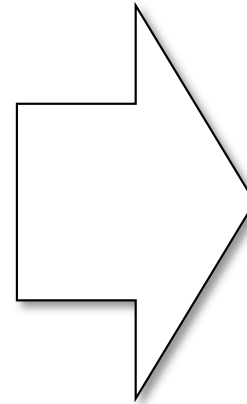
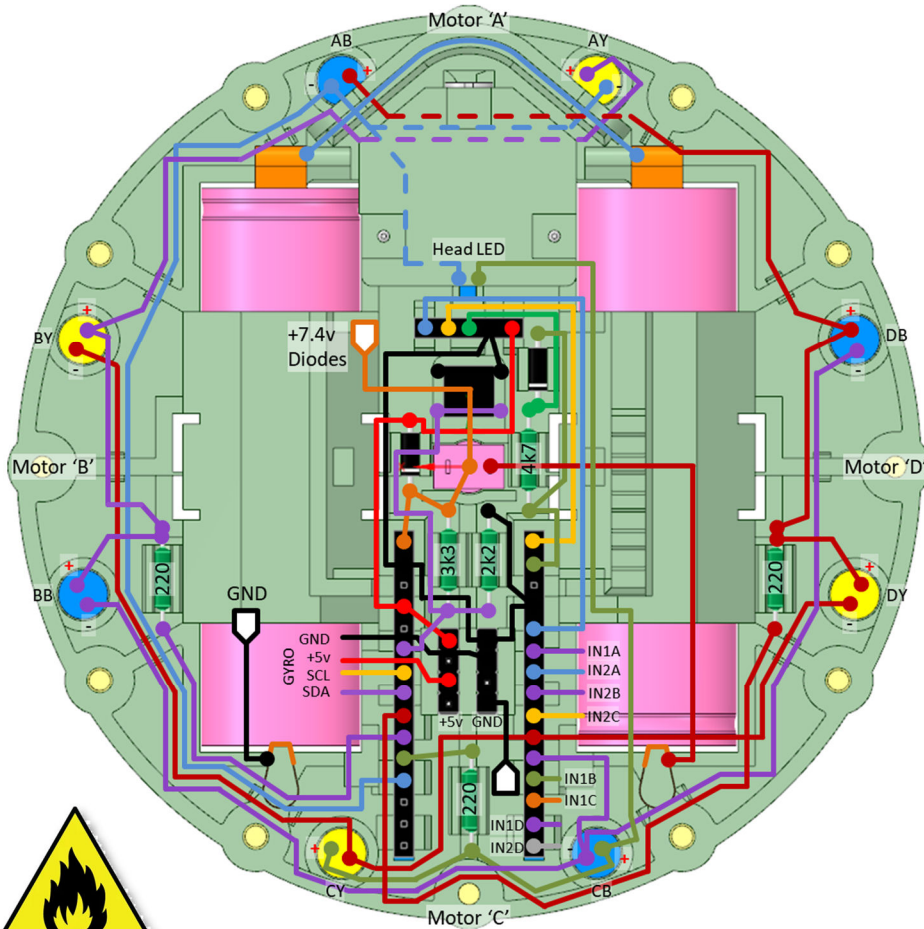


4x4 Ball Balancing Robot

Circuits



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:

Fine Nosed Pliers
Side Cutters
M3 Tap
M4 Tap
2.5 mm Drill
3.0 mm Drill
3.5mm Drill
6.0 mm Drill
Needle Files
M3 Box Spanner
Screwdriver
Craft Knife



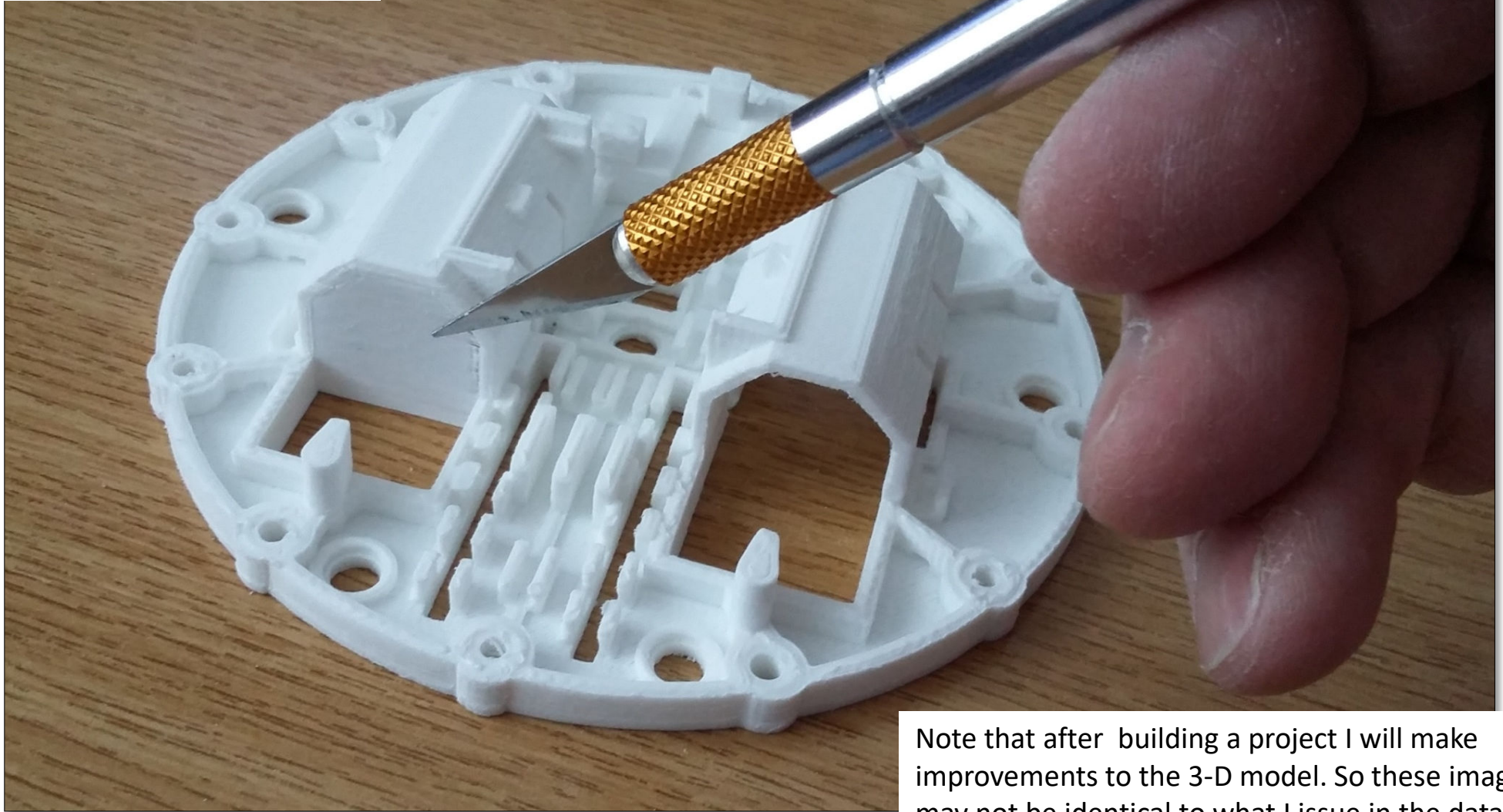
Note: Not all items are shown here.

Hand Tools:

- Temperature controlled iron
- Heat shrink sleeving gun
- Hot melt glue gun
- Solder flux
- Resin cored solder
- 6mm adhesive copper tape
- Screw drivers
- Wire wrapping tool
- Wire wrapping wire 30 AWG

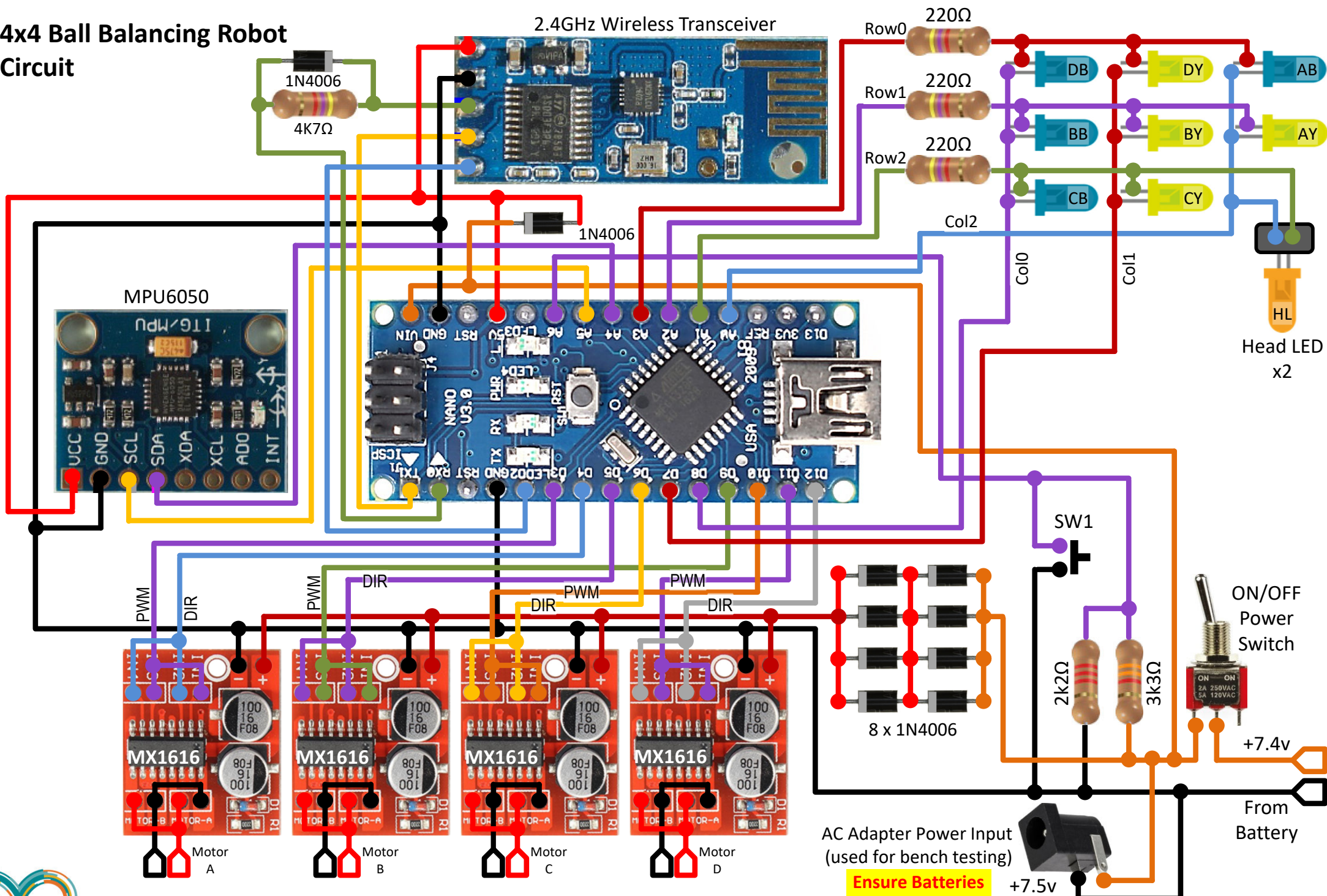


After printing the plastic parts, remove the thin walls that are included in the model to improve its printability.



Note that after building a project I will make improvements to the 3-D model. So these images may not be identical to what I issue in the data pack.

4x4 Ball Balancing Robot Circuit



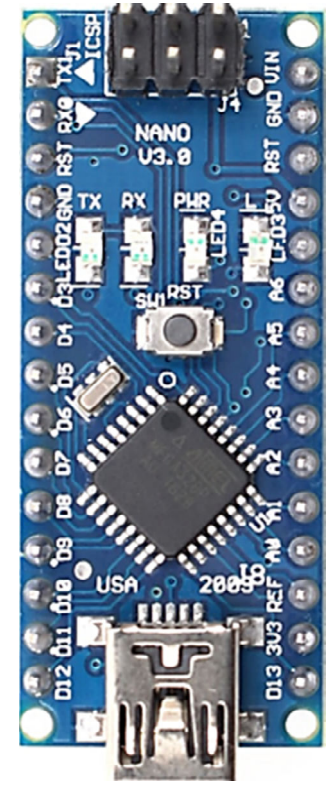
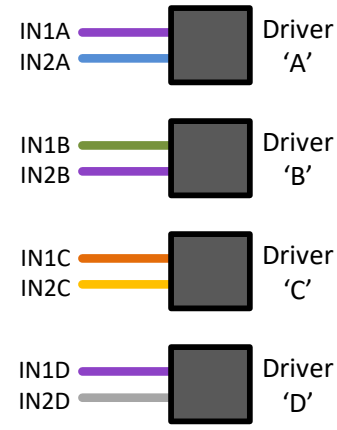
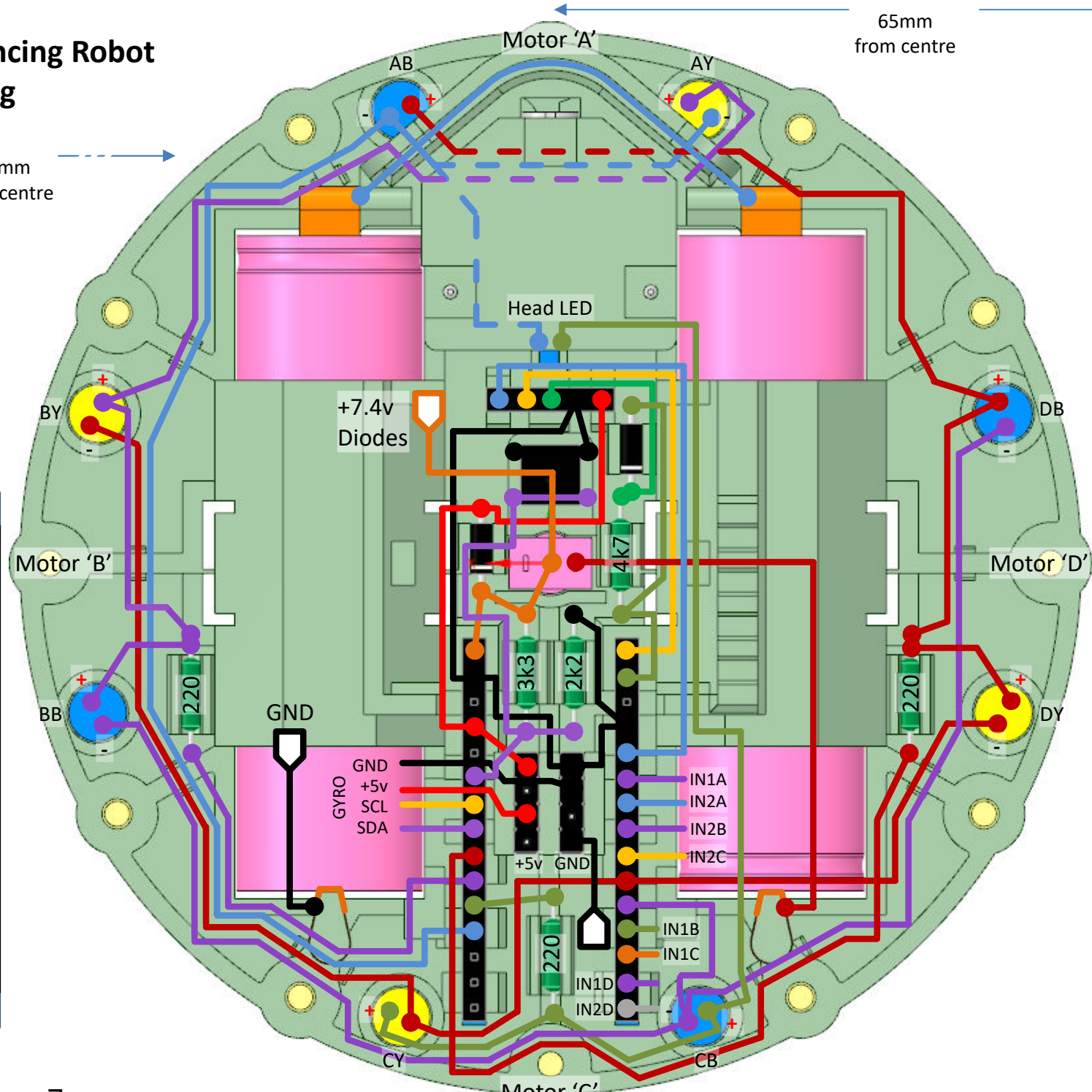
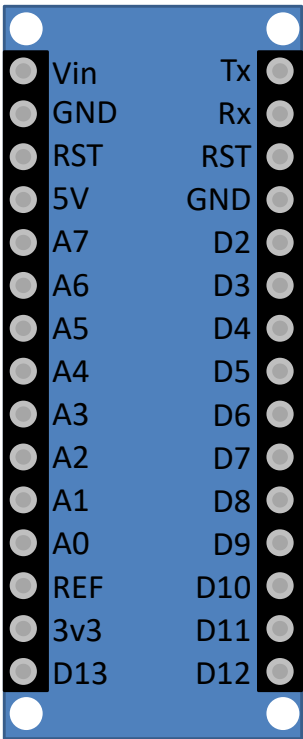
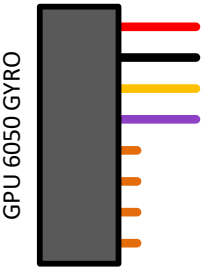
AC Adapter Power Input (used for bench testing)
Ensure Batteries are disconnected!
 Release: 1.0

