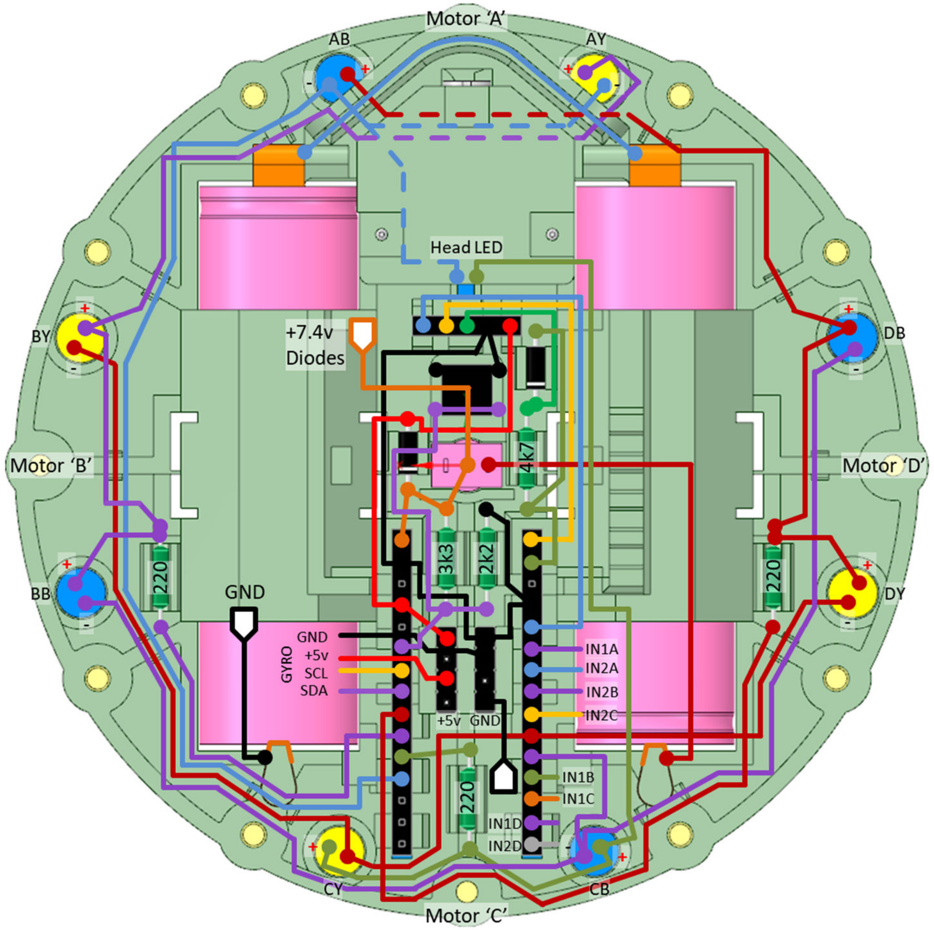
4x4 Ball Balancing Robot

Circuits



ARDUINO OPEN-SOURCE COMMUNITY

Release: 1.0 TechKnowTone

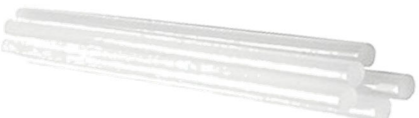
Hand Tools:

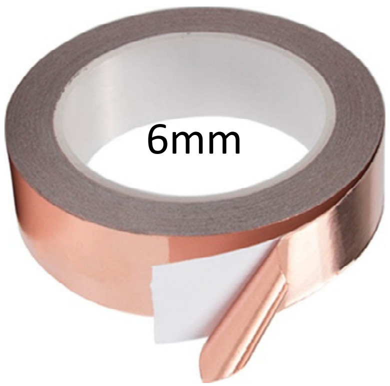
Fine Nosed Pliers
Side Cutters
M3 Tap
M4 Tap
2.5 mm Drill
3.0 mm Drill
3.5mm Drill
6.0 mm Drill
Needle Files
M3 Box Spanner
Screwdriver
Craft Knife

Note: Not all items are shown here.

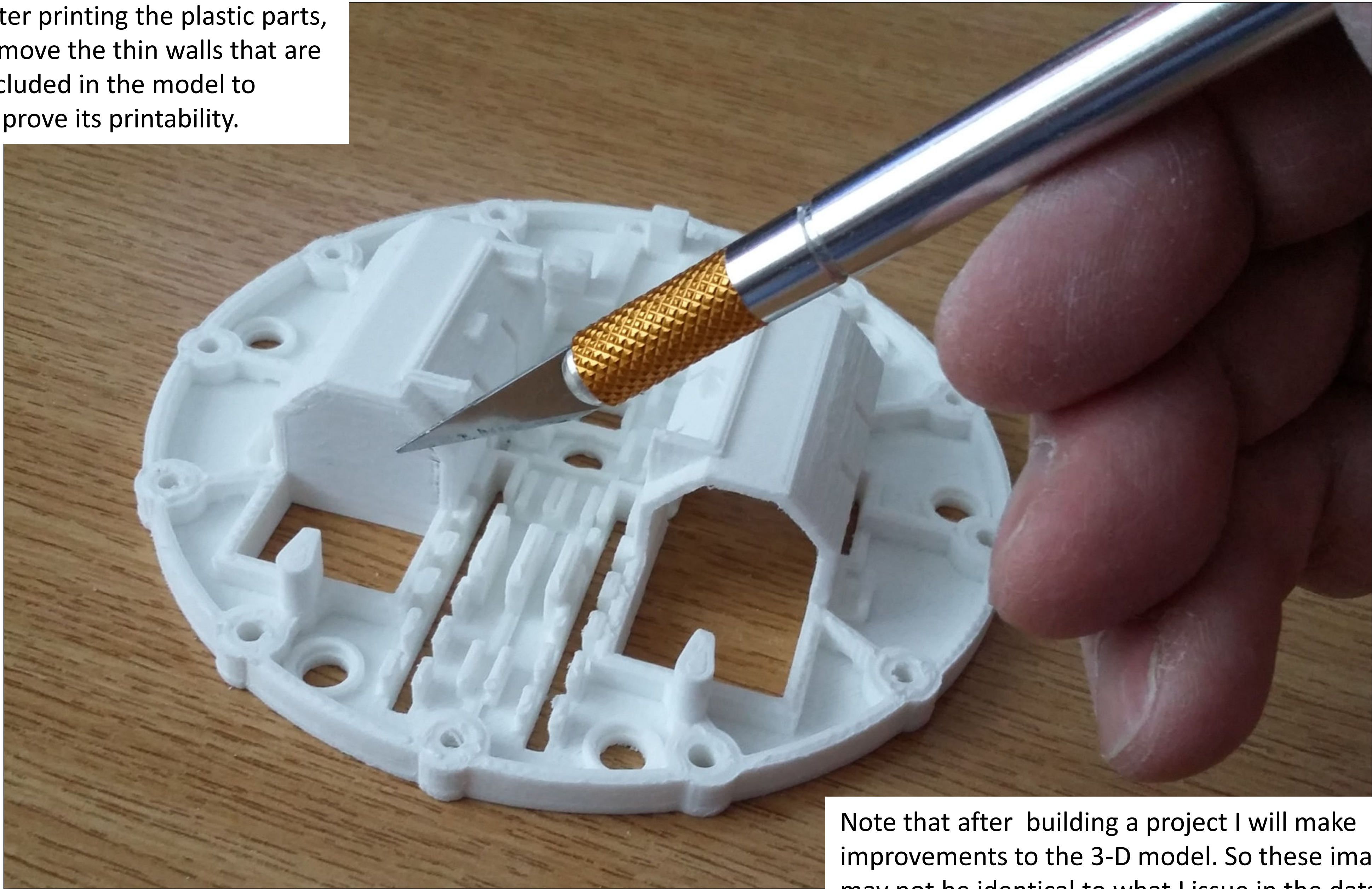
Hand Tools:

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



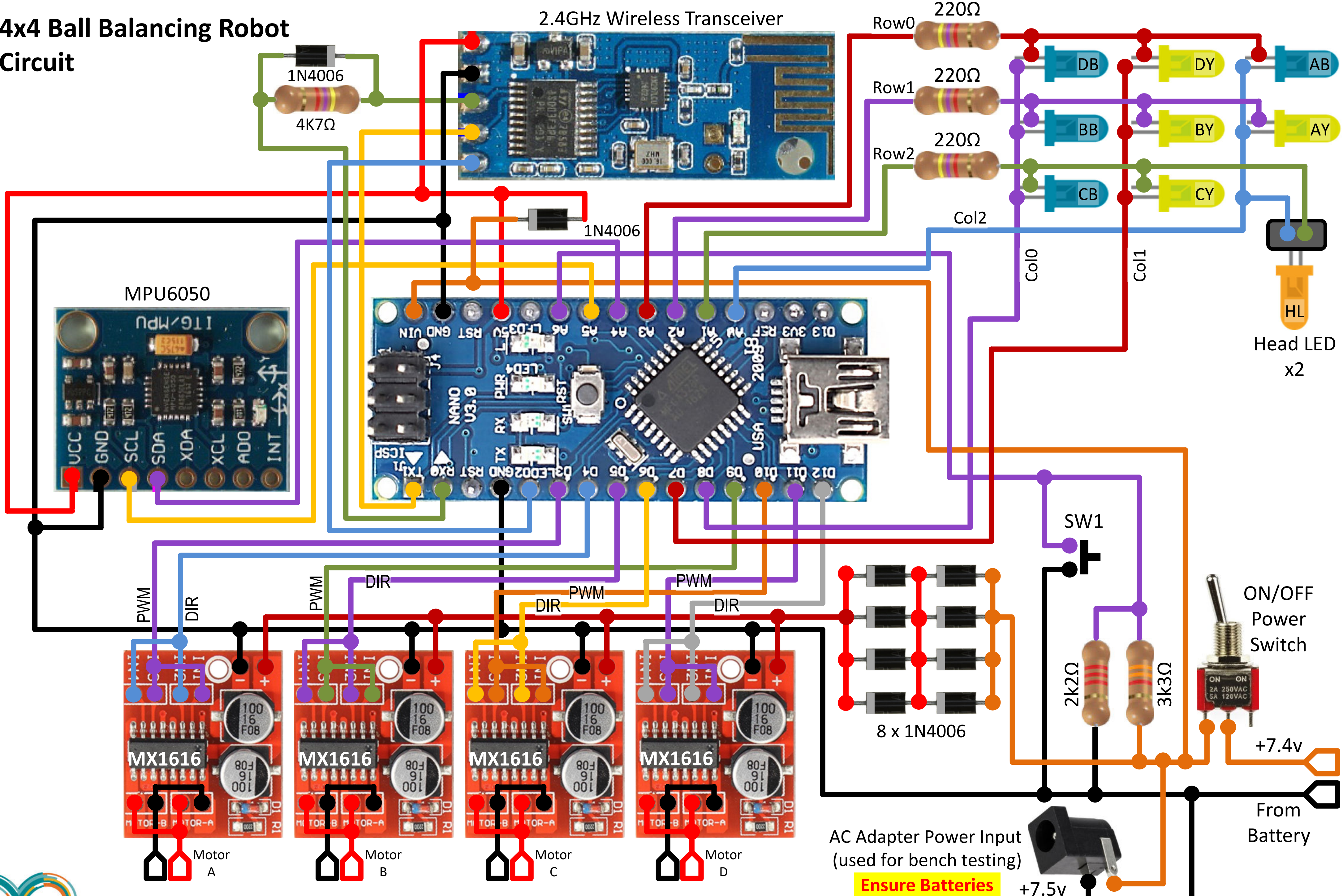


After printing the plastic parts, remove the thin walls that are included in the model to improve its printability.



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



Release: 1.0

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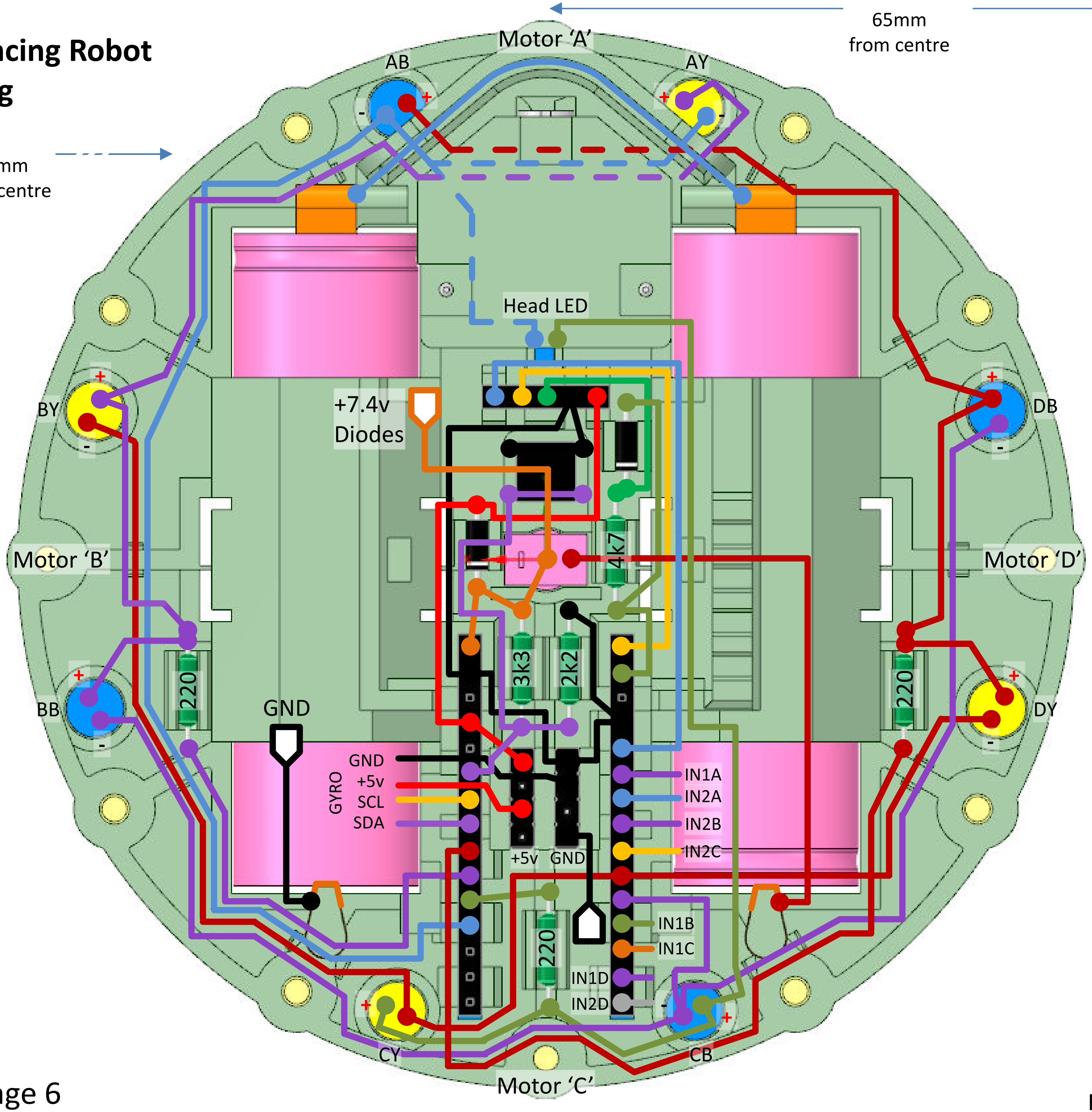
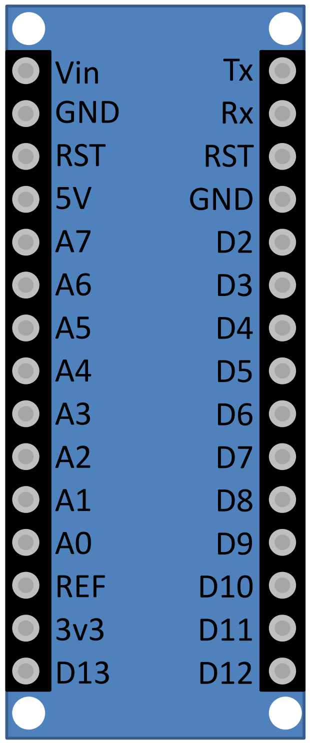
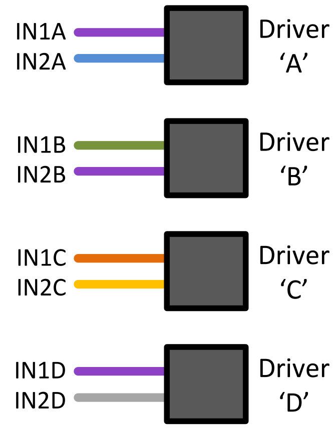
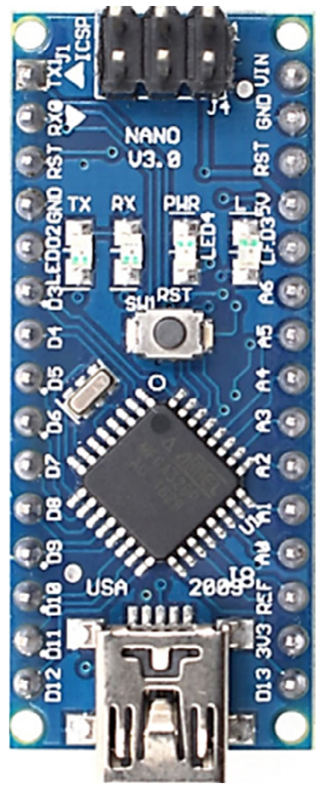
4x4 Ball Balancing Robot Control Wiring





