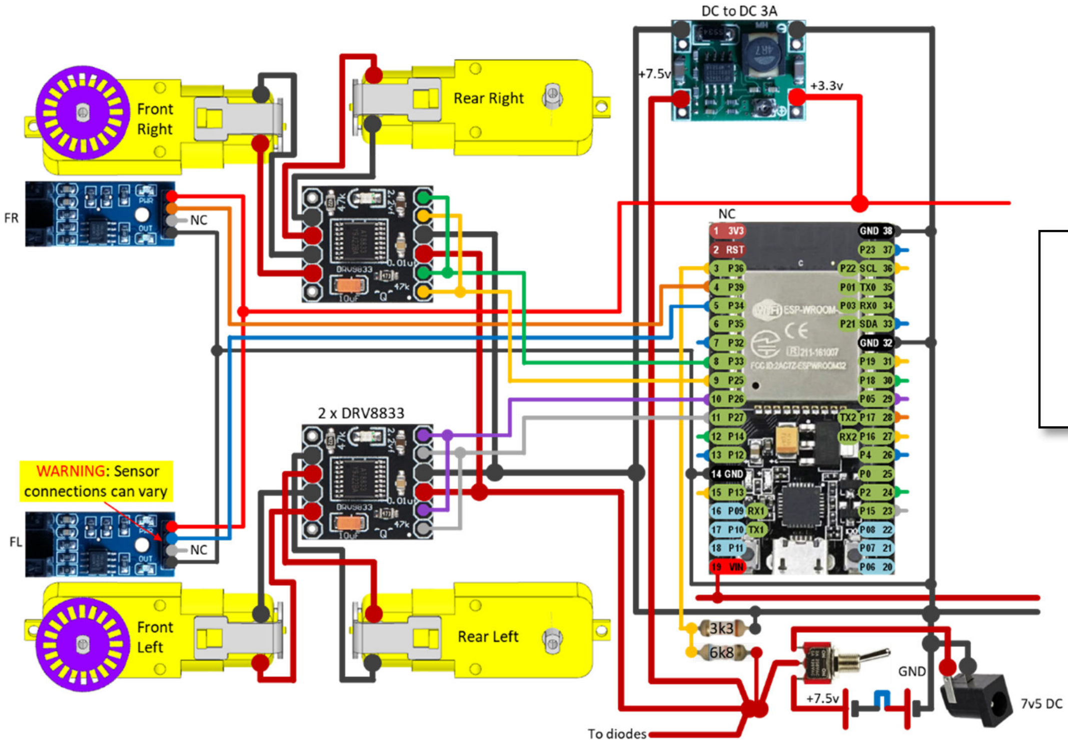
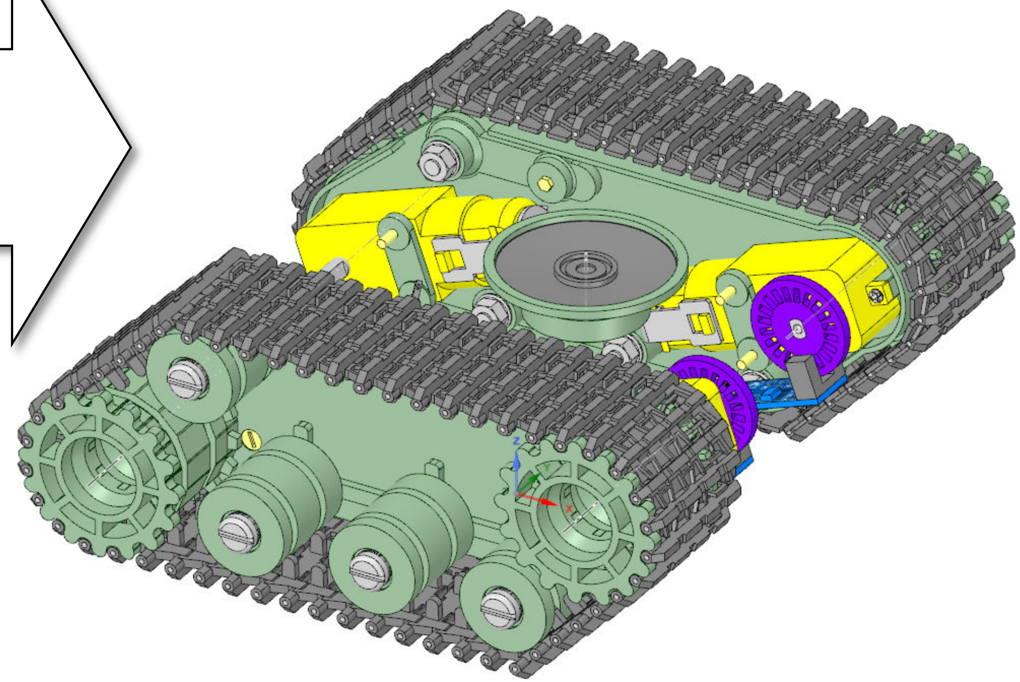
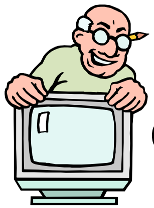
# Project TankBot Mk1