Released: 08/12/2025 **TechKnowTone**

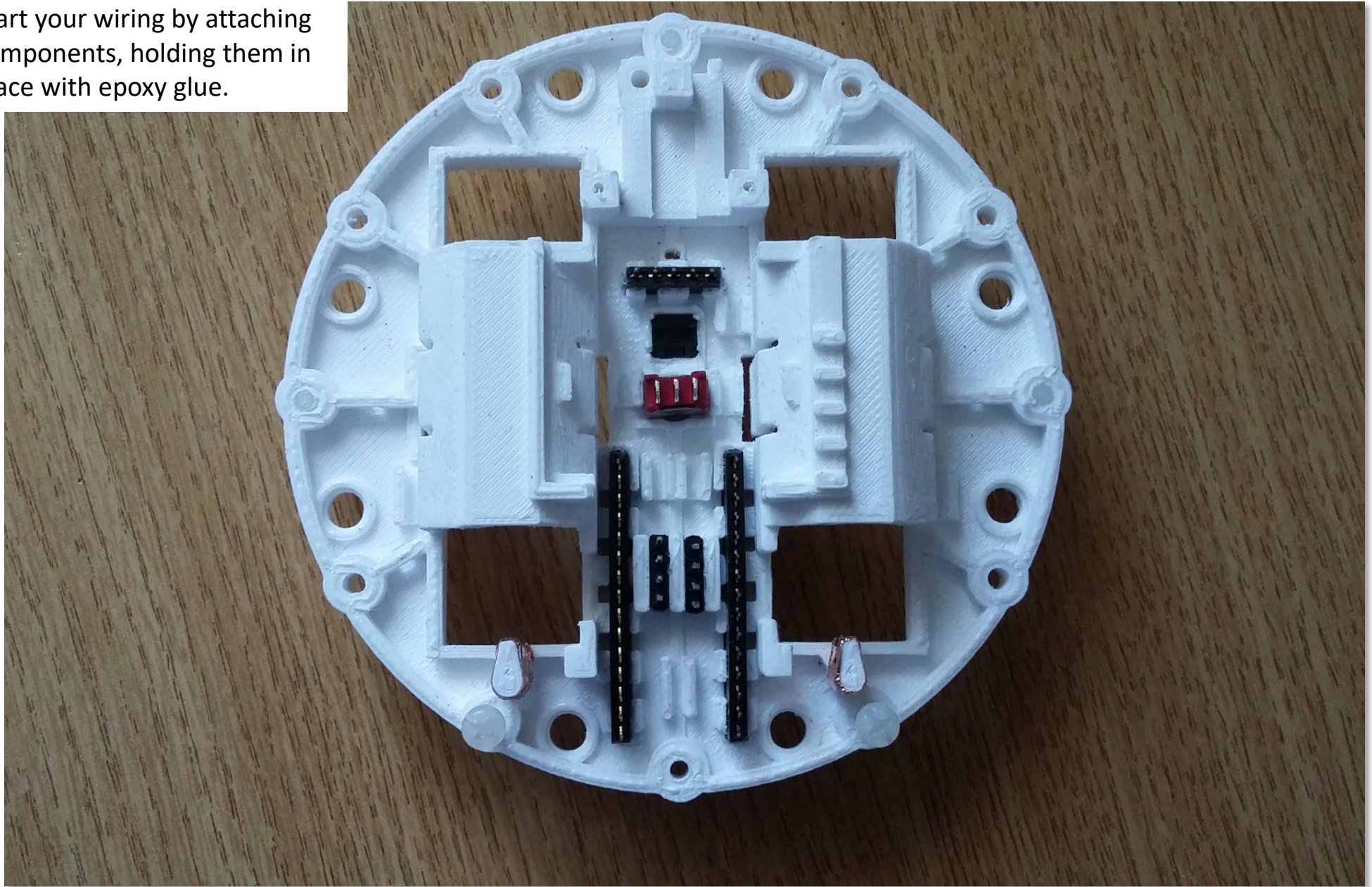
4x4 Ball Balancing Robot Control Wiring

80mm from centre

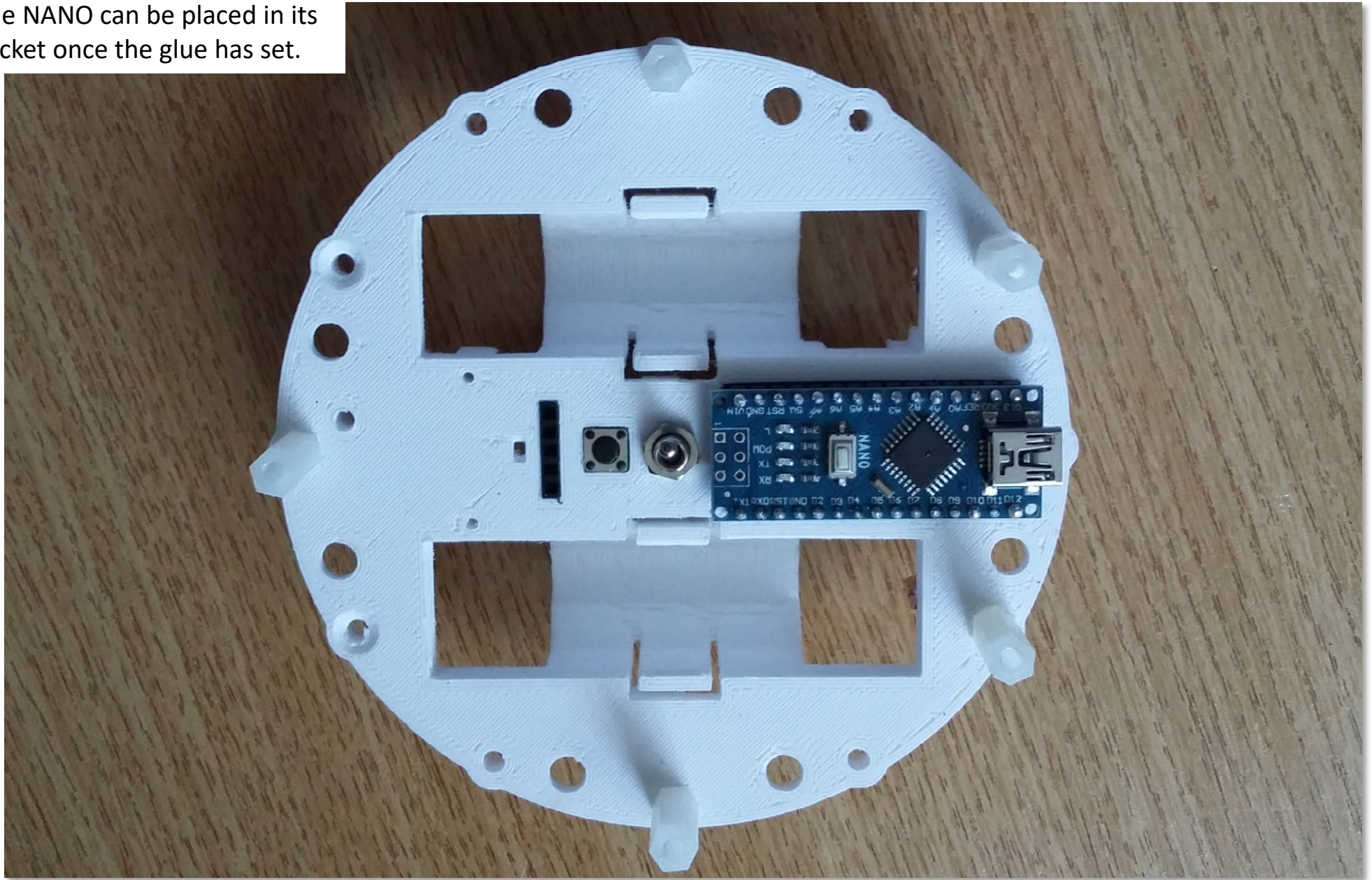
65mm from centre



Start your wiring by attaching components, holding them in place with epoxy glue.

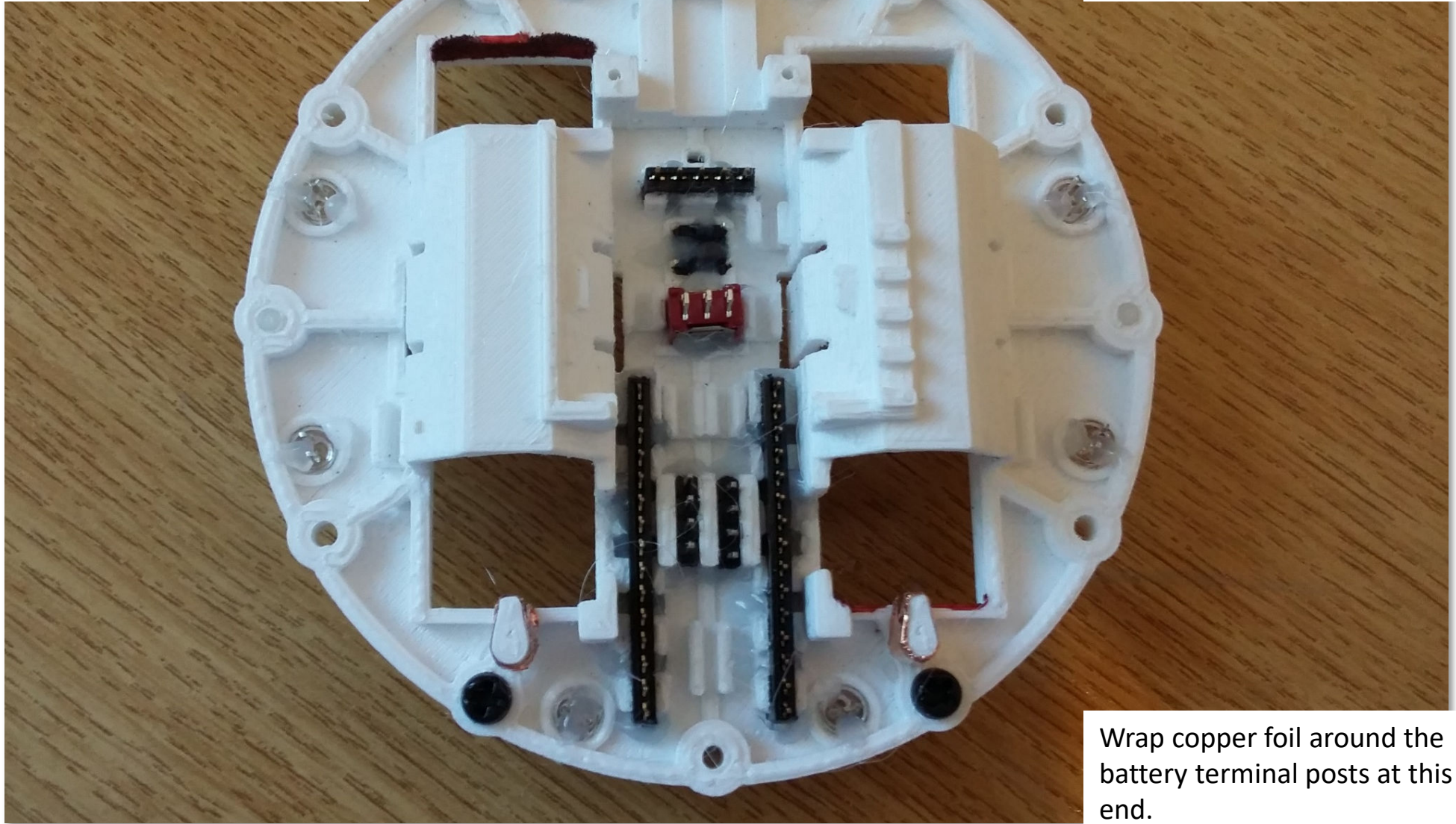


The NANO can be placed in its socket once the glue has set.



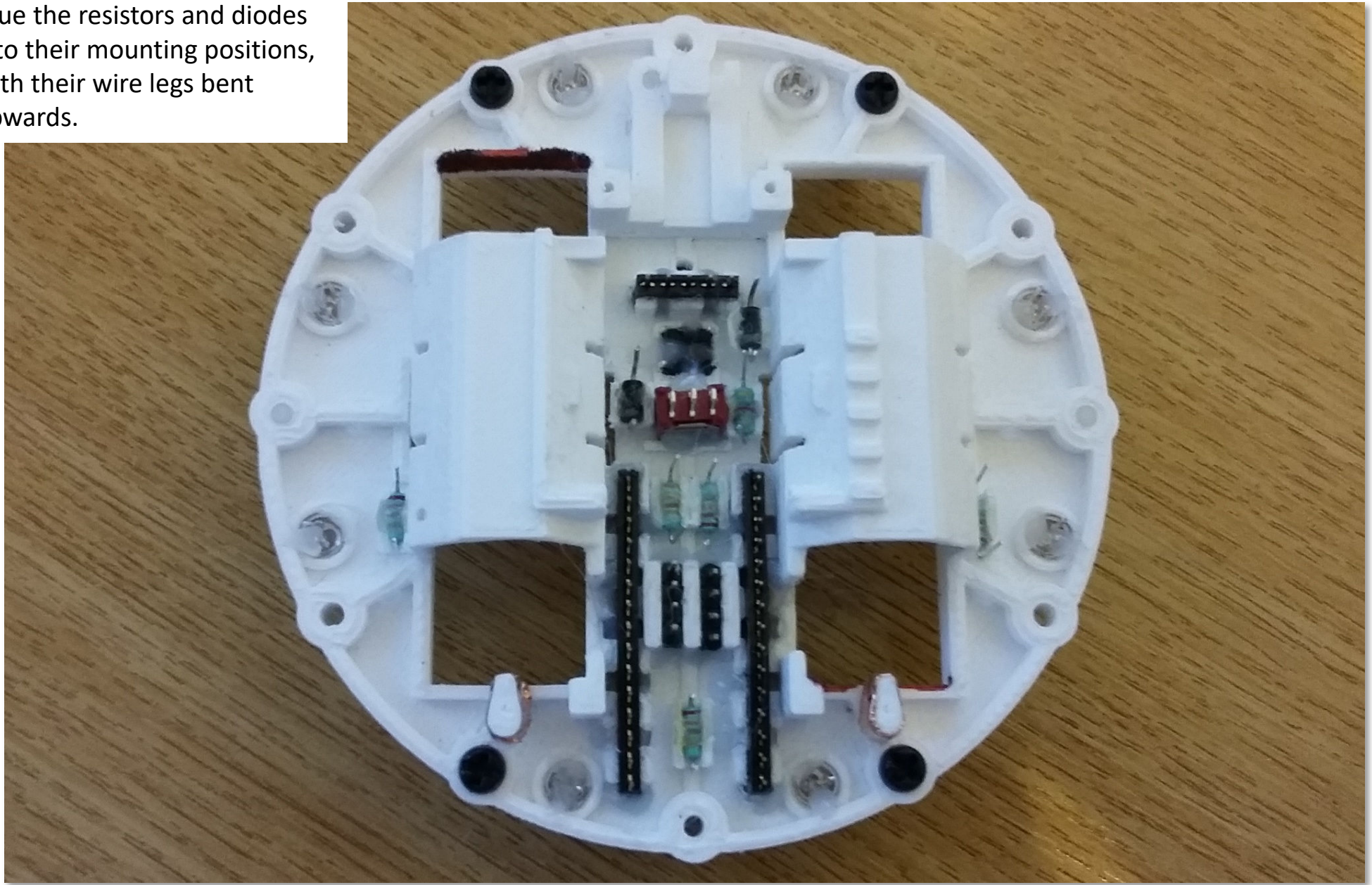
Identify the positive ends of the battery compartments with a red felt tipped pen.

Insert the coloured LEDs, ensuring that they are orientated to match their polarity

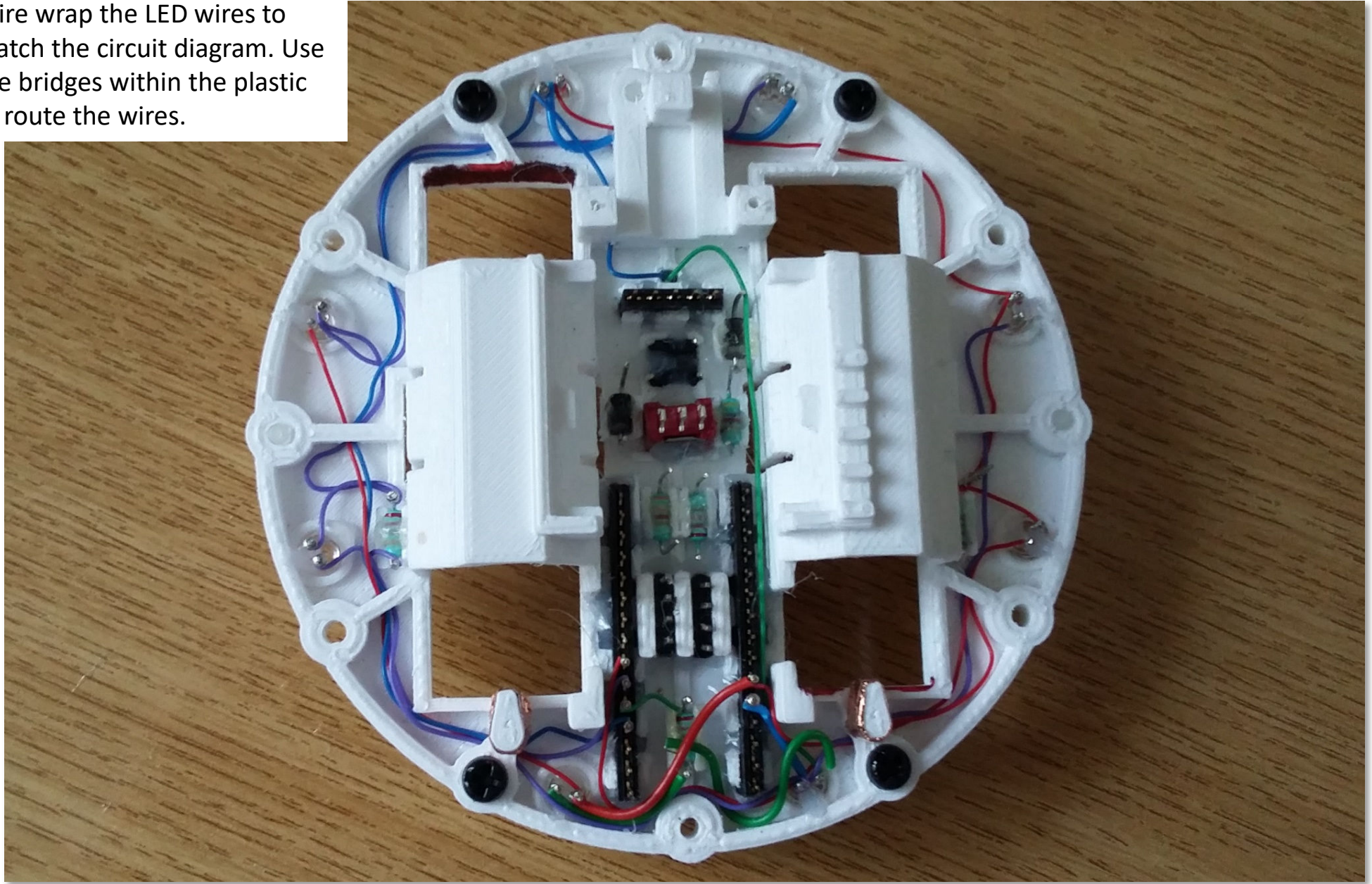


Wrap copper foil around the battery terminal posts at this end.