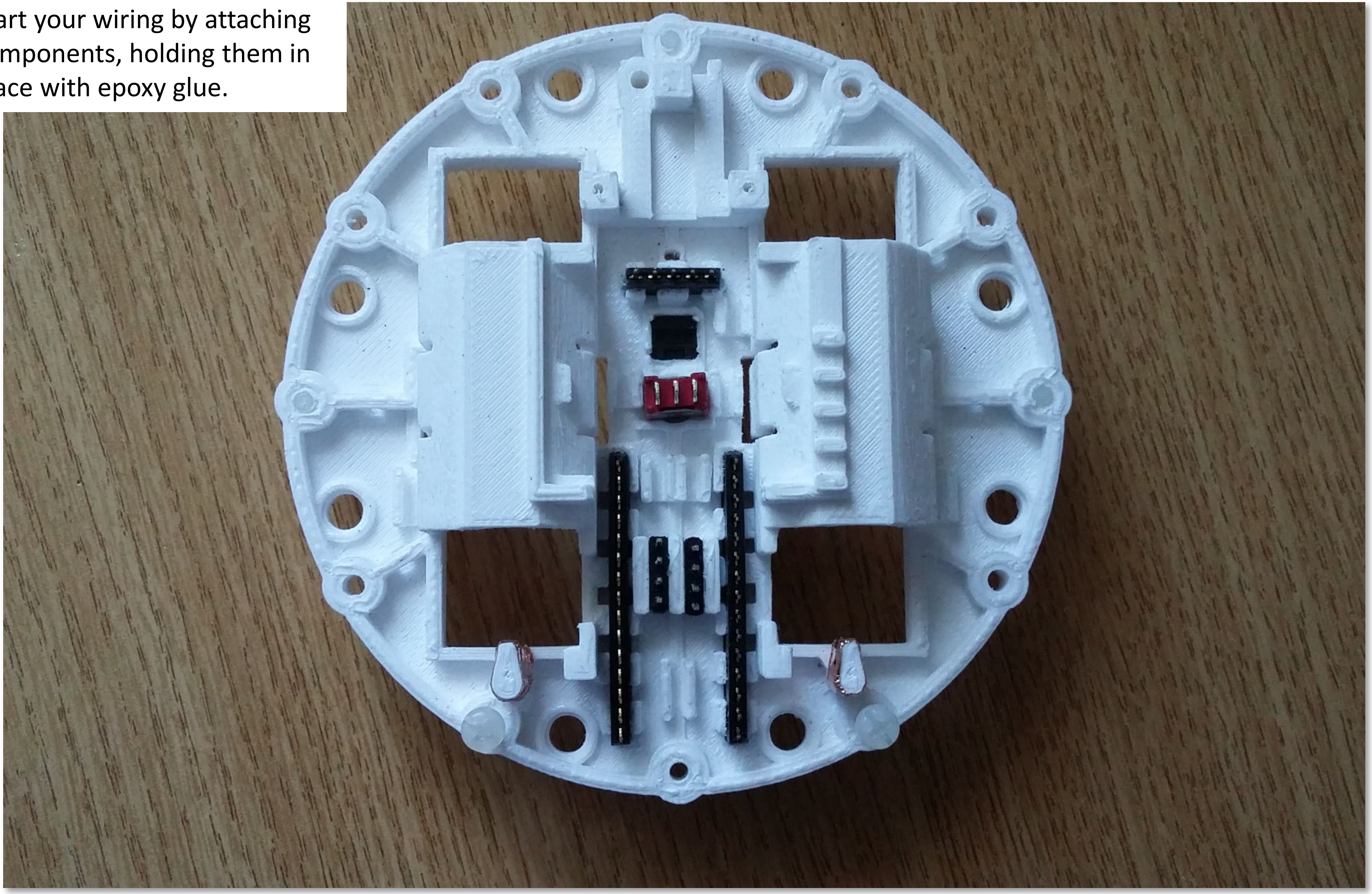




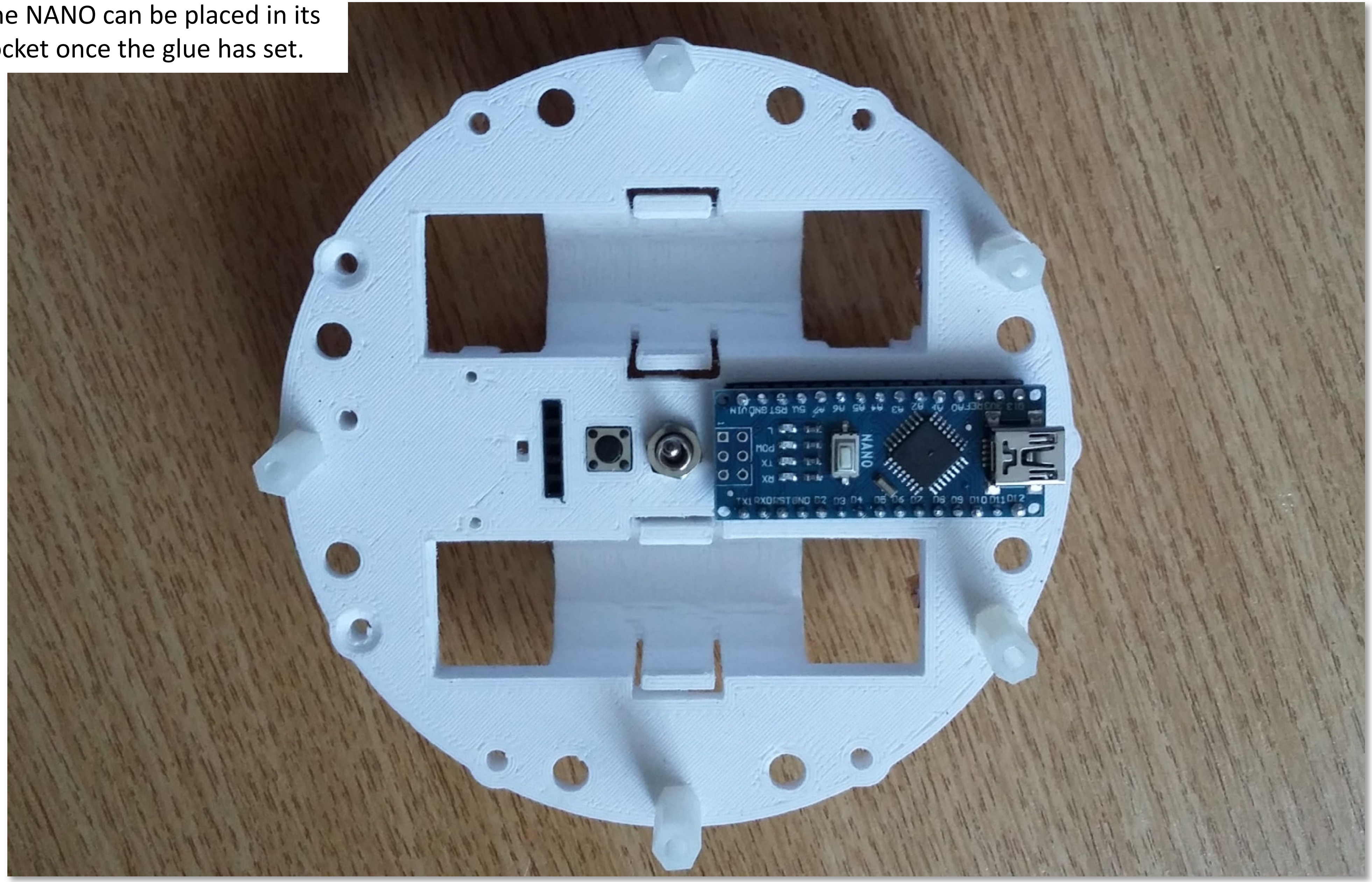
Release: 1.0

TechKnowTone

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

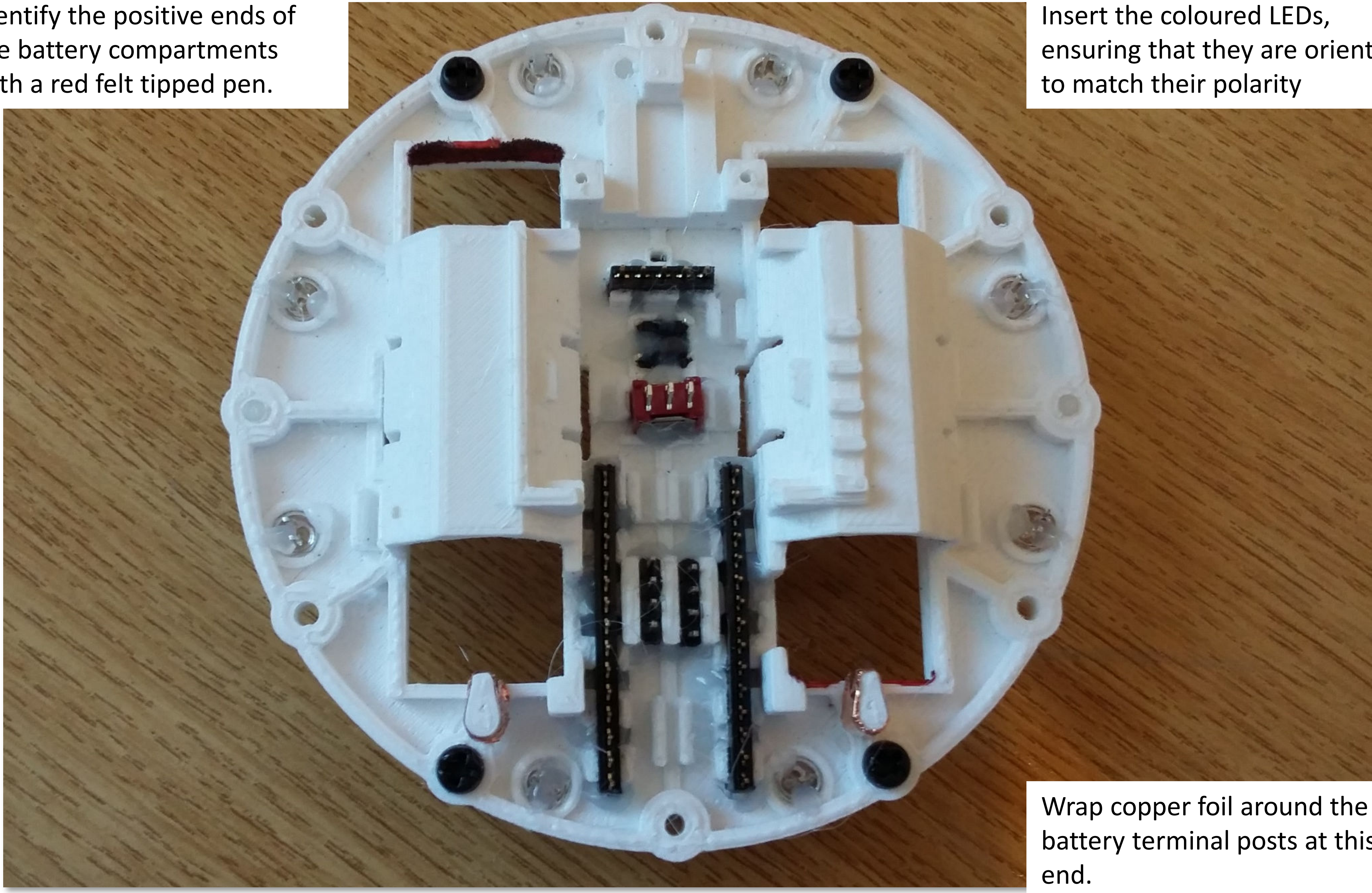


The NANO can be placed in its socket once the glue has set.



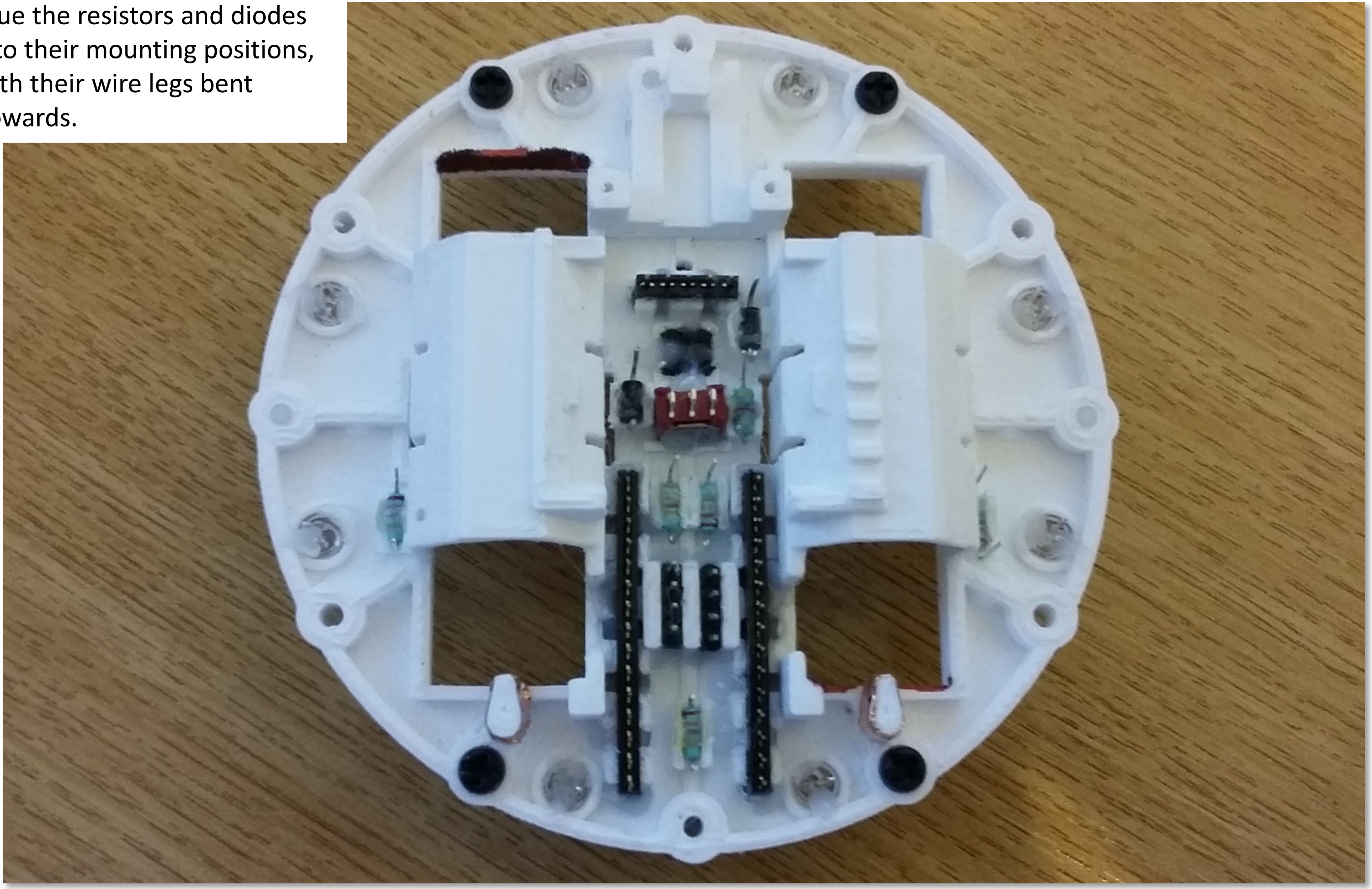
Identify the positive ends of the battery compartments with a red felt tipped pen.

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

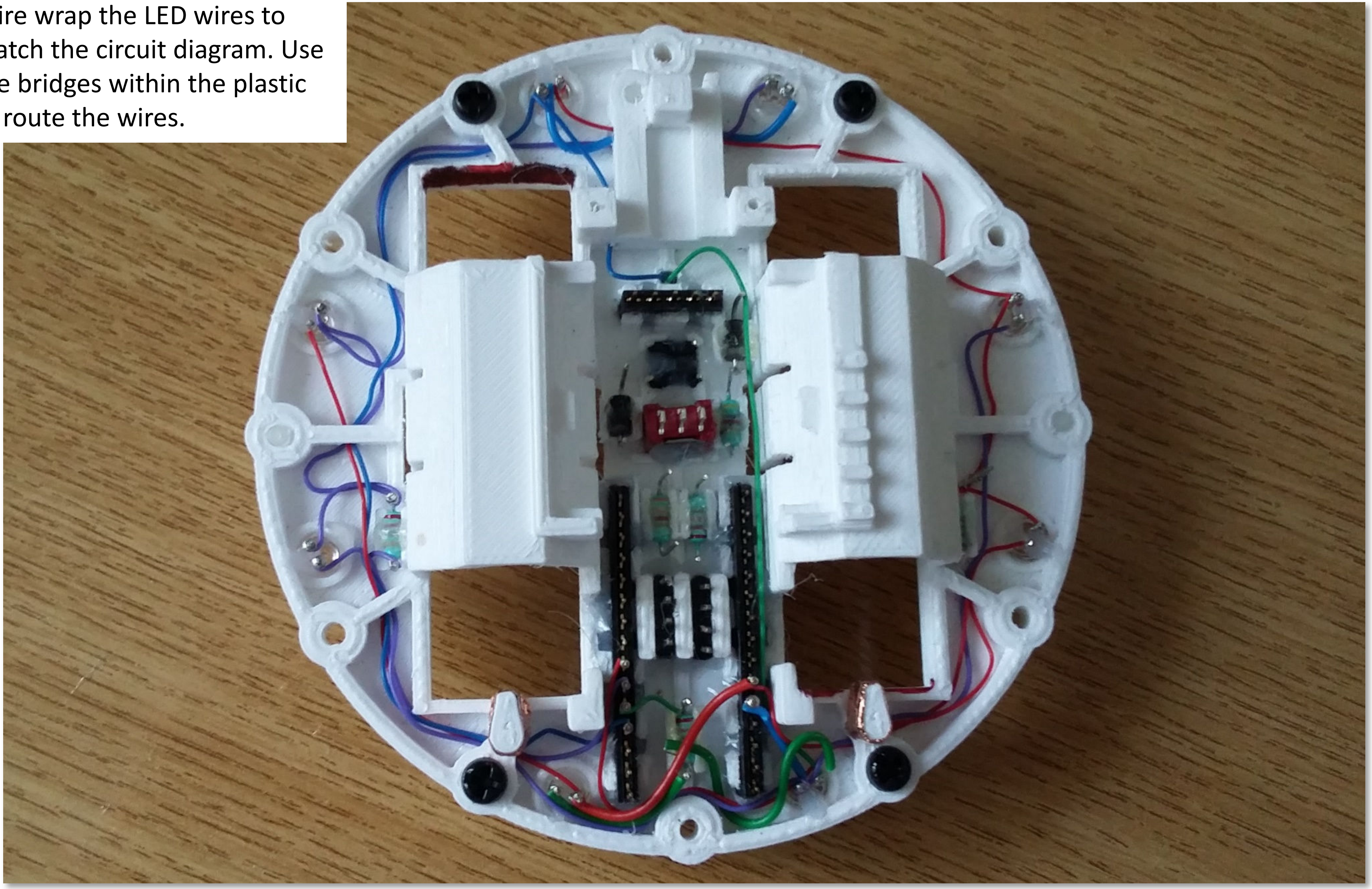


Wrap copper foil around the battery terminal posts at this end.