## Circuits & Wiring



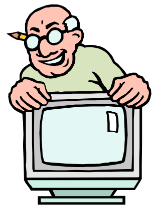



Quite a complex project, please read through this document before starting.

Issue: 1.1 Released: 08/12/2025 TechKnowTone

# 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.

# 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









# Construction - Tools:

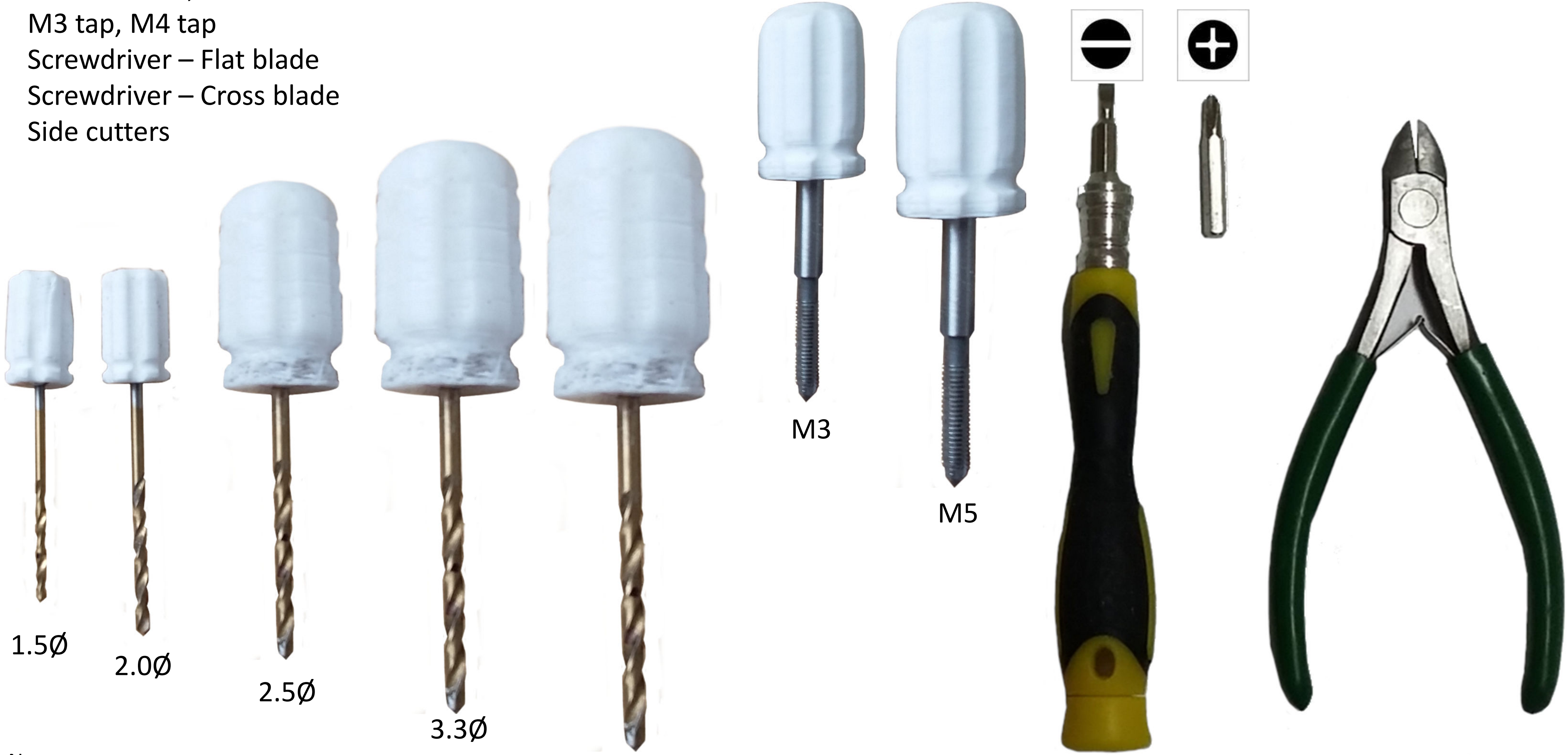
Drills: 1.5mm, 2.0mm, 2.5mm,
3.3mm, 4.0mm

