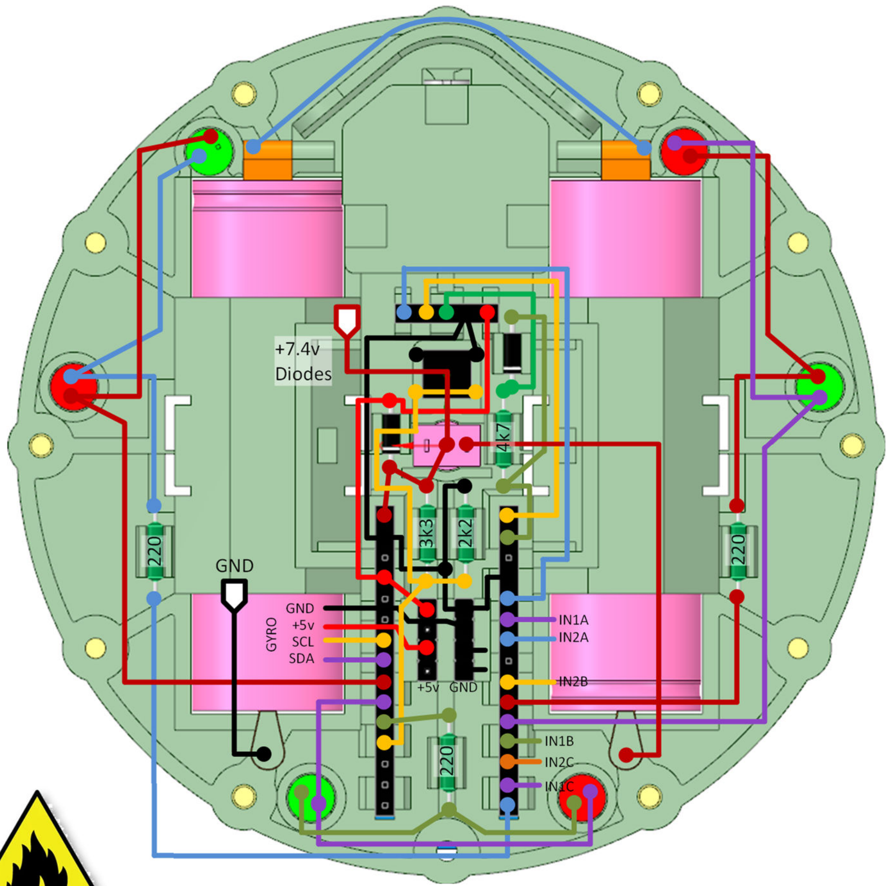
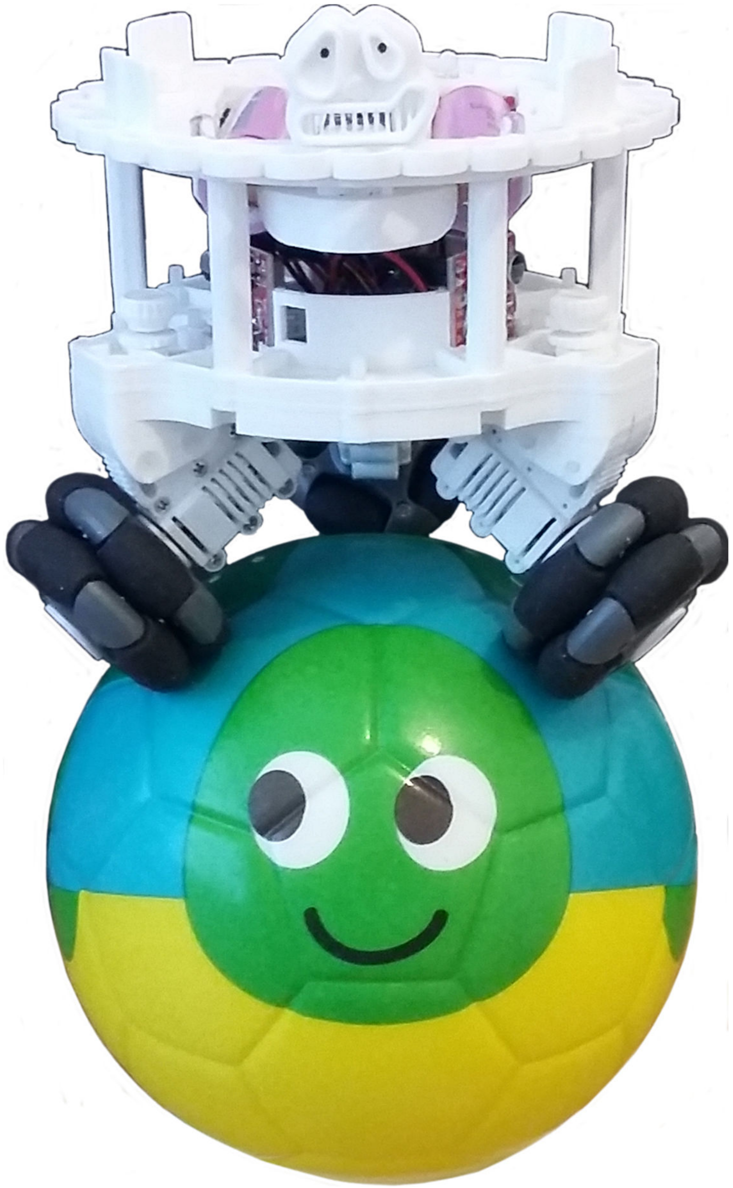
Ball Balancing Robot

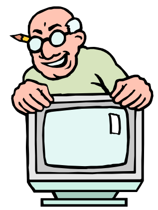
Circuits





Issue: 1.1 Released: 08/12/2025 TechKnowTone

CAUTION



Lithium batteries can be <u>extremely</u> dangerous, if not handled and cared for properly. This design does not include any form of current limiting circuit, like a fuse. So, care <u>must</u> 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:

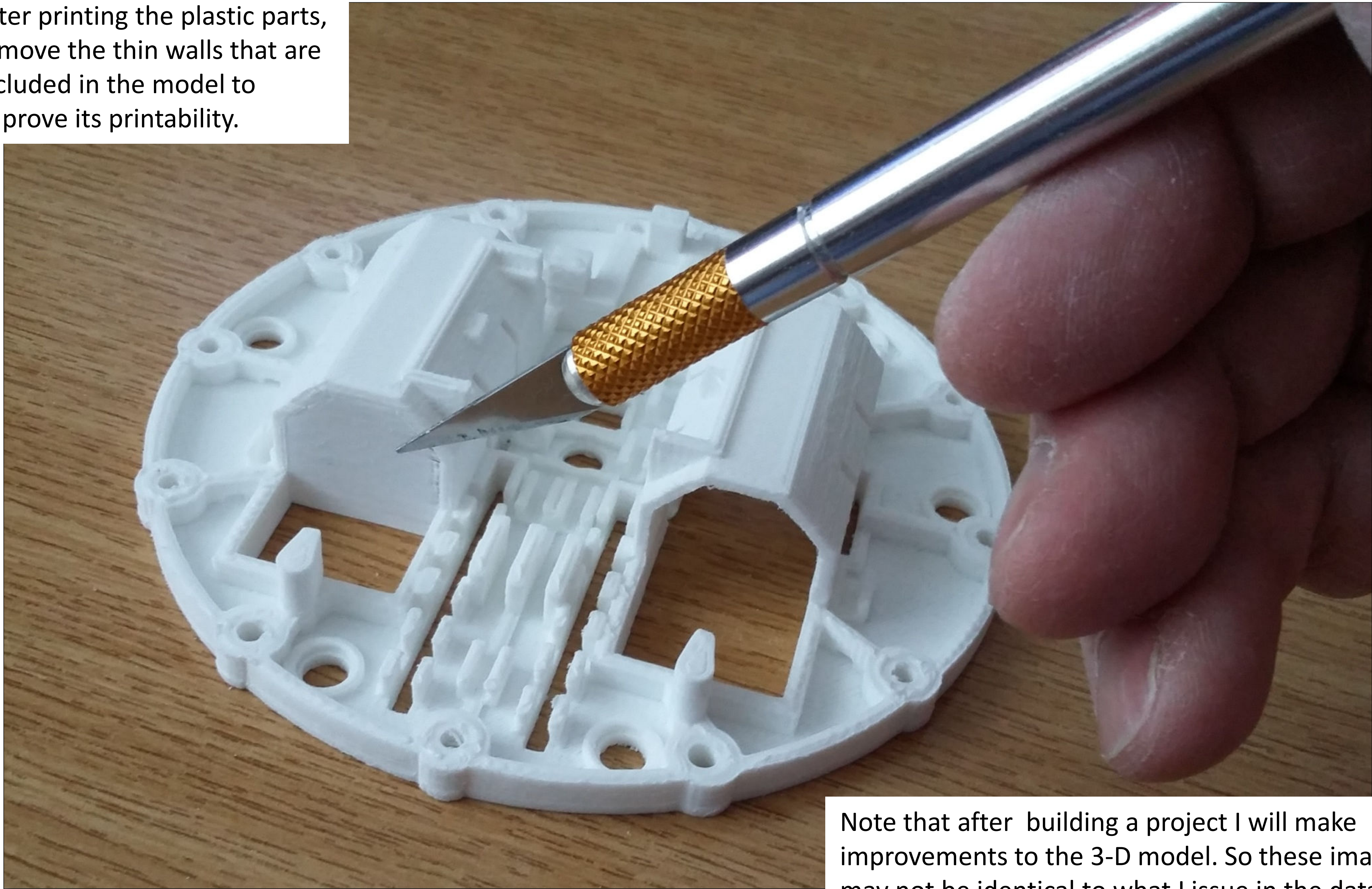
Fine Nosed Pliers
Side Cutters
M3 Tap
M4 Tap
2.5 mm Drill
3.0 mm Drill
3.5mm Drill
6.0 mm Drill
Needle Files
M3 Box Spanner
Screwdriver
Craft Knife

Note: Not all items are shown here.

Tools & Materials:

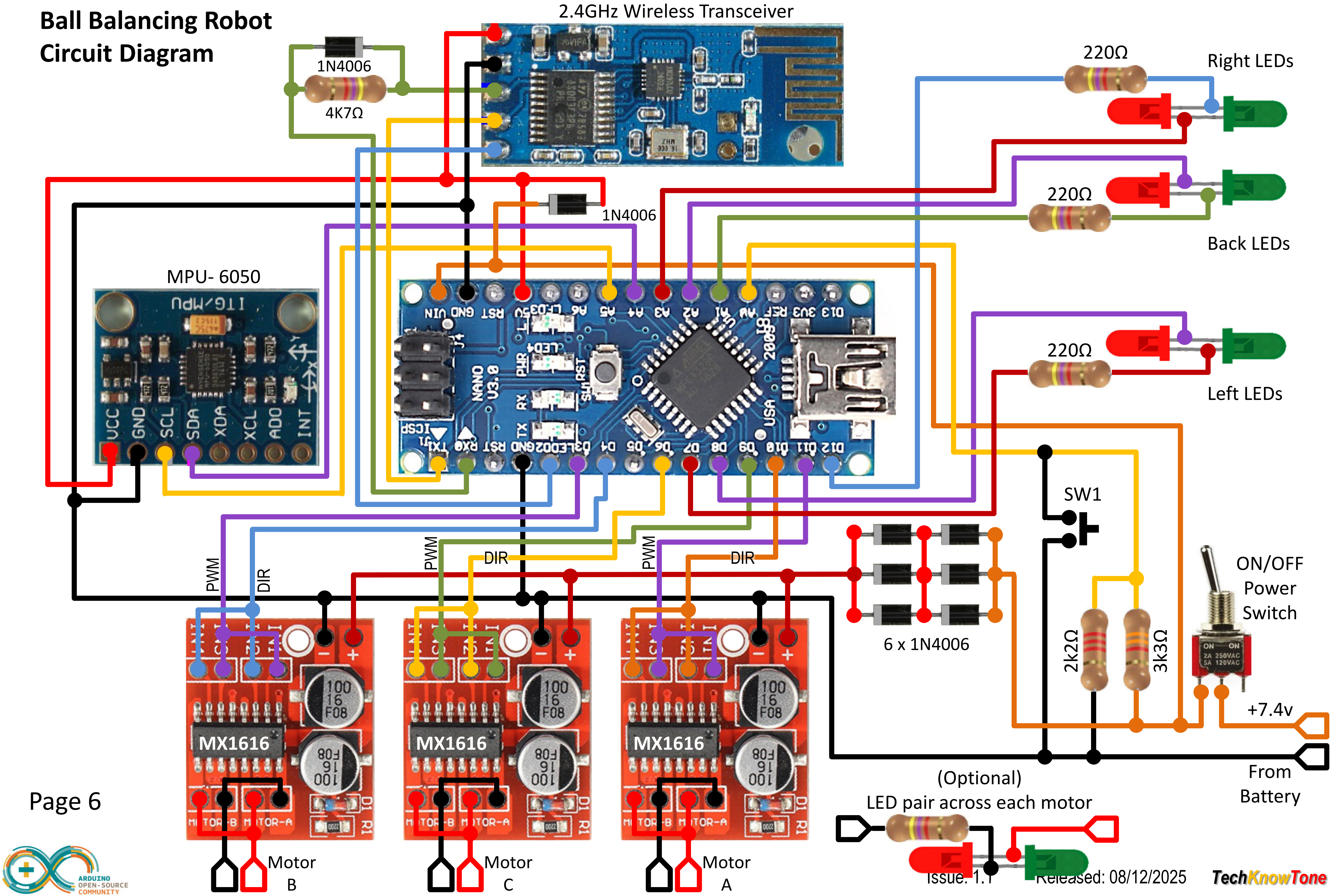
Temperature controlled iron
Solder flux
Resin cored solder
Hot melt glue gun {optional}
2-part epoxy resin glue
Screw drivers
Tweezers
Wire wrapping tool
Wire wrapping wire 30 AWG
24 AWG stranded wire (red, black & yellow)
Multimeter

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.