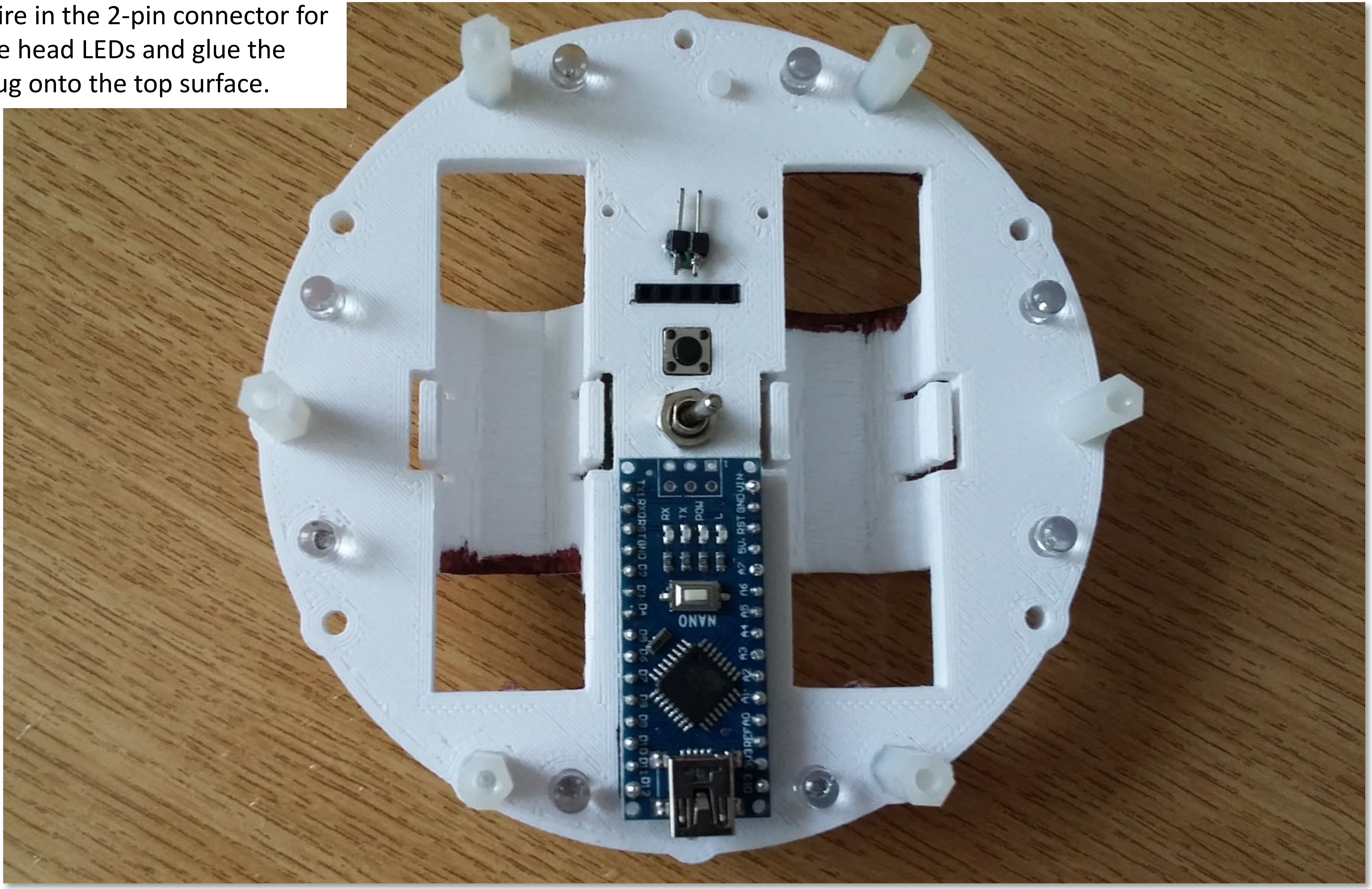
Glue the resistors and diodes into their mounting positions, with their wire legs bent upwards.



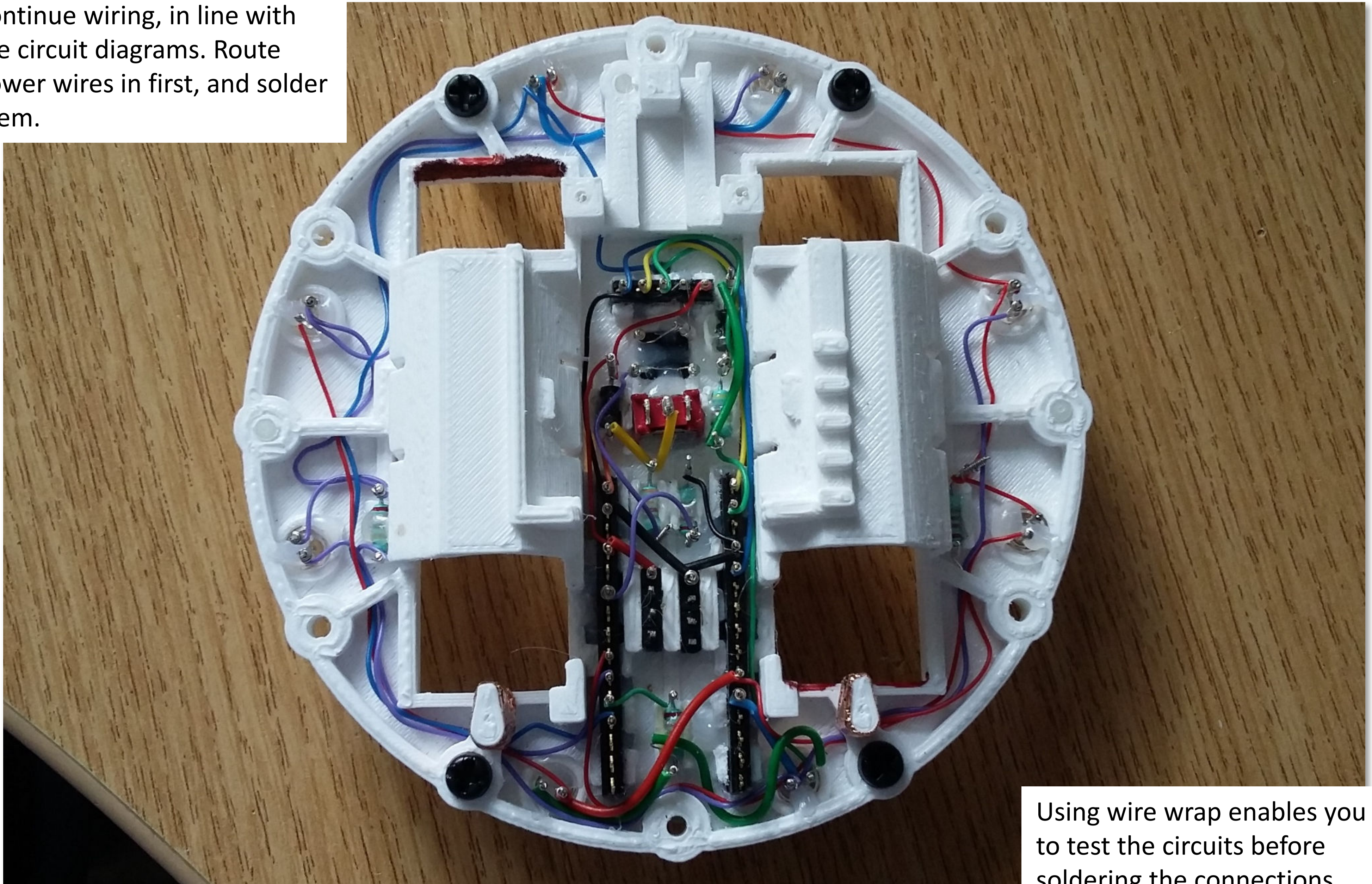
Wire wrap the LED wires to match the circuit diagram. Use the bridges within the plastic to route the wires.



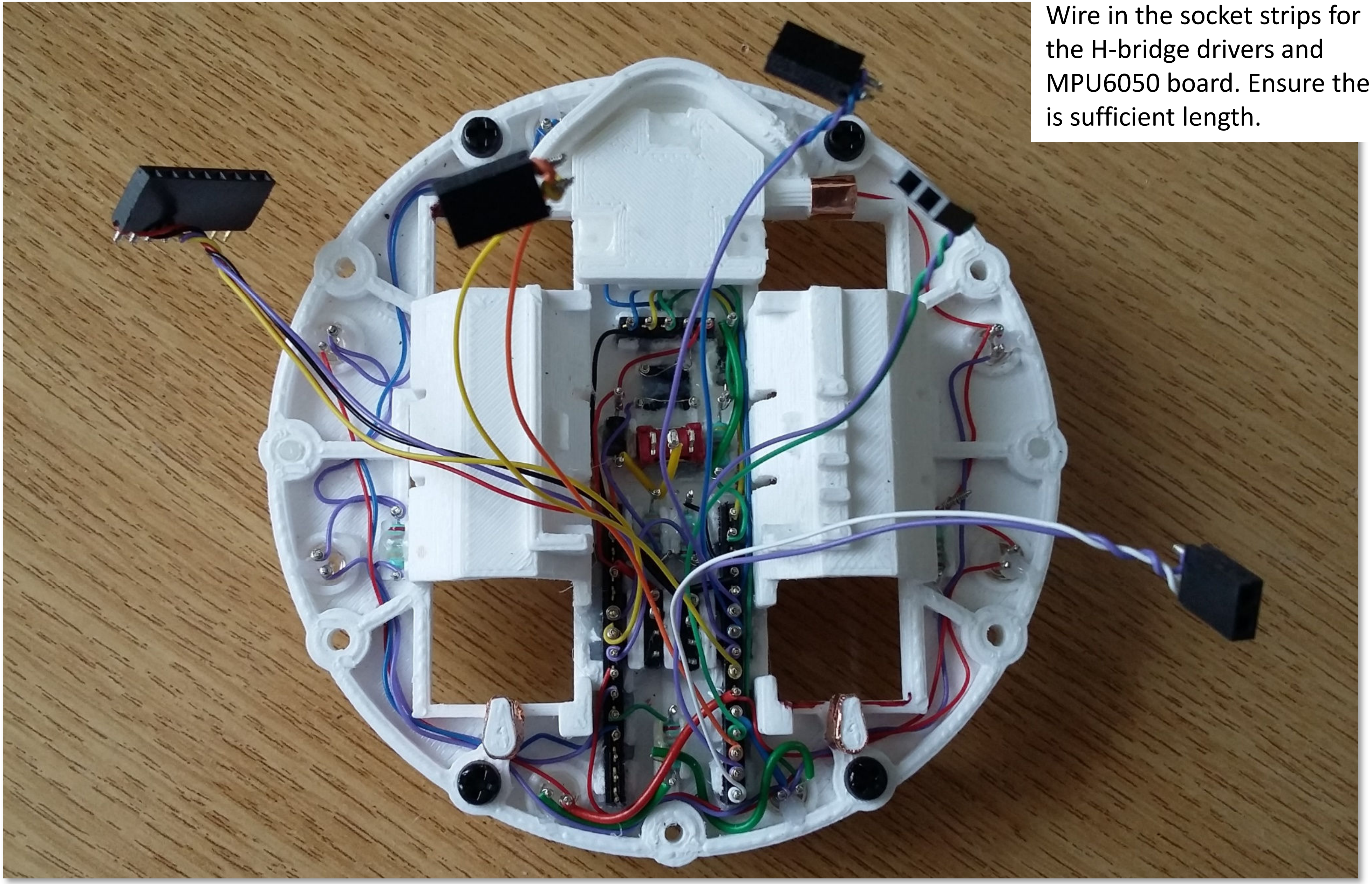
Wire in the 2-pin connector for the head LEDs and glue the plug onto the top surface.



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

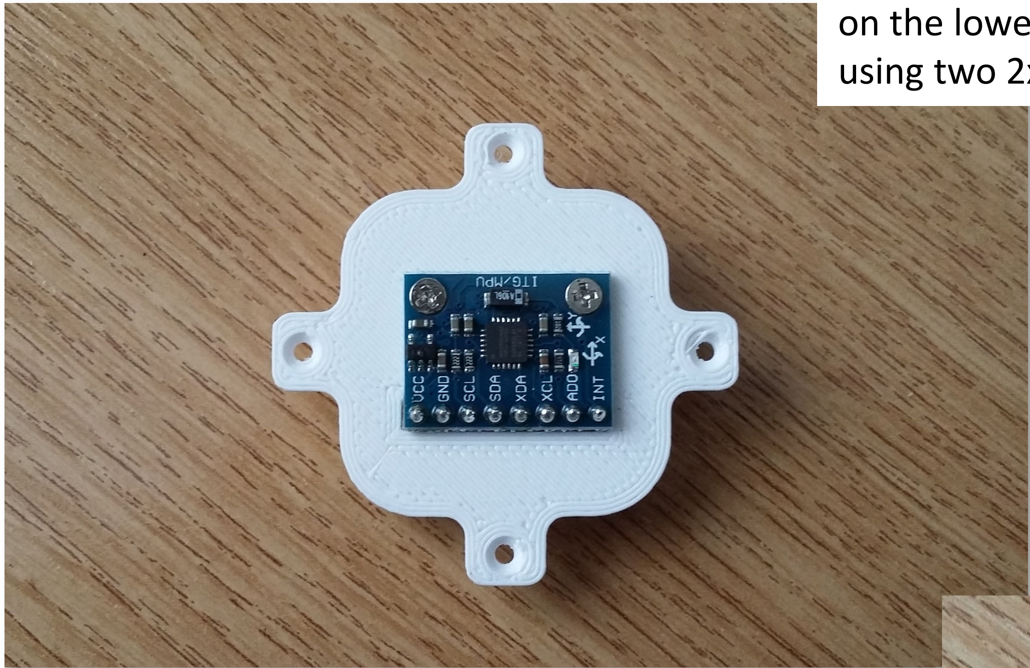


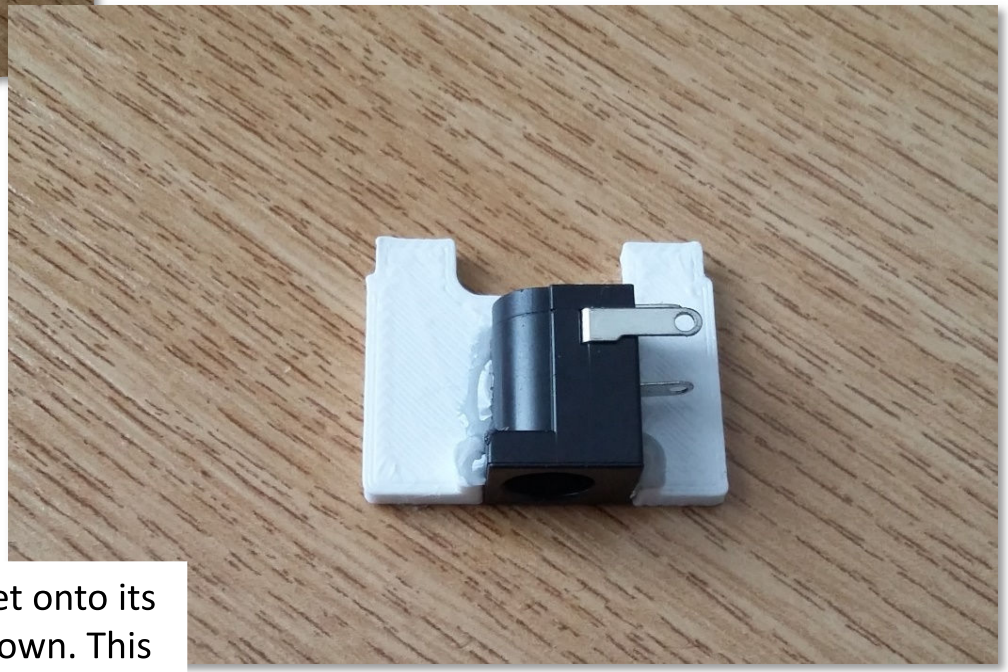
Using wire wrap enables you to test the circuits before soldering the connections.