M3 tap, M4 tap

Screwdriver – Flat blade

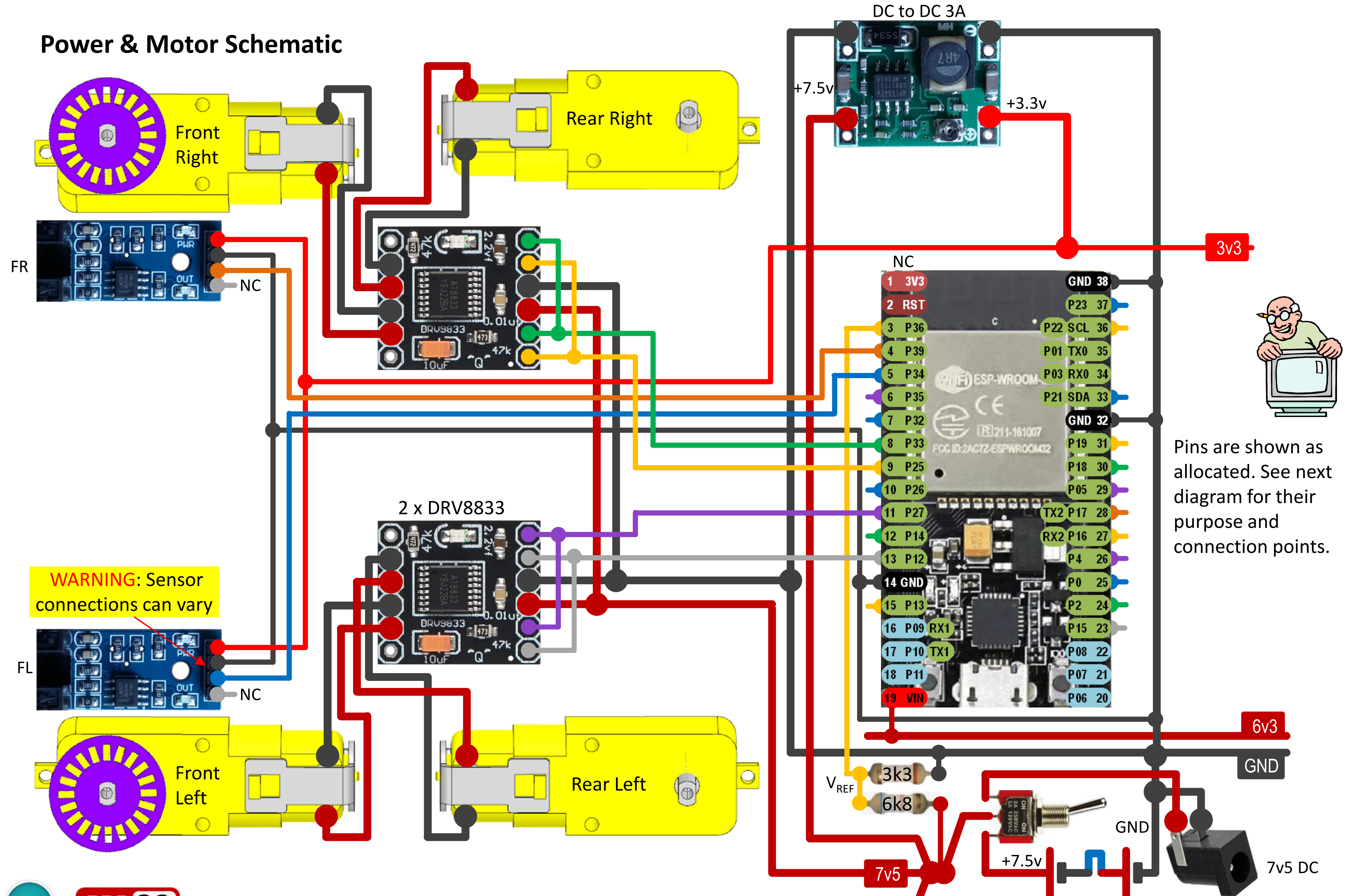
Screwdriver – Cross blade

Side cutters




Note:
A 3D printer is great for making handles for small drills and taps.

