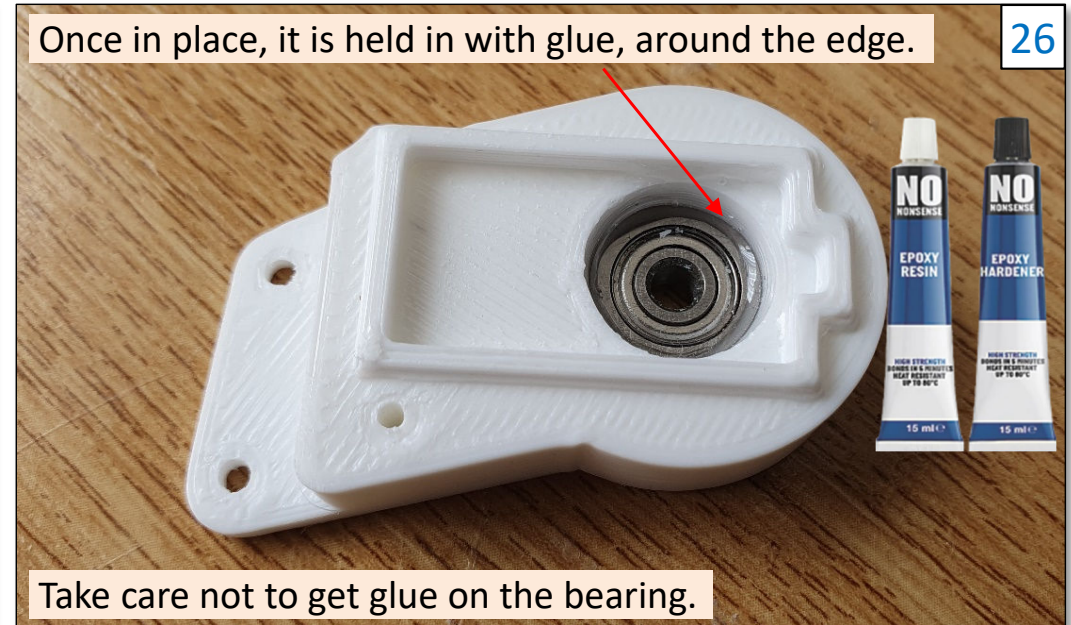
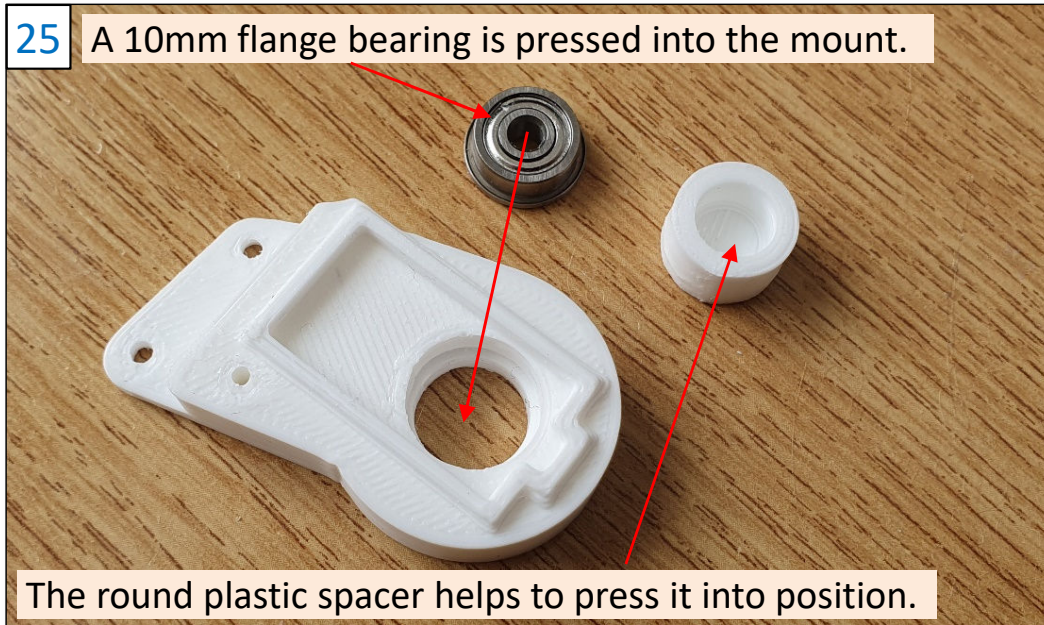
I used a bench vice to achieve this.