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

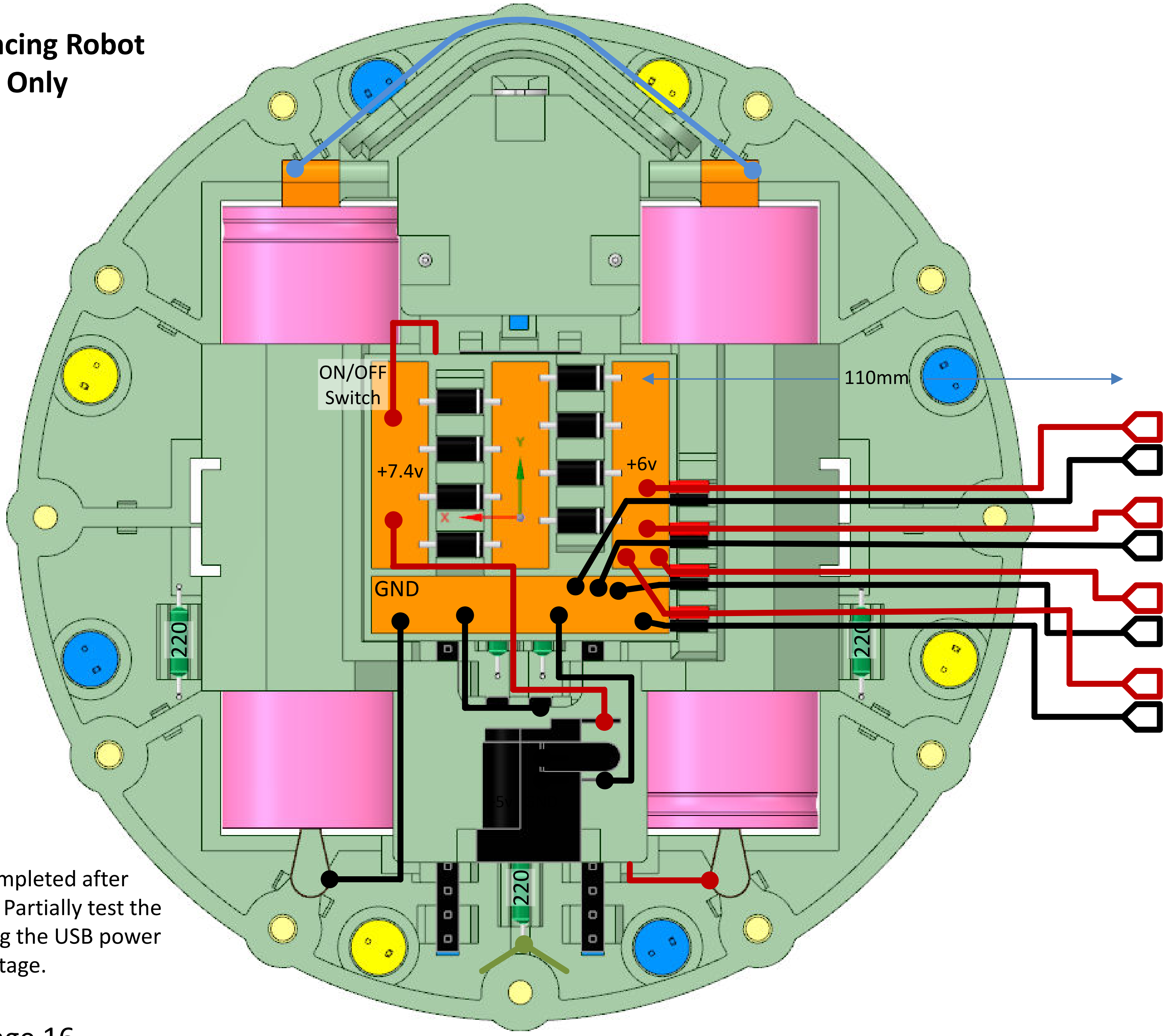
Mount the MPU6050 device on the lower mounting plate, using two 2x10mm screws.





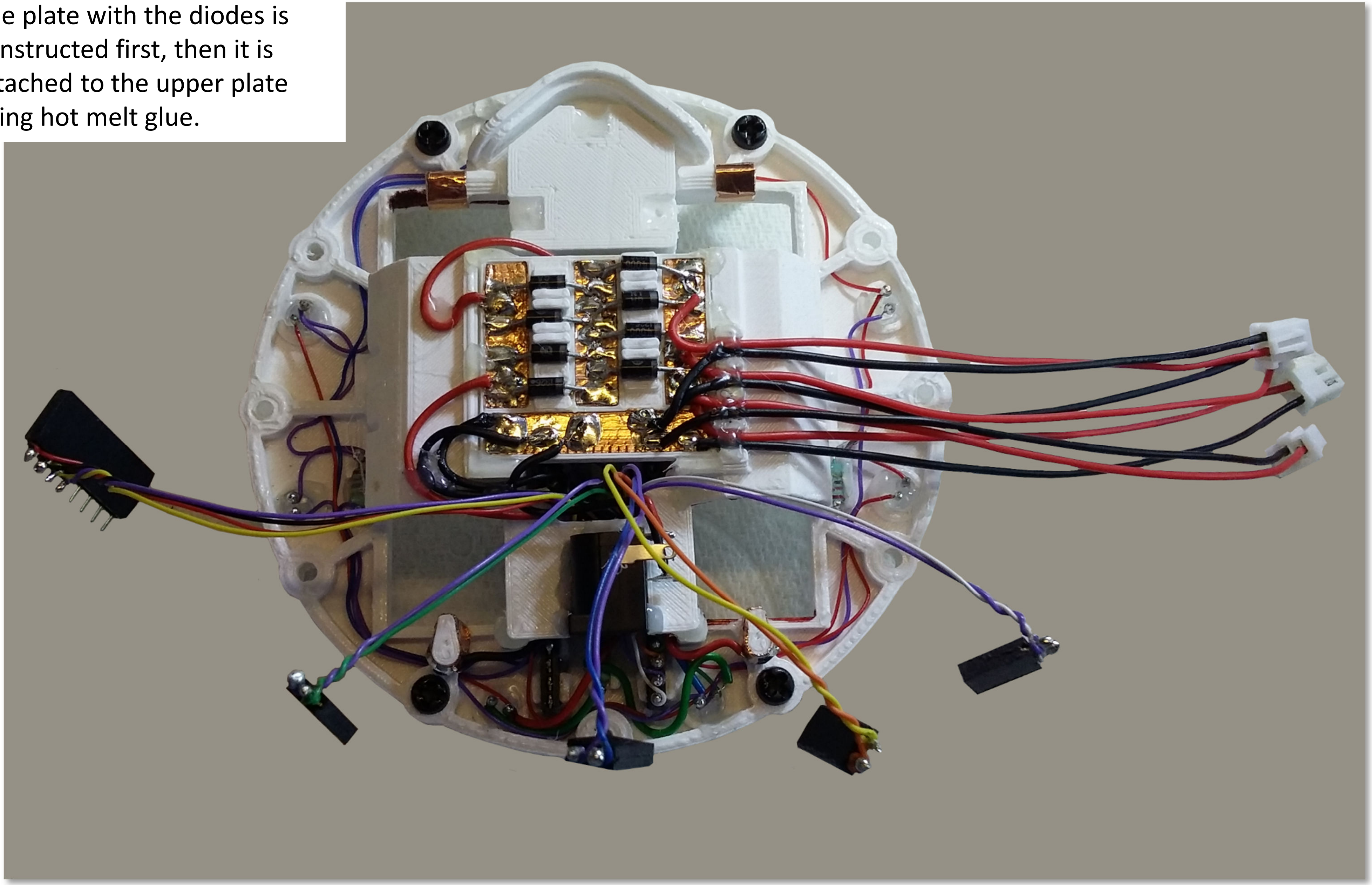
Glue the power socket onto its mounting plate as shown. This socket is used for testing.

4x4 Ball Balancing Robot
Power Wiring Only

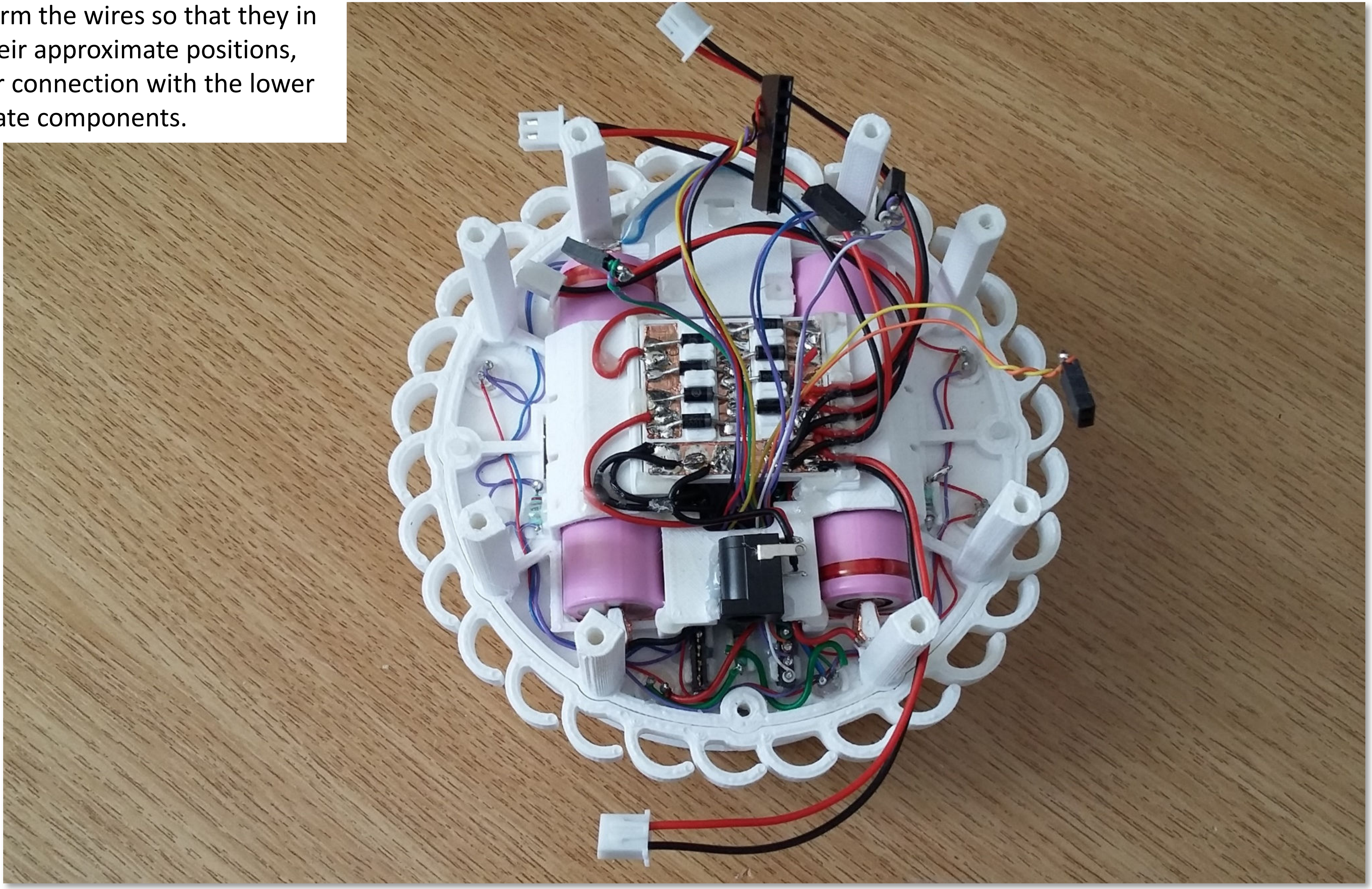


Note:
Power wiring is completed after the control wiring. Partially test the control wiring using the USB power before doing this stage.

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



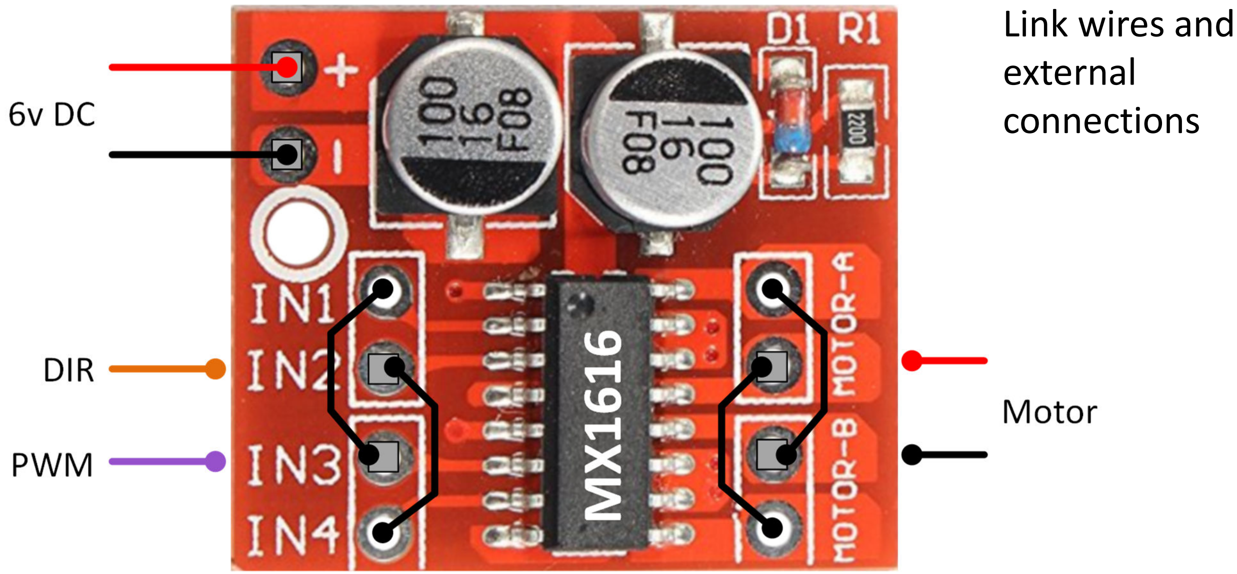
Form the wires so that they in their approximate positions, for connection with the lower plate components.

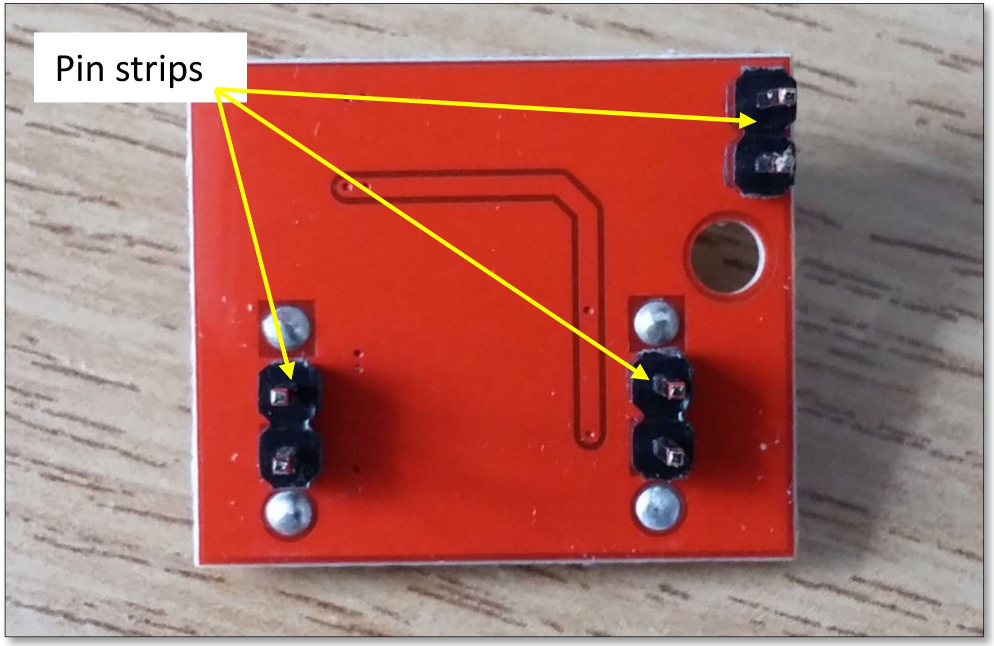


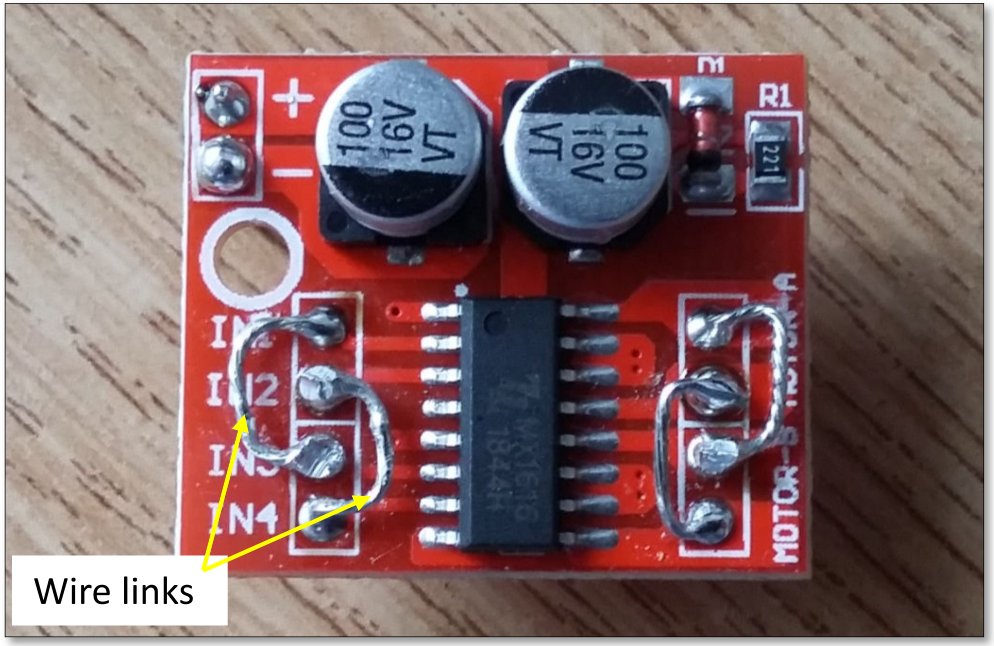
The 3 H-bridge driver boards need to be pre-wired as follows using formed link wires and pin strips.