Ball Balancing Robot Circuit Diagram



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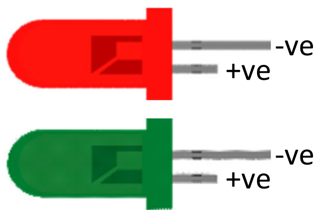
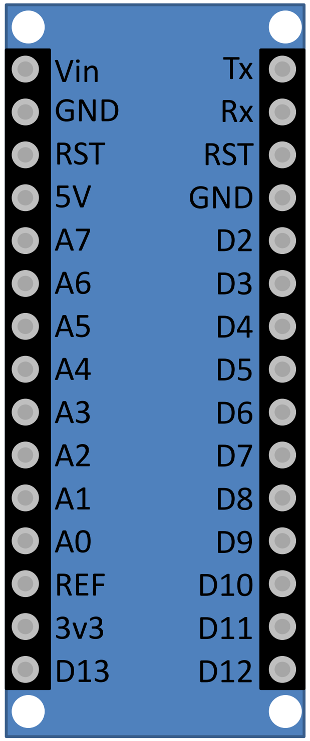
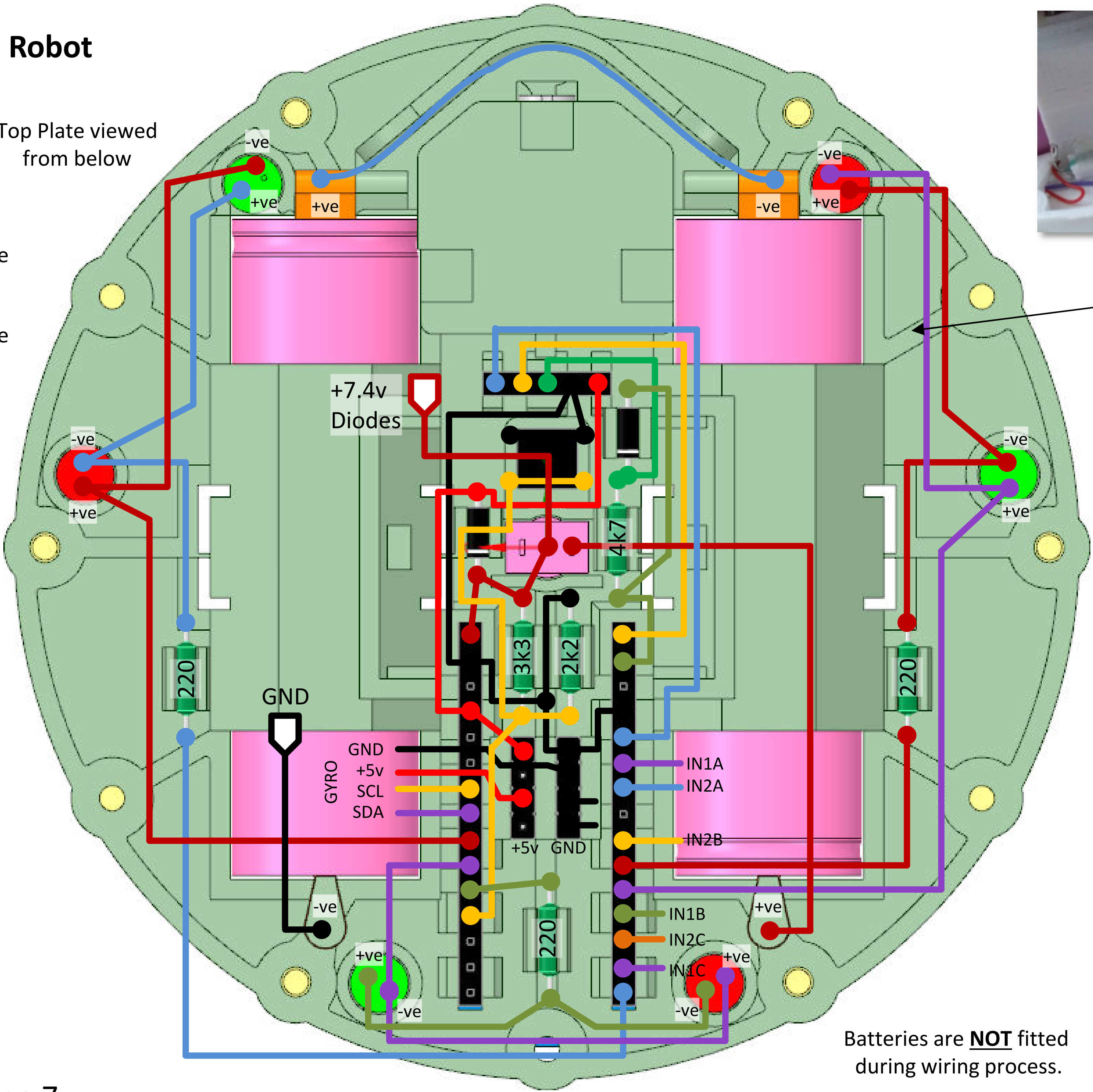
Ball Balancing Robot Wiring

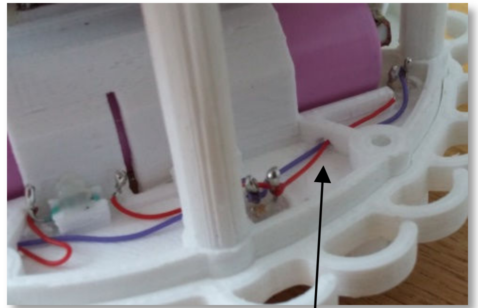


Viewed from below



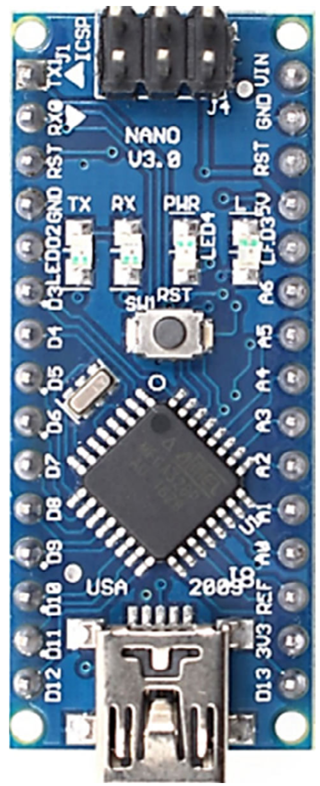
Top Plate viewed from below





Wires pass through small tunnels

Viewed from above



Batteries are **NOT** fitted during wiring process.

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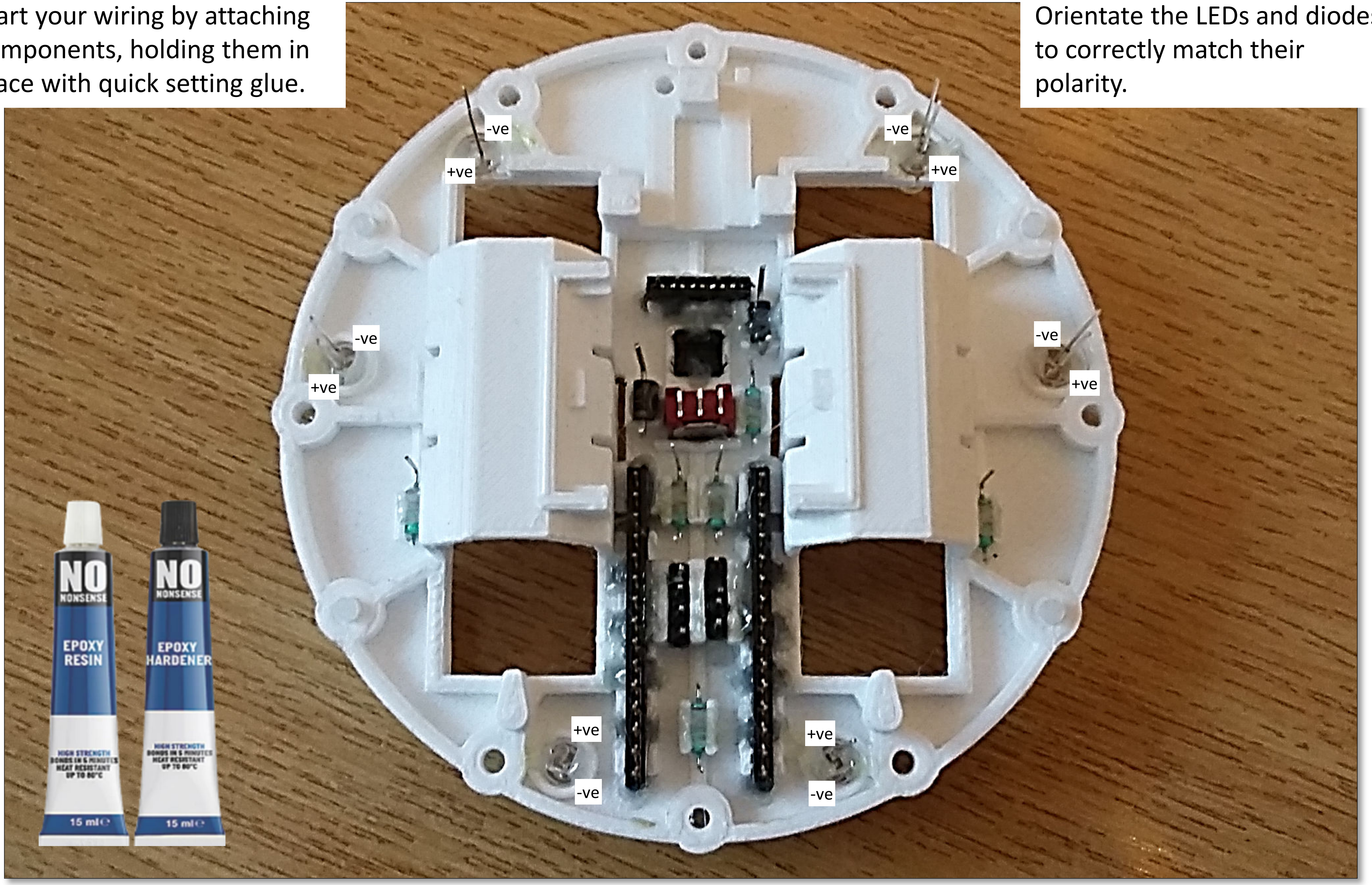
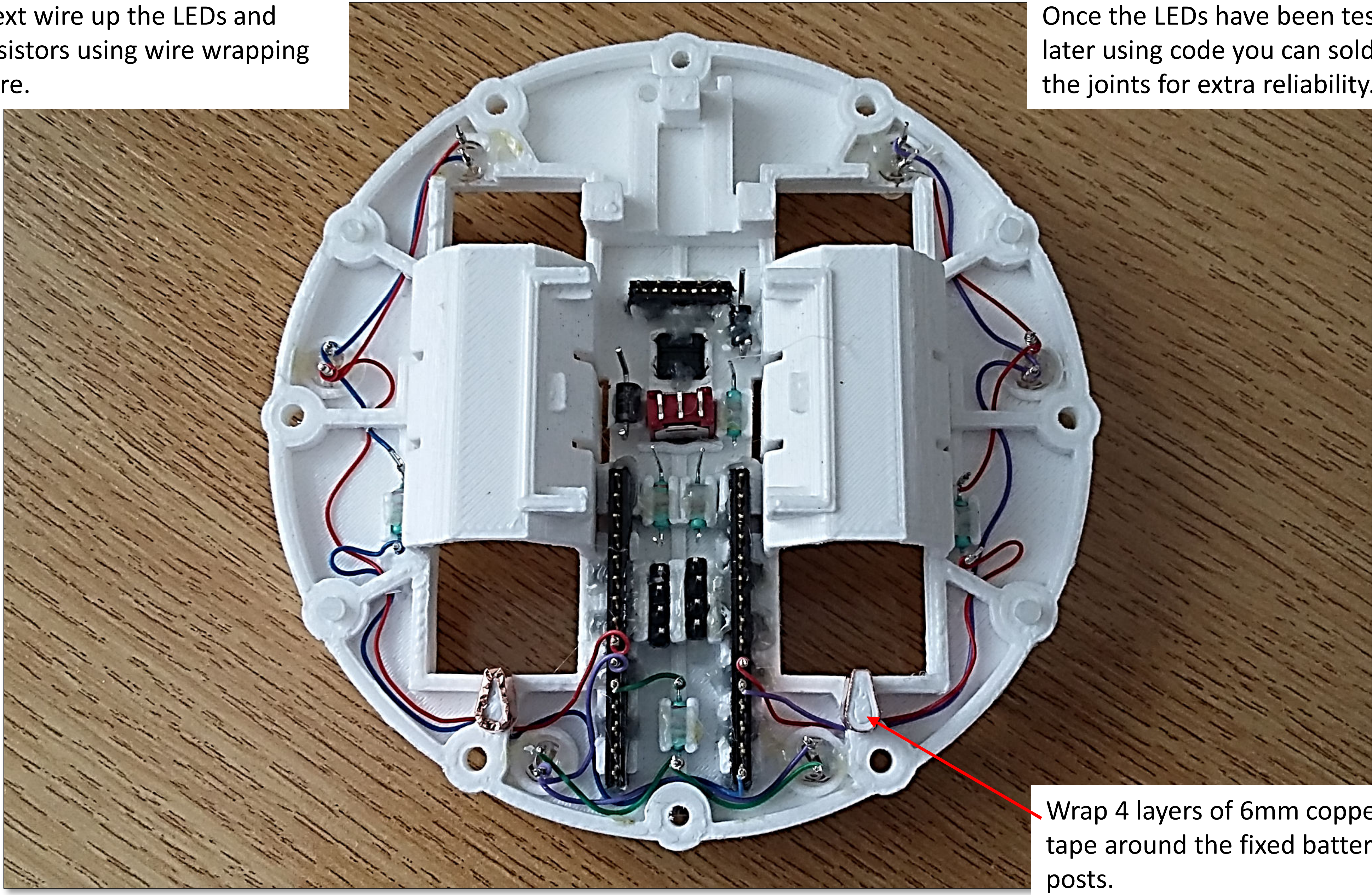
Start your wiring by attaching components, holding them in place with quick setting glue.

Orientate the LEDs and diodes to correctly match their polarity.



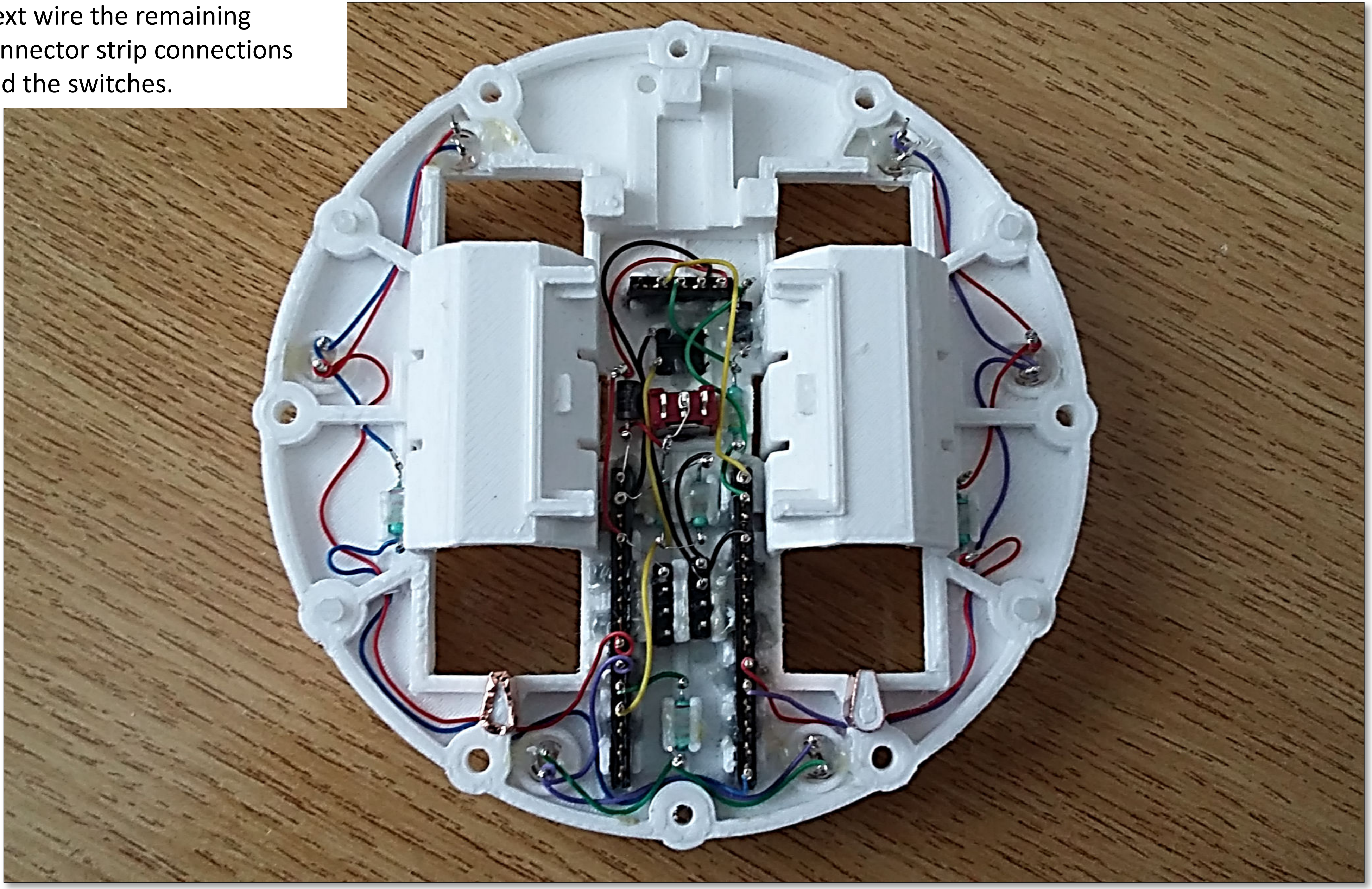
Next wire up the LEDs and resistors using wire wrapping wire.