# Power & Motor Schematic

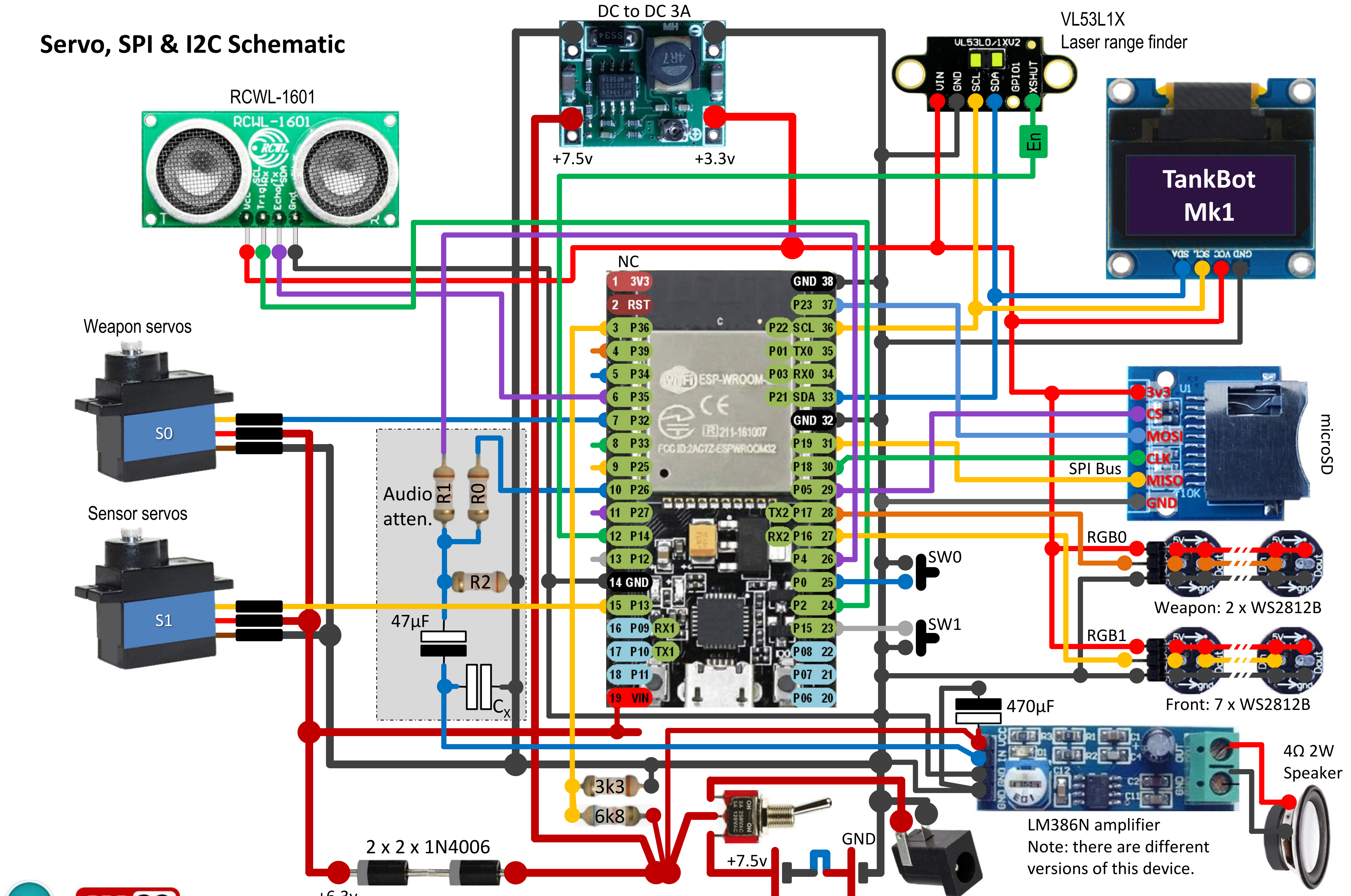



Pins are shown as allocated. See next diagram for their purpose and connection points.