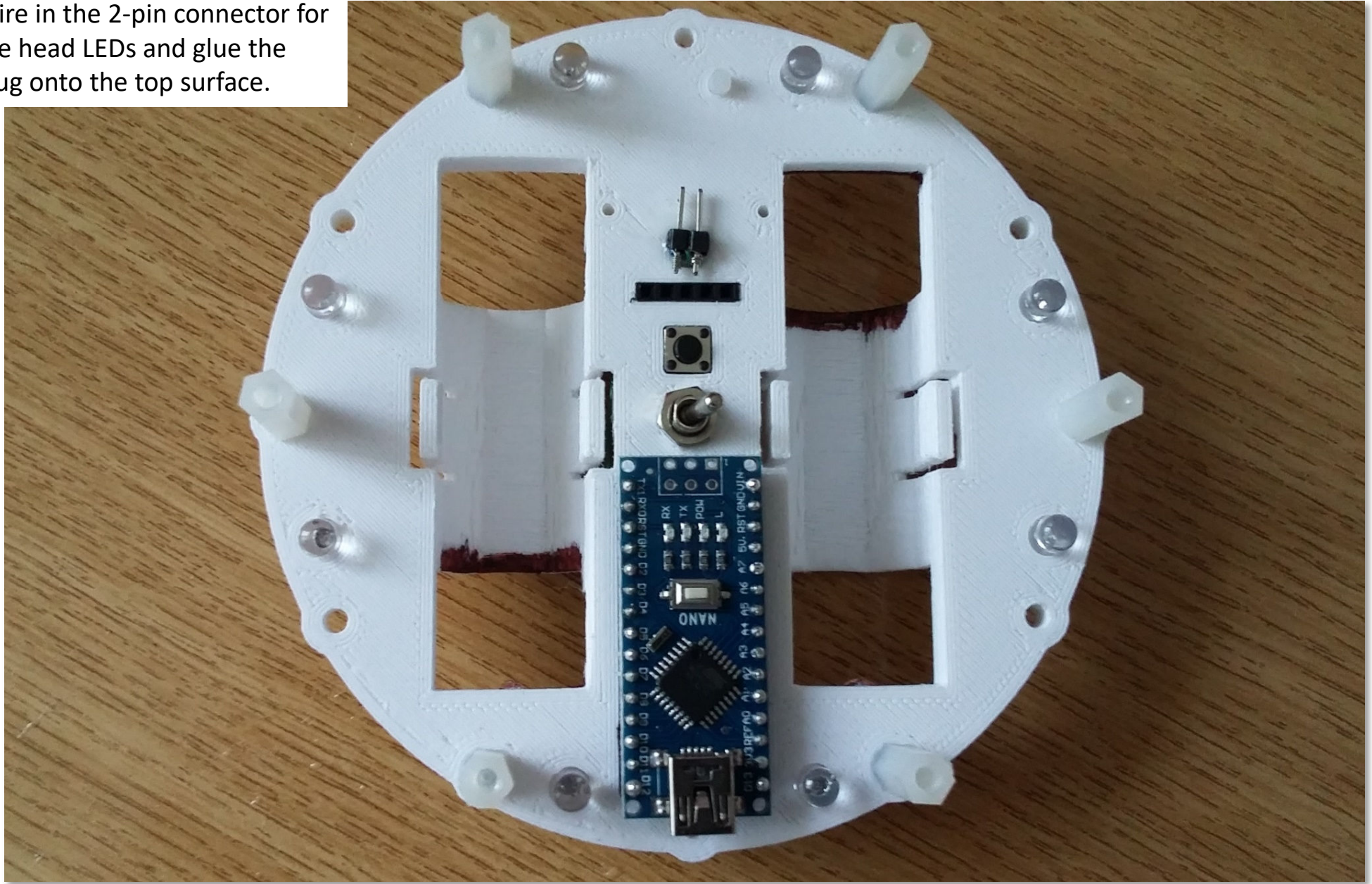
Glue the resistors and diodes into their mounting positions, with their wire legs bent upwards.



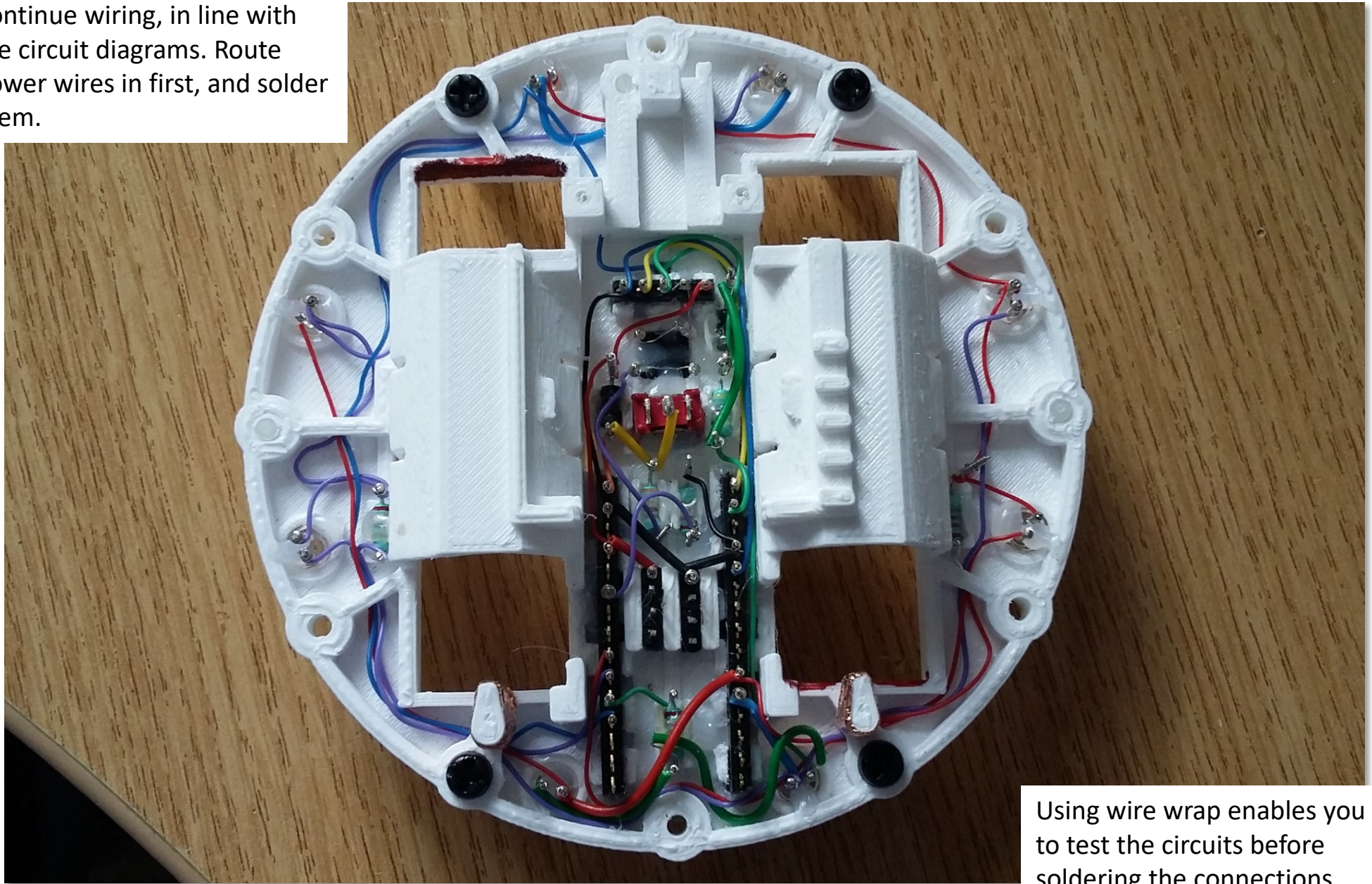
Wire wrap the LED wires to match the circuit diagram. Use the bridges within the plastic to route the wires.



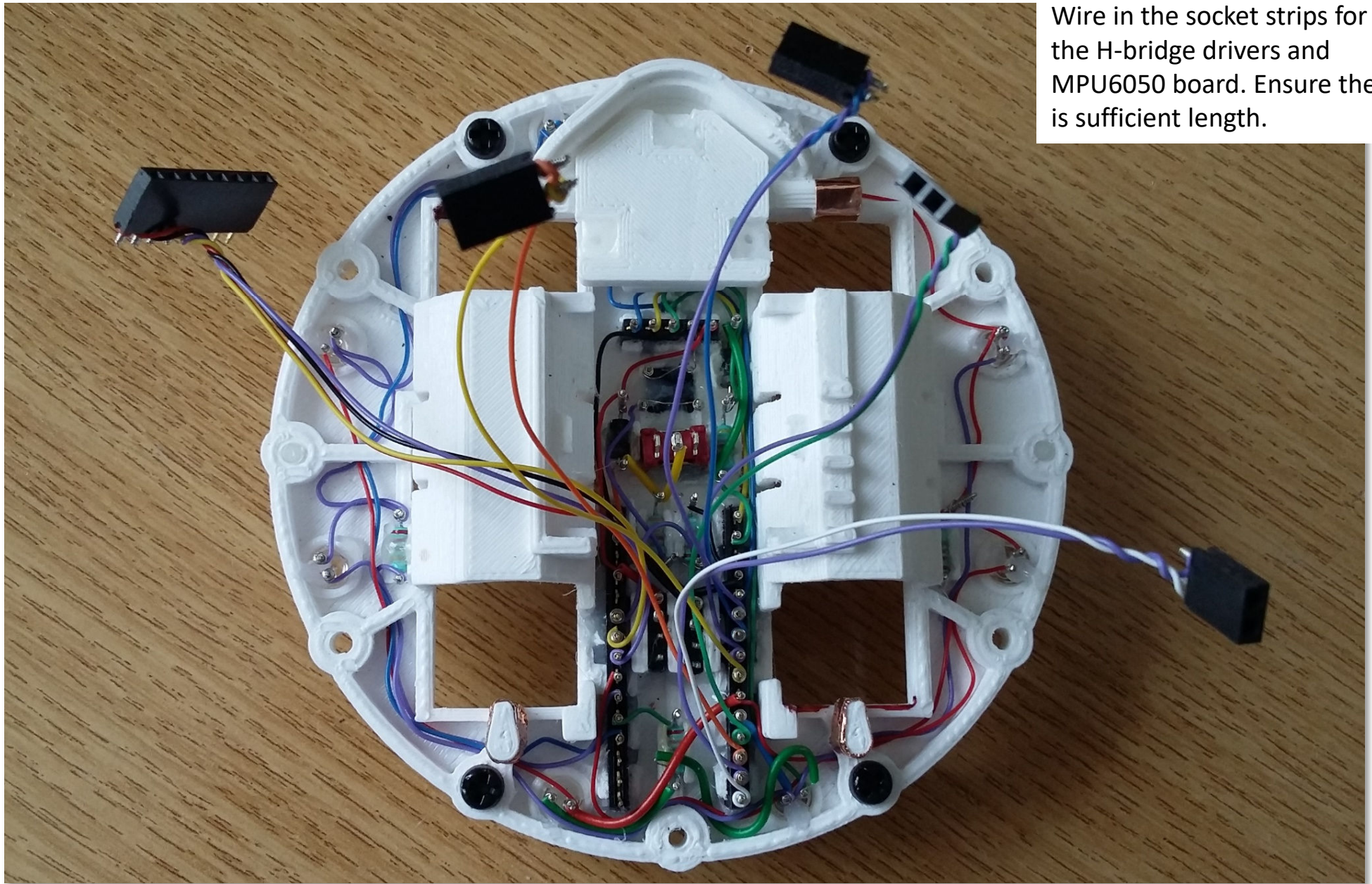
Wire in the 2-pin connector for the head LEDs and glue the plug onto the top surface.



Continue wiring, in line with the circuit diagrams. Route power wires in first, and solder them.

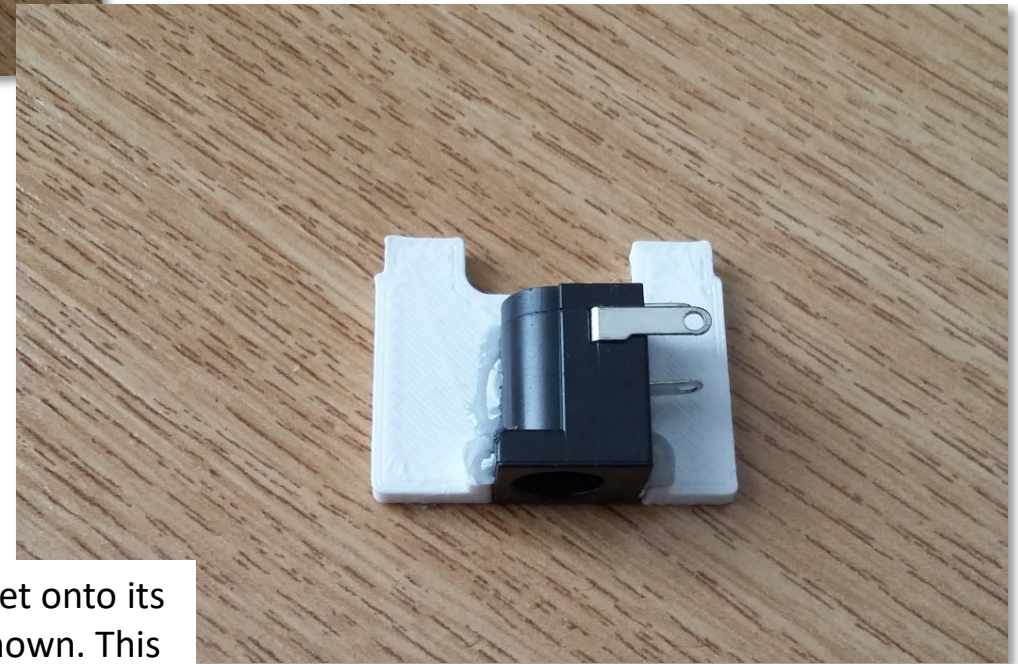
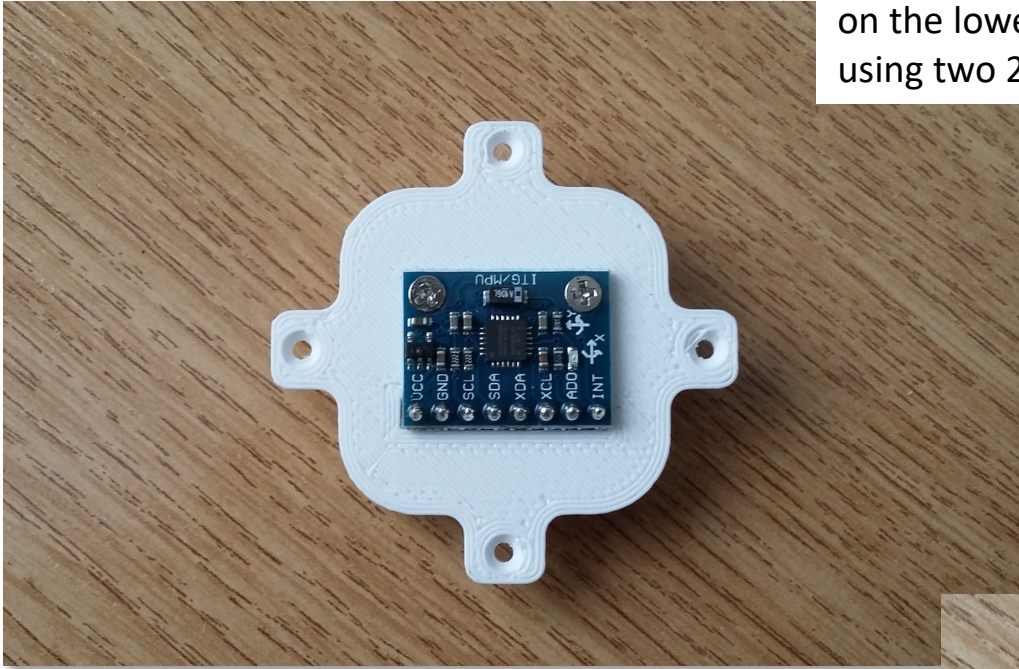


Using wire wrap enables you to test the circuits before soldering the connections.



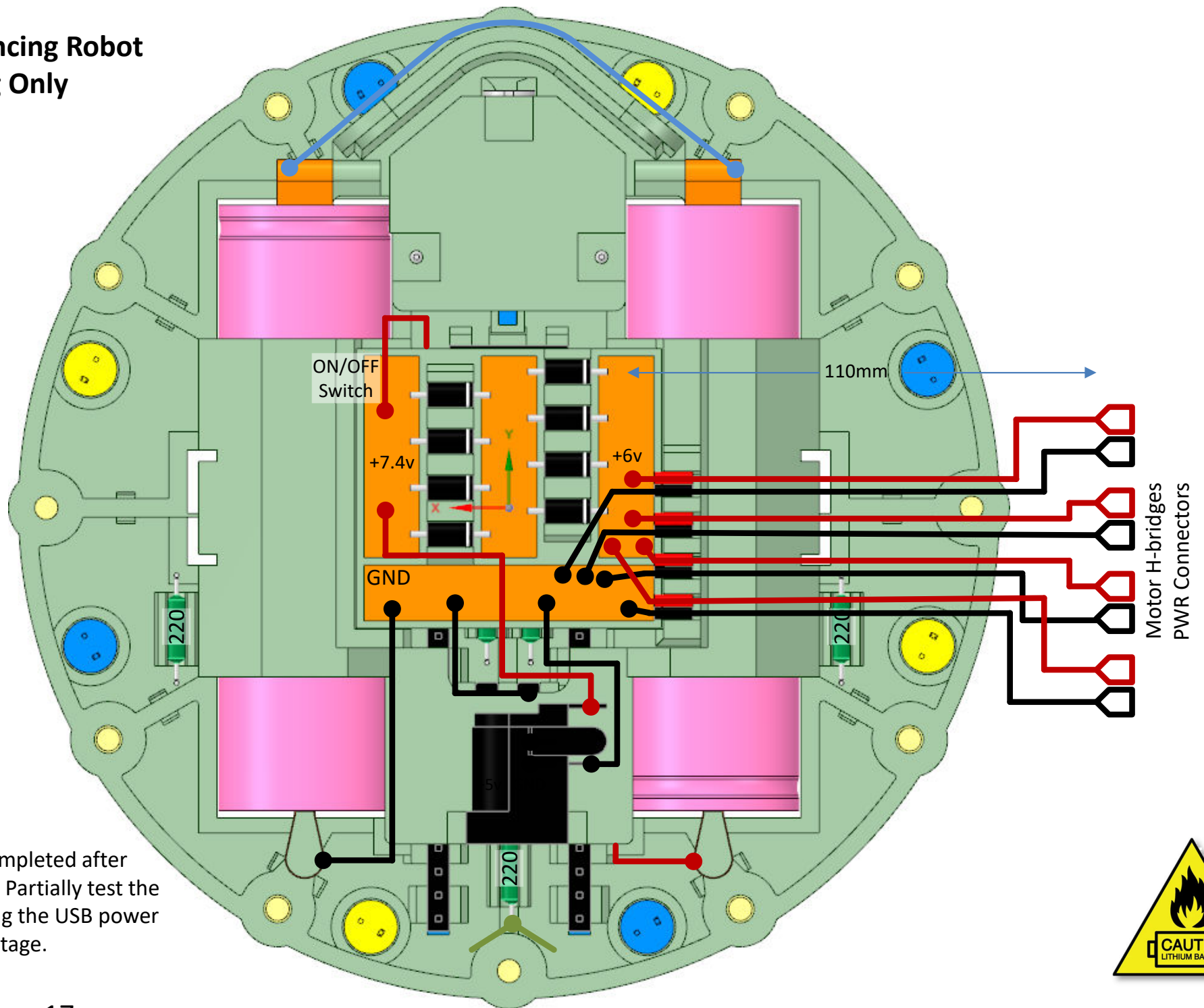
Wire in the socket strips for the H-bridge drivers and MPU6050 board. Ensure there is sufficient length.