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

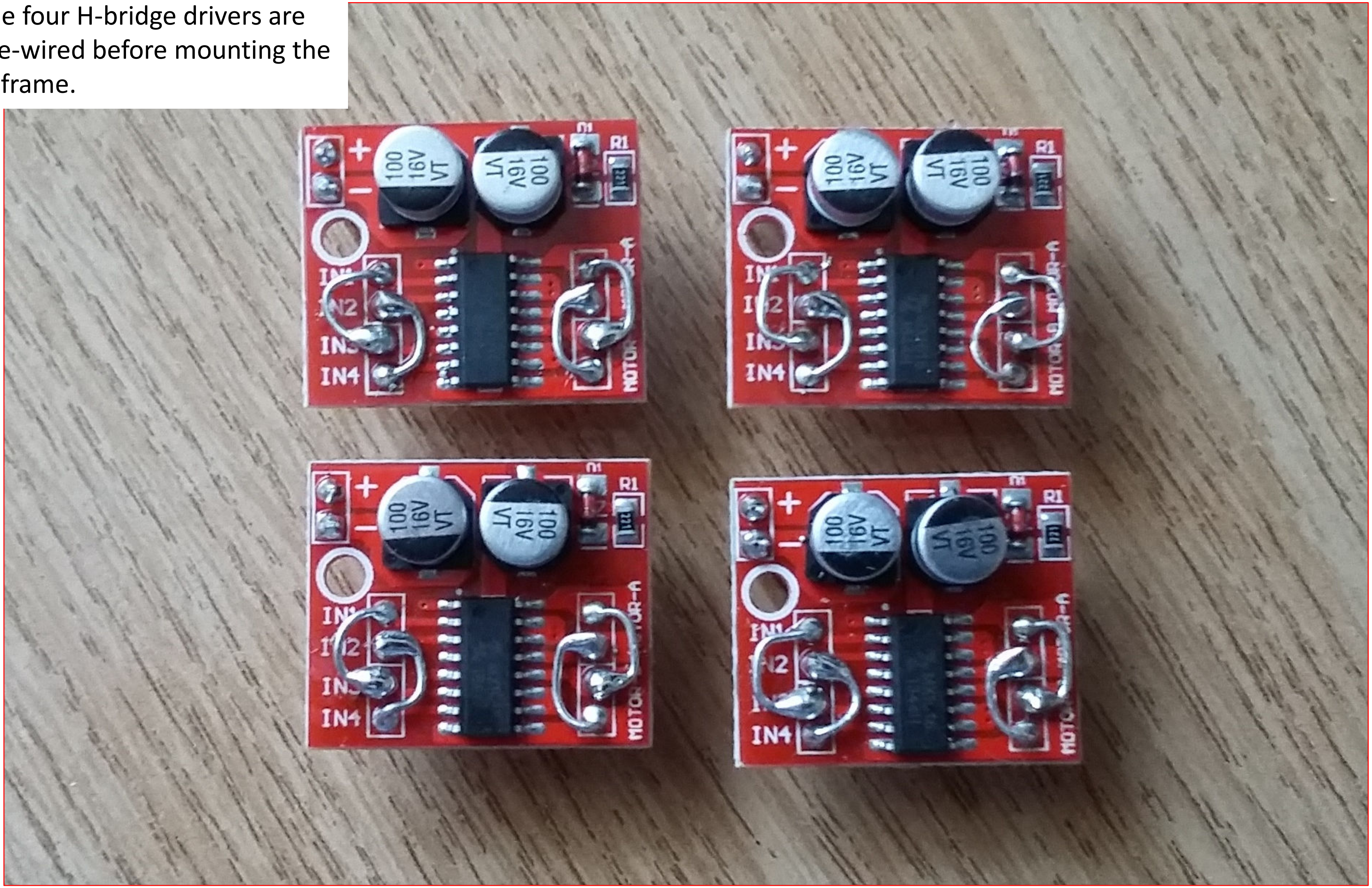
Pin strips are applied to the reverse side of the board before forming and attaching the wire links.



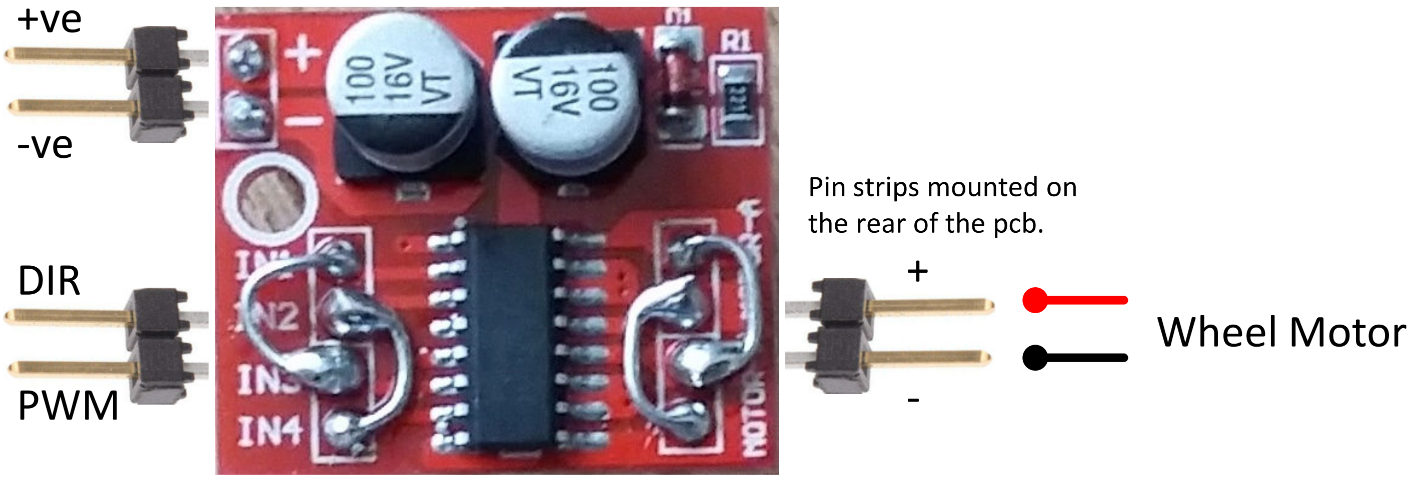




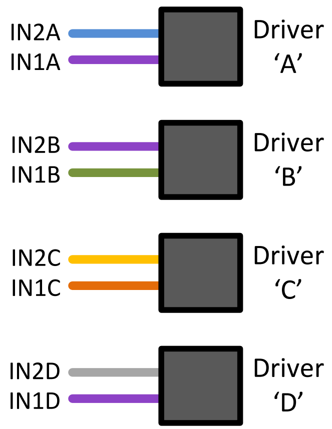
The four H-bridge drivers are pre-wired before mounting the in frame.

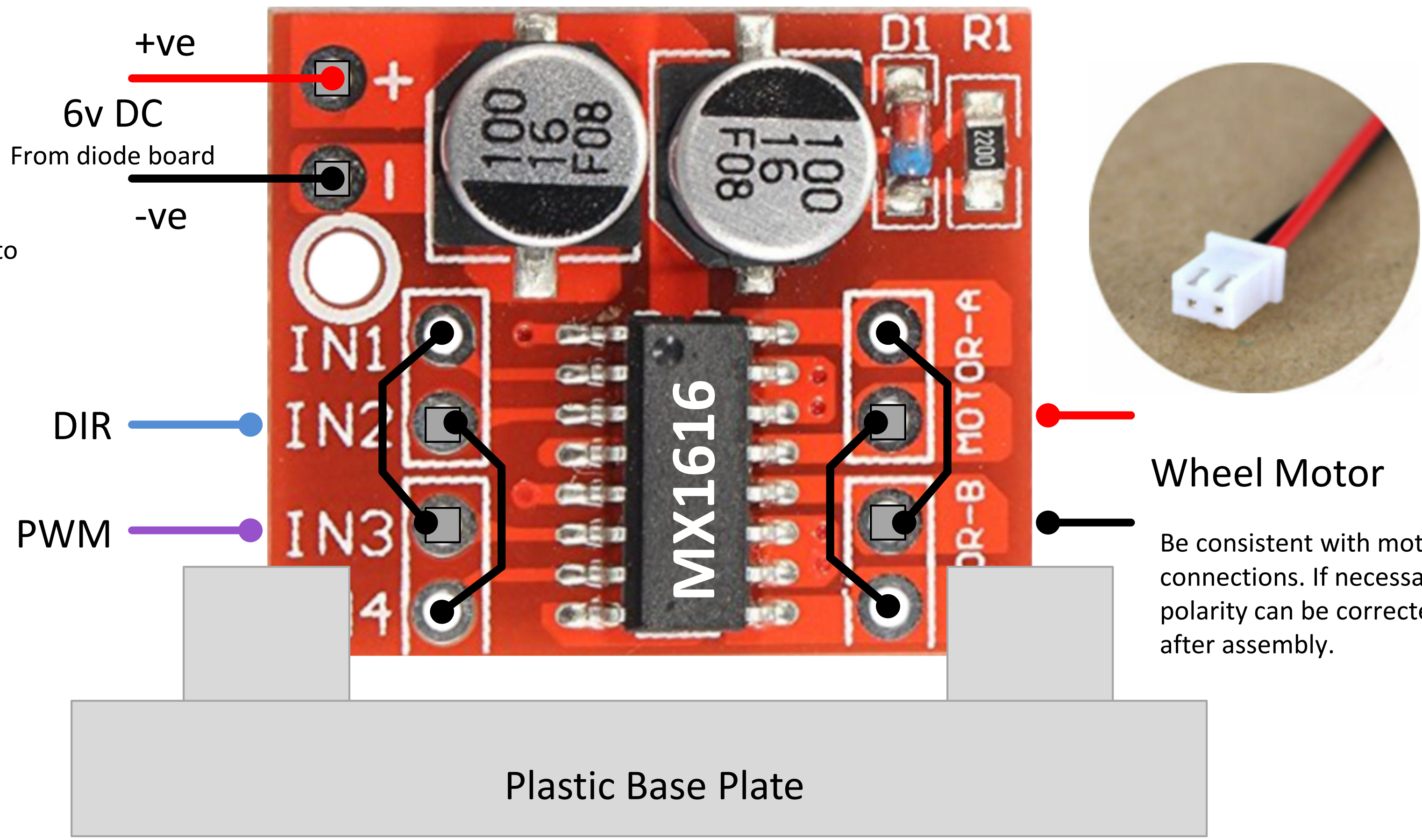


4x4 Ball Balancing Robot
H-Bridge Driver Connections



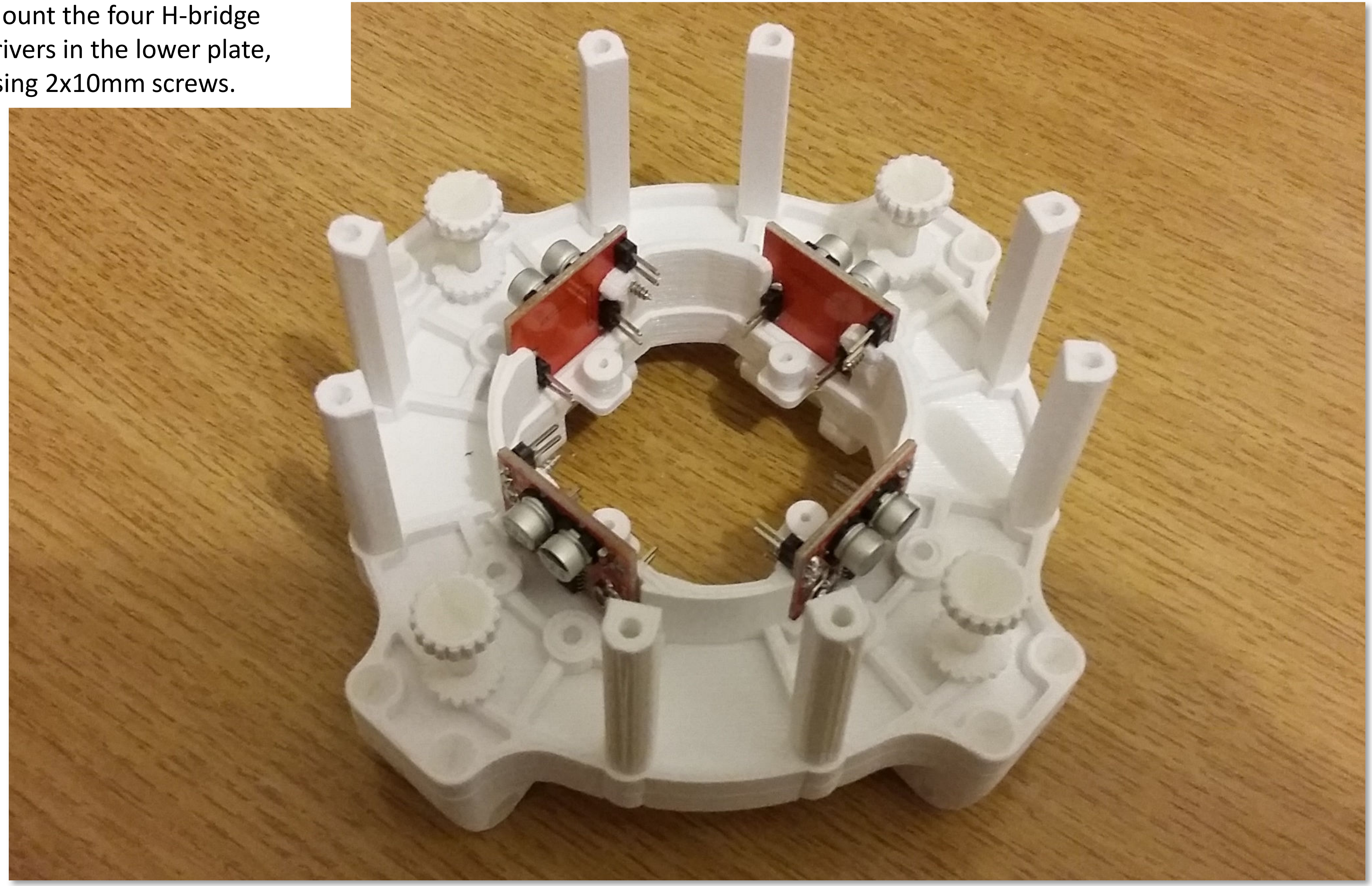
WARNING – Observe polarity to avoid damaging components



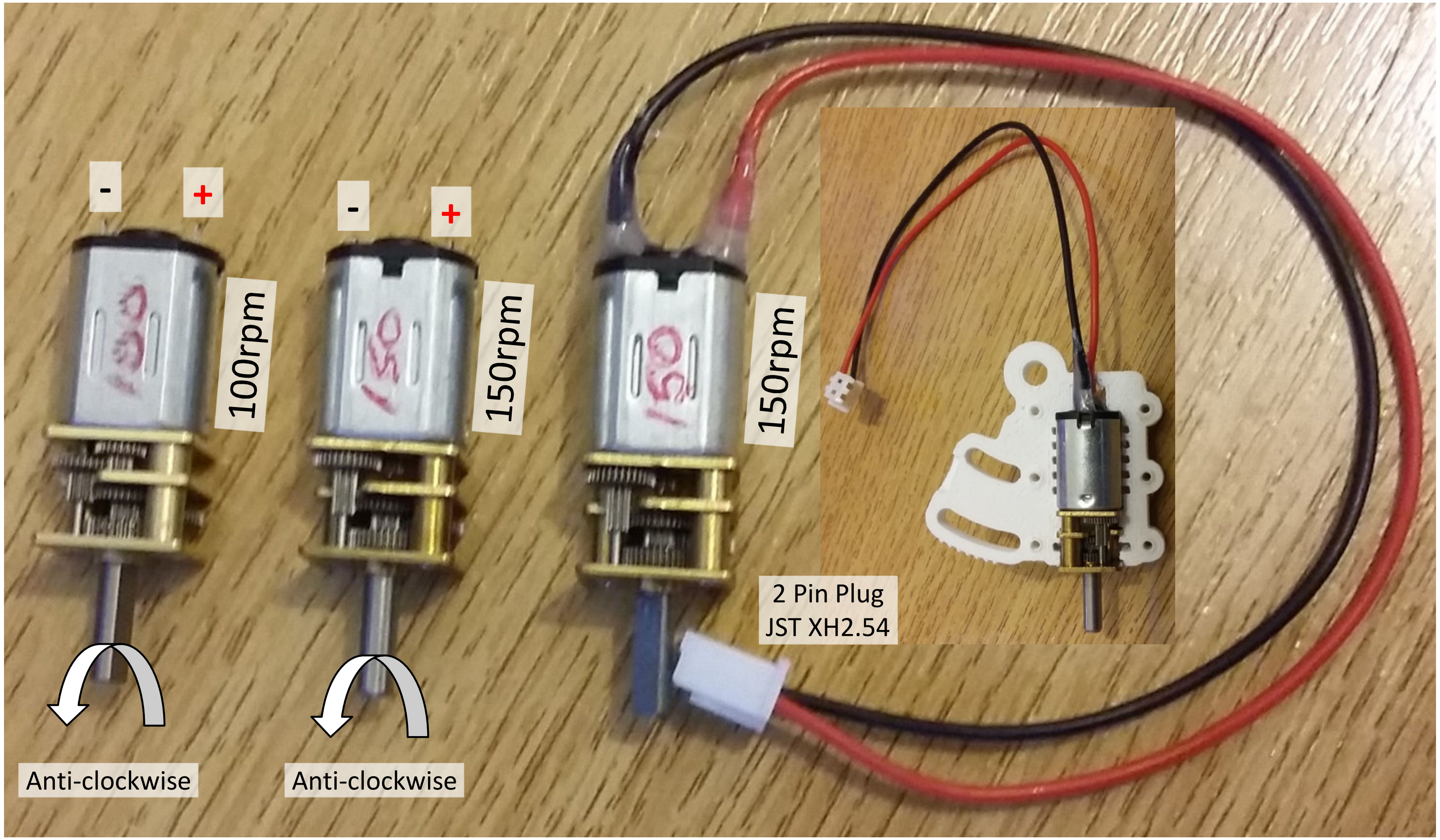


Be consistent with motor connections. If necessary reverse polarity can be corrected in code after assembly.