Issue: 1.1 Released: 08/12/2025

# Servo, SPI & I2C Schematic






Issue: 1.1 Released: 08/12/2025 TechKnowTone

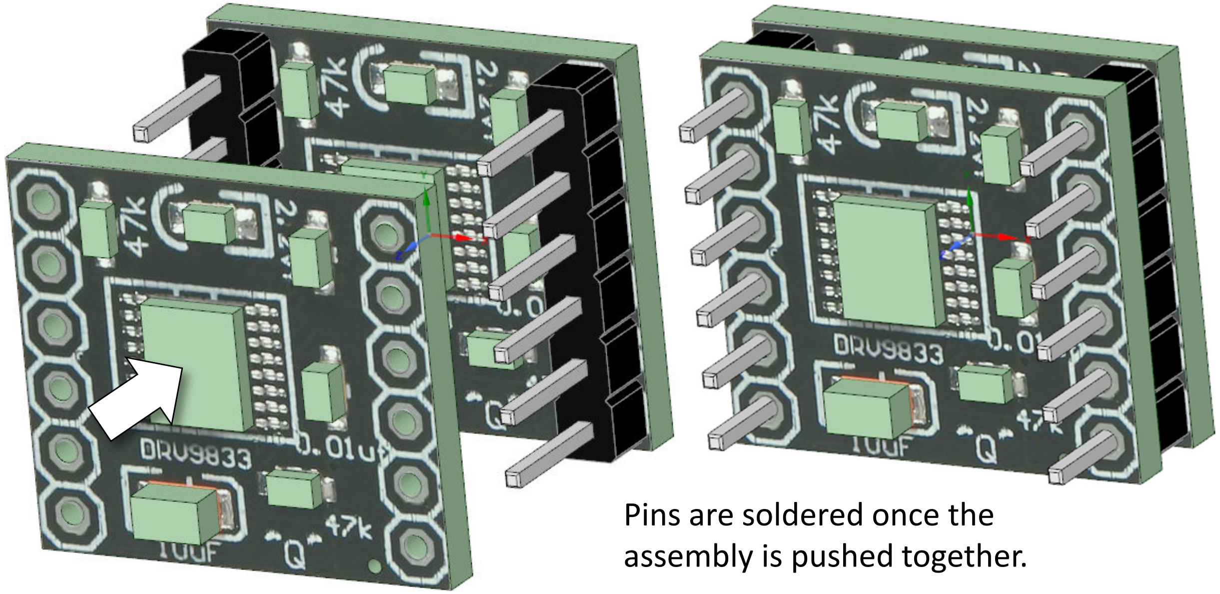
## Dual H-bridge Wiring

In this design we run two H-bridge controllers in parallel in order to combined their 2A max current capability, and half their MOS-FETs on-channel resistance.

This is achieved by creating a sandwich using two controllers pcb's with 6 pin strips between them. The pins are soldered into each pcb, and the protruding longer pins are used as the connection points.

These sandwich modules are mounted in the design such that cooling airflow can circulate over the DRV8833 driver ICs.

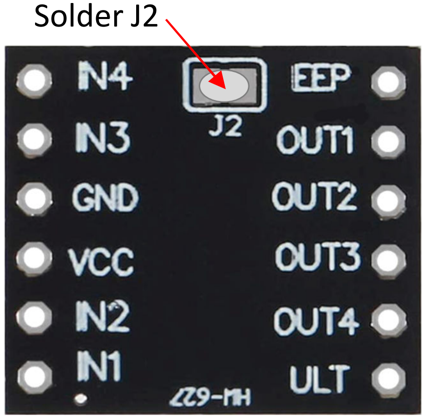
The nSLEEP and nFAULT pins are not connected; however, the nSLEEP pin is pulled HIGH by an on-board 47kΩ resistor when you bridge J2 with a blob of solder.



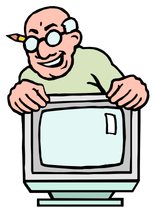
Pins are soldered once the assembly is pushed together.

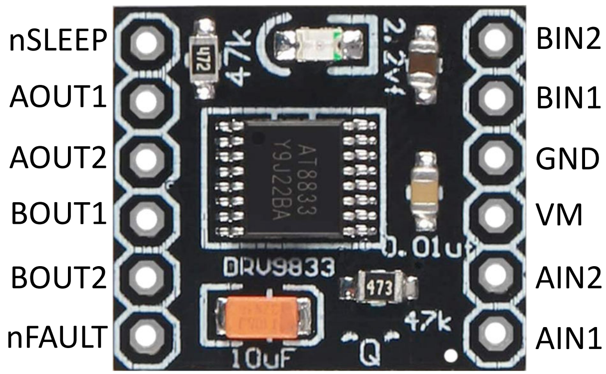
Applying a small amount of flux to the pins before soldering can improve solderability.