Mount the MPU6050 device on the lower mounting plate, using two 2x10mm screws.



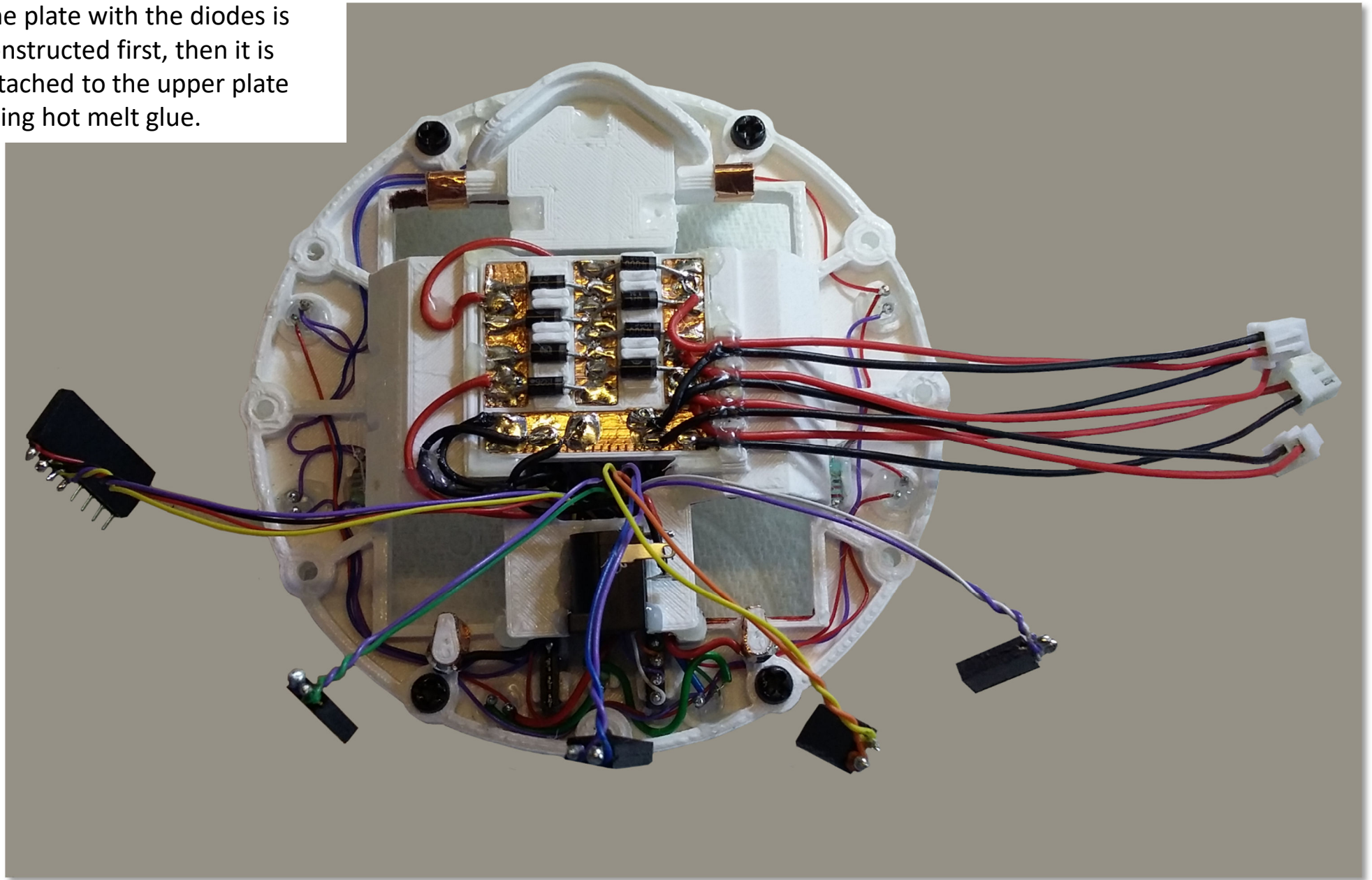
Glue the power socket onto its mounting plate as shown. This socket is used for testing.

4x4 Ball Balancing Robot Power Wiring Only

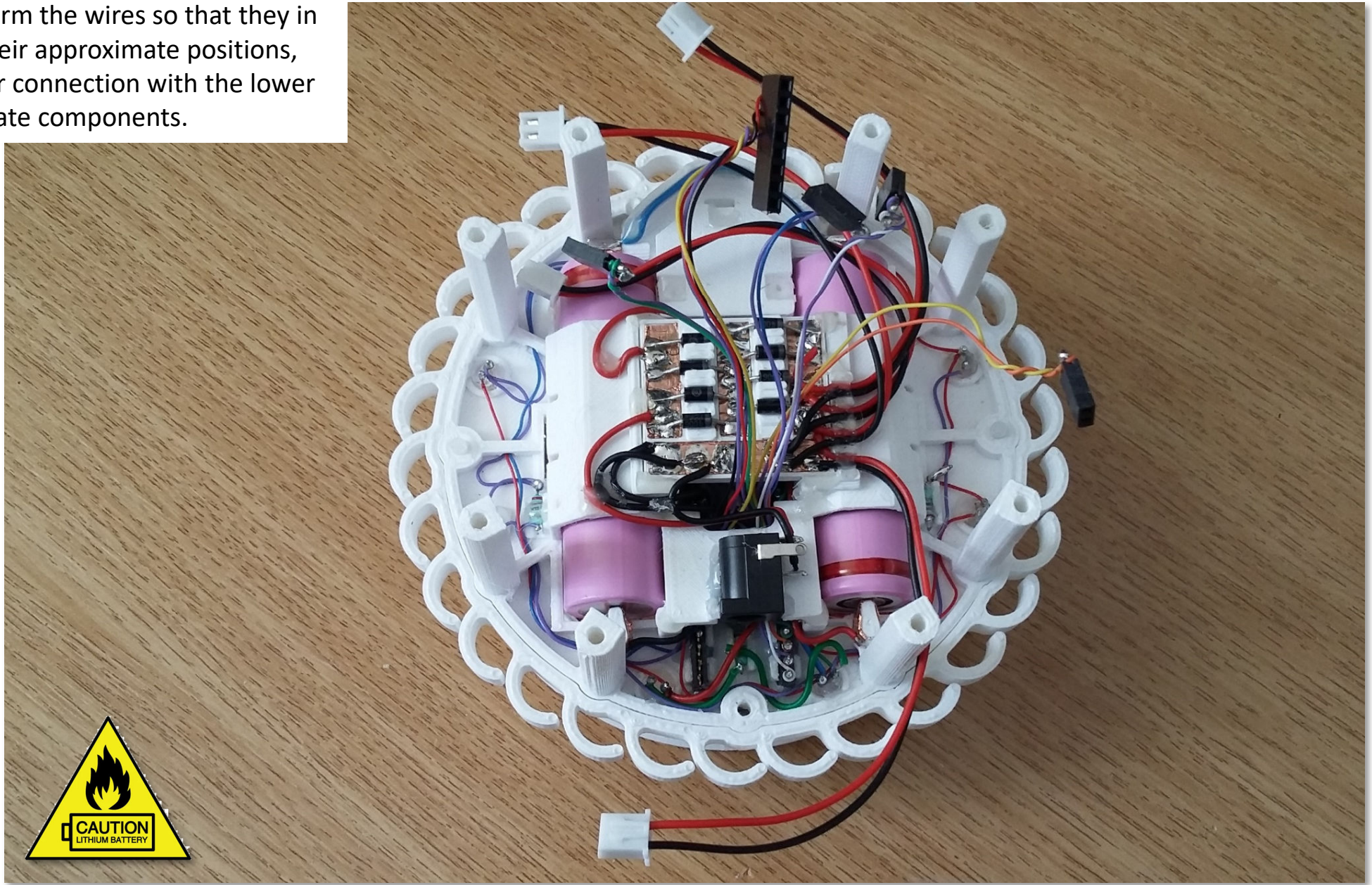


Note:
Power wiring is completed after the control wiring. Partially test the control wiring using the USB power before doing this stage.

The plate with the diodes is constructed first, then it is attached to the upper plate using hot melt glue.



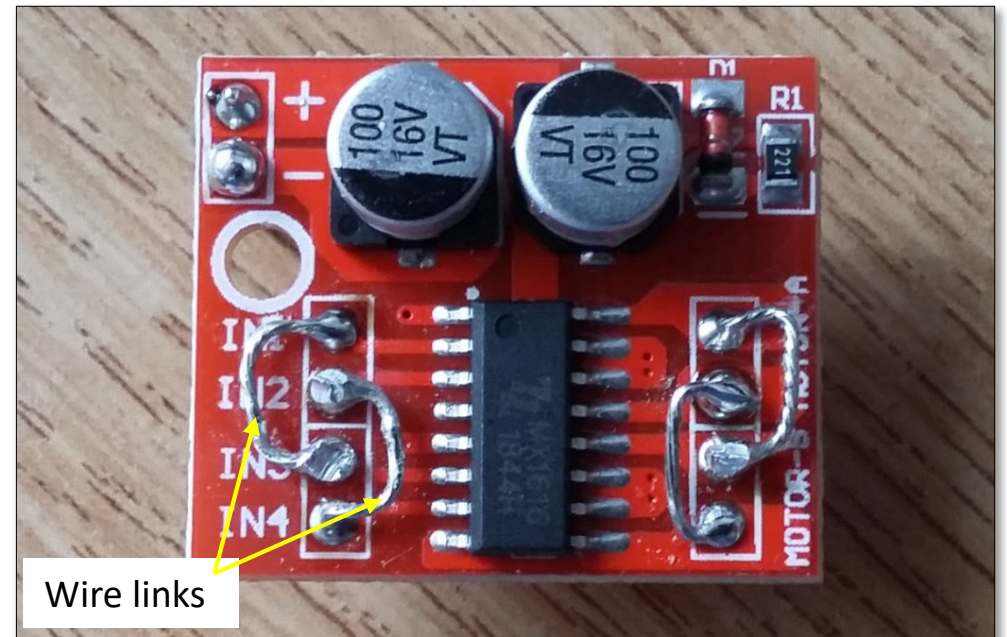
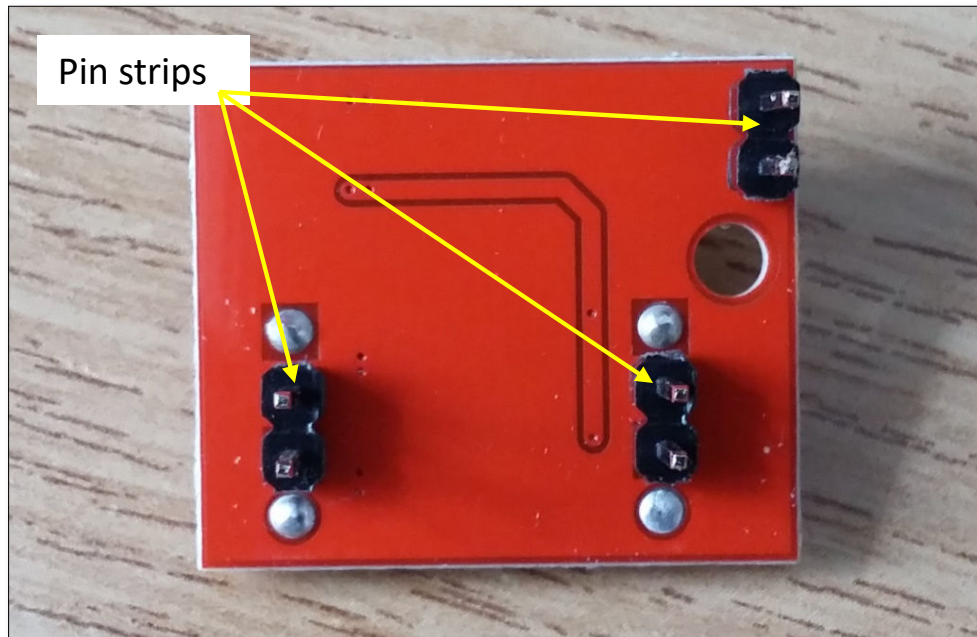
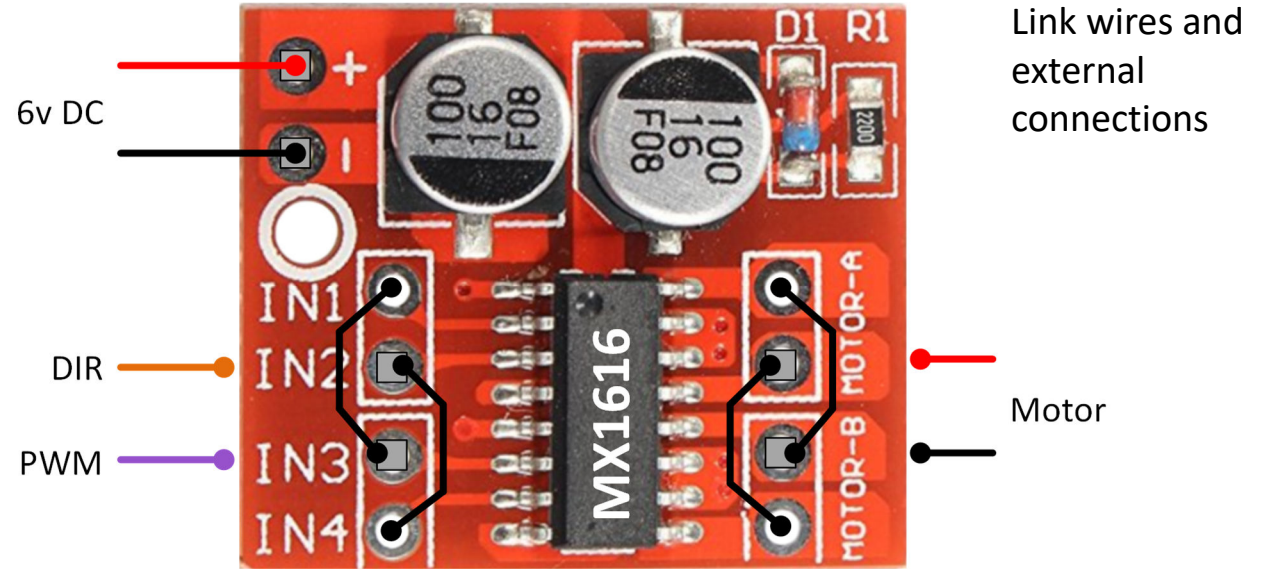
Form the wires so that they in their approximate positions, for connection with the lower plate components.



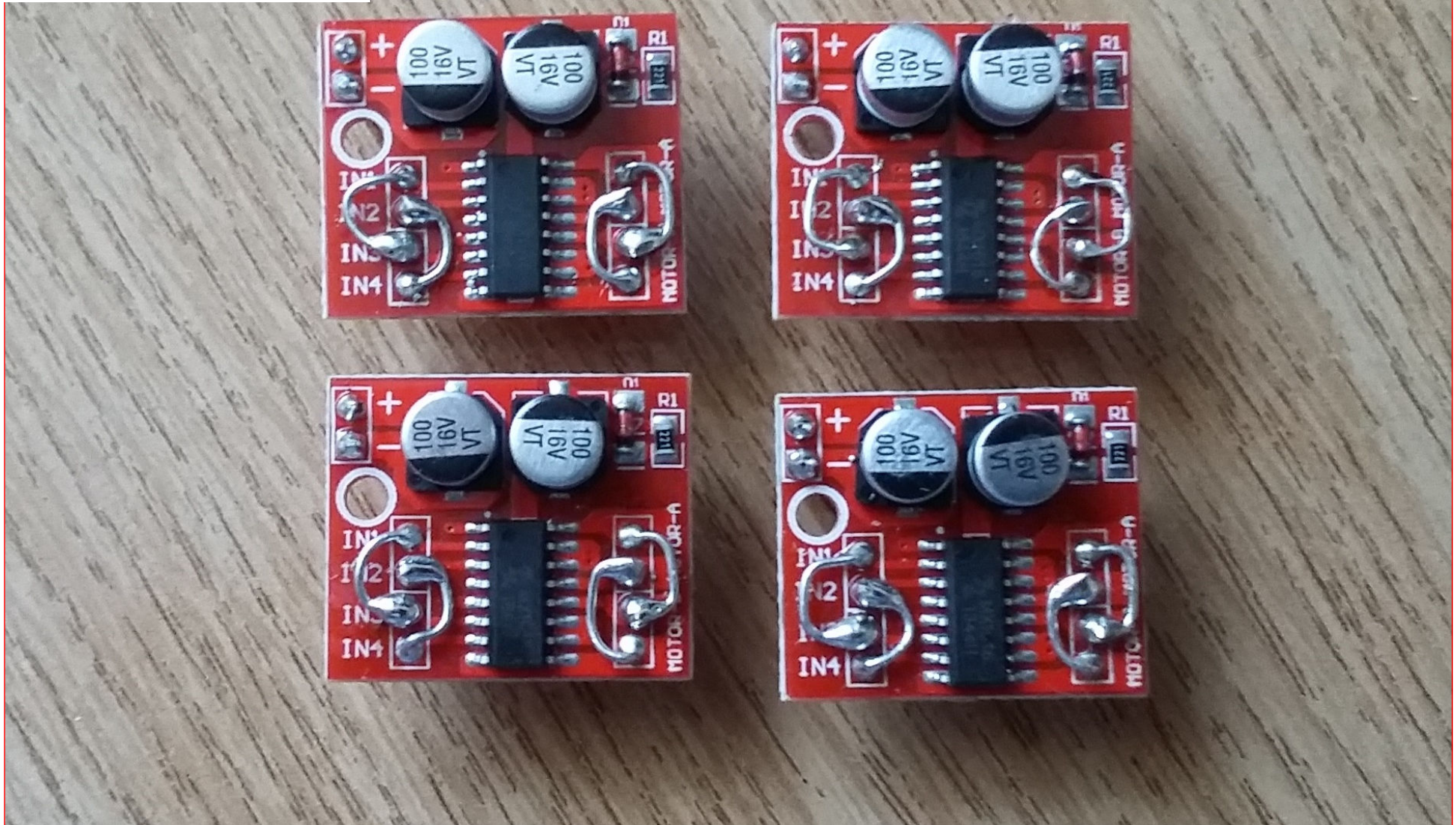
The 3 H-bridge driver boards need to be pre-wired as follows using formed link wires and pin strips.