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

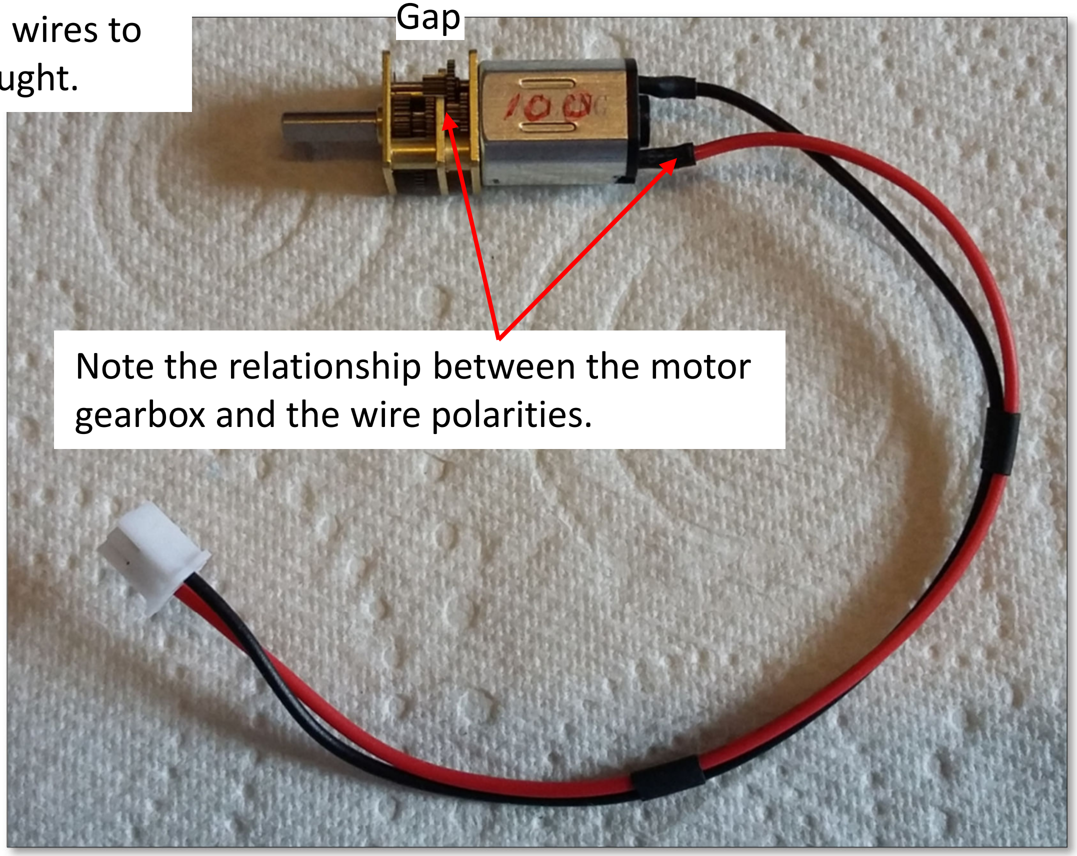


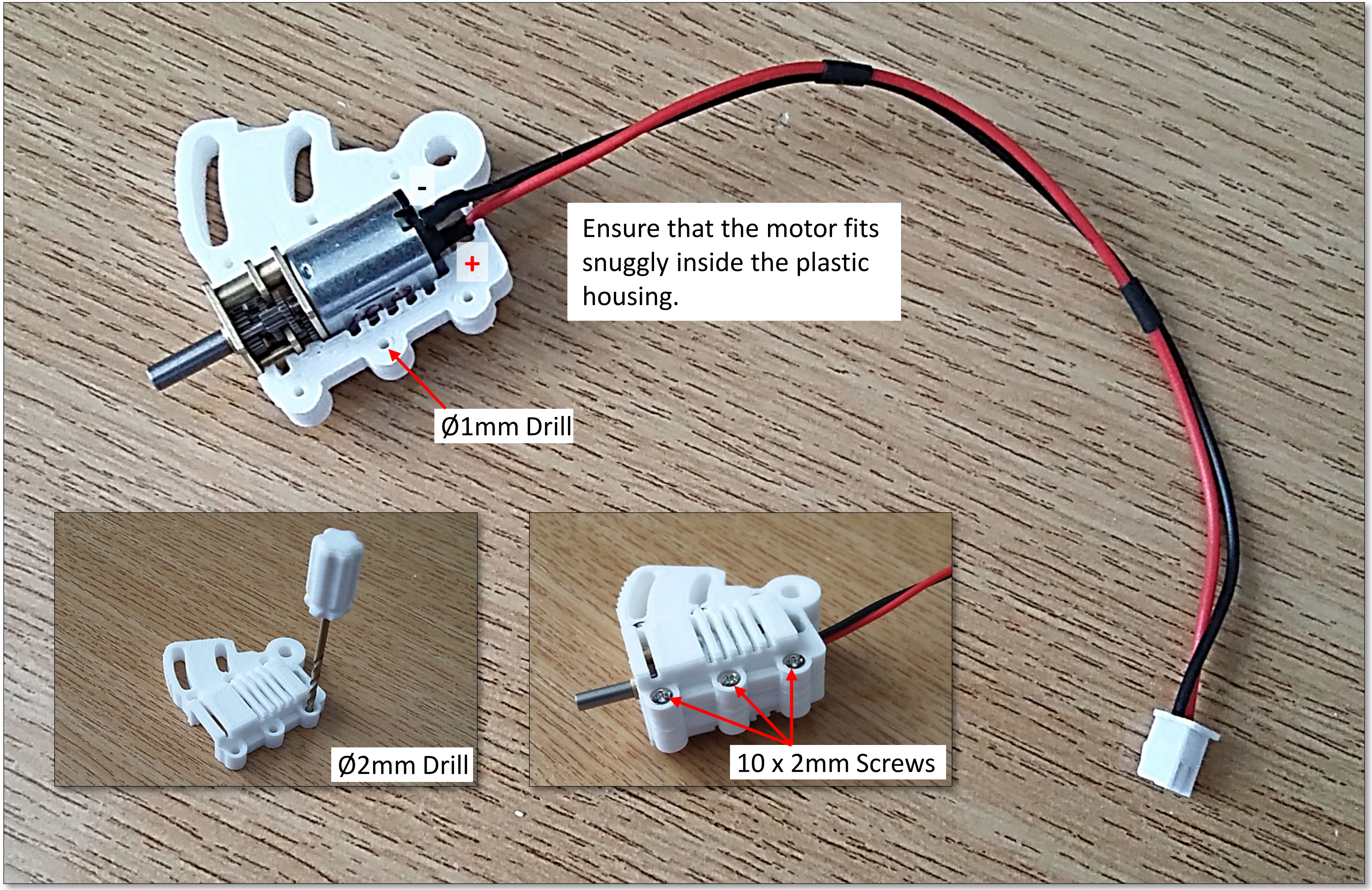
Motor Wiring

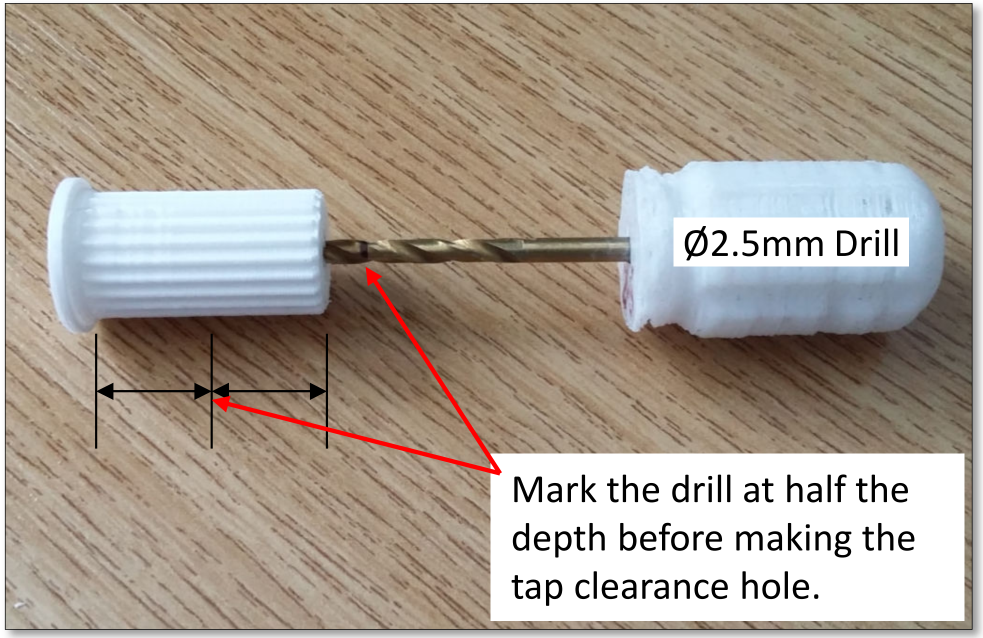


Note: All three motors need to have matching rpm values (obviously!). I started with 150rpm but later switched to 100rpm for increased torque at the expense of slower speed. If your motors are not pre-wired, then you need to wire them up in this fashion. You can source the motors and cable separately.

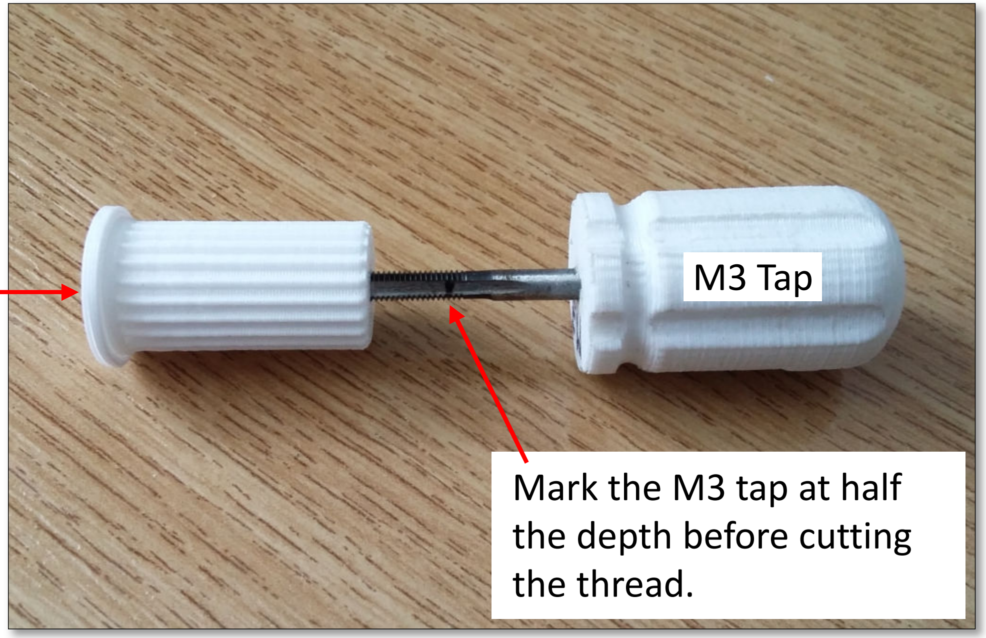
I needed to add my own wires to the 100rpm motors I bought.




-
+
Ensure that the motor fits snuggly inside the plastic housing.
Ø1mm Drill
Ø2mm Drill
10 x 2mm Screws



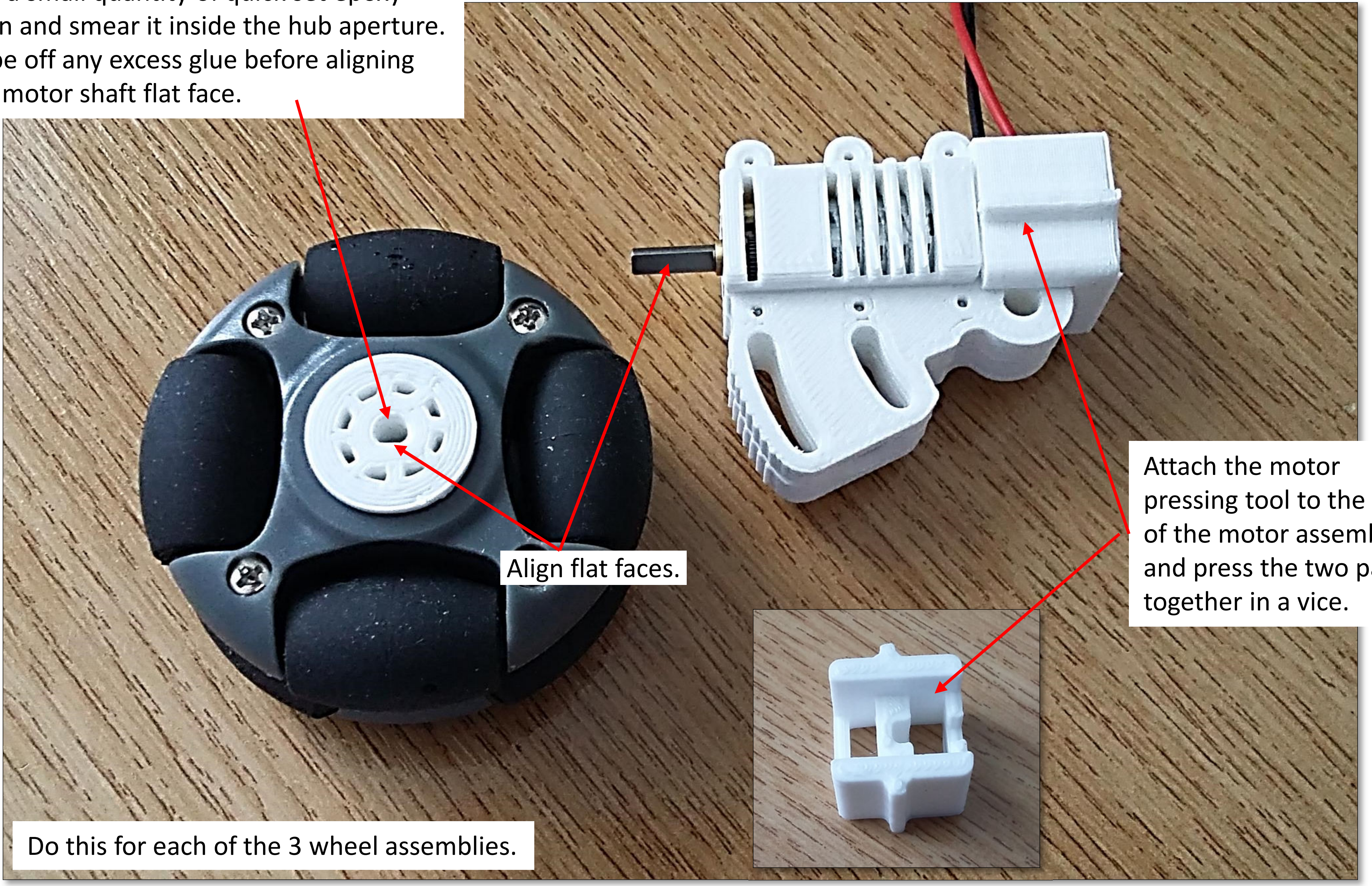
Ensure that you do not damage the half-round hole which mates with the motors drive shaft.



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.

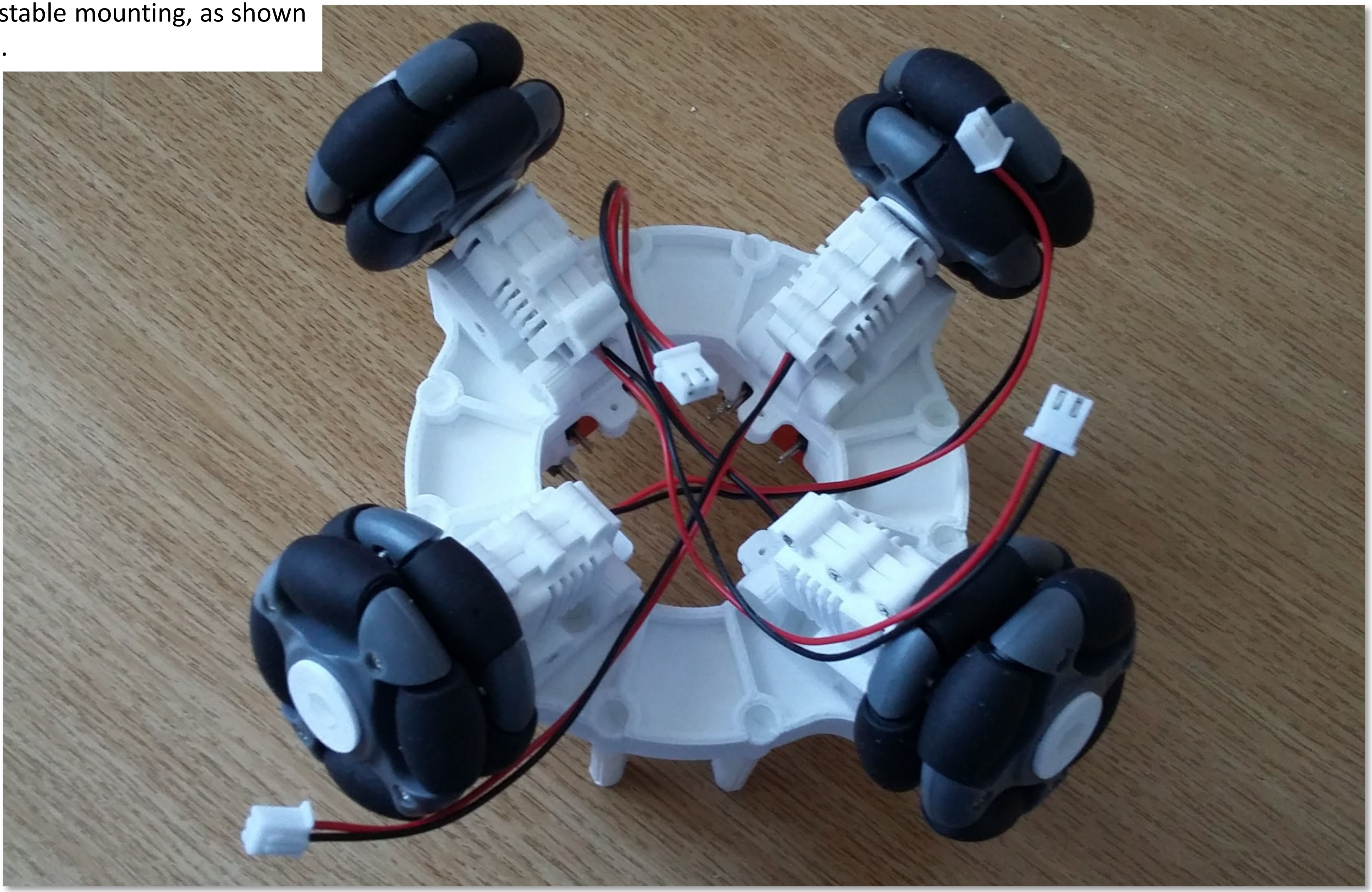


Align flat faces.