Solder J2

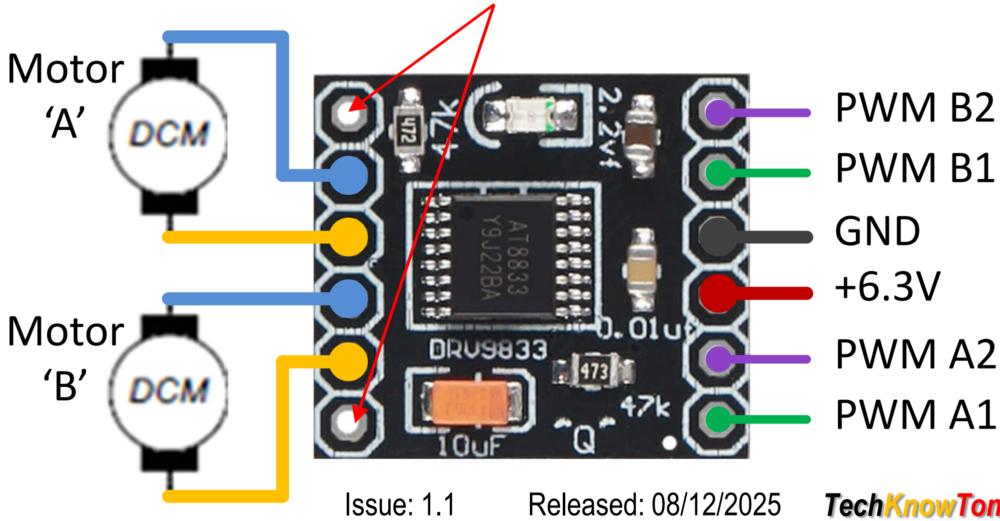



Solder J2 **before** you make the sandwich assembly!

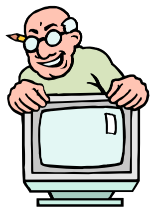





Crop unused SLEEP and FAULT pins after soldering.



## Dual H-bridge Quality Check

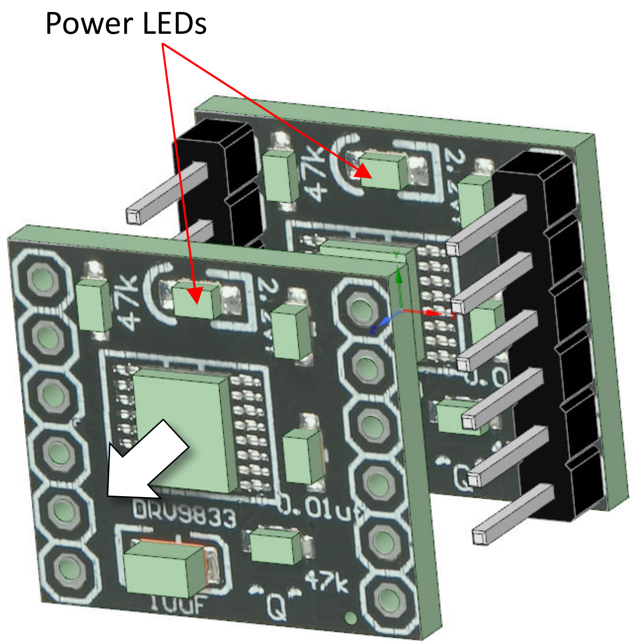


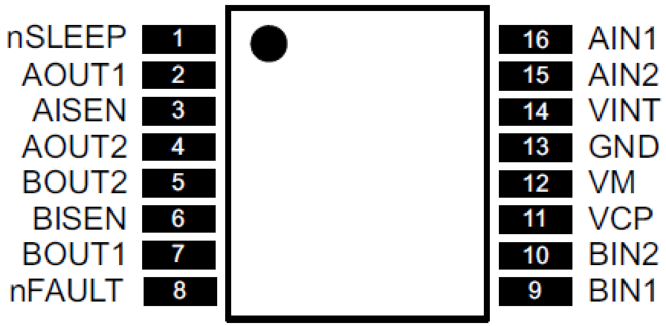
Soldering the pins to the board can be tricky, with some connections not being made. So it is best to perform a continuity check after soldering the rear board, <u>before</u> soldering the top board.

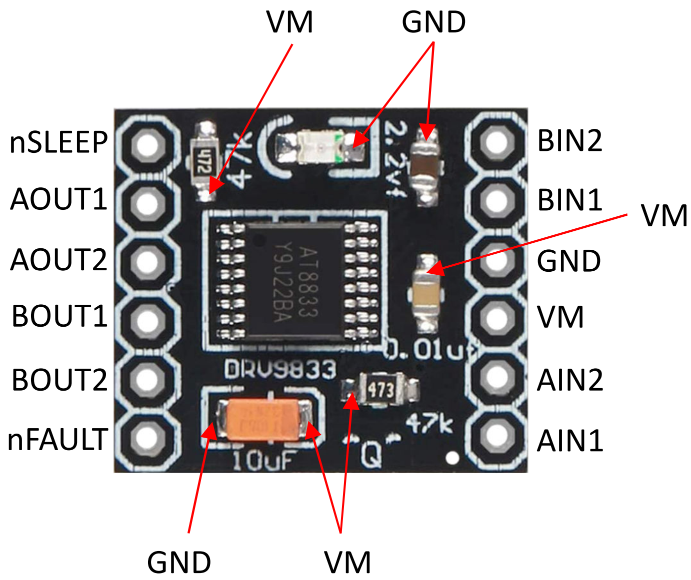
Separate the two halves of the assembly and probe between pins and points on the board, to ensure that all pins are connected to the board.