Once the LEDs have been tested later using code you can solder the joints for extra reliability.



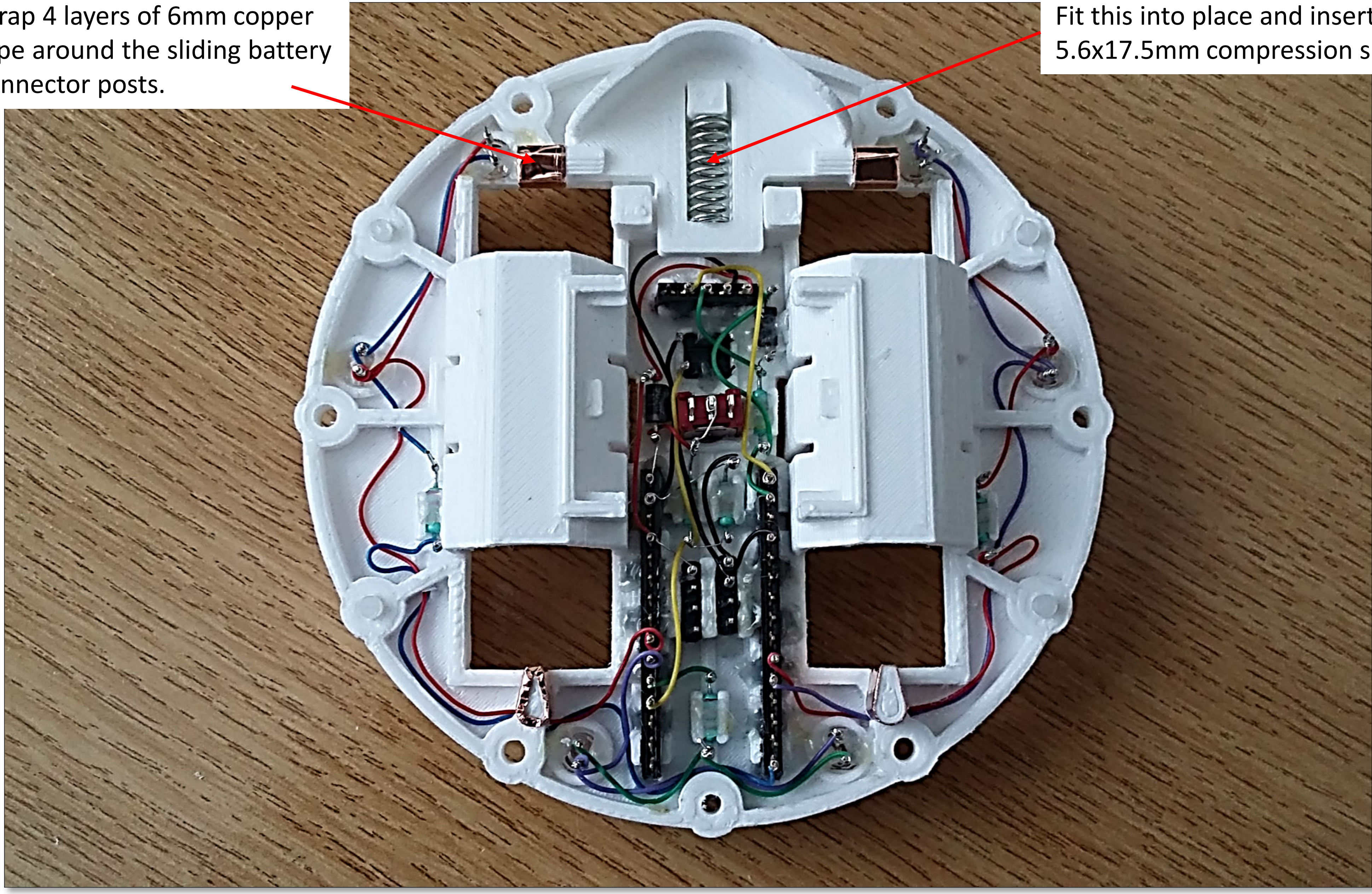
Wrap 4 layers of 6mm copper tape around the fixed battery posts.

Next wire the remaining connector strip connections and the switches.

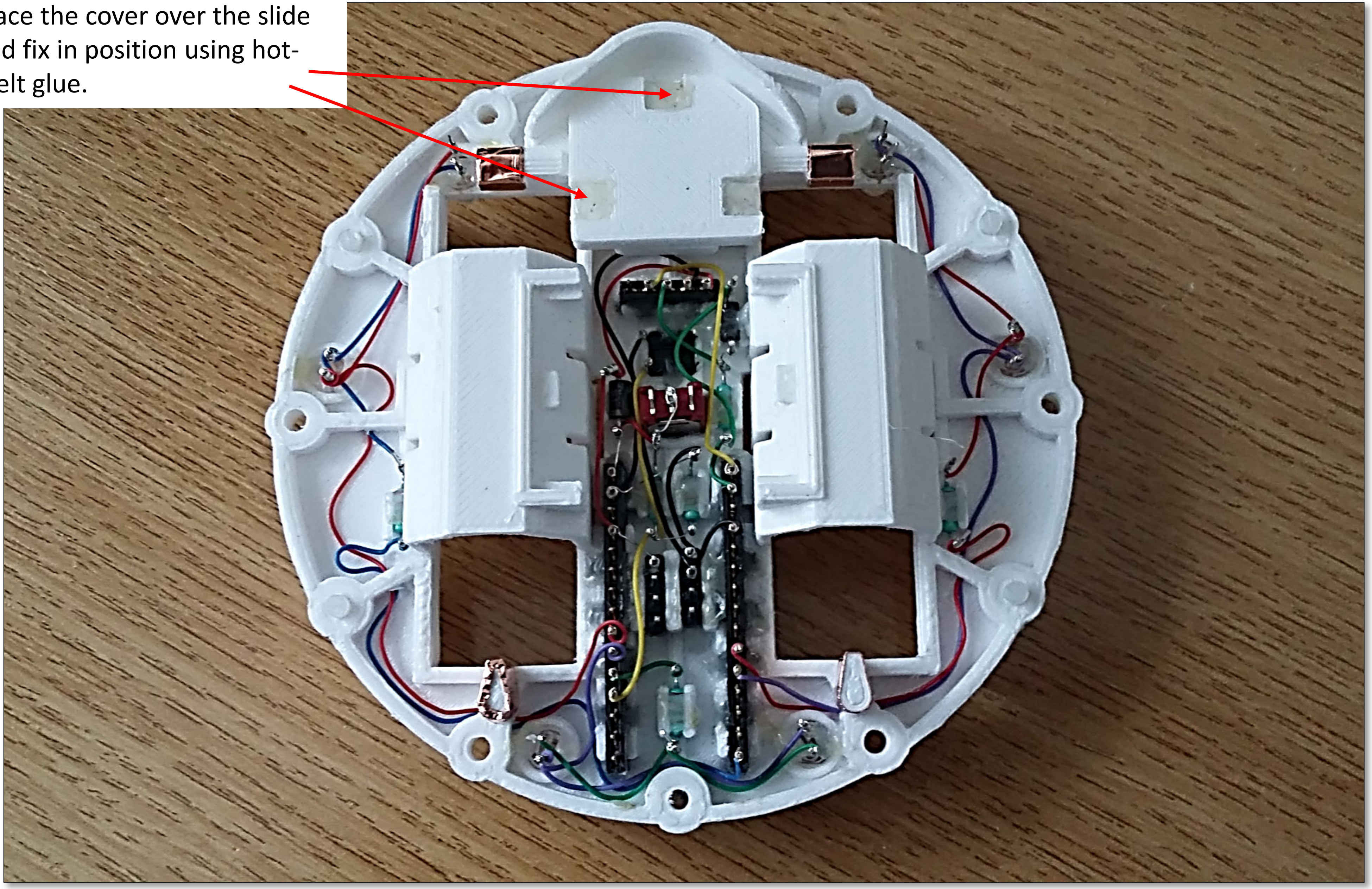


Wrap 4 layers of 6mm copper tape around the sliding battery connector posts.

Fit this into place and insert the 5.6x17.5mm compression spring.

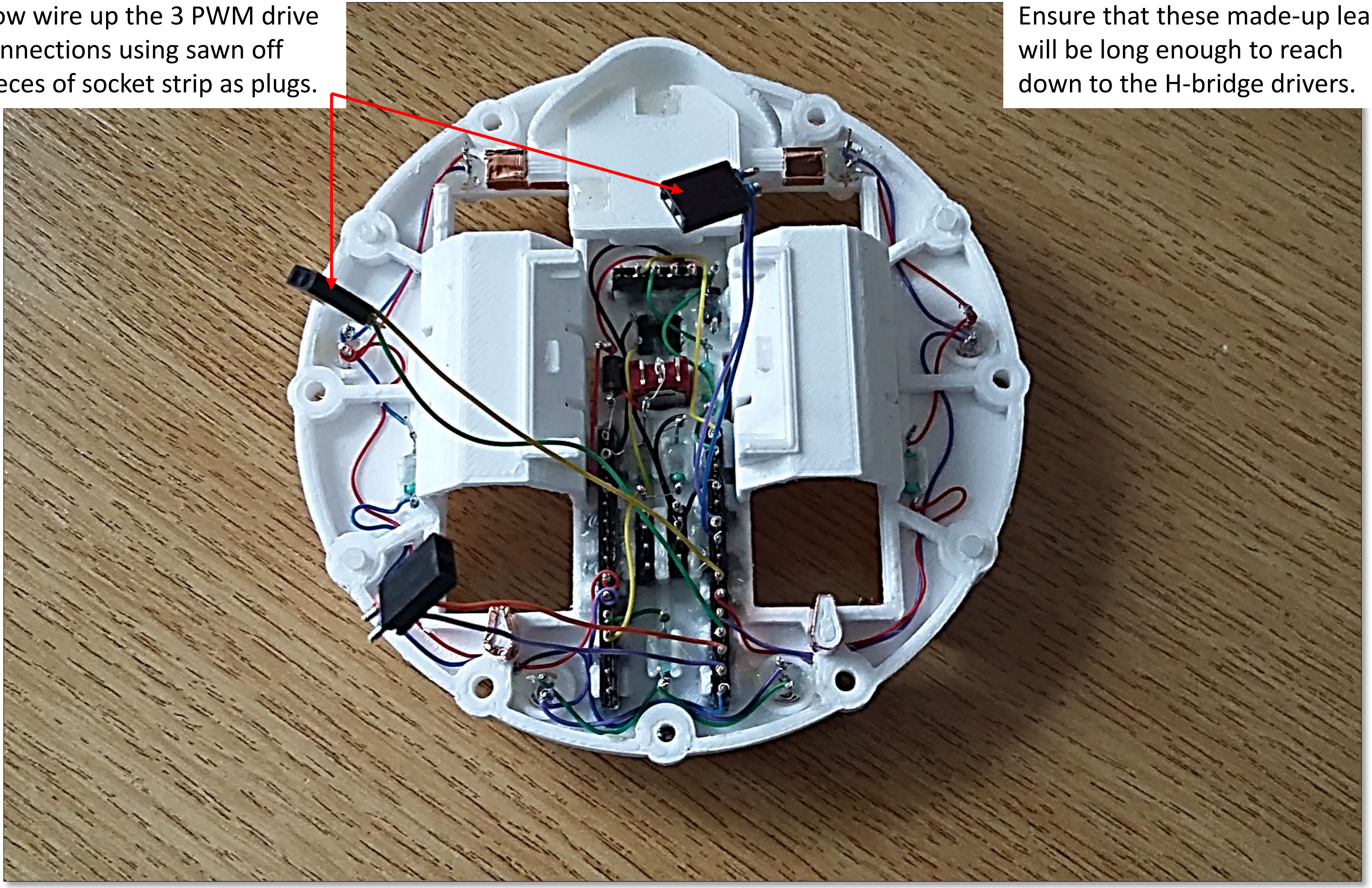


Place the cover over the slide and fix in position using hot-melt glue.



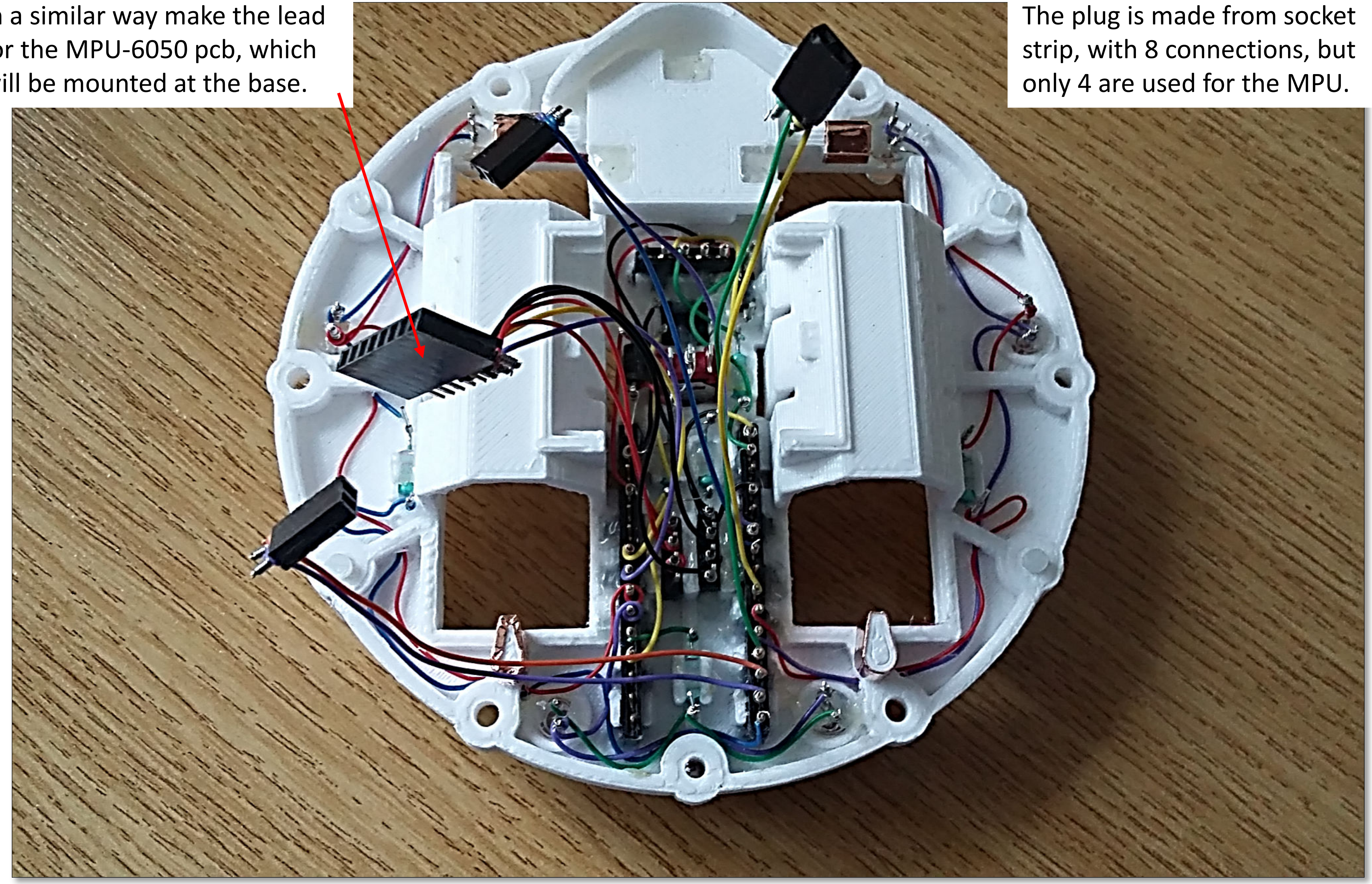
Now wire up the 3 PWM drive connections using sawn off pieces of socket strip as plugs.