Each driver board contains two circuits, which we combine to drive a motor. The circuits need to be combined in a very specific way.

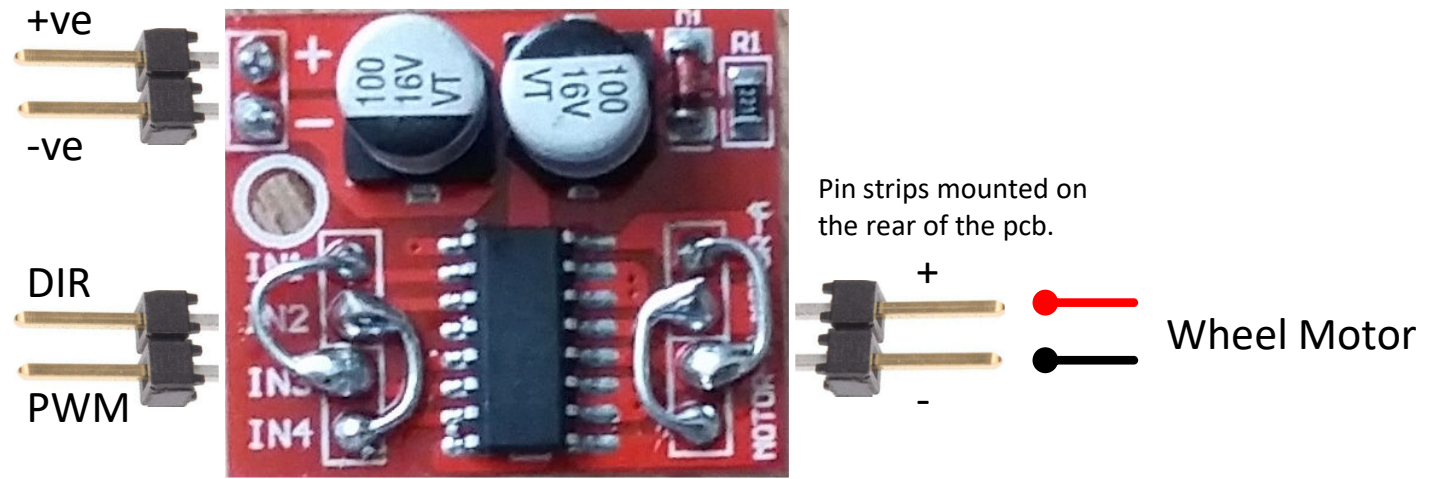
Pin strips are applied to the reverse side of the board before forming and attaching the wire links.



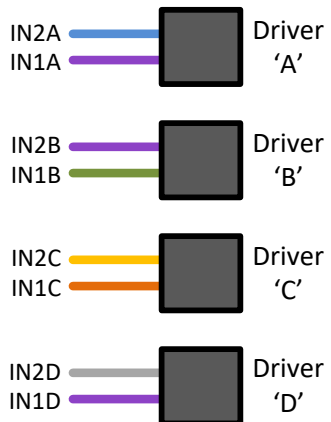
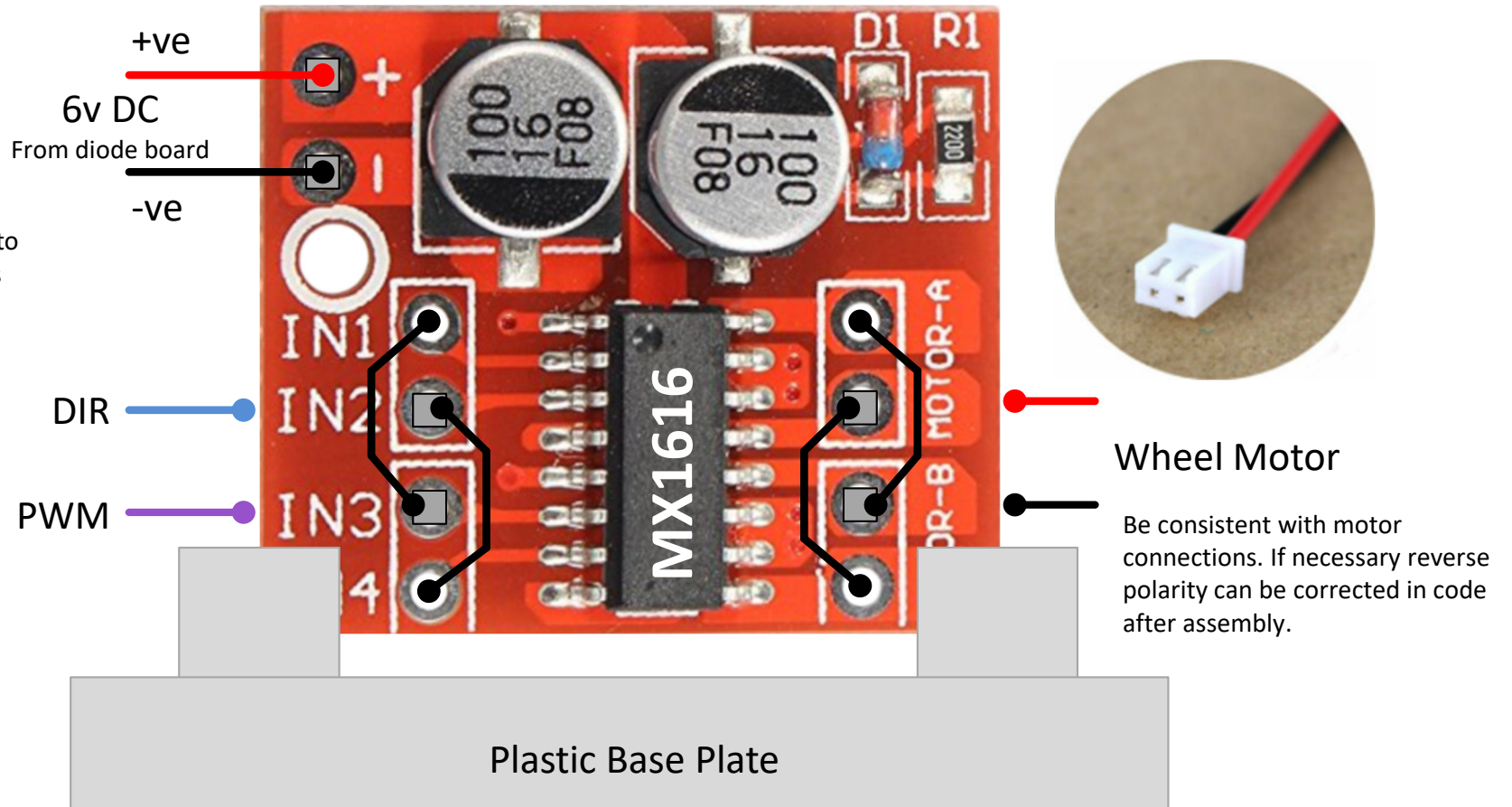
The four H-bridge drivers are pre-wired before mounting the in frame.



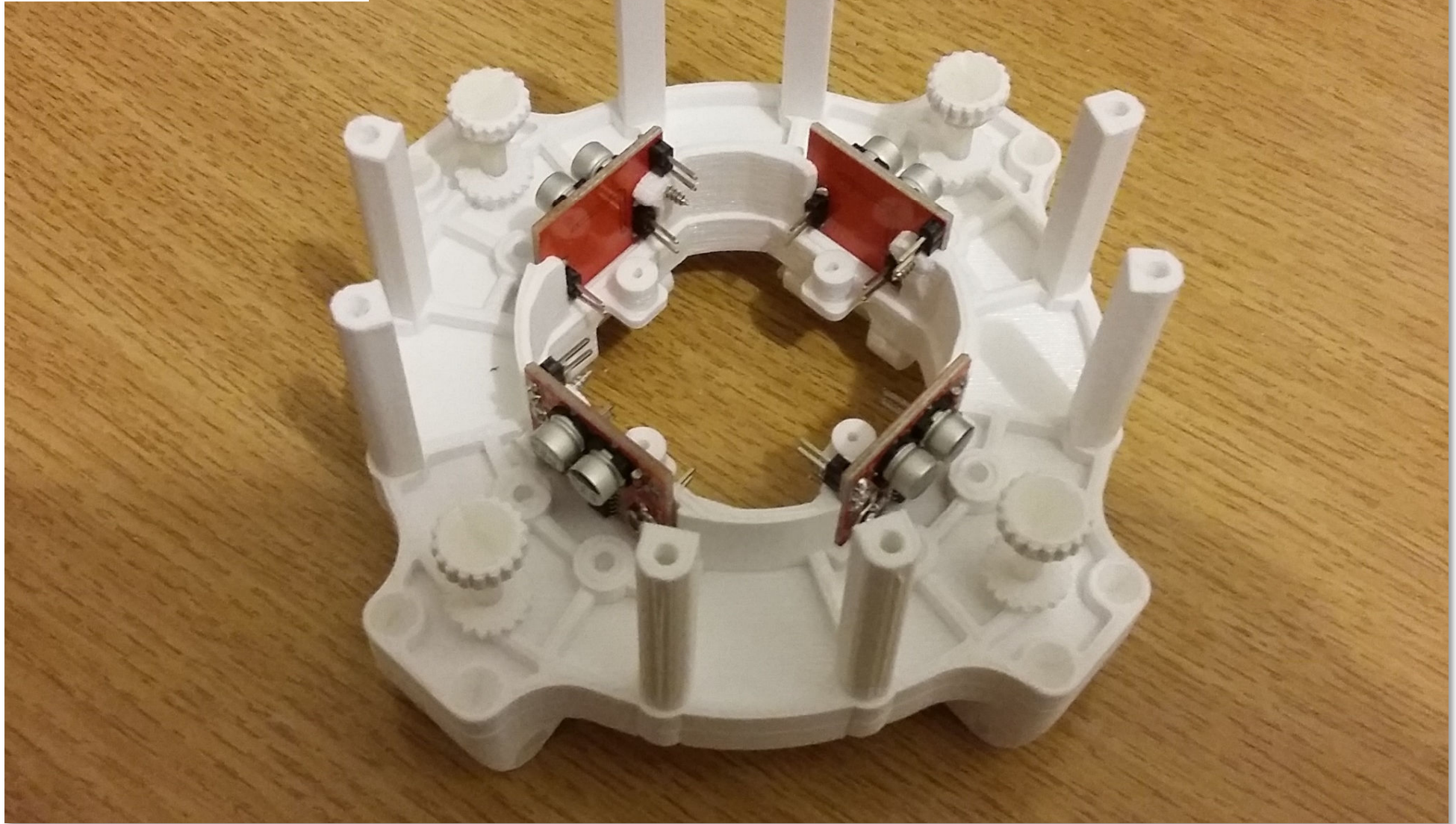
4x4 Ball Balancing Robot H-Bridge Driver Connections



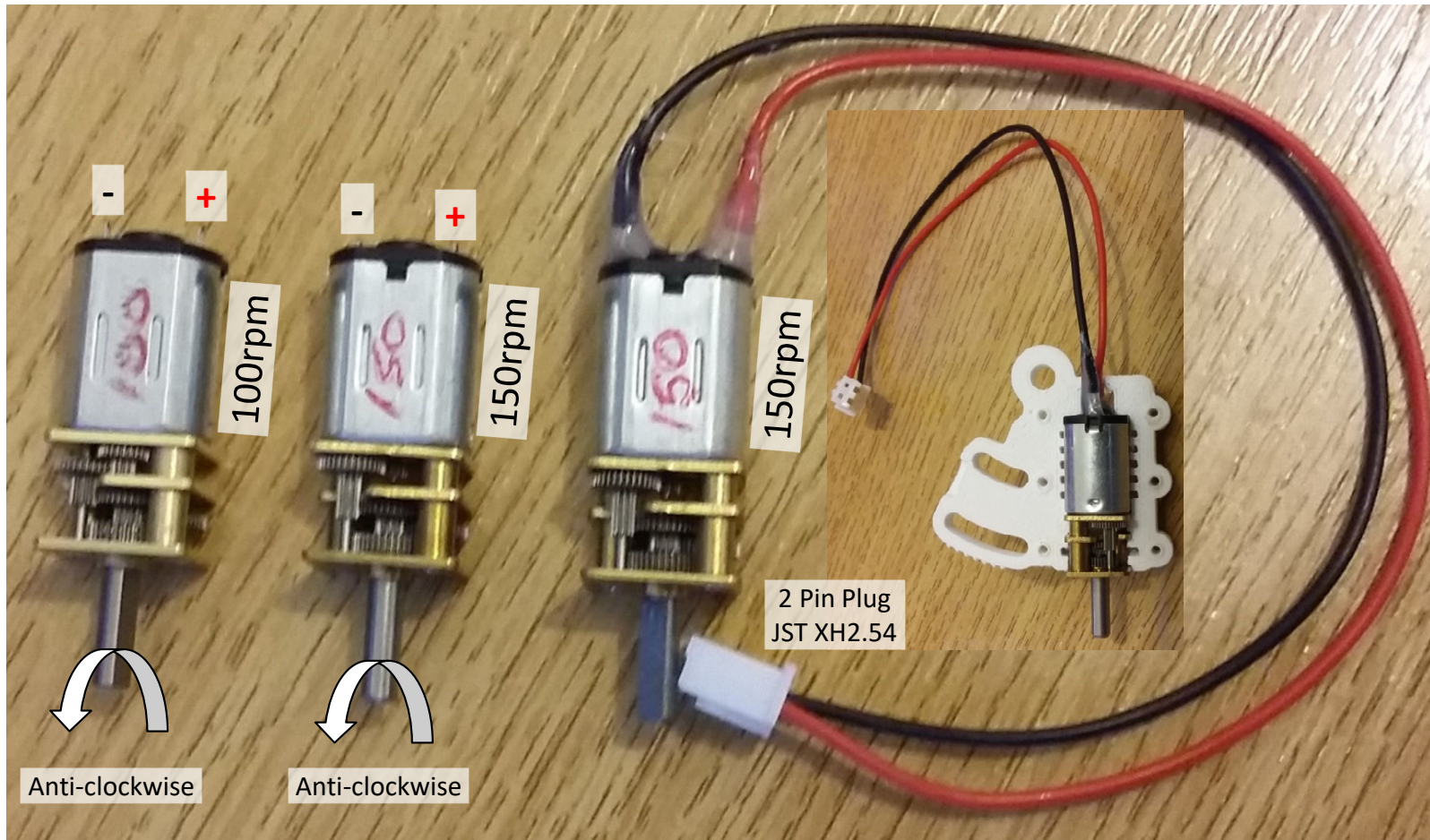
WARNING – Observe polarity to avoid damaging components



Mount the four H-bridge drivers in the lower plate, using 2x10mm screws.