Once the top board is re-fitted and soldered, repeat these continuity tests for that board too.

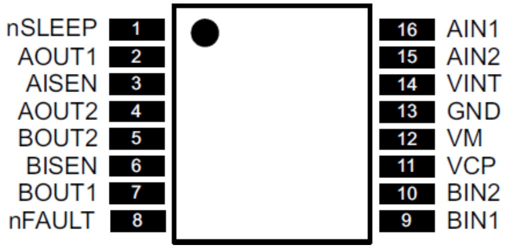
You can also briefly apply 5v power to the VM and GND pins, from an external source, to ensure that both power LEDs light up.

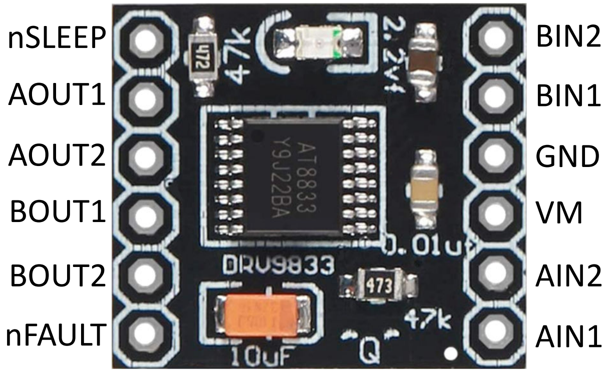


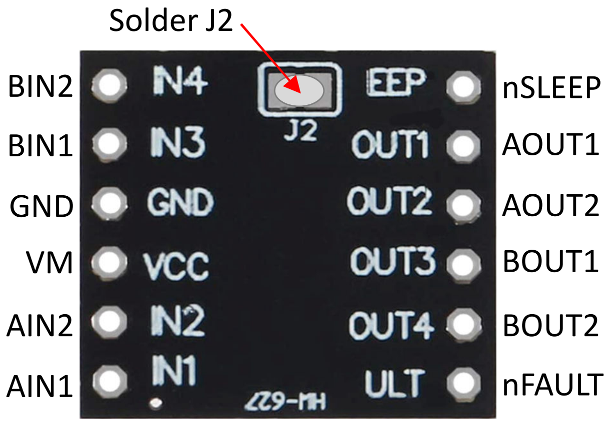



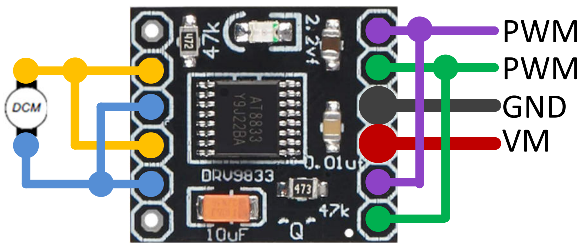
# DRV8833 H-bridge Driver

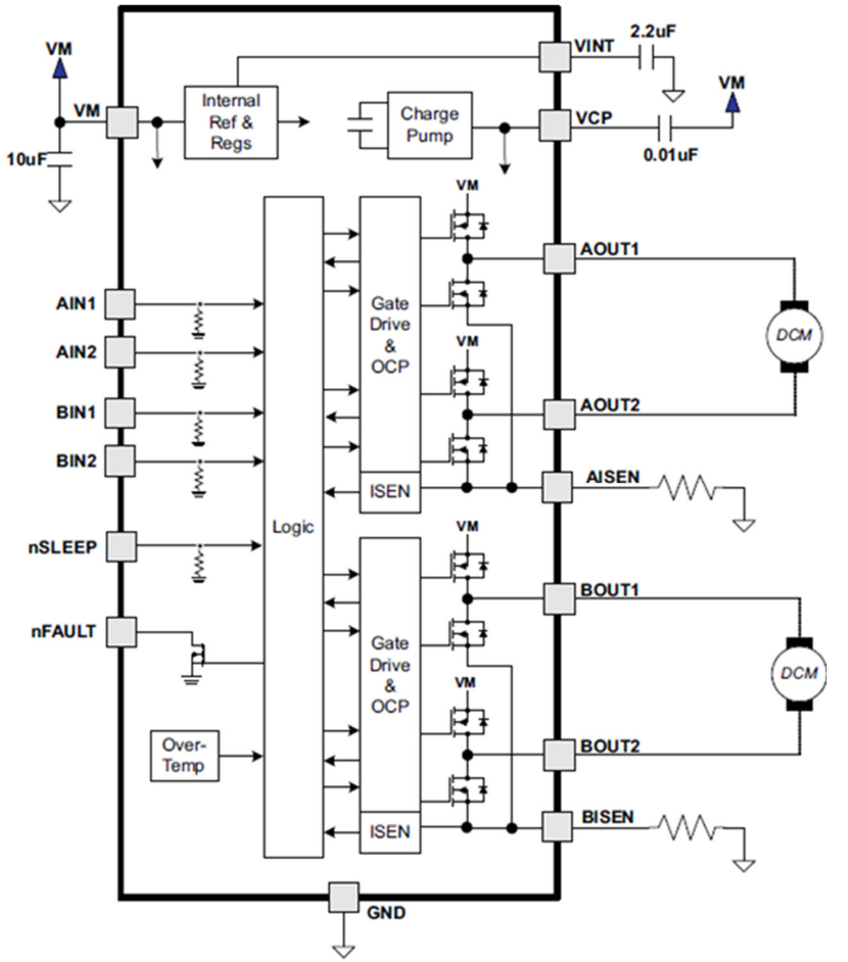



Combined H-bridge.



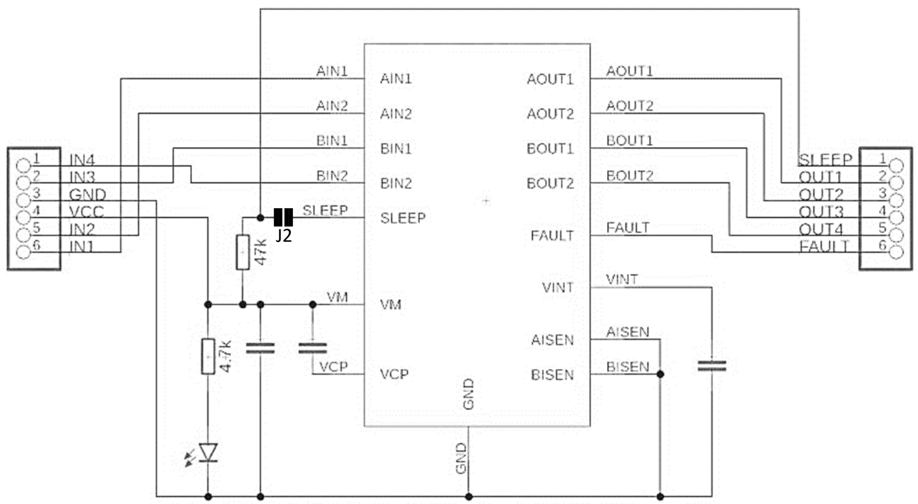