Ensure that these made-up leads will be long enough to reach down to the H-bridge drivers.

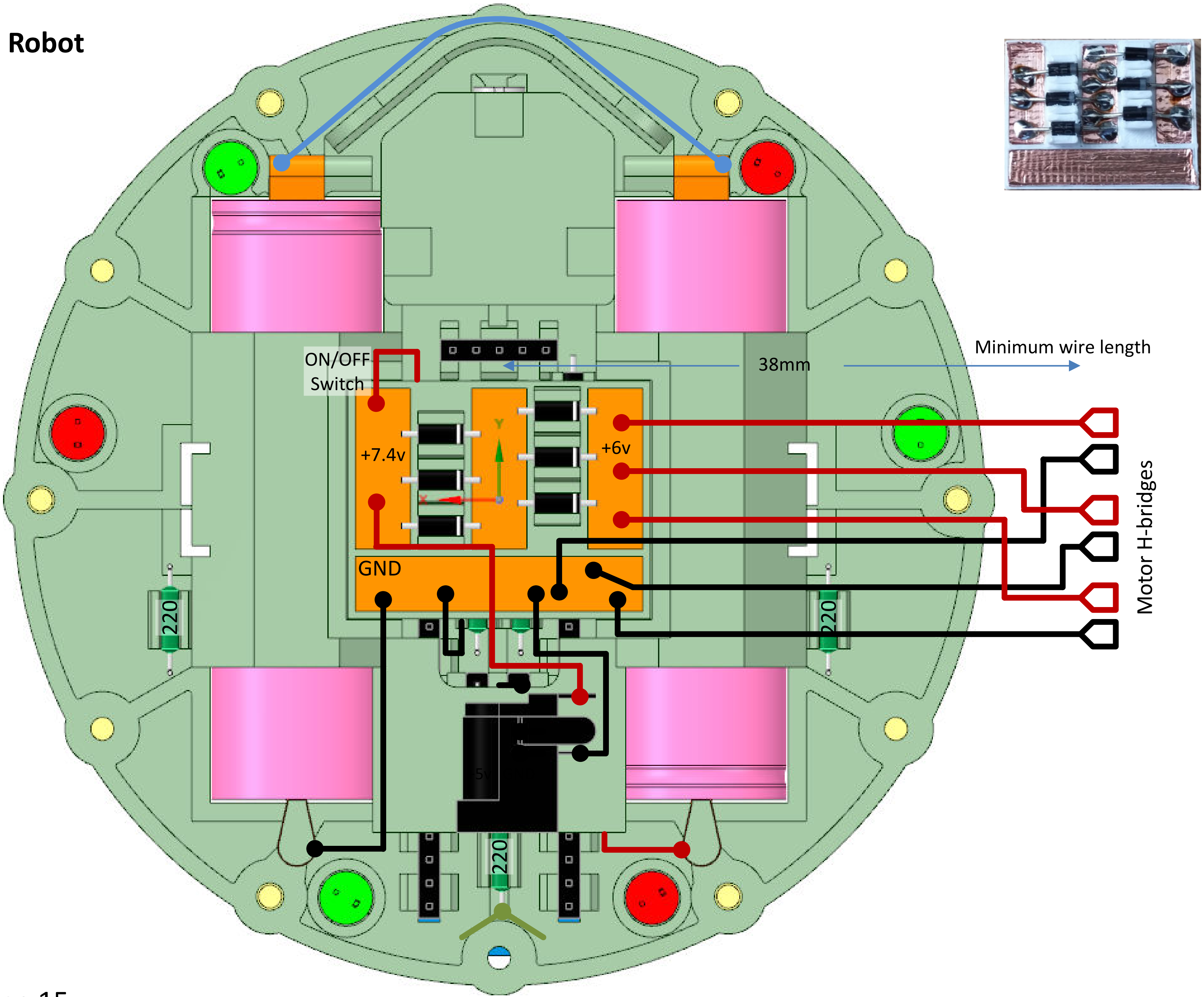


In a similar way make the lead for the MPU-6050 pcb, which will be mounted at the base.

The plug is made from socket strip, with 8 connections, but only 4 are used for the MPU.

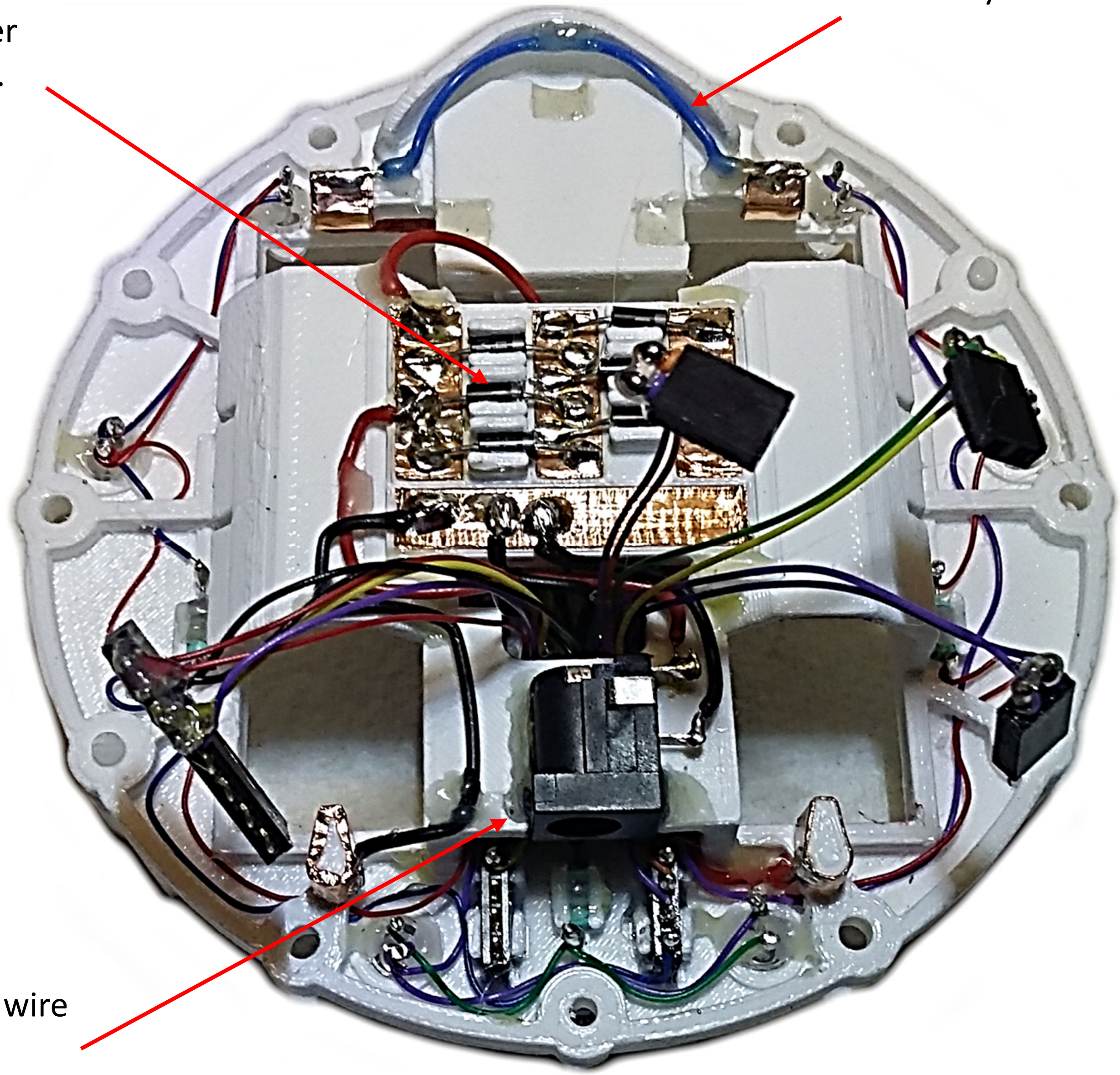


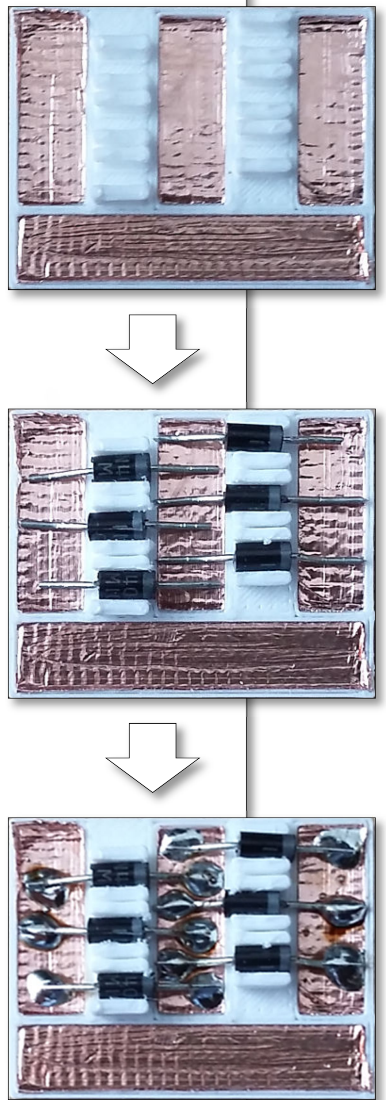
Ball Balancing Robot
Power Wiring



Now make up the diode board using 4 layers of 6mm copper tape and 6 x 1N4006 diodes.

Add the battery link wire.

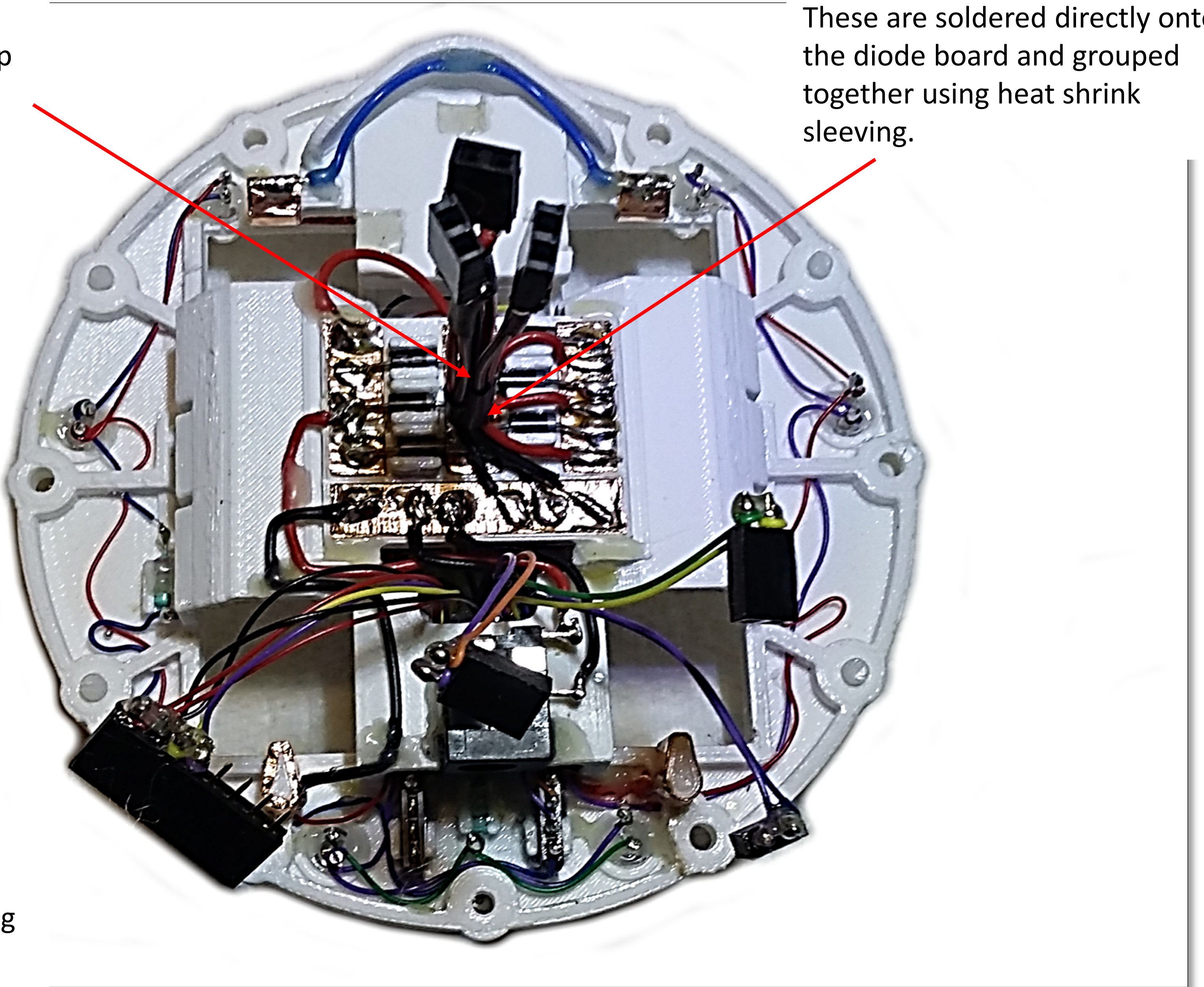




Glue plate into position and wire it up, along with the power socket and mounting plate.

Finally make up the 3 power leads, again using socket strip for the 2 pin plugs.

These are soldered directly onto the diode board and grouped together using heat shrink sleeving.