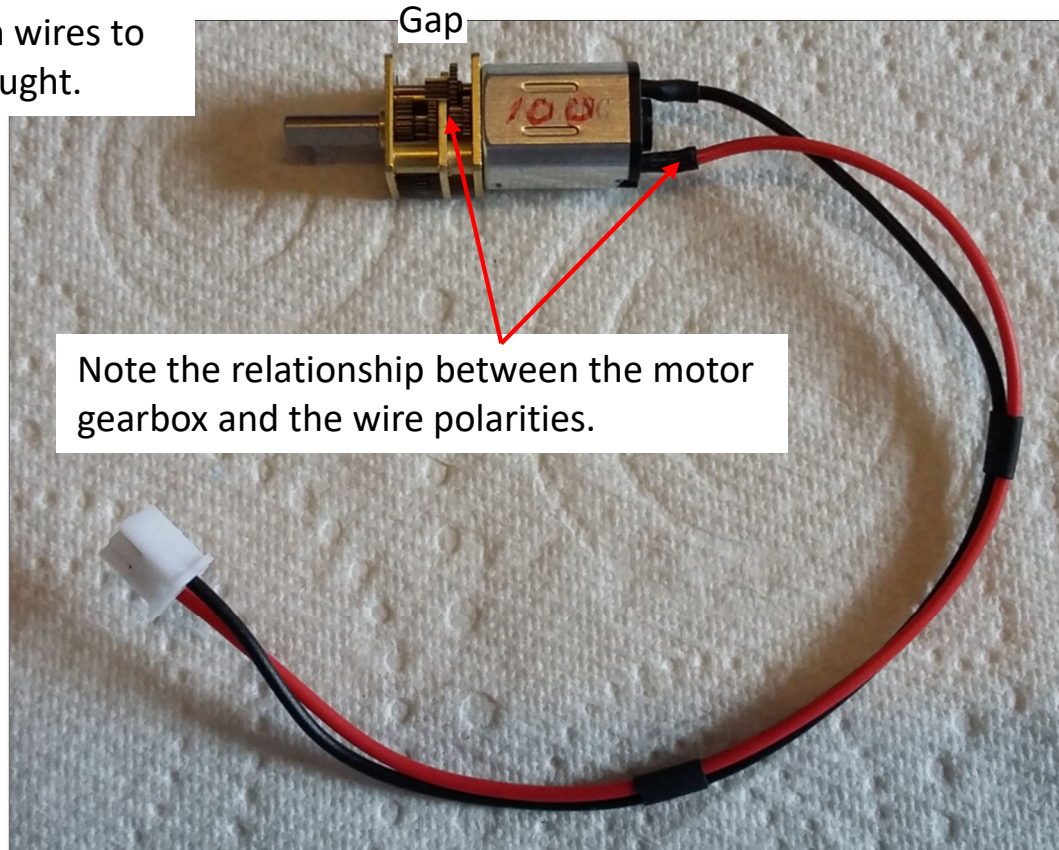


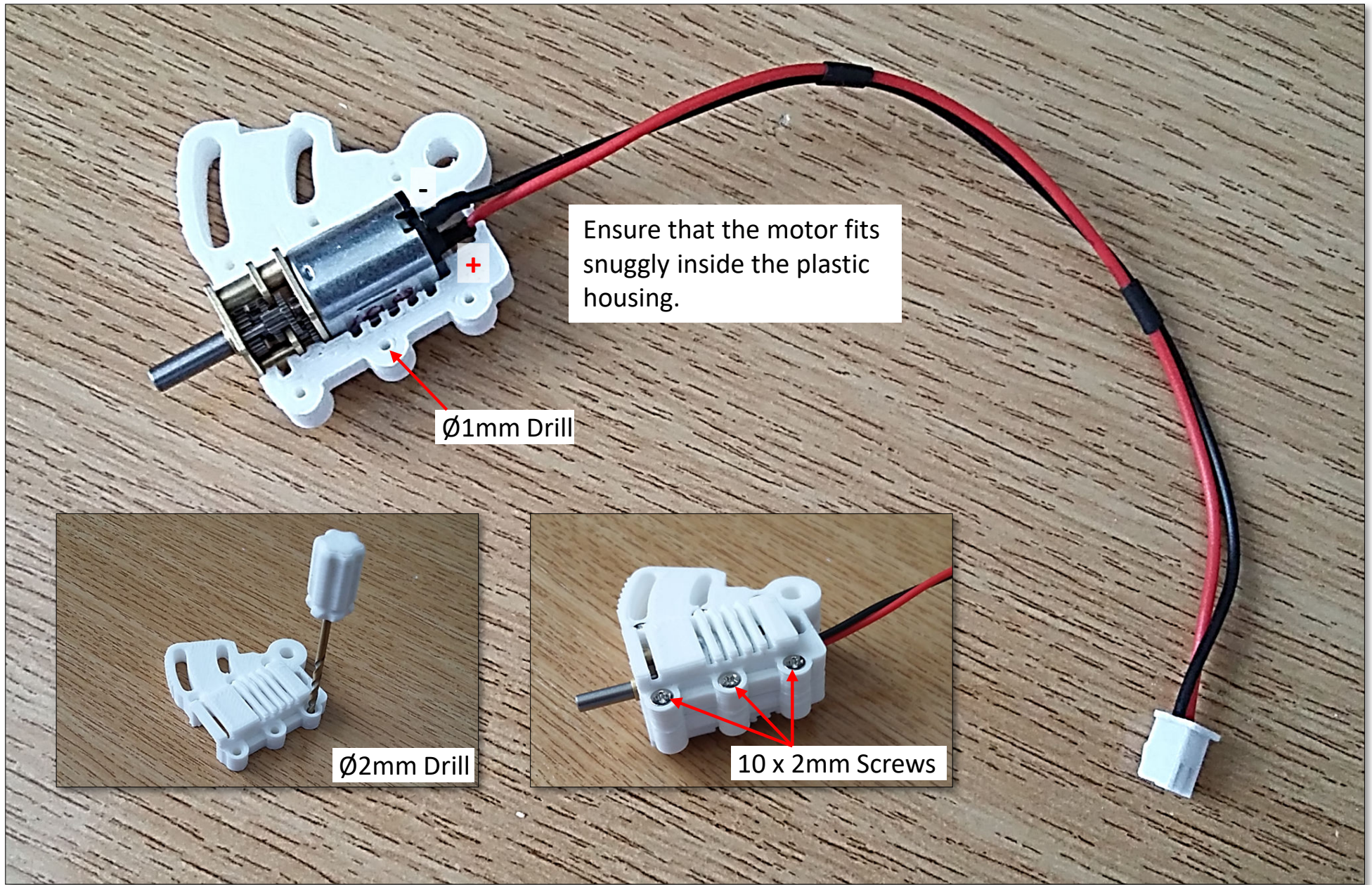
Motor Wiring



Note: All three motors need to have matching rpm values (obviously!). I started with 150rpm but later switched to 100rpm for increased torque at the expense of slower speed. If your motors are not pre-wired, then you need to wire them up in this fashion. You can source the motors and cable separately.

I needed to add my own wires to the 100rpm motors I bought.



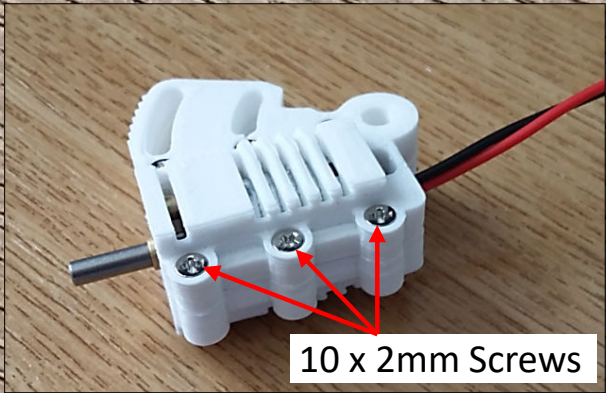


Ensure that the motor fits snugly inside the plastic housing.

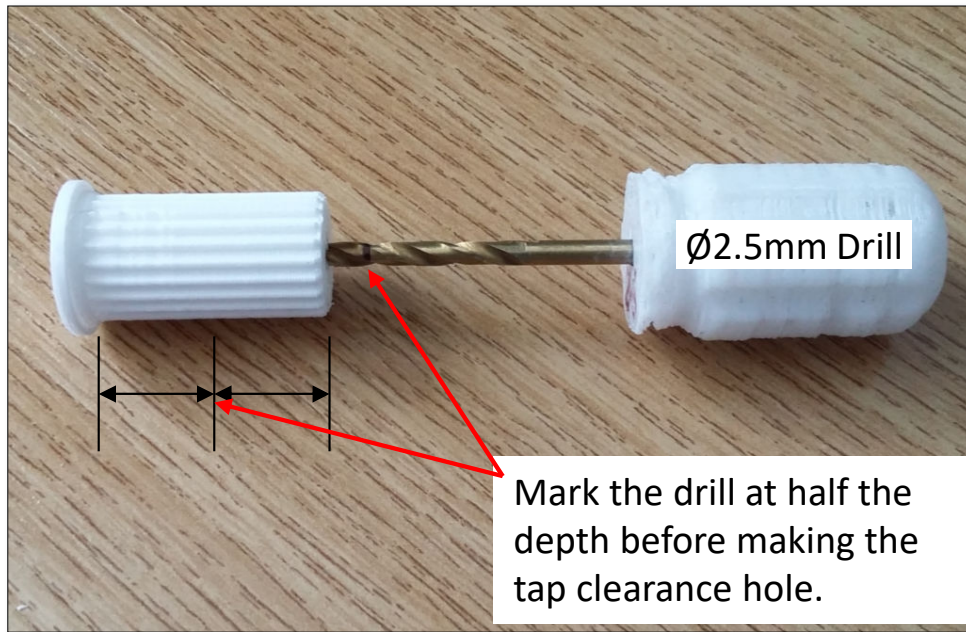
Ø1mm Drill



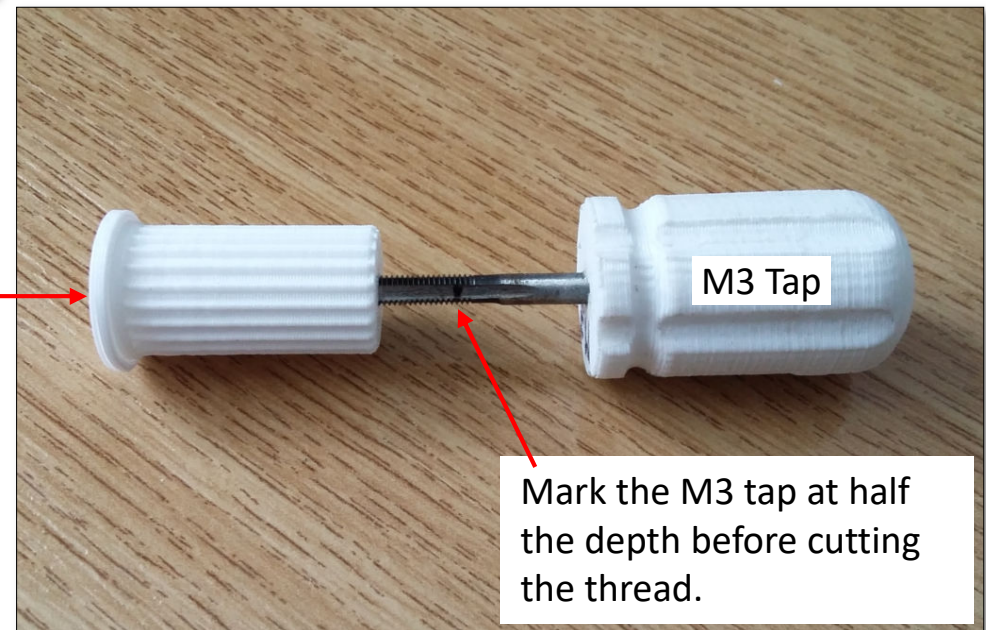
Ø2mm Drill



10 x 2mm Screws



Ensure that you do not damage the half-round hole which mates with the motors drive shaft.



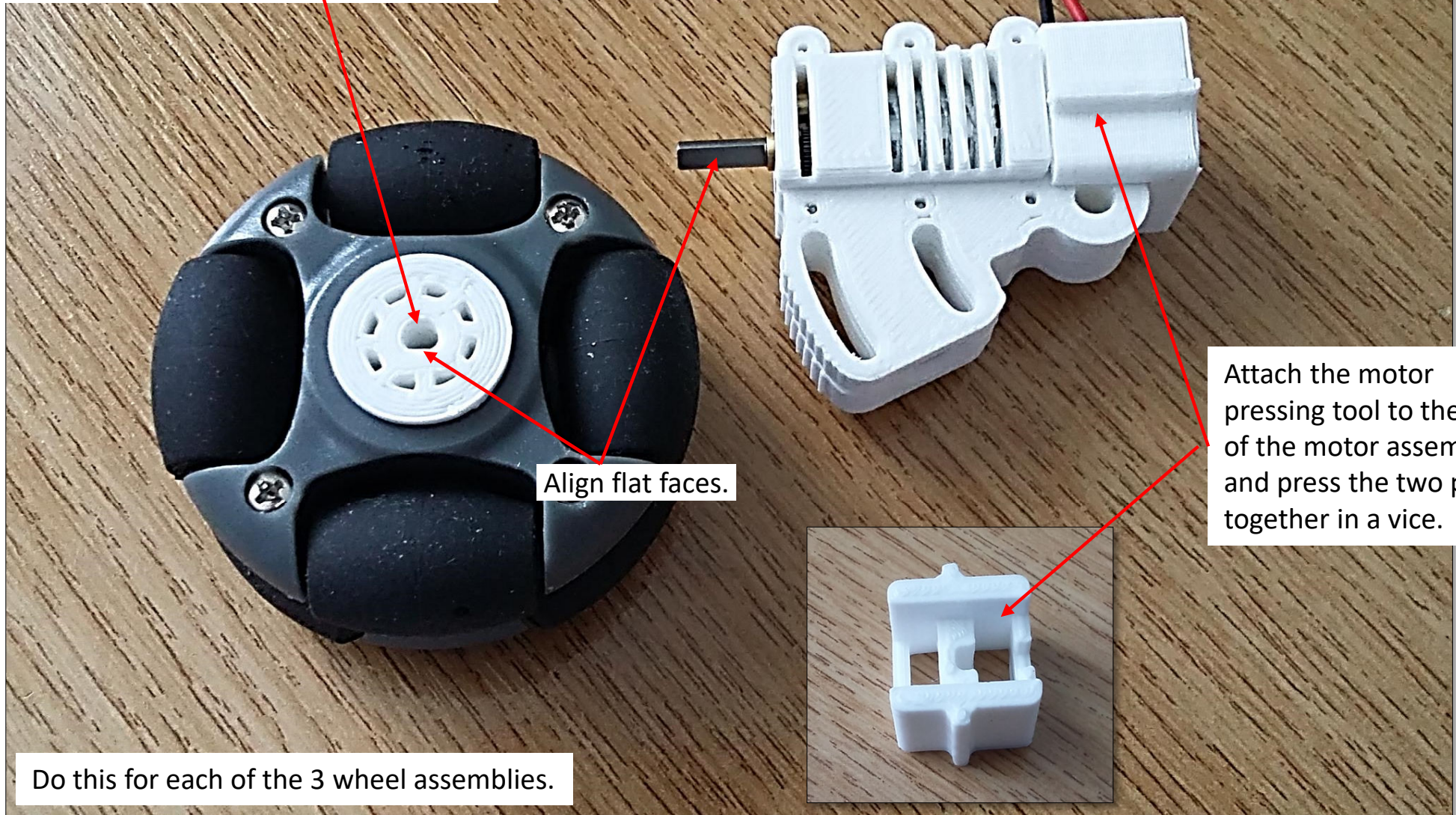


Place the hub inside the Omni-wheel. It should only go half way in by hand.

Place the assembly in a vice or use a G-clamp to press the hub all the way into the wheel.

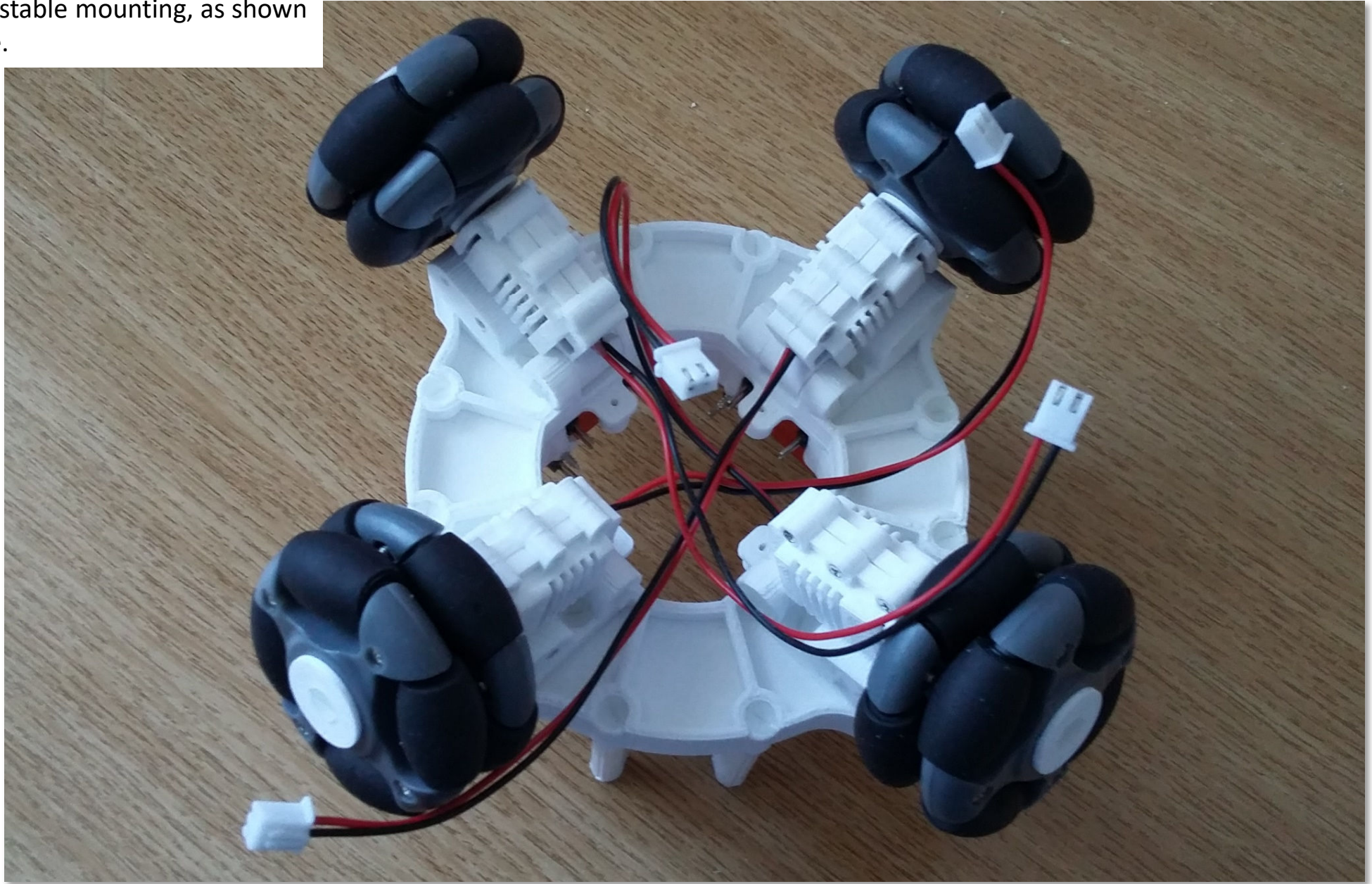


Mix a small quantity of quick set epoxy resin and smear it inside the hub aperture. Wipe off any excess glue before aligning the motor shaft flat face.