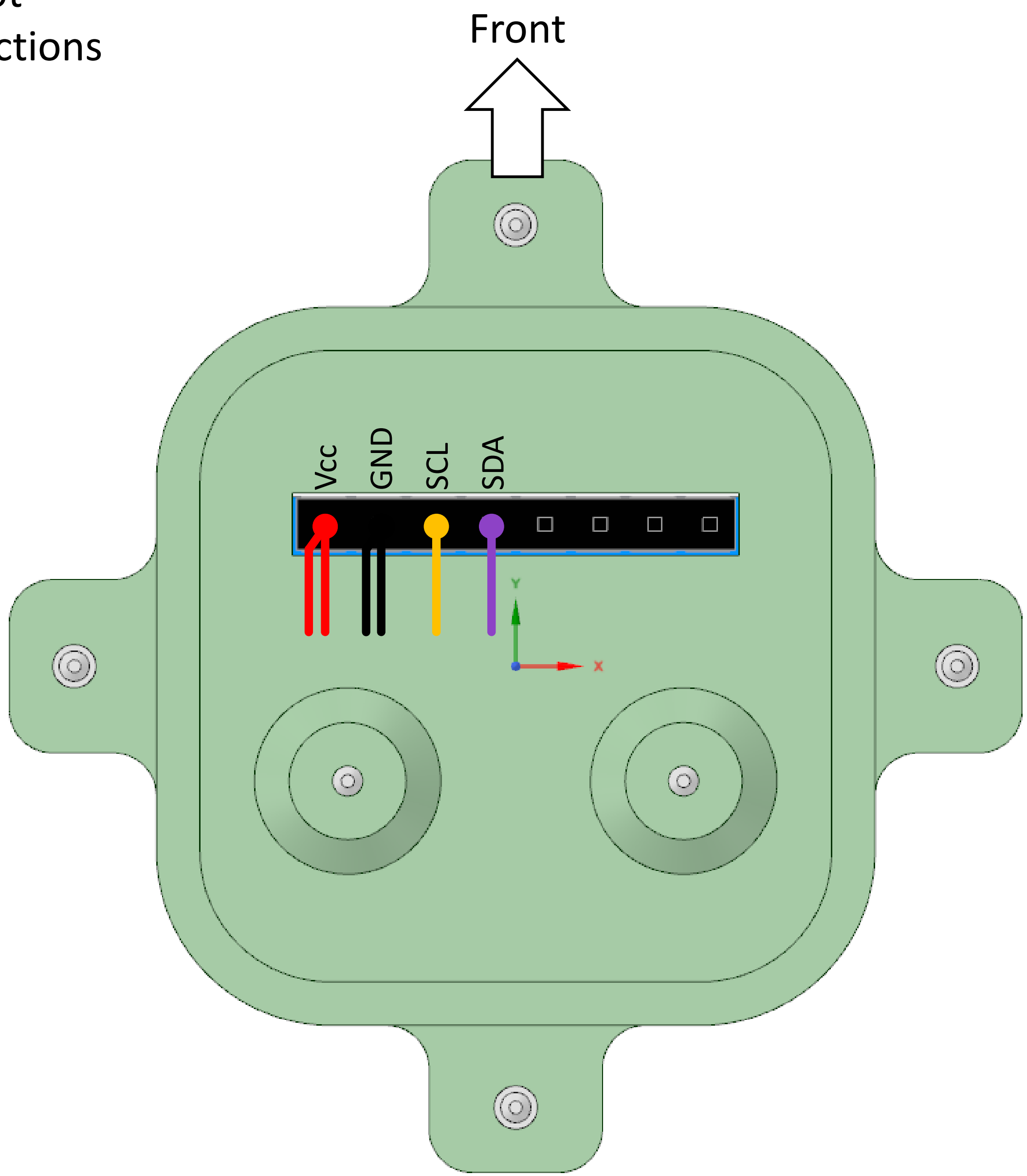
Attach the motor pressing tool to the rear of the motor assembly and press the two parts together in a vice.

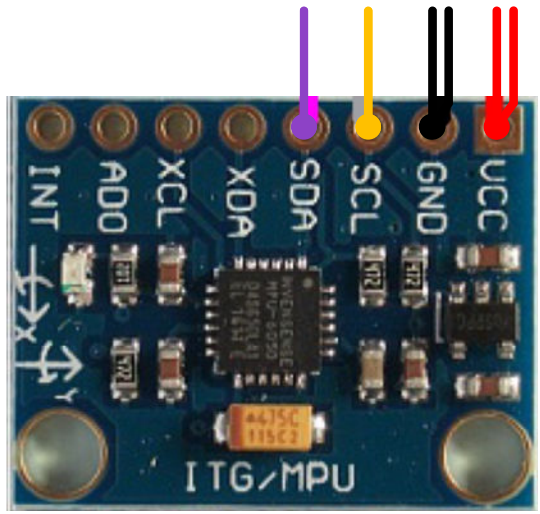
Do this for each of the 3 wheel assemblies.

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



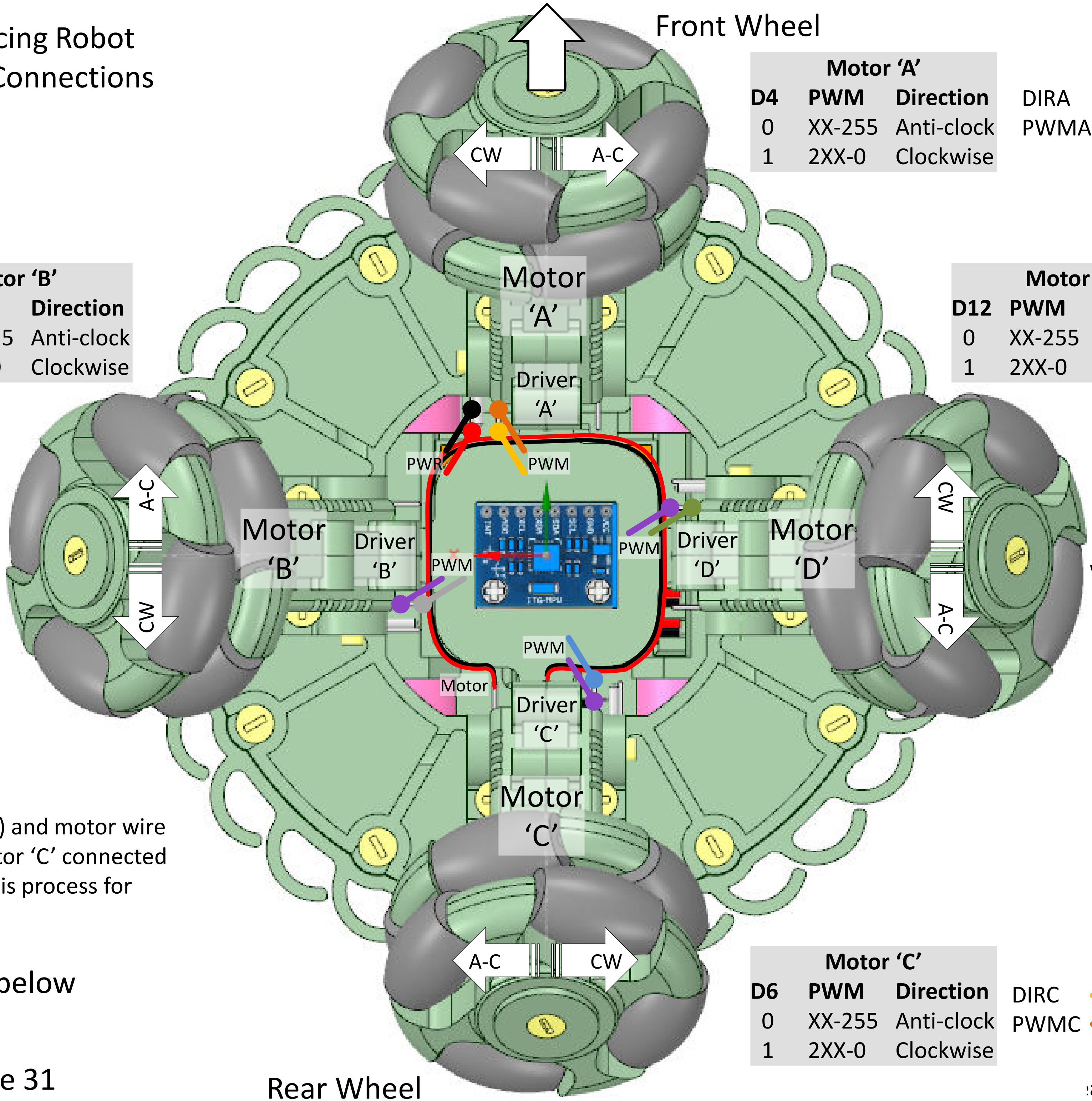
4x4 Ball Balancing Robot
MPU 6050 Gyro Connections





View from below

4x4 Ball Balancing Robot Motor/PWM Connections



Motor 'A'		
D4	**PWM**	**Direction**
0	XX-255	Anti-clock
1	2XX-0	Clockwise

DIRA — D4
PWMA — D3

Motor 'B'		
D5	**PWM**	**Direction**
0	XX-255	Anti-clock
1	2XX-0	Clockwise

DIRB — D5
PWMB — D9

Motor 'D'		
D12	**PWM**	**Direction**
0	XX-255	Anti-clock
1	2XX-0	Clockwise

DIRD — D12
PWMD — D11

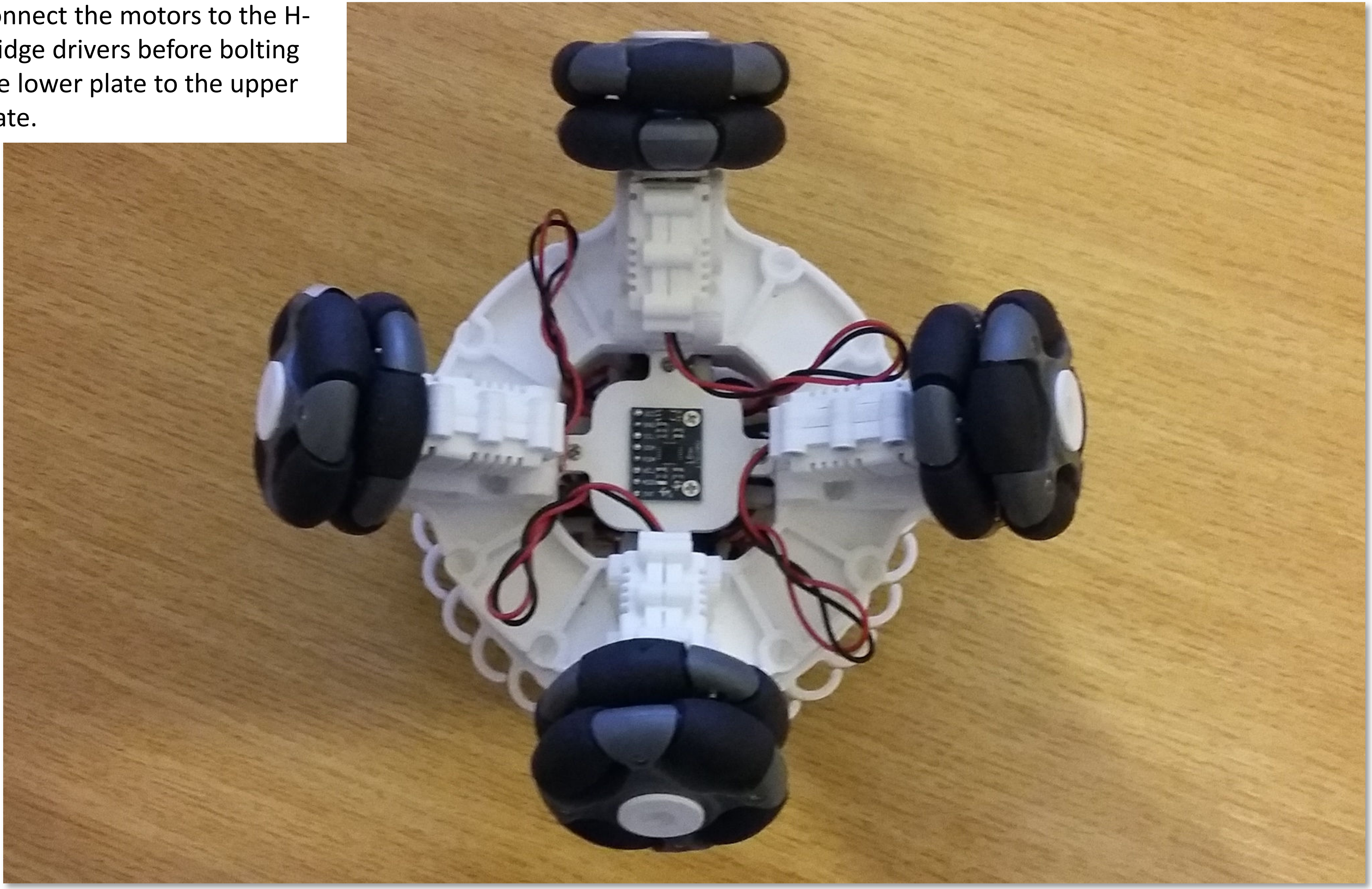
Motor 'C'		
D6	**PWM**	**Direction**
0	XX-255	Anti-clock
1	2XX-0	Clockwise

DIRC — D6
PWMC — D10

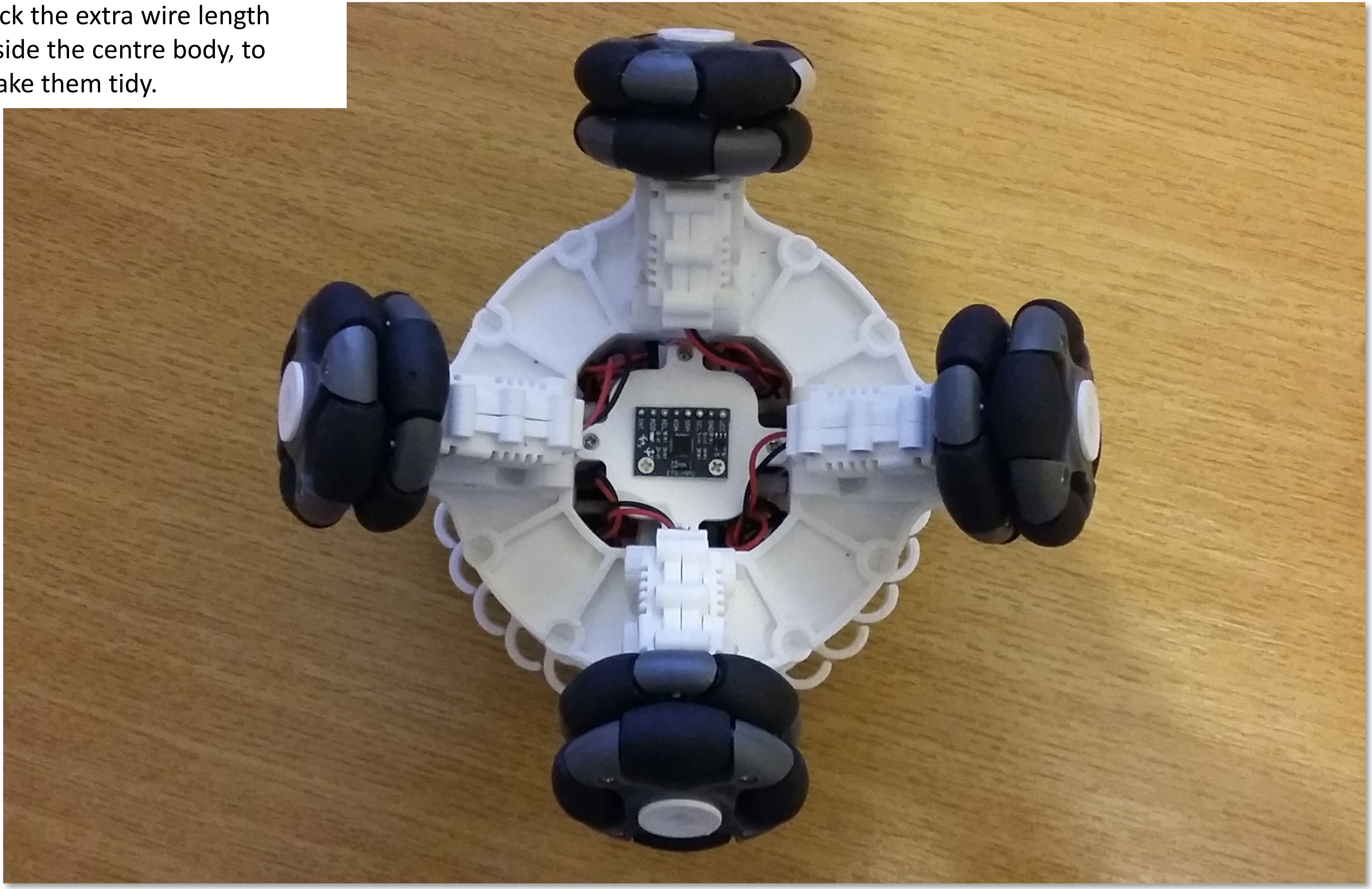
Note:
'A' Driver power (PWR) and motor wire routing shown for Motor 'C' connected to driver 'C'. Repeat this process for motors 'A', 'B' and 'D'.