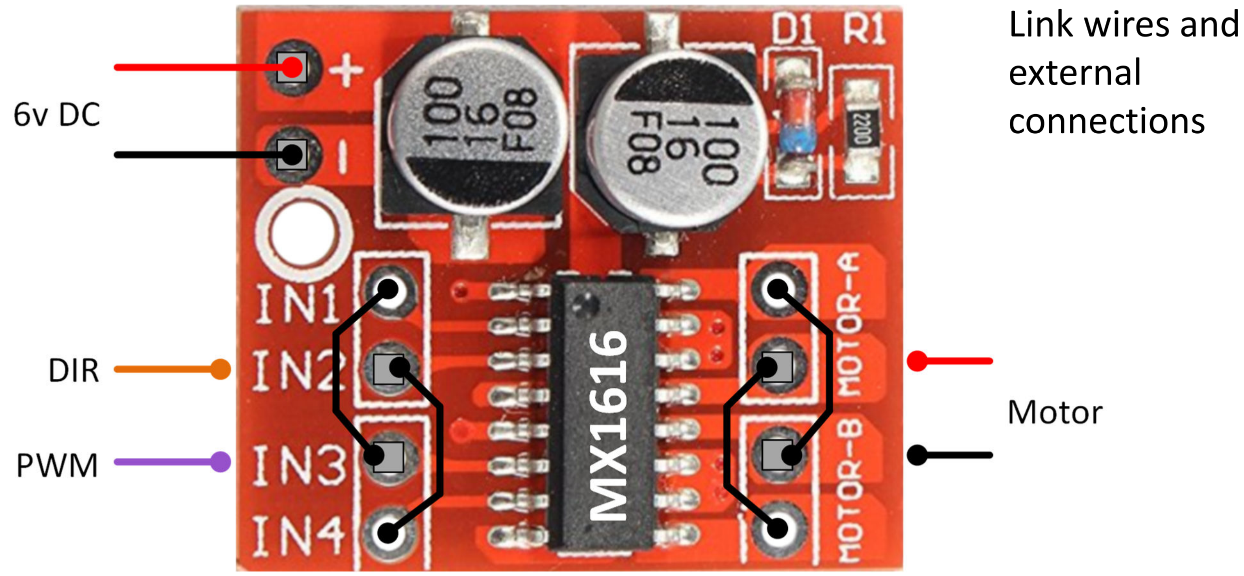


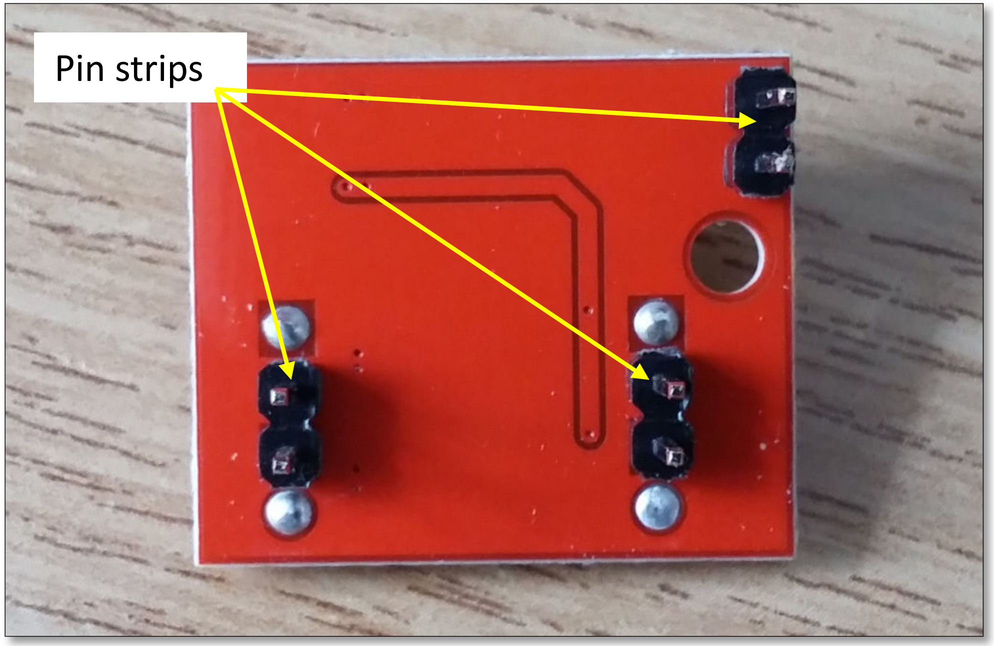
Ensure that the leads are long enough to reach the power input pins on the driver pcbs.

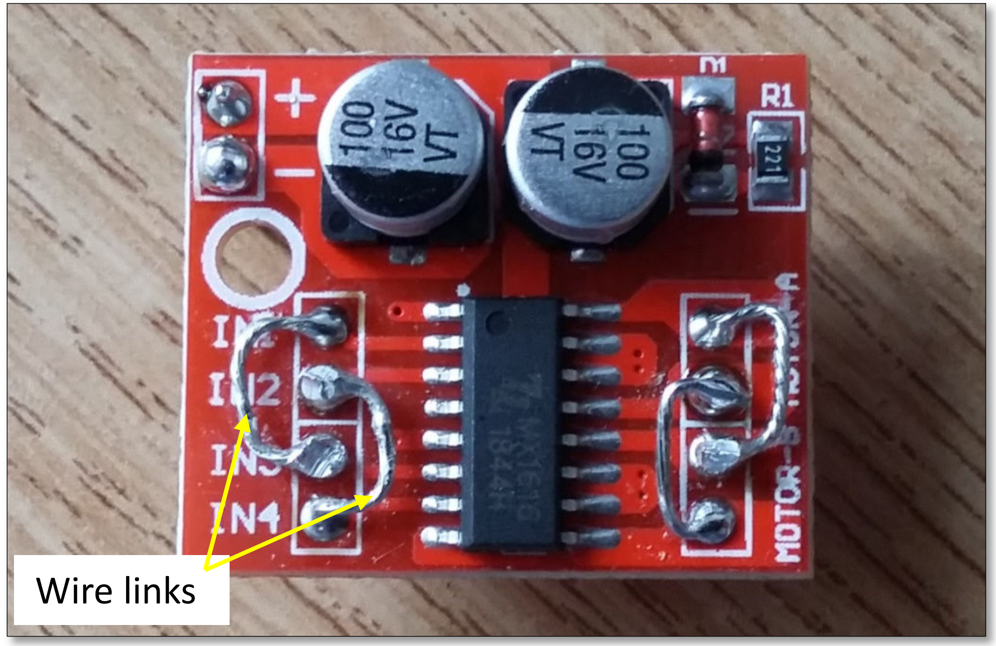
The 3 H-bridge driver boards need to be pre-wired as follows using formed link wires and pin strips.

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

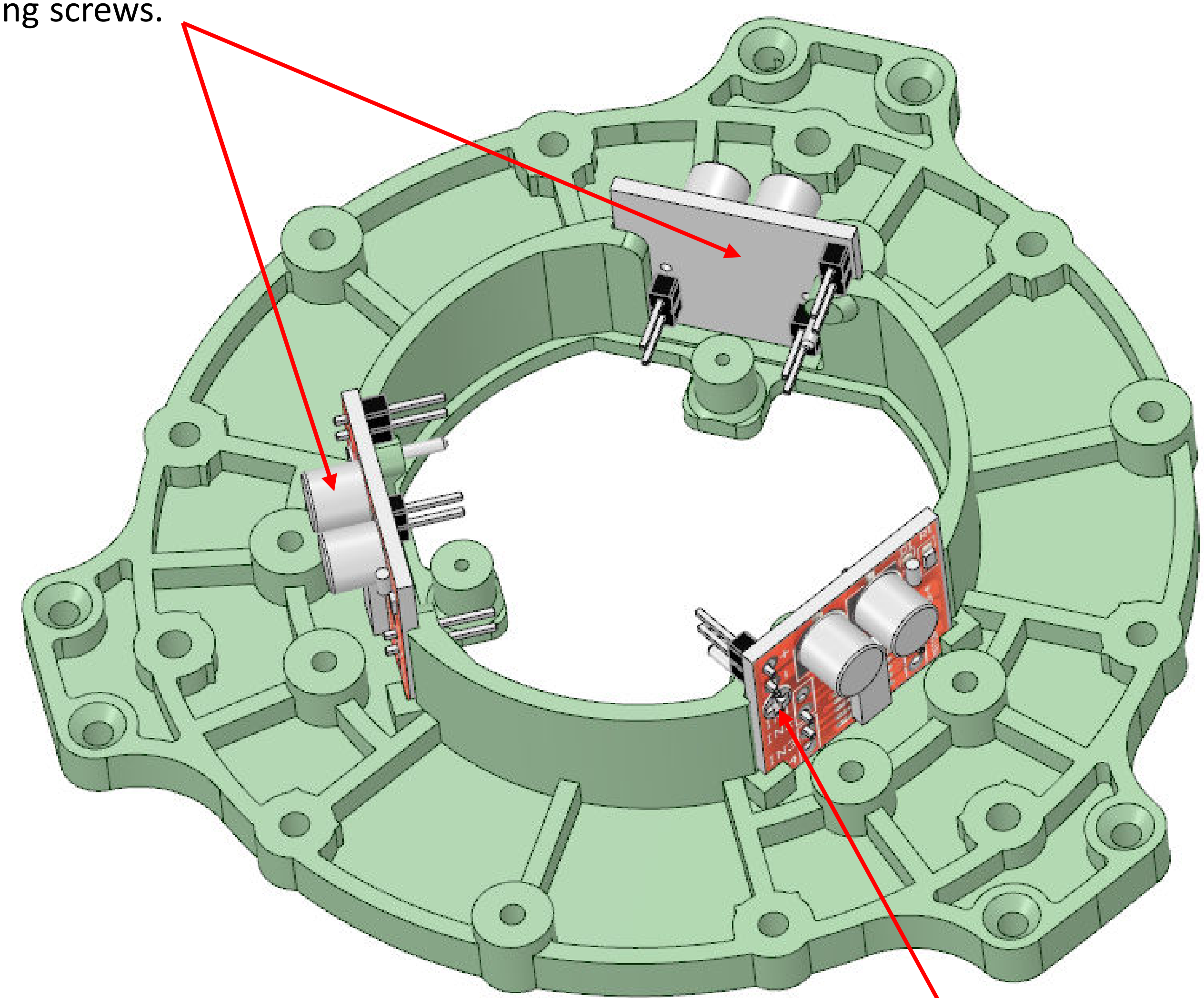
Pin strips are applied to the reverse side of the board before forming and attaching the wire links.





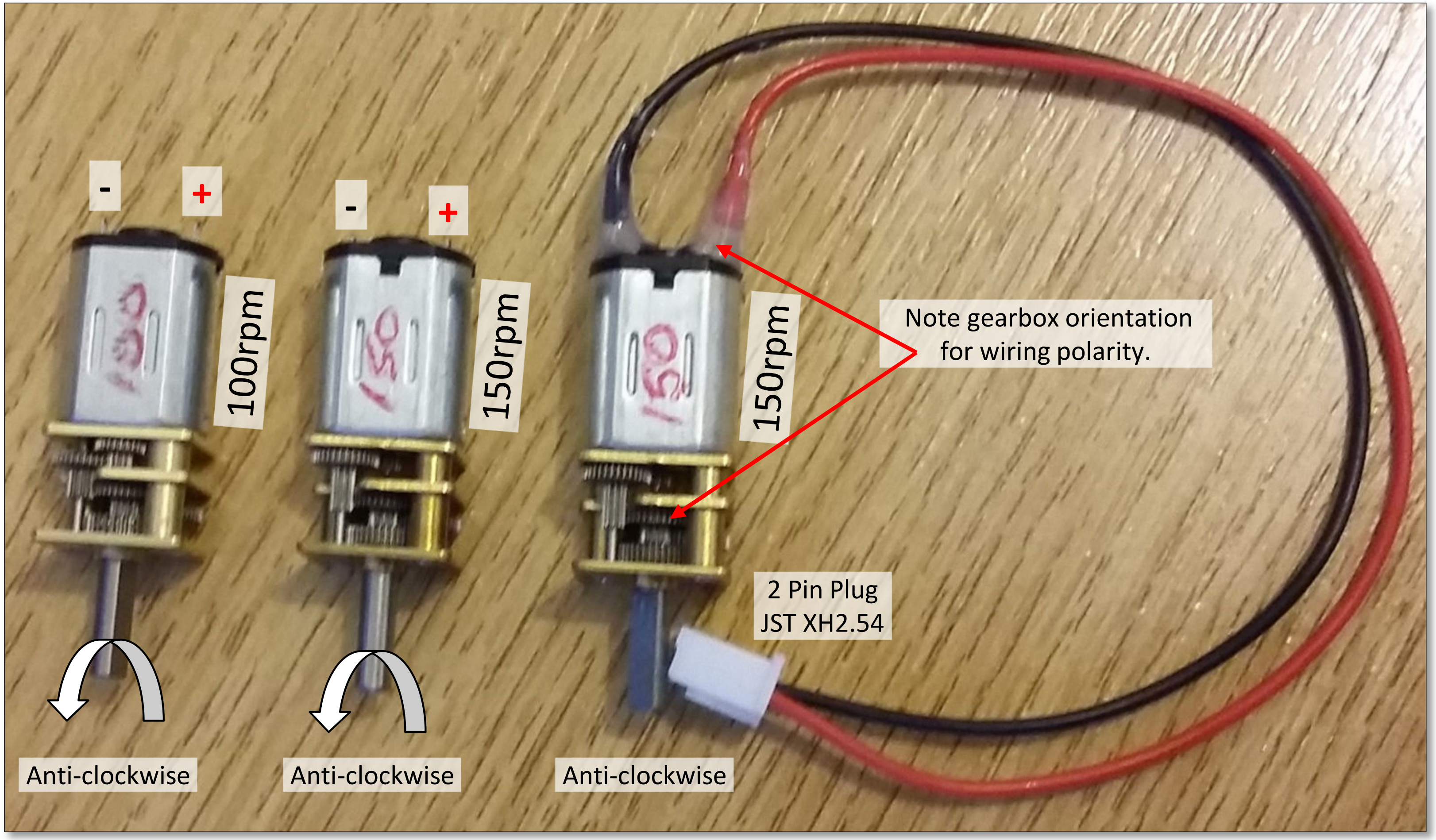


Mount the 3 H-bridge driver boards in the base plate using 10 x 2mm self tapping screws.



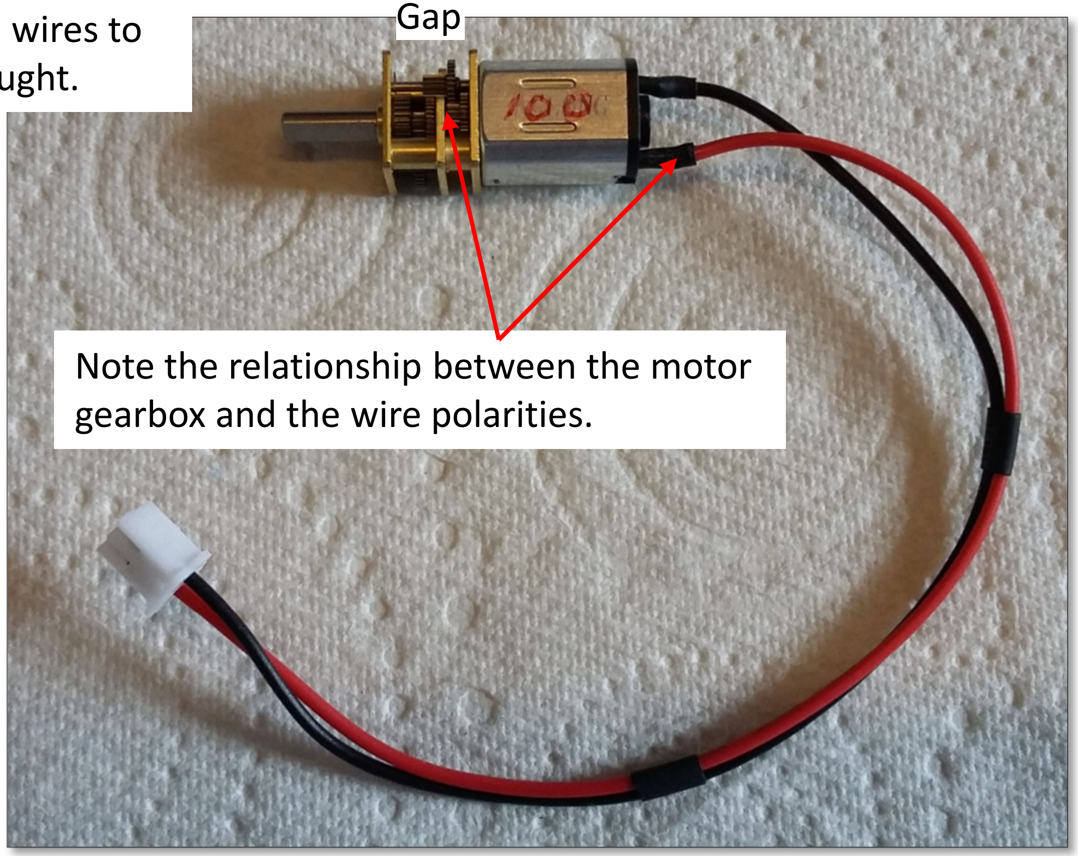
Self tapping screw.