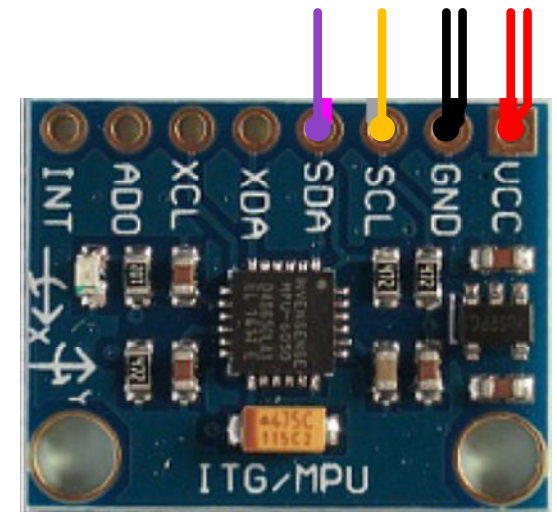
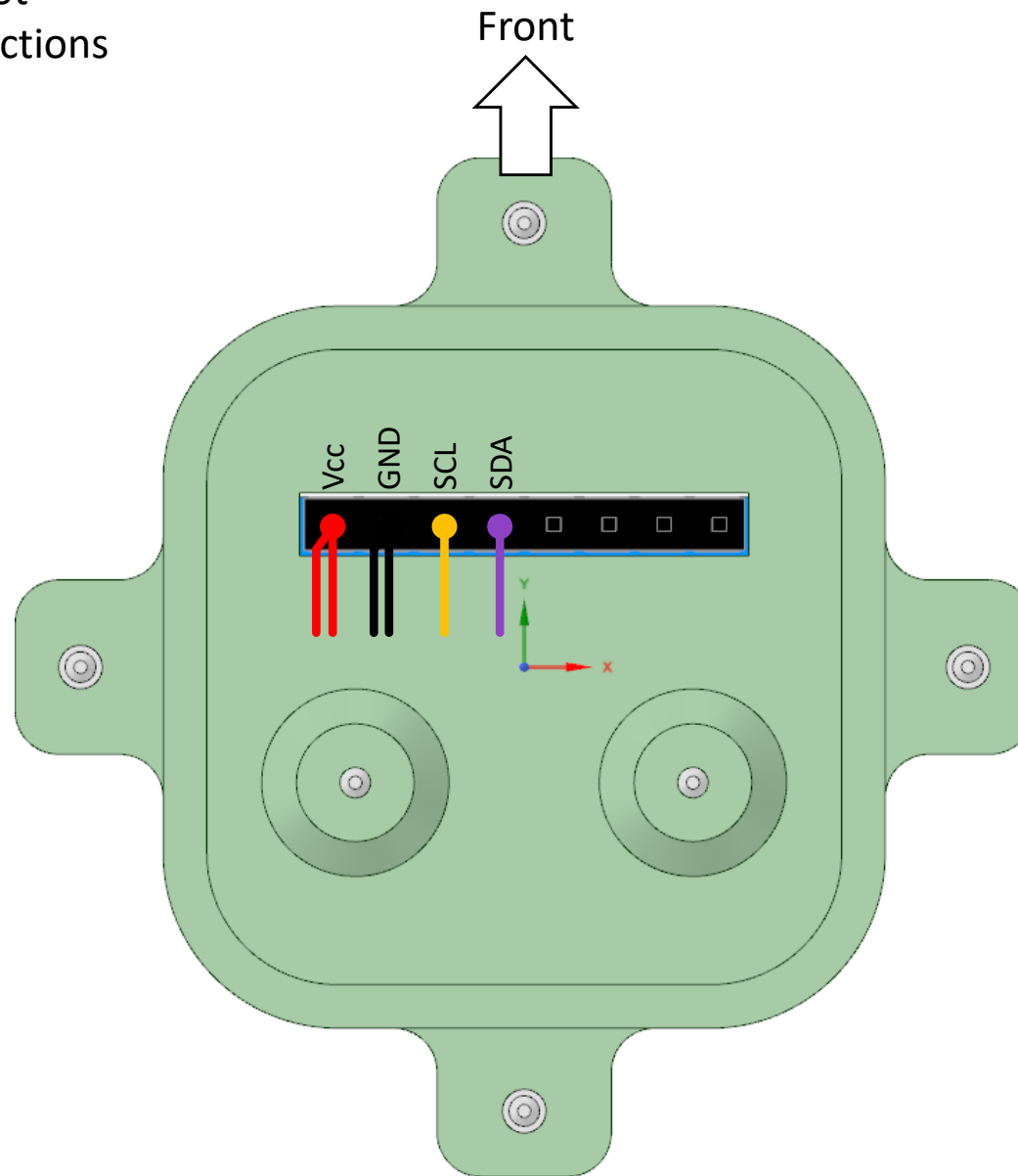


Do this for each of the 3 wheel assemblies.

Mount each motor in its adjustable mounting, as shown here.

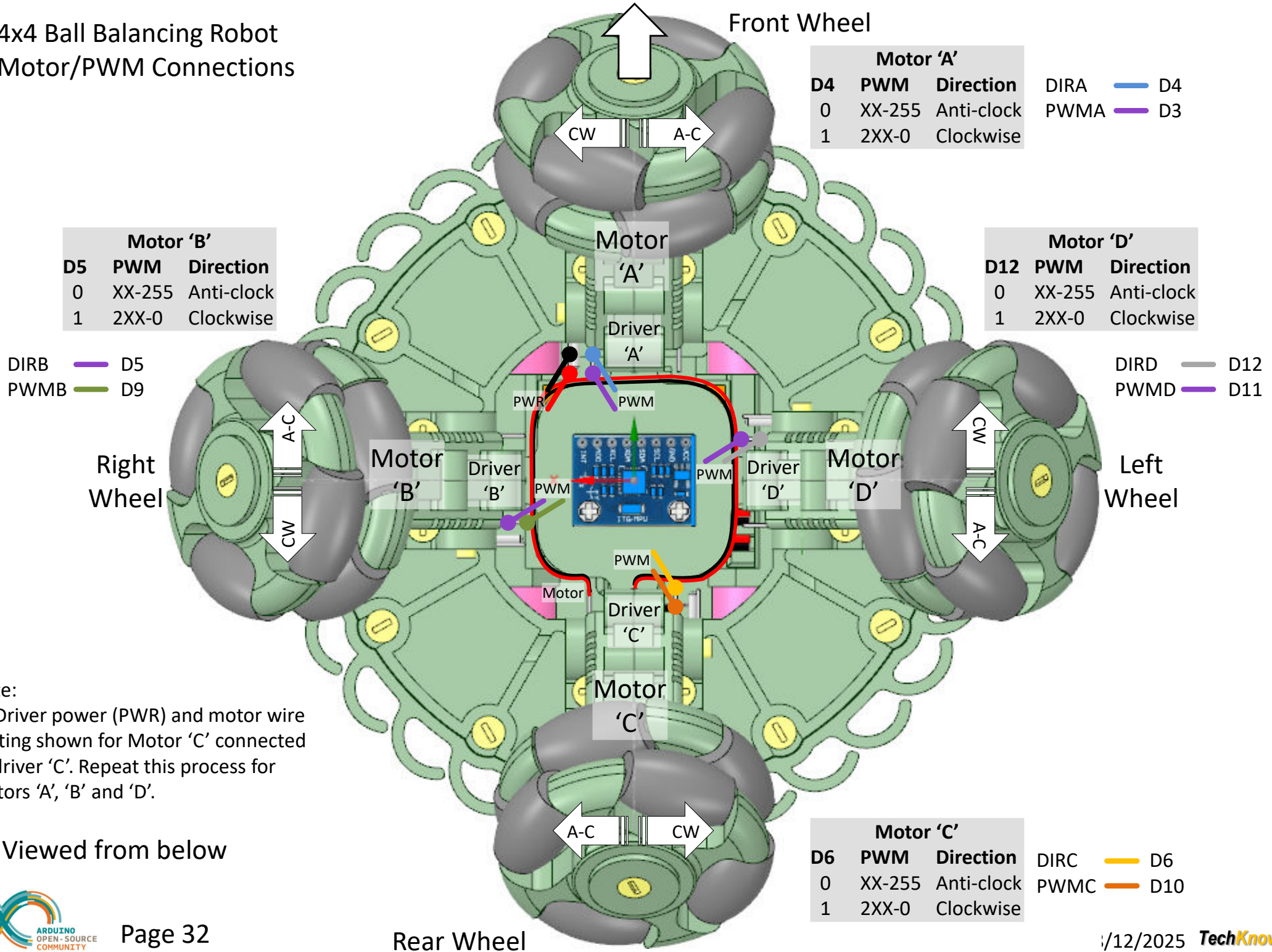


4x4 Ball Balancing Robot MPU 6050 Gyro Connections



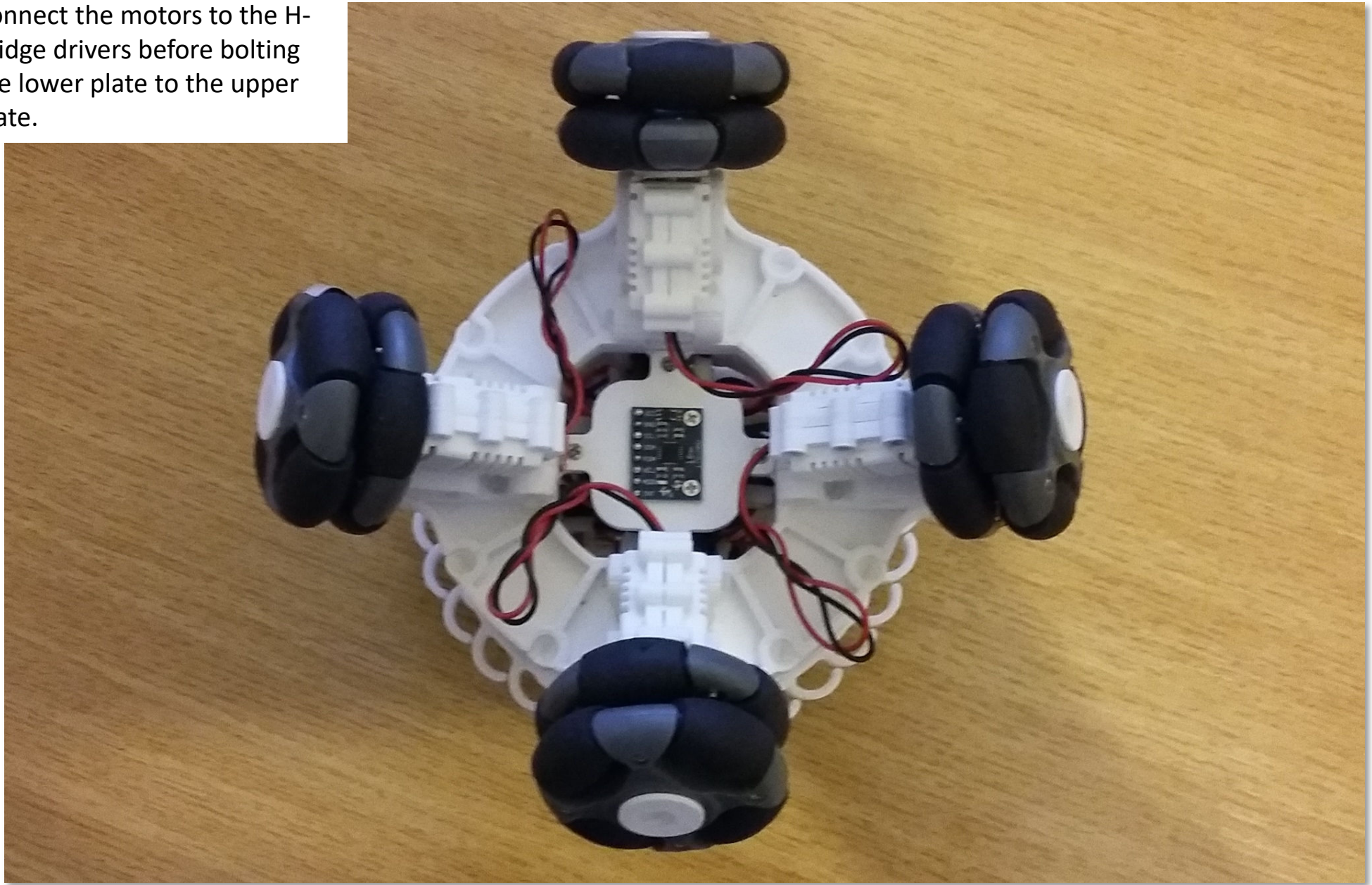
View from below

4x4 Ball Balancing Robot Motor/PWM Connections

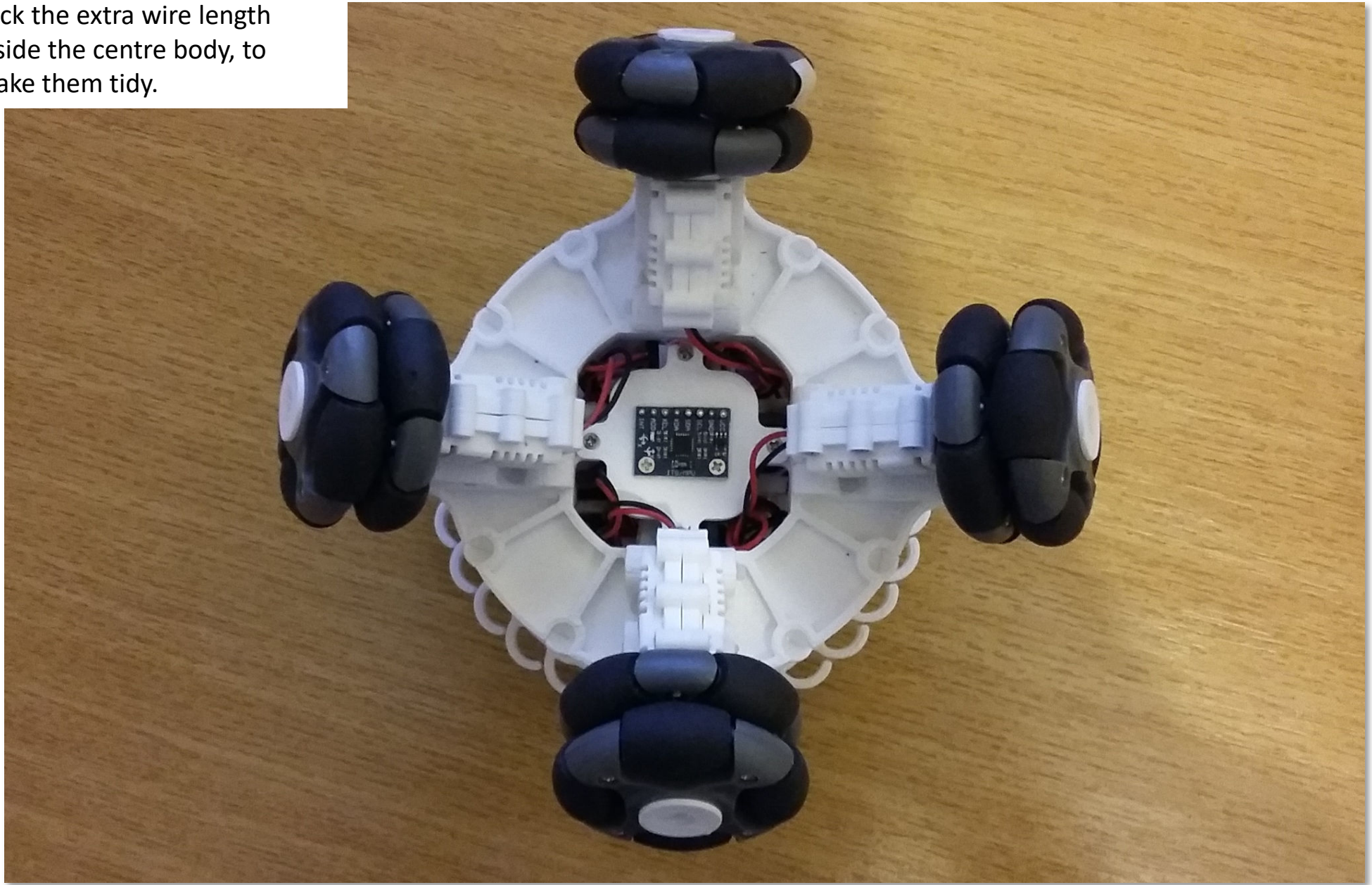


Viewed from below

Connect the motors to the H-bridge drivers before bolting the lower plate to the upper plate.

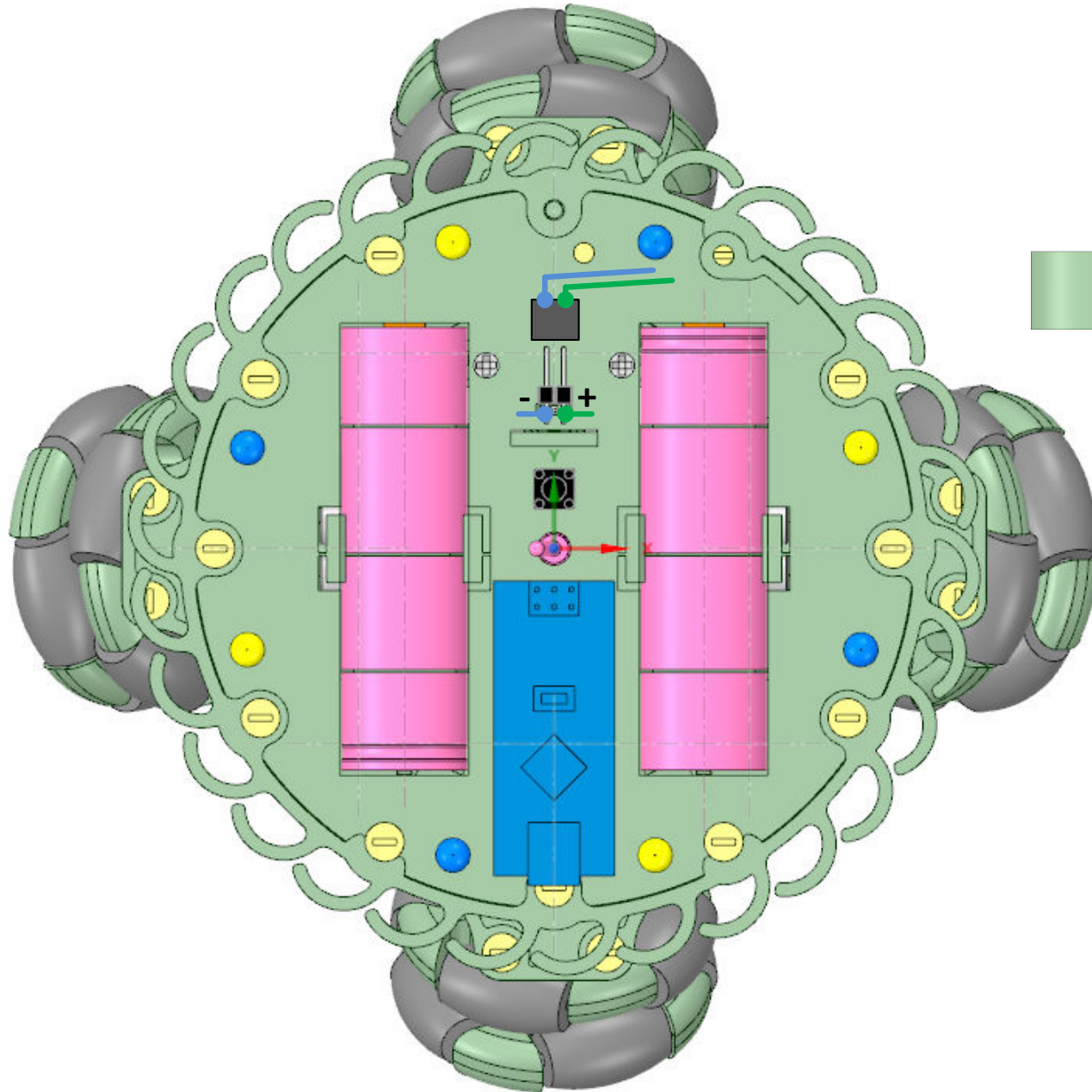


Tuck the extra wire length inside the centre body, to make them tidy.