Viewed from below

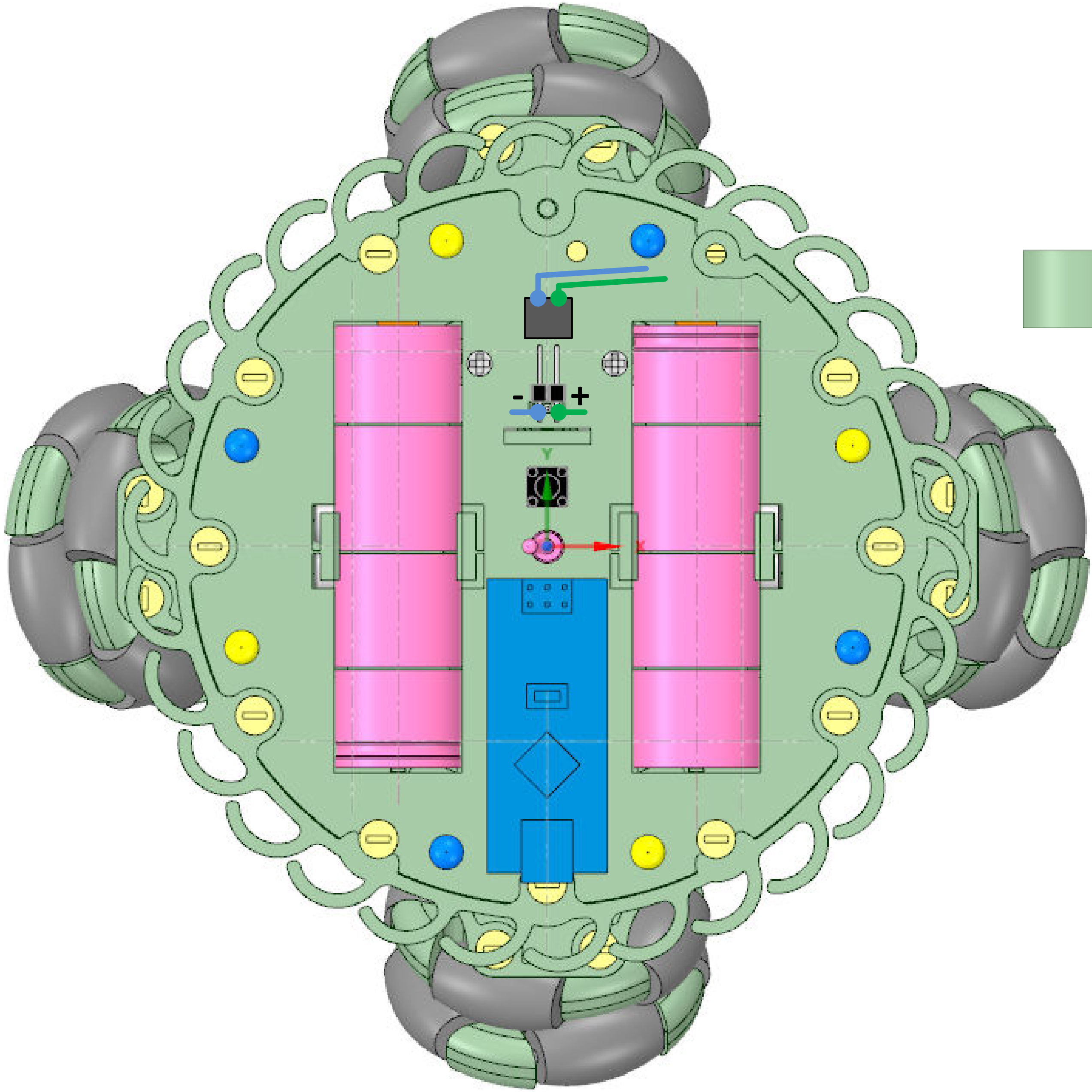
Connect the motors to the H-bridge drivers before bolting the lower plate to the upper plate.



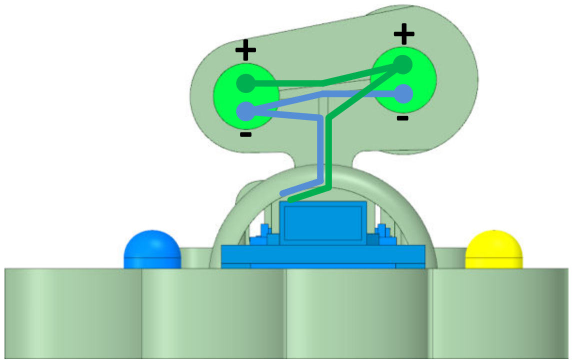
Tuck the extra wire length inside the centre body, to make them tidy.



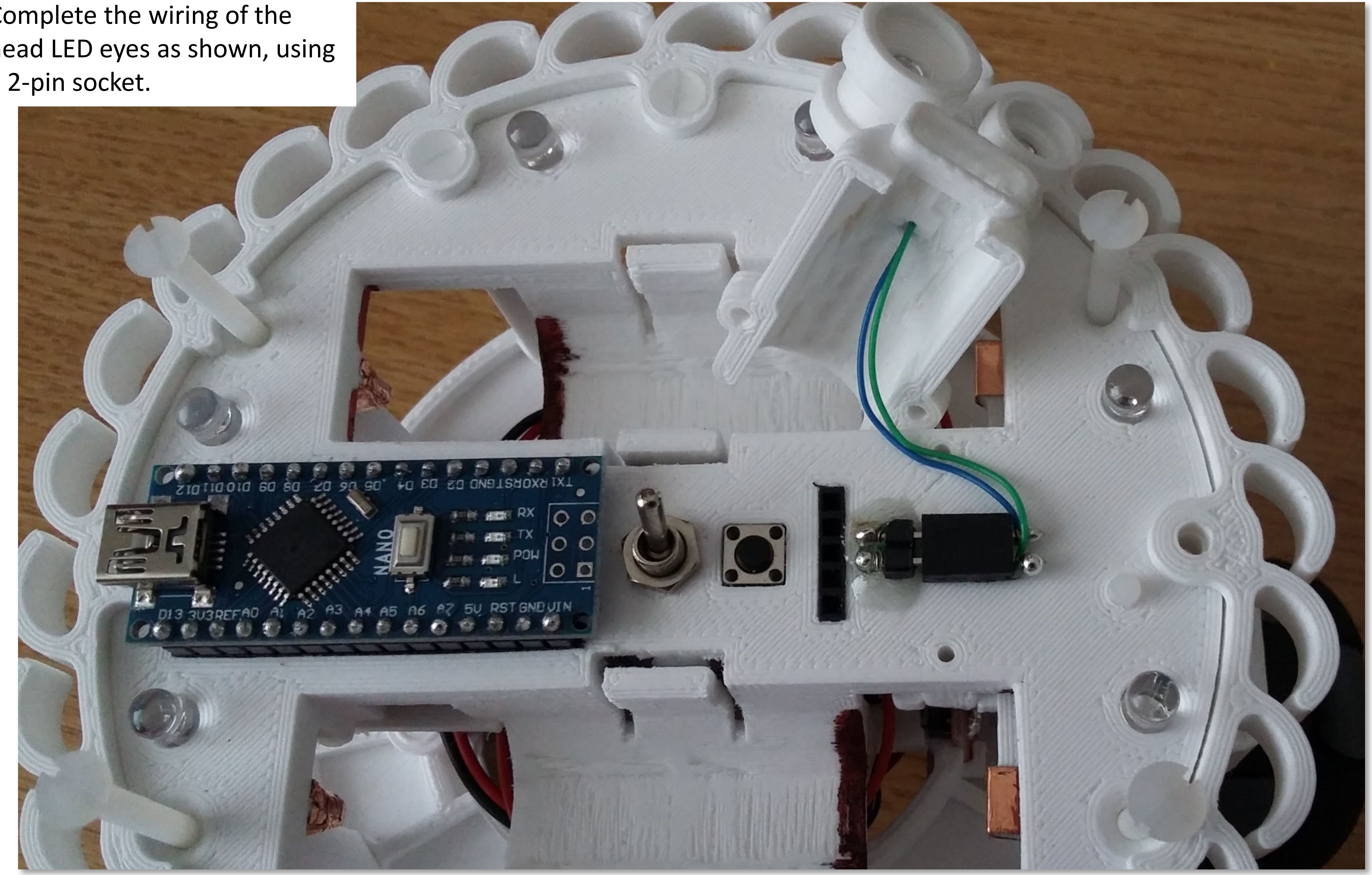
4x4 Ball Balancing Robot
Head LED Eyes Connections



Robot Head Rear View



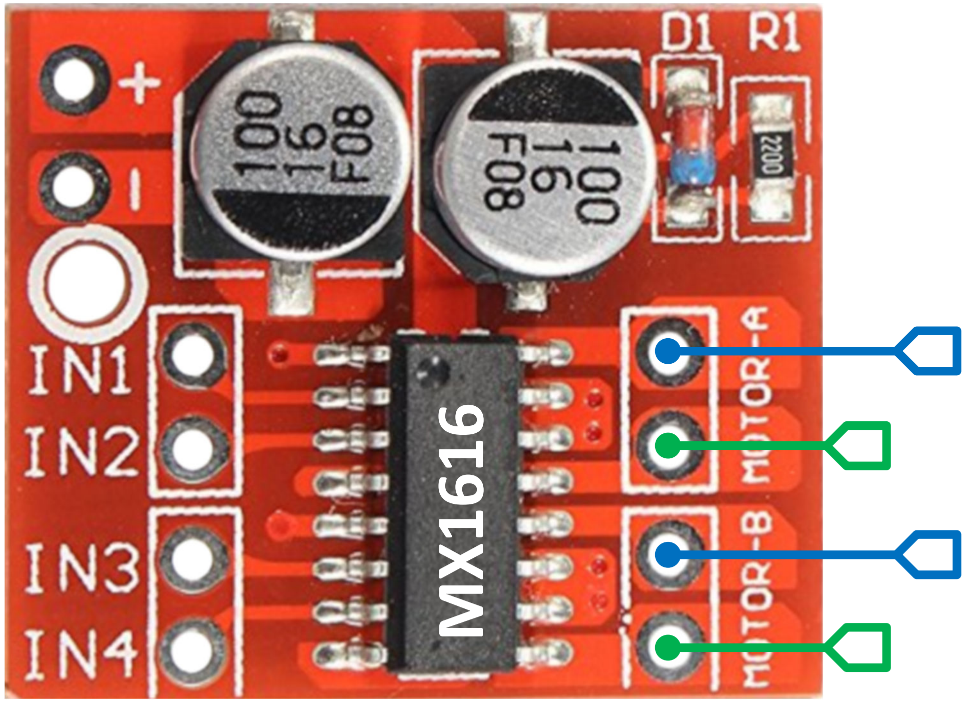
Complete the wiring of the head LED eyes as shown, using a 2-pin socket.



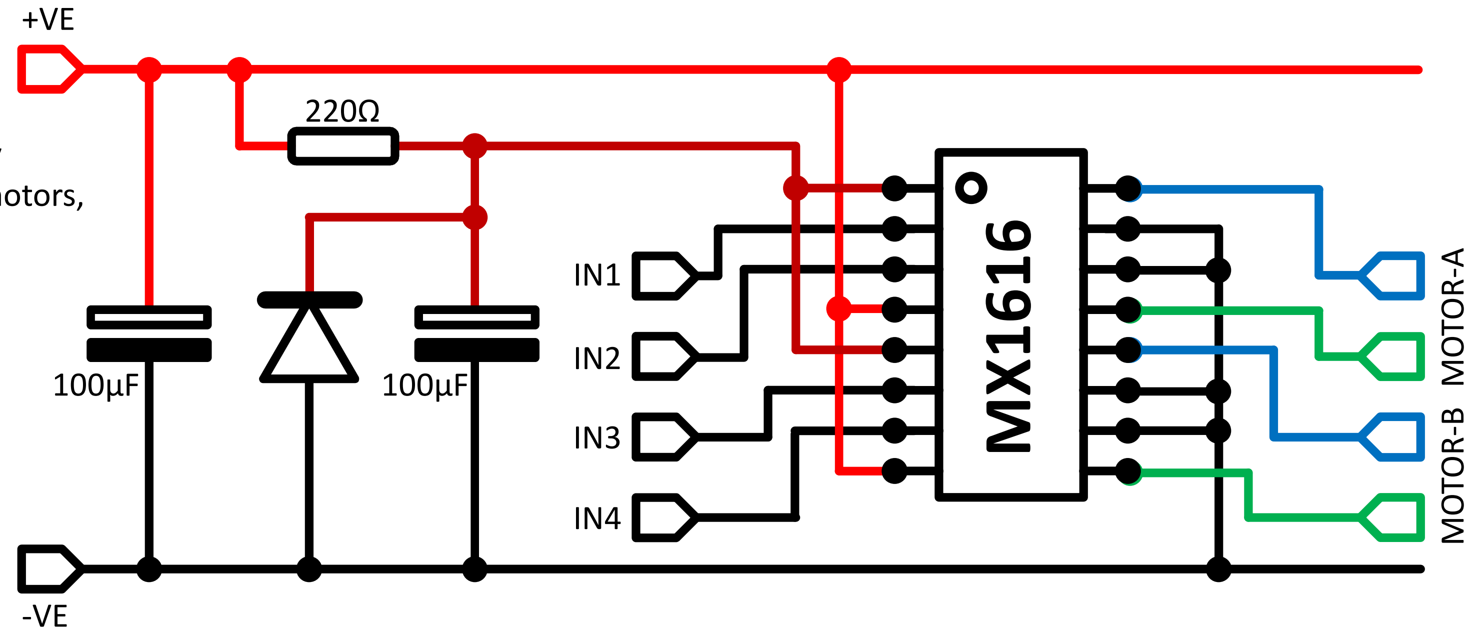
Data Sheet

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.

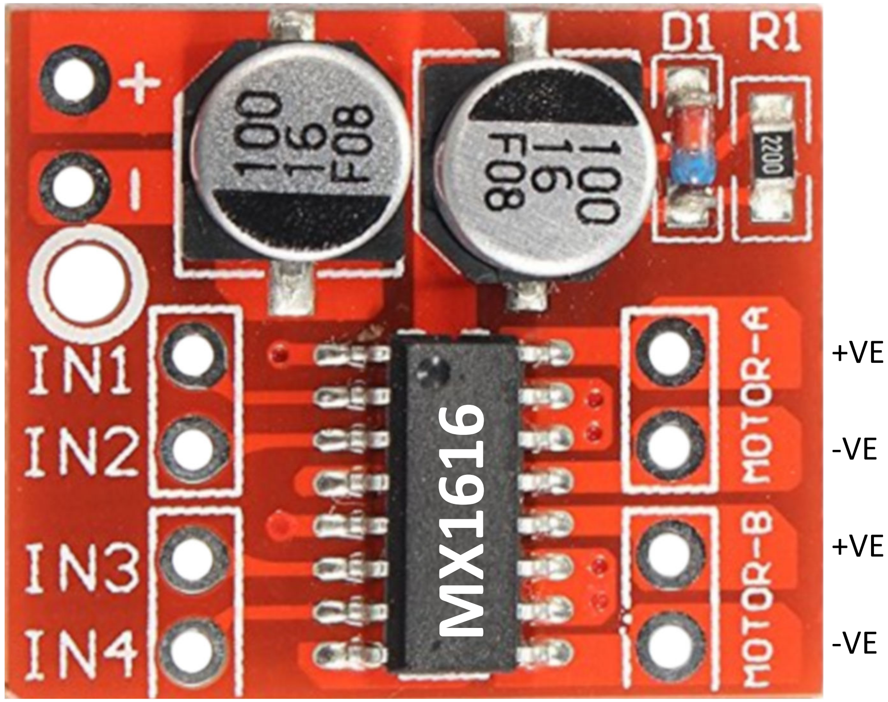


Built-in low on-resistance MOS switch.
Dual 1.5A o/p with peak current of 2.5A
Built-in thermal protection, automatic recovery
Dual H-bridge motor driver, can drive two DC motors, or a 4-wire two-phase stepper motors.
The module supply voltage: 2V-10V
Signal input voltage: 1.8-7V
Single Operating Current: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



Data Sheet

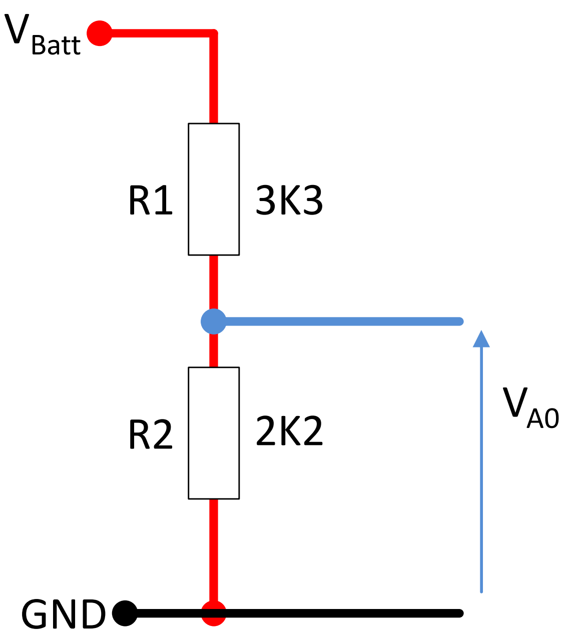
		PWM	DIR	PWM	DIR
DC MOTOR	**MODE**	**IN1**	**IN2**	**IN3**	**IN4**
MOTOR - A	Forward	PWM – 1	0		
	Reverse	0	PWM – 1		
	Forward	1	PWM – 0		
	Reverse	PWM – 0	1		
	Standby	0	0		
	Brake	1	1		
MOTOR - B	Forward			PWM - 1	0
	Reverse			0	PWM – 1
	Forward			1	1 – PWM
	Reverse			1 - PWM	1
	Standby			0	0
	Brake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



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

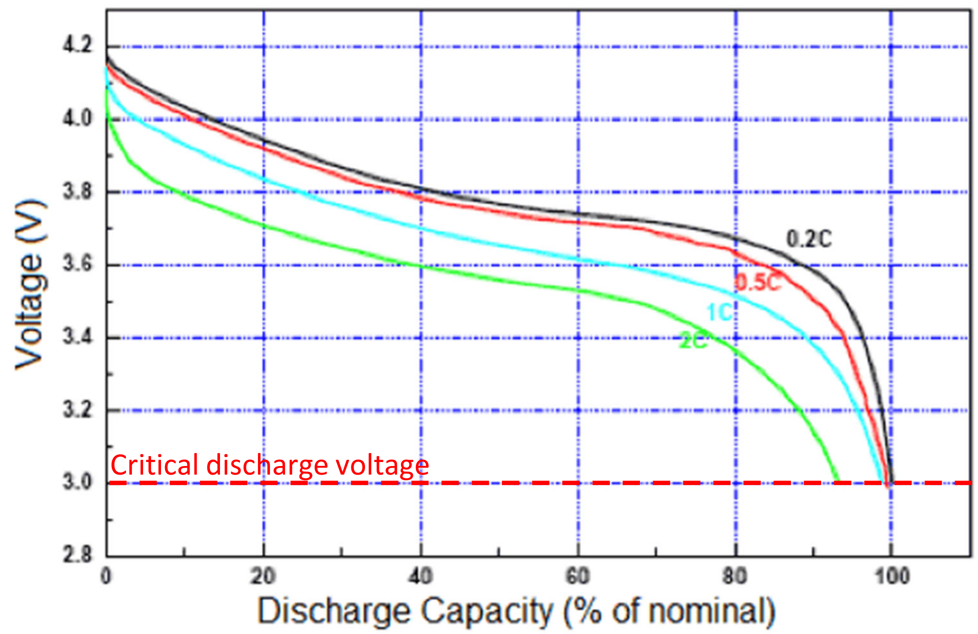
$$V_{A0D} = \frac{V_{A0} \times 1023}{5}$$ voltage read by 10-bit ADC

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

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

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

18650 Lithium Battery
Discharge Profile



Discharge: 3.0V cutoff at room temperature.

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.