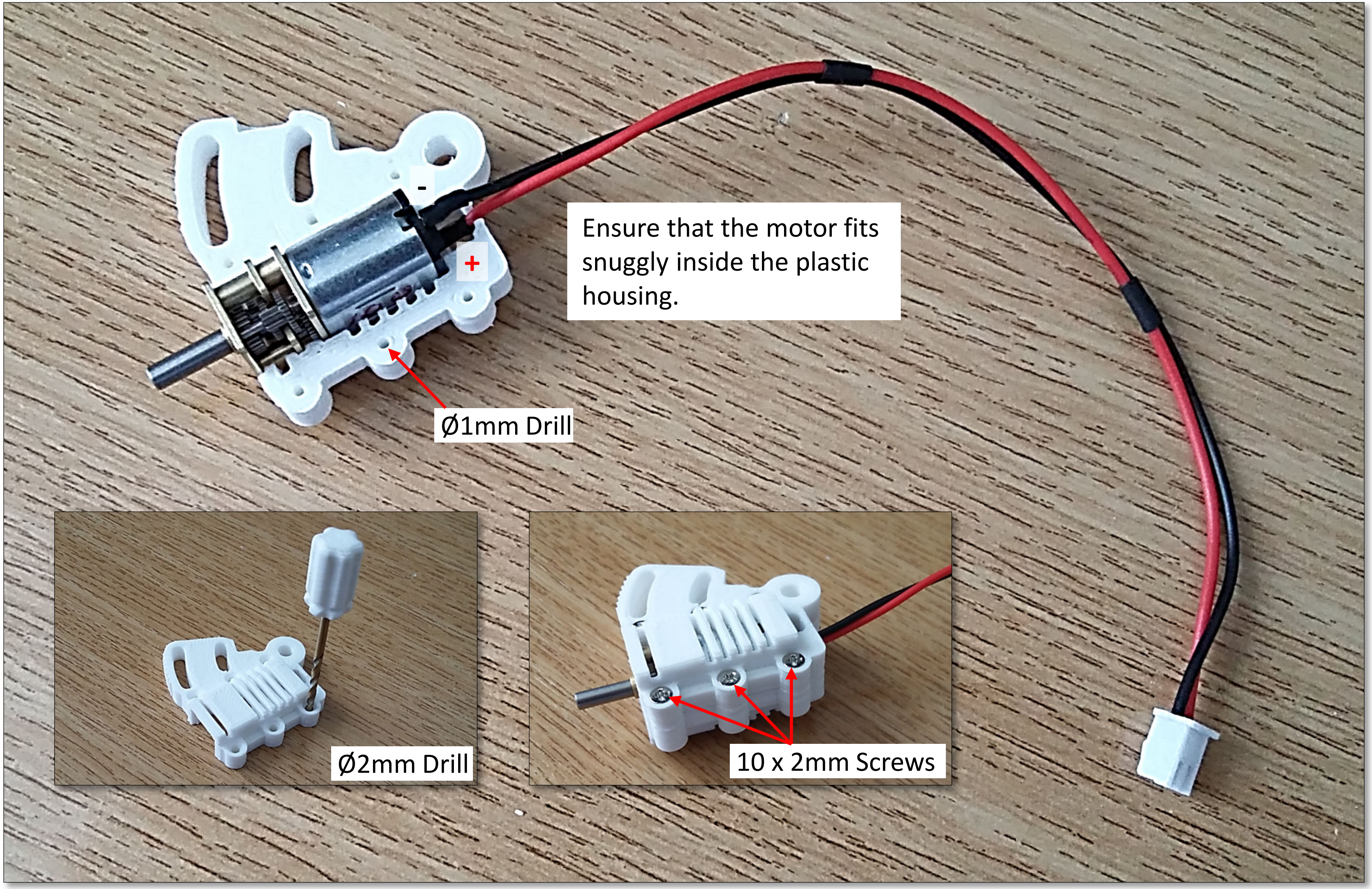
Motor Wiring

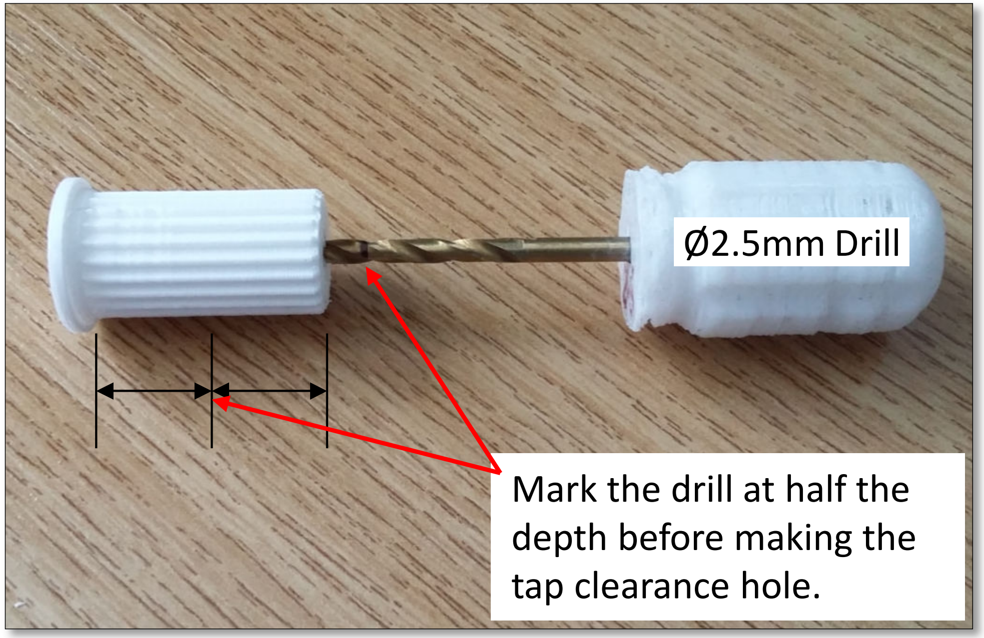


Note: All three motors need to have matching rpm values (obviously!). I started with 150rpm but later switched to 100rpm for increased torque at the expense of slower speed. If your motors are not pre-wired, then you need to wire them up in this way. If not pre-wired you can source the motors and cable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

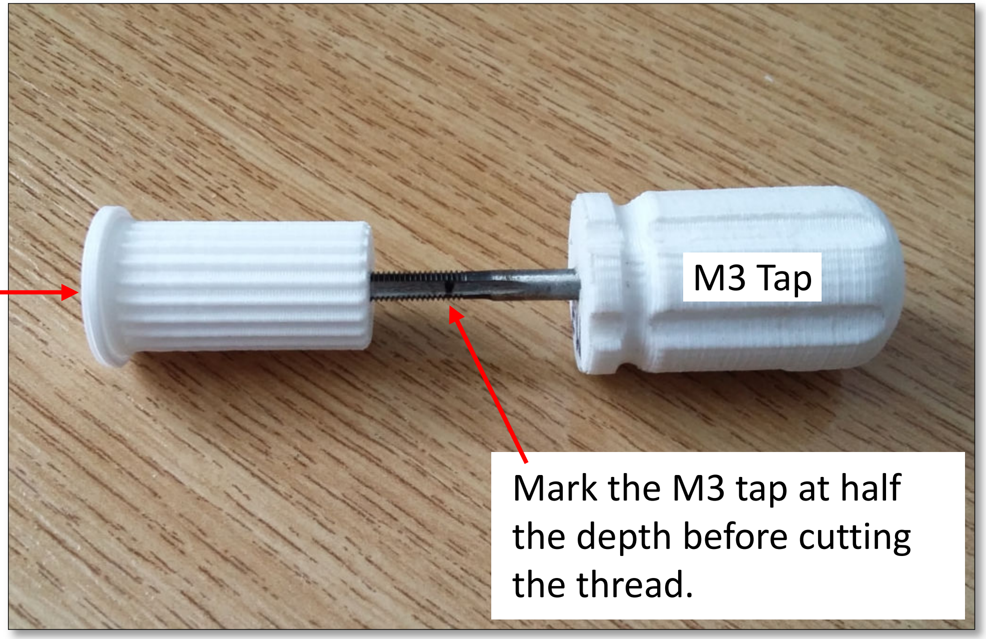
I needed to add my own wires to the 100rpm motors I bought.




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



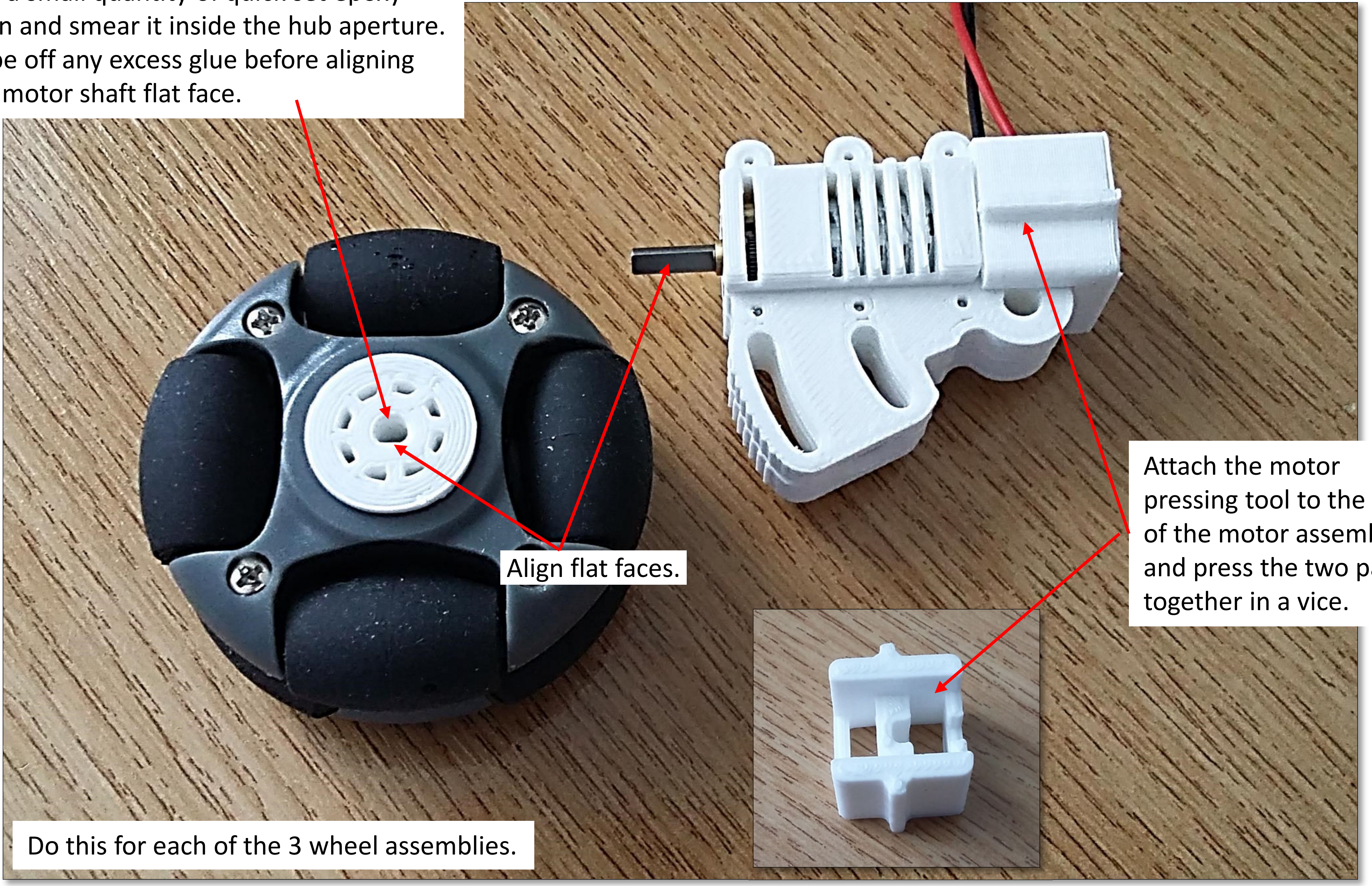
Ensure that you do not damage the half-round hole which mates with the motors drive shaft.



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.

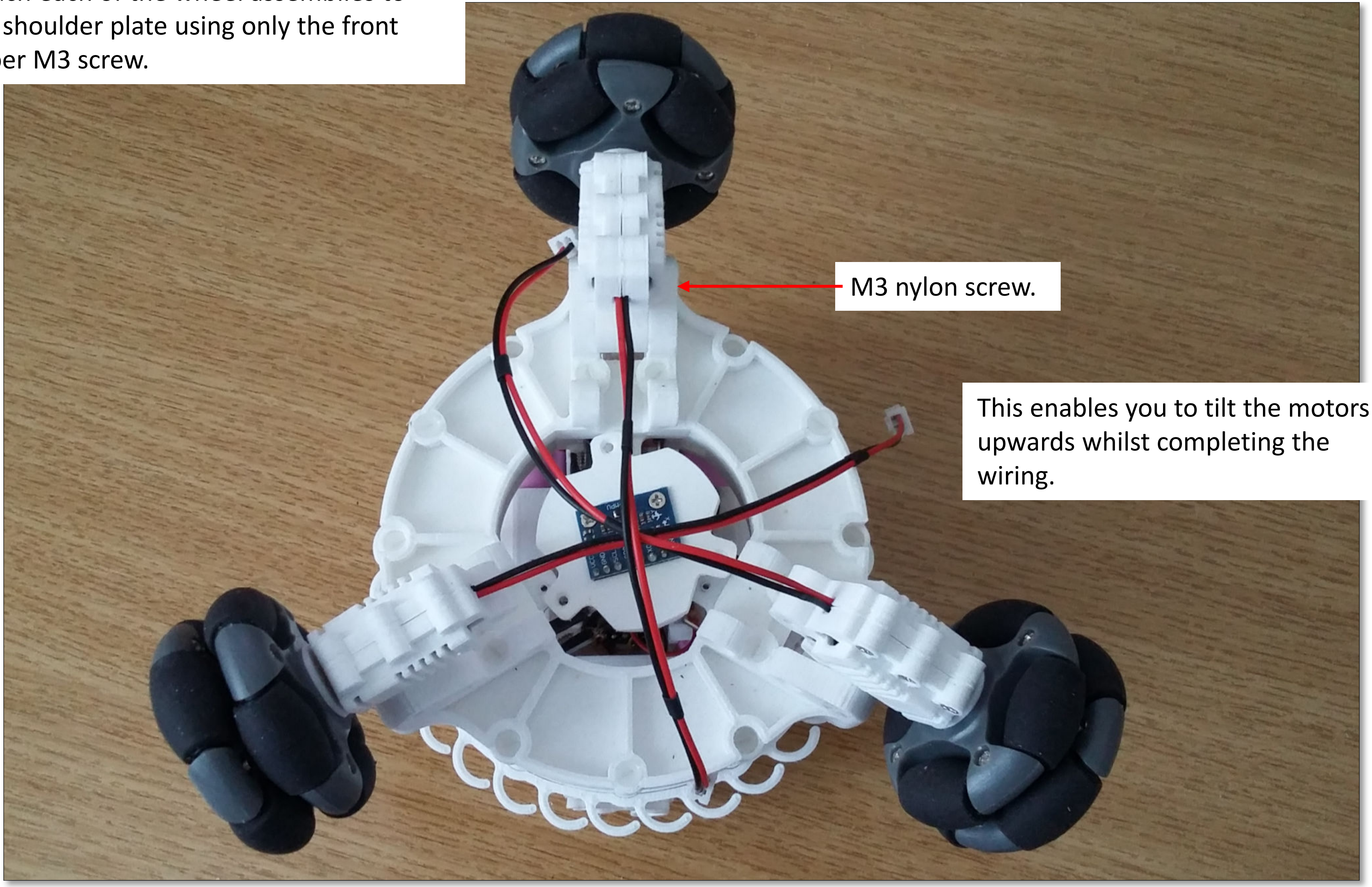


Align flat faces.