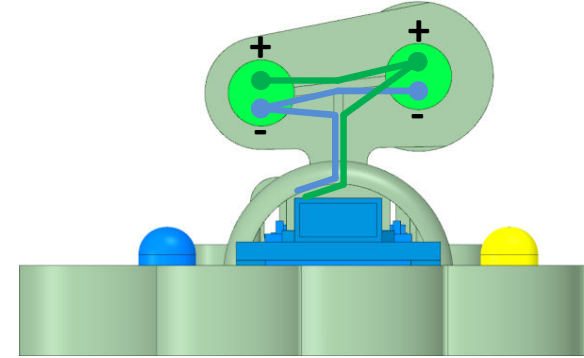


4x4 Ball Balancing Robot

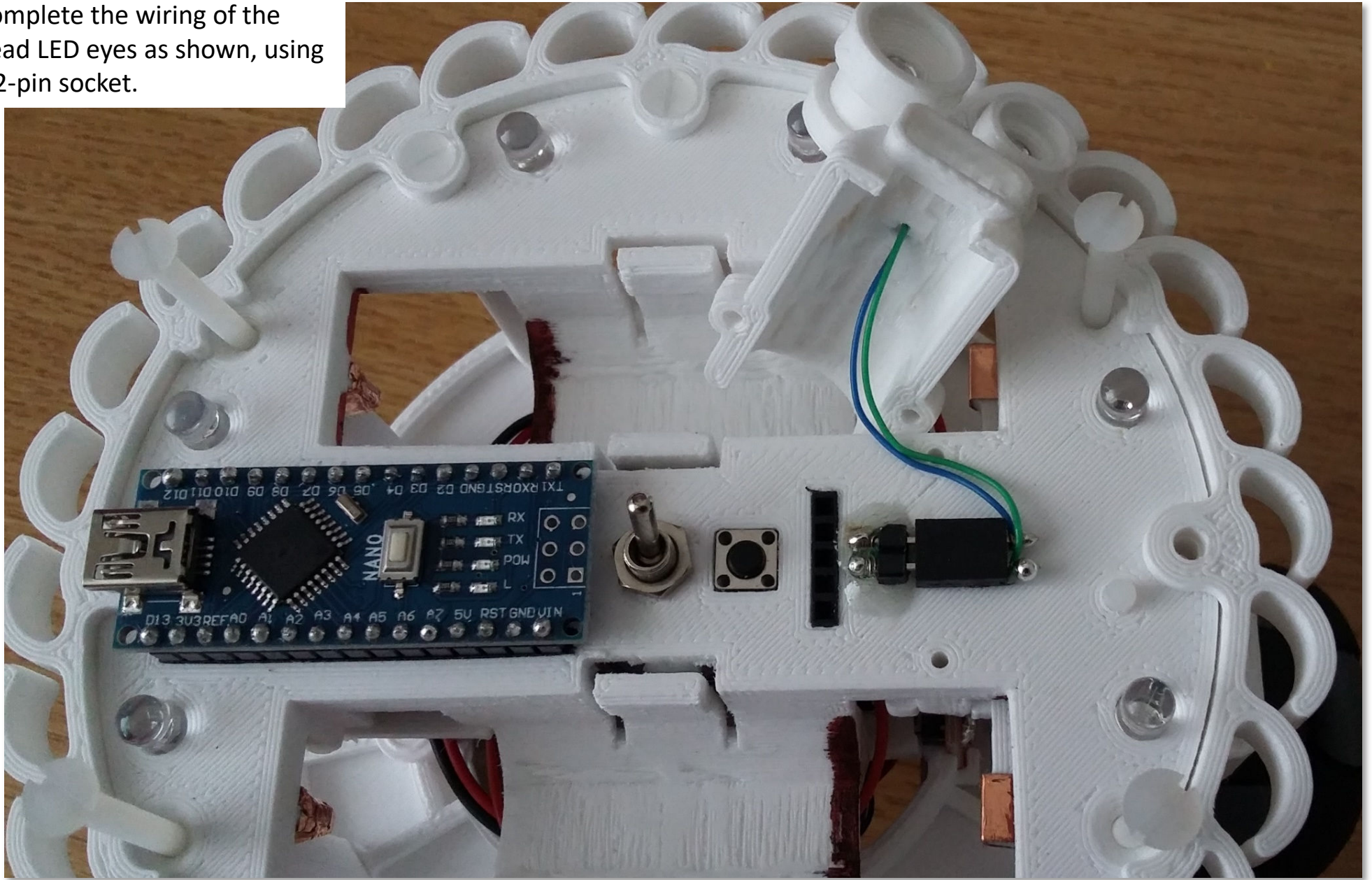
Head LED Eyes Connections



Robot Head Rear View



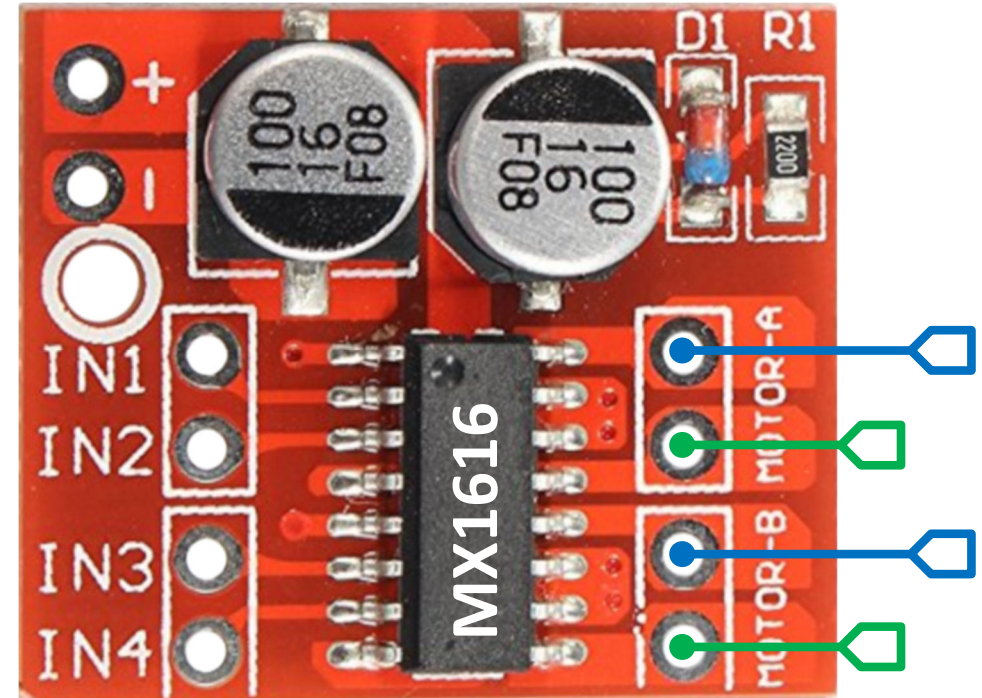
Complete the wiring of the head LED eyes as shown, using a 2-pin socket.



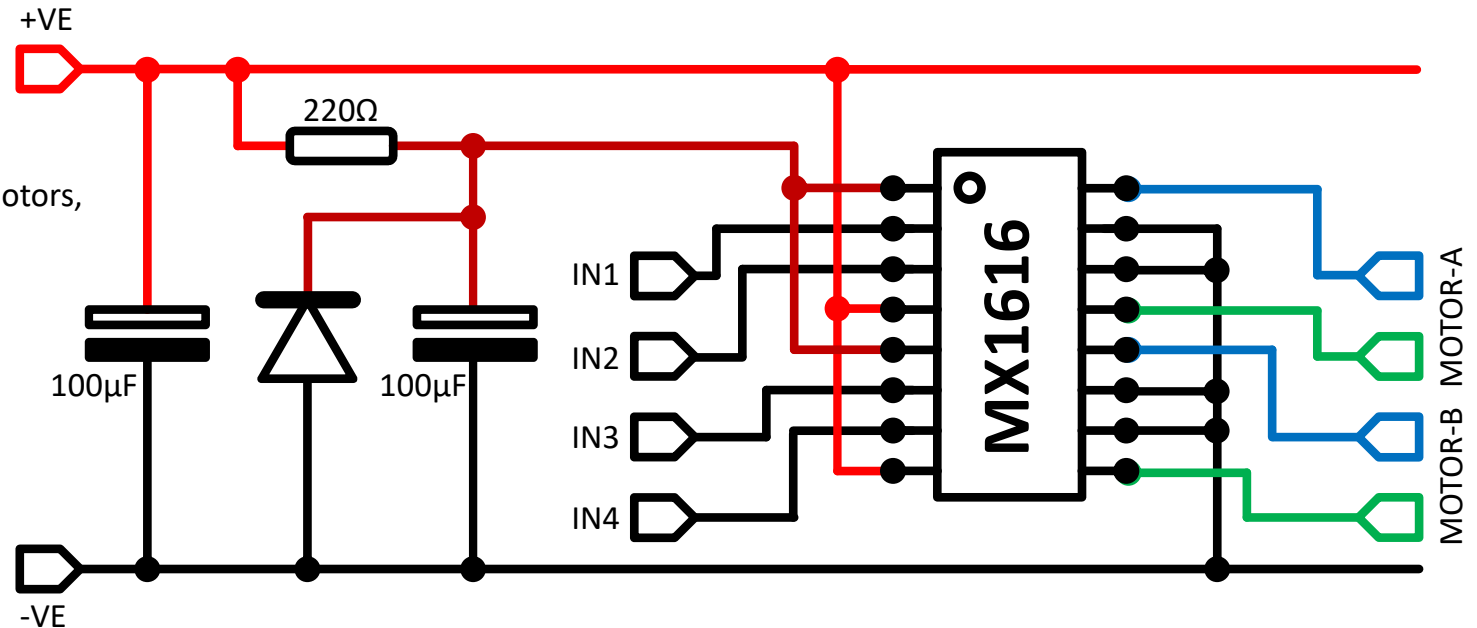
Data Sheet

DC MOTOR	MODE	IN1	IN2	IN3	IN4
MOTOR-A	Forward	1/PWM	0		
	Reversion	0	1/PWM		
	Standby	0	0		
	Brake	1	1		
MOTOR-B	Forward			1/PWM	0
	Reversion			0	1/PWM
	Standby			0	0
	Brake			1	1

Note:
 1. "1" represents a high level; "0" represents a low level; "PWM" on behalf of pulse width modulated wave, adjusts the duty cycle to change speed.
 2. IN1, IN2 control MOTOR-A; IN3, IN4 control MOTOR-B; two are completely independent.
 3. INx anti input common conduction function, pin floating is equivalent to low input.

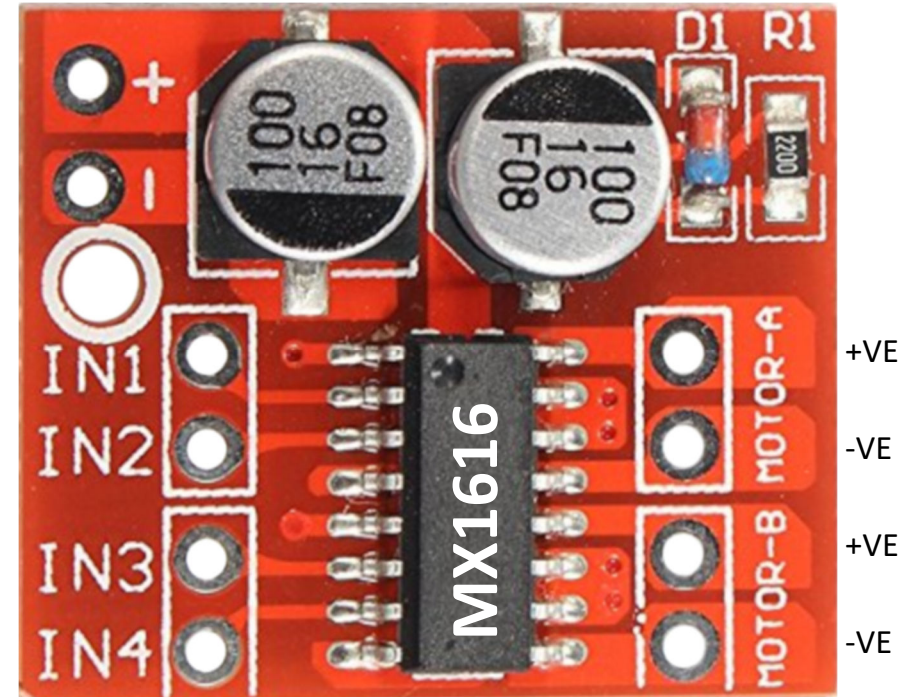


Built-in low on-resistance MOS switch.
 Dual 1.5A o/p with peak current of 2.5A
 Built-in thermal protection, automatic recovery
 Dual H-bridge motor driver, can drive two DC motors, or a 4-wire two-phase stepper motors.
 The module supply voltage: 2V-10V
 Signal input voltage: 1.8-7V
 Single Operating Current: 1.5A
 Peak current up to: 2.5A
 Size: 24.5 x 21.0 mm
 Mount hole: 3.0 mm dia
 Connector holes: 1.0 mm dia, 2.5 mm centres



Data Sheet

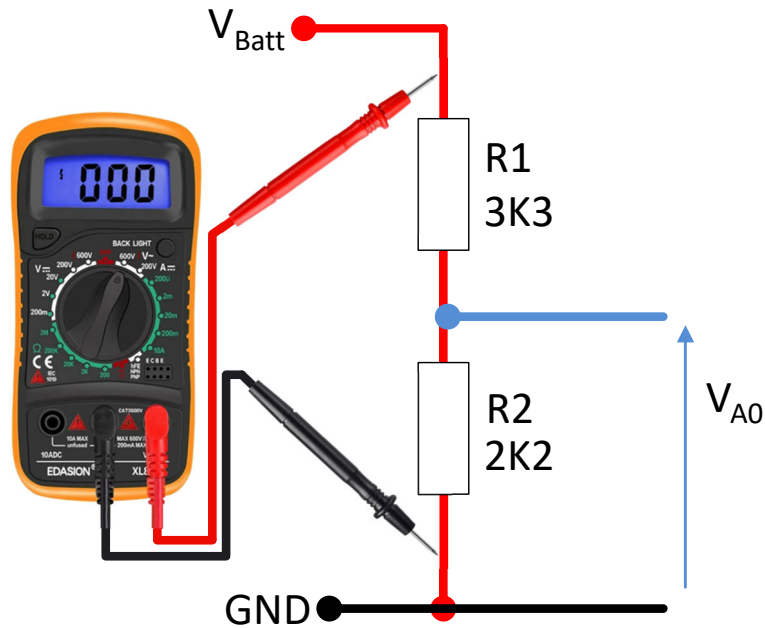
DC MOTOR	MODE	PWM	DIR	PWM	DIR
		IN1	IN2	IN3	IN4
MOTOR - A	Forward	PWM - 1	0		
	Reverse	0	PWM - 1		
	Forward	1	PWM - 0		
	Reverse	PWM - 0	1		
	Standby	0	0		
	Brake	1	1		
MOTOR - B	Forward			PWM - 1	0
	Reverse			0	PWM - 1
	Forward			1	1 - PWM
	Reverse			1 - PWM	1
	Standby			0	0
	Brake			1	1



Note:

1. Table indicates that 'Forward' and 'Reverse' can be achieved with only one PWM signal, with the direction being set by the other pin. However to control speed in reverse the PWM value is effectively inverted. See lines 1 and 4 in the truth table for single PWM and DIRection control.
2. If only one channel is required then inputs can be tied together, IN1+IN3 and IN2+IN4, then H-bridge common 'MOTOR' outputs can also be tied together, -VE & -VE and +VE & +VE.
3. Input pull-down resistors measured in the region of 11kΩ, so an Arduino digital pin can easily drive two or more INx pins.

Battery Monitor (Protection)



$$V_{A0} = \frac{V_{Batt} \times R2}{R1 + R2}$$

$$V_{A0} = \frac{V_{Batt} \times 2K2}{5K5}$$

$$V_{FSD} = 12.5v @ V_{A0} = 5$$

$$V_{A0D} = \frac{V_{A0} \times 1023}{5} \quad \text{voltage read by 10-bit ADC}$$

$$V_{A0D} = \frac{V_{Batt} \times 0.4 \times 1023}{5}$$

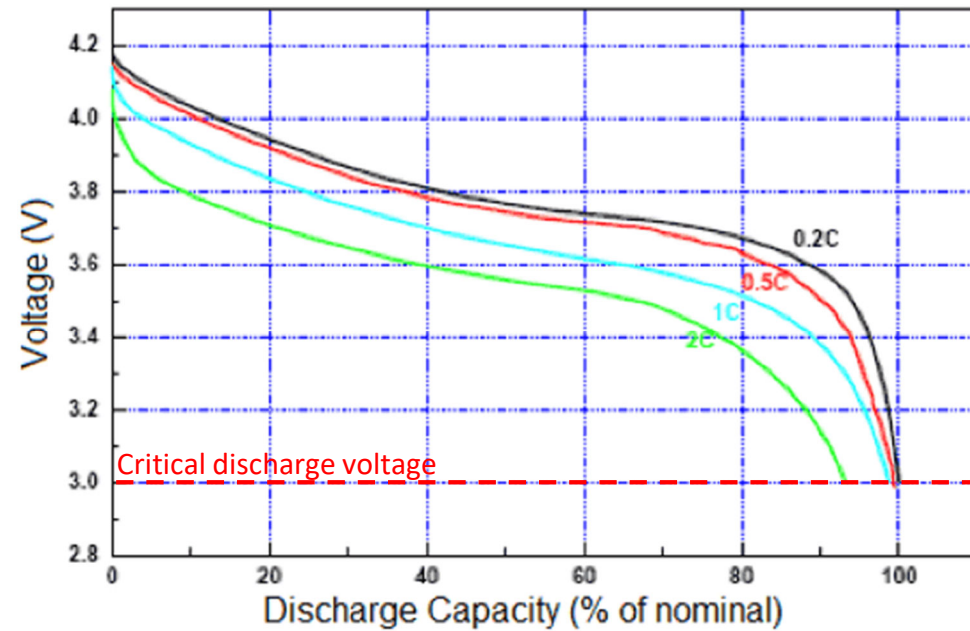
Two cells in series gives a nominal 7.4v constant discharge voltage. To prevent damage, stop using once the following conditions are reached:

- 3.60 + 3.00 = 6.60v (one battery fades early)
- 3.30 + 3.30 = 6.60v (both batteries fade together)

Hence $V_{A0D} = 540 @ V_{Batt} = 6.60v$

The code will shut down when the value drops to 540.

18650 Lithium Battery Discharge Profile



Discharge: 3.0V cutoff at room temperature.