24 The pin was pressed flush to the other side.



The protruding part enters the ball bearing.

Build Images



Build Images

29

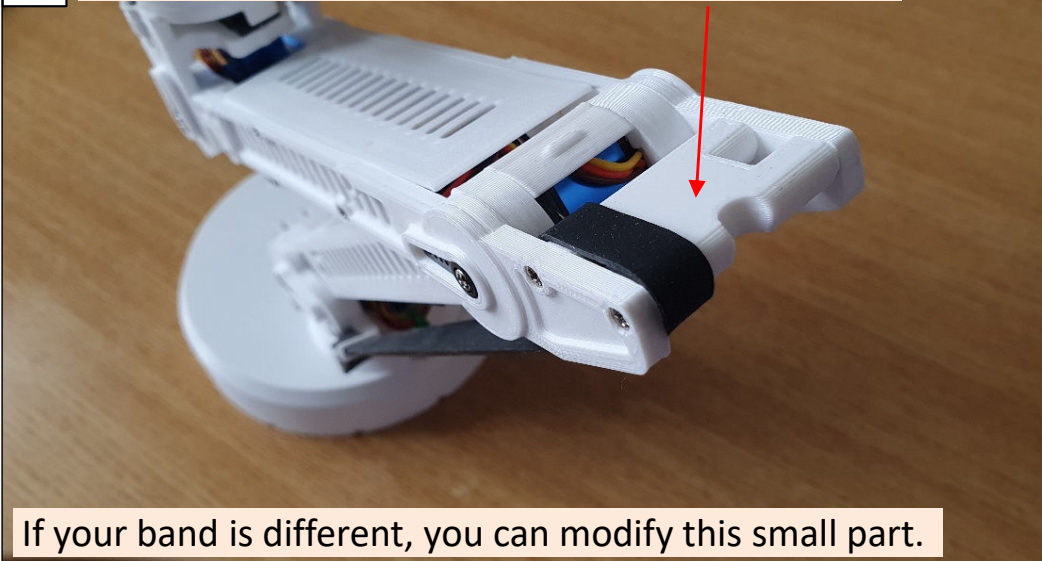
The front switch was wrapped in heat shrink.



The rubber band is kept tidy with printed sleeves.

30

The rubber band is attached to the canter lever.



If your band is different, you can modify this small part.

31

The completed robot:



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 $V_{BM} \approx 8.4v$ 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 x 3.3v)

The ESP32 is powered via a 5v voltage regulator, connected to the V_{in} pin, but the 6k8 supply sampling resistor is connected to source V_{Batt} .

For ESP32 $V_{ADC} \approx 4095$ 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 $10.1v \approx 4095$, or 2.47mV/bit, or 405.4 bit/v

Using a Multimeter and a variable DC supply, I determined the following V_{ADC} values for corresponding threshold voltages:

MAX: (100%) $V_M = 8.2v$, gave A0 = 3130 on V_{ADC} (2 x 4.1v)

HIGH: (80%) $V_H = 7.6v$, gave A0 = 2892 on V_{ADC} (2 x 3.8v)