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

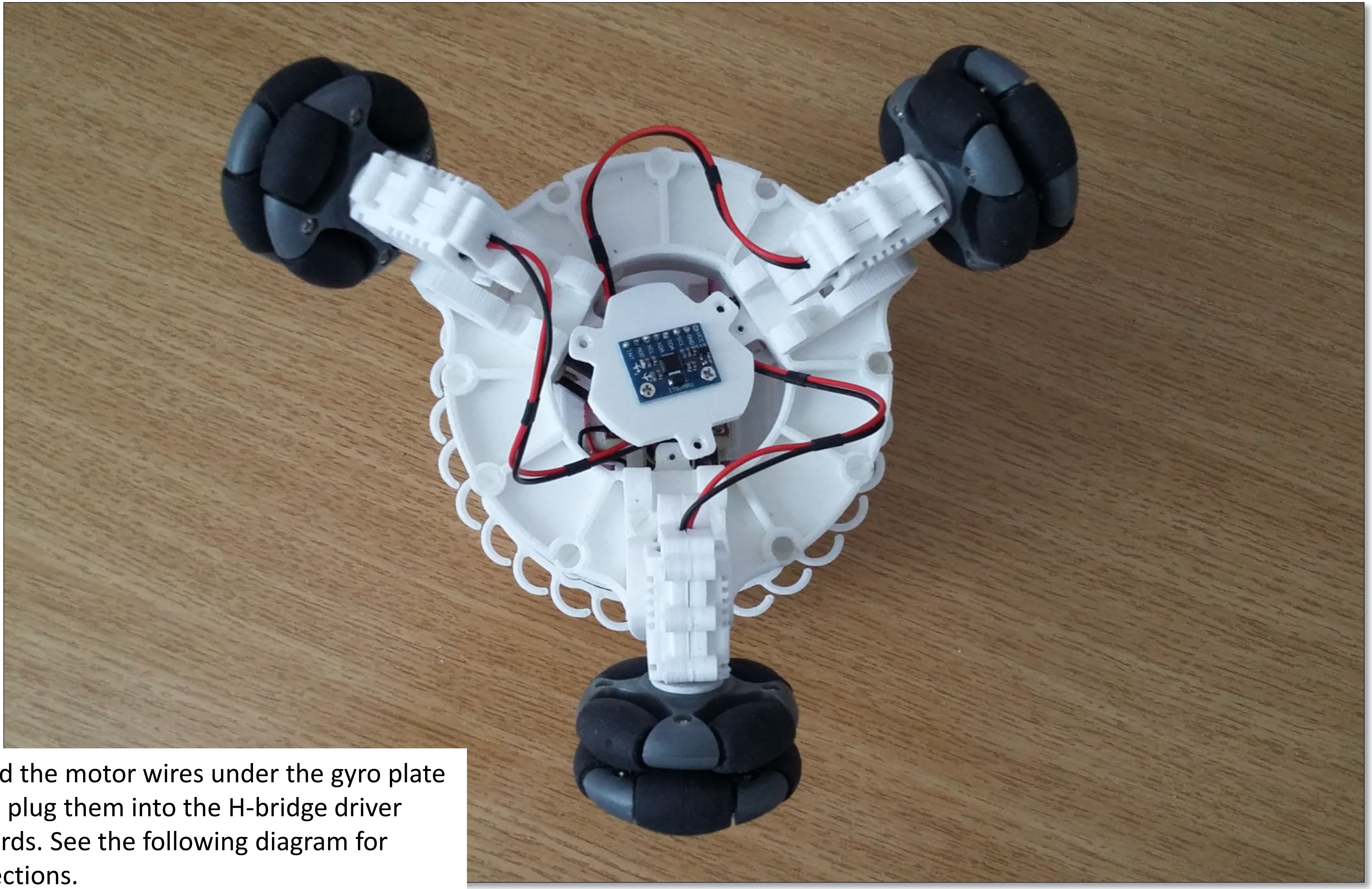
Do this for each of the 3 wheel assemblies.

Attach each of the wheel assemblies to the shoulder plate using only the front upper M3 screw.



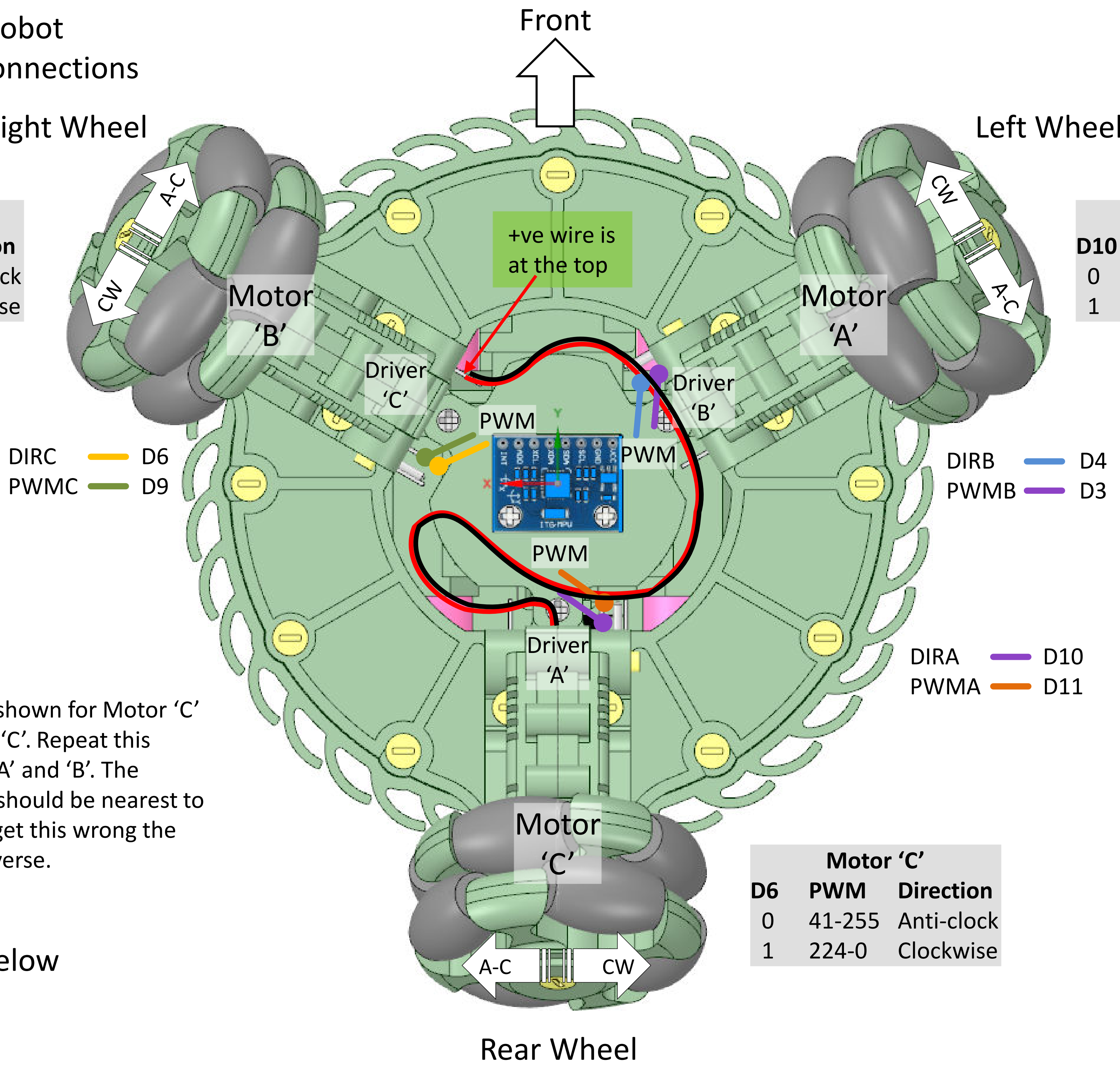
M3 nylon screw.

This enables you to tilt the motors upwards whilst completing the wiring.



Feed the motor wires under the gyro plate and plug them into the H-bridge driver boards. See the following diagram for directions.

Ball Balancing Robot
Motor/PWM Connections



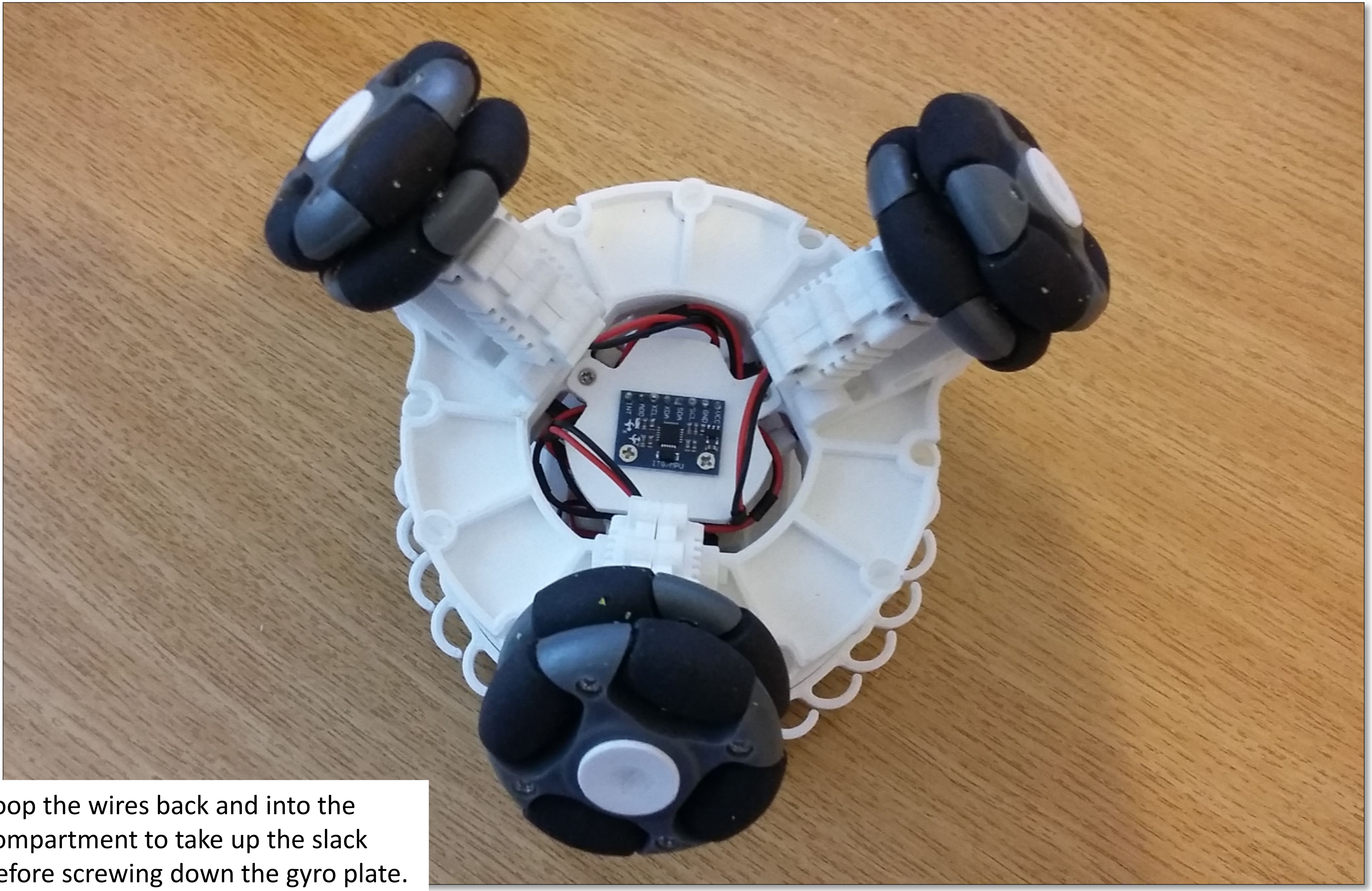
Motor 'B'		
D4	**PWM**	**Direction**
0	36-255	Anti-clock
1	233-0	Clockwise

Motor 'A'		
D10	**PWM**	**Direction**
0	49-255	Anti-clock
1	223-0	Clockwise

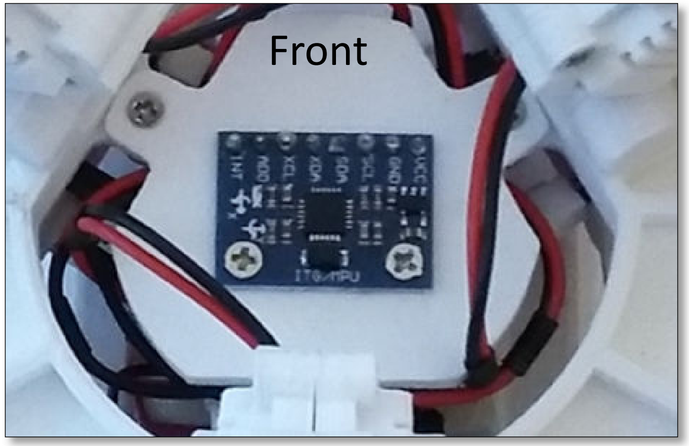
Motor 'C'		
D6	**PWM**	**Direction**
0	41-255	Anti-clock
1	224-0	Clockwise

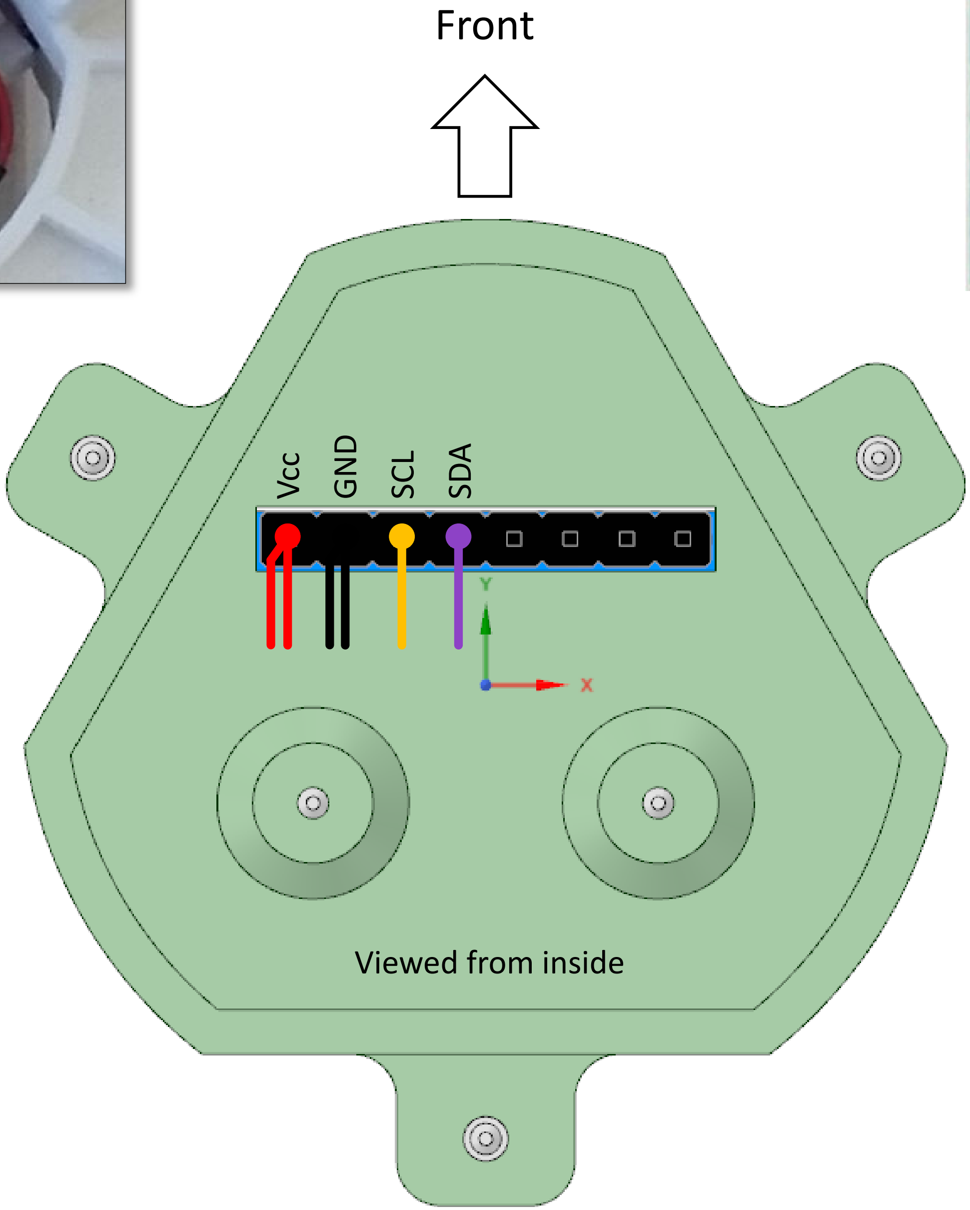
Note:
Motor wire routing shown for Motor 'C' connected to driver 'C'. Repeat this process for motors 'A' and 'B'. The connector +ve wire should be nearest to the opening. If you get this wrong the motor will run in reverse.

Viewed from below

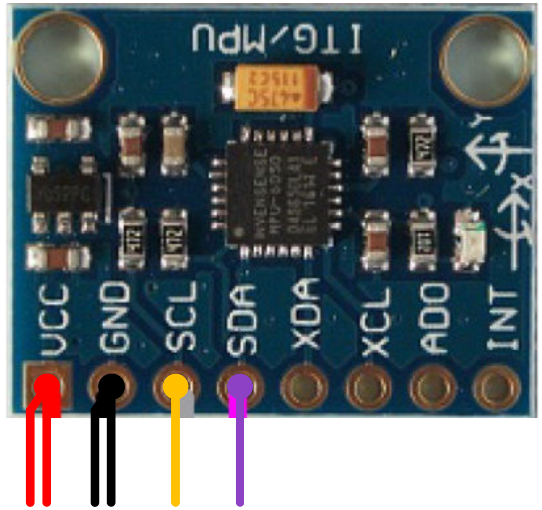


Loop the wires back and into the compartment to take up the slack before screwing down the gyro plate.





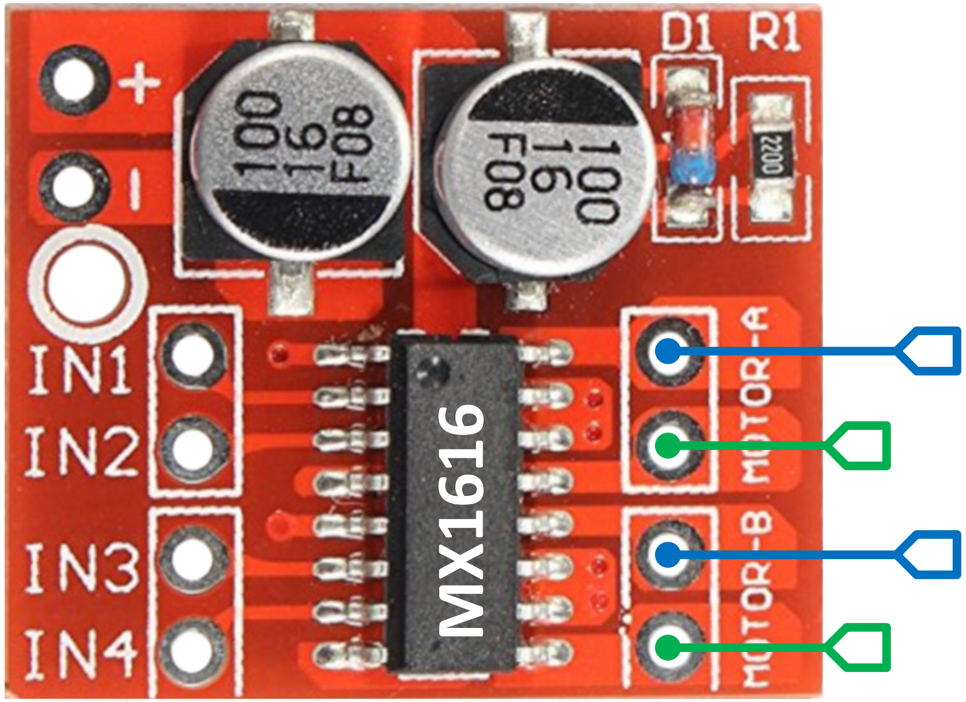
Viewed from below



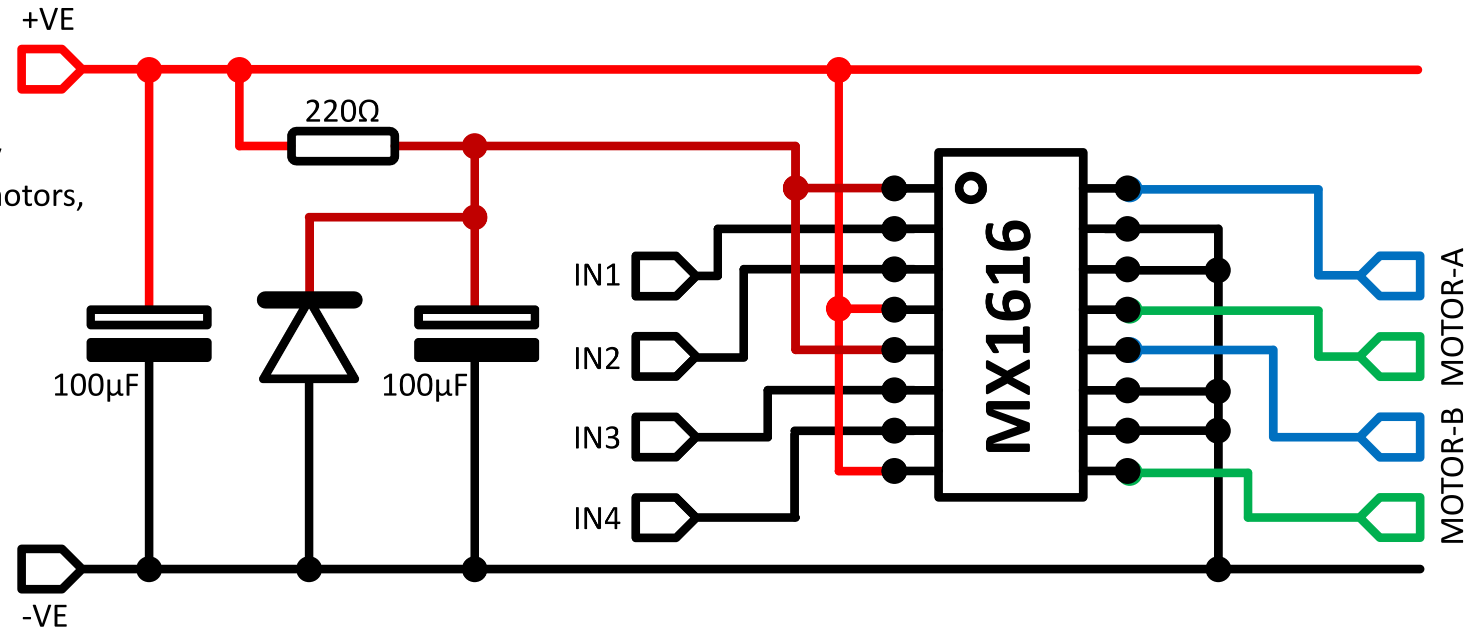
Data Sheet

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.

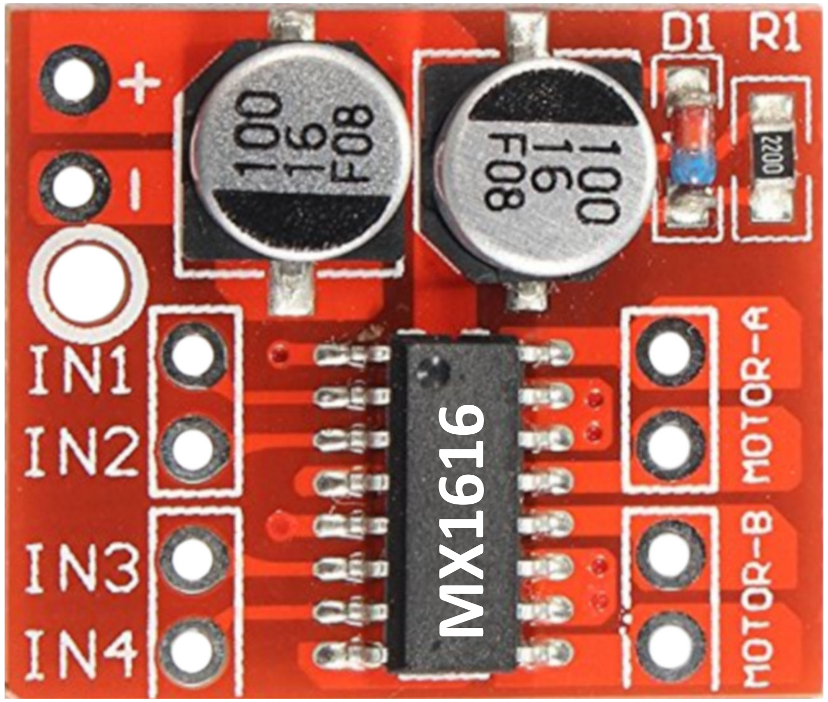


Built-in low on-resistance MOS switch.
Dual 1.5A o/p with peak current of 2.5A
Built-in thermal protection, automatic recovery
Dual H-bridge motor driver, can drive two DC motors, or a 4-wire two-phase stepper motors.
The module supply voltage: 2V-10V
Signal input voltage: 1.8-7V
Single Operating Current: 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

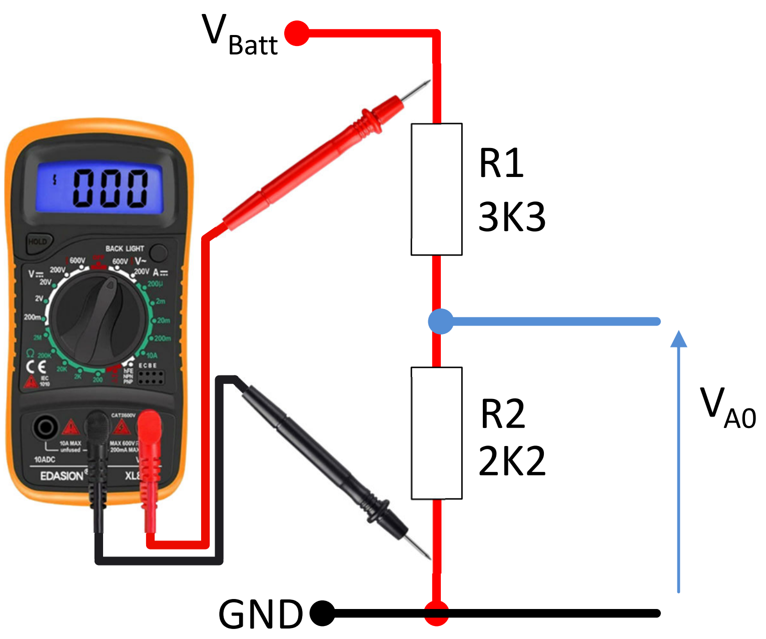


+VE
-VE
+VE
-VE

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

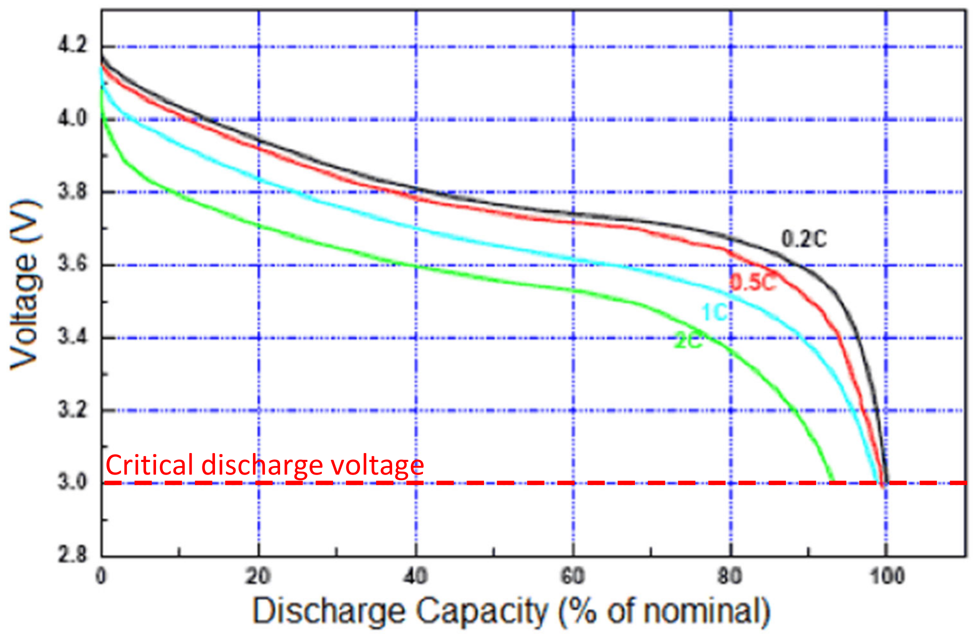
$$V_{A0} = \frac{V_{Batt} \times 2K2}{5K5}$$

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

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

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.