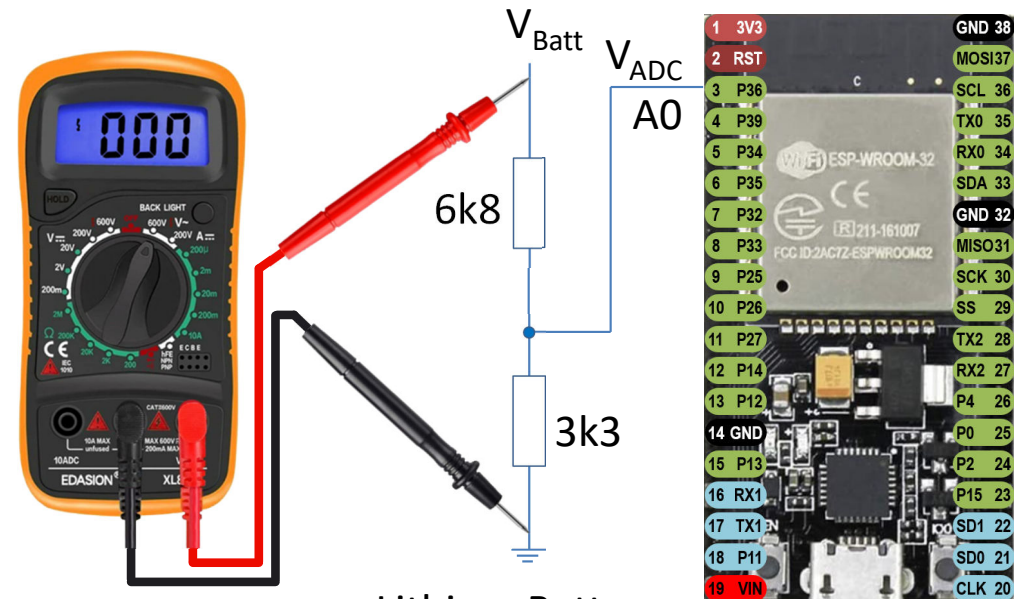
WARNING: (20%) $V_{BW} = 7.2v$, gives A0 = 2722 on V_{ADC} (2 x 3.6v)

CRITICAL: (0%) $V_{BC} = 6.6v$, gives A0 = 2485 on V_{ADC} (2 x 3.3v)

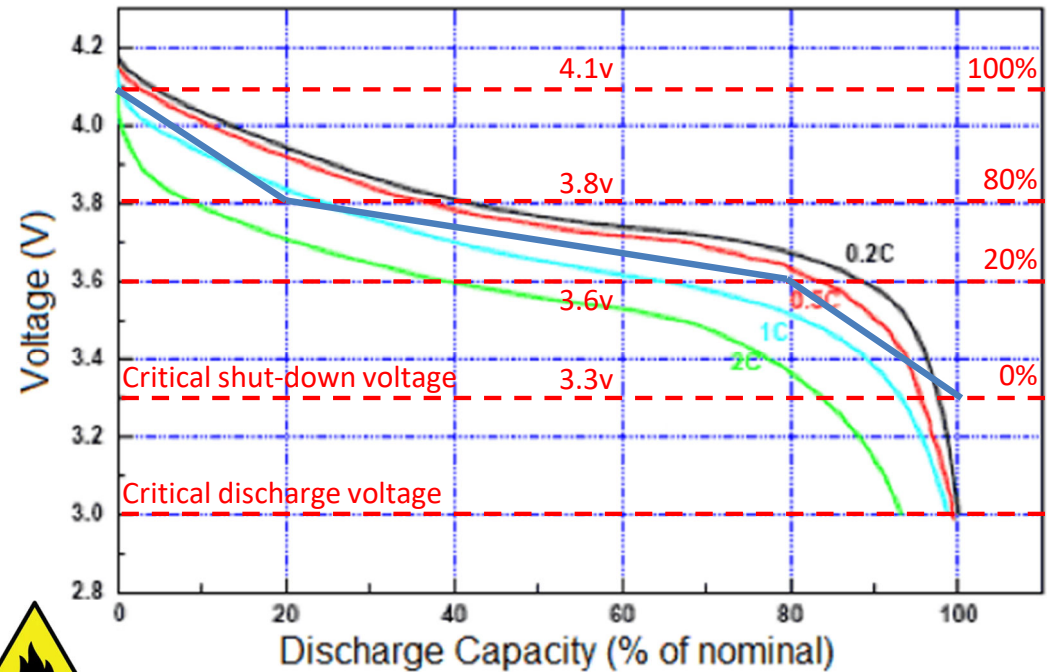
The code will sample the battery voltage on power-up to ensure it is sufficient, then at every 40ms interval, calculating an average (1/50) to remove noise. It also detects no battery as USB mode.

In the code I have assumed a discharge curve ranging from 8.2v (100%) to 6.6v (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.



Lithium Battery Discharge Profile



Discharge: 3.0V cutoff at room temperature.