**Table 1. H-Bridge Logic**

| xIN1 | xIN2 | xOUT1 | xOUT2 | FUNCTION |
|---|---|---|---|---|
| 0 | 0 | Z | Z | Coast/fast decay |
| 0 | 1 | L | H | Reverse |
| 1 | 0 | H | L | Forward |
| 1 | 1 | L | L | Brake/slow decay |

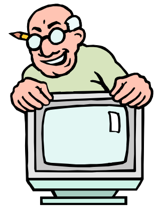
**Table 2. PWM Control of Motor Speed**

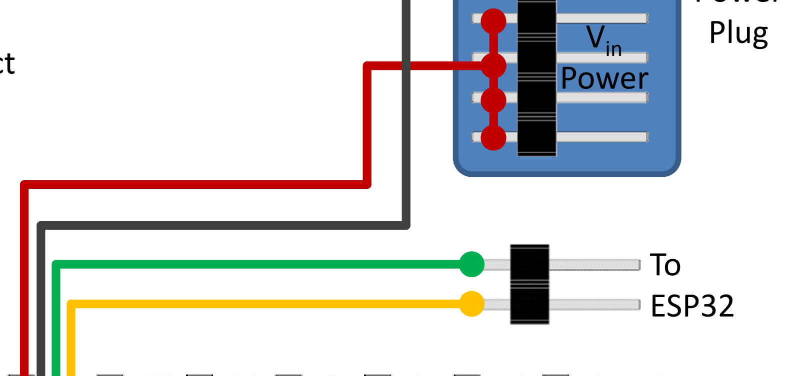
| xIN1 | xIN2 | FUNCTION |
|---|---|---|
| PWM | 0 | Forward PWM, fast decay |
| 1 | PWM | Forward PWM, slow decay |
| 0 | PWM | Reverse PWM, fast decay |
| PWM | 1 | Reverse PWM, slow decay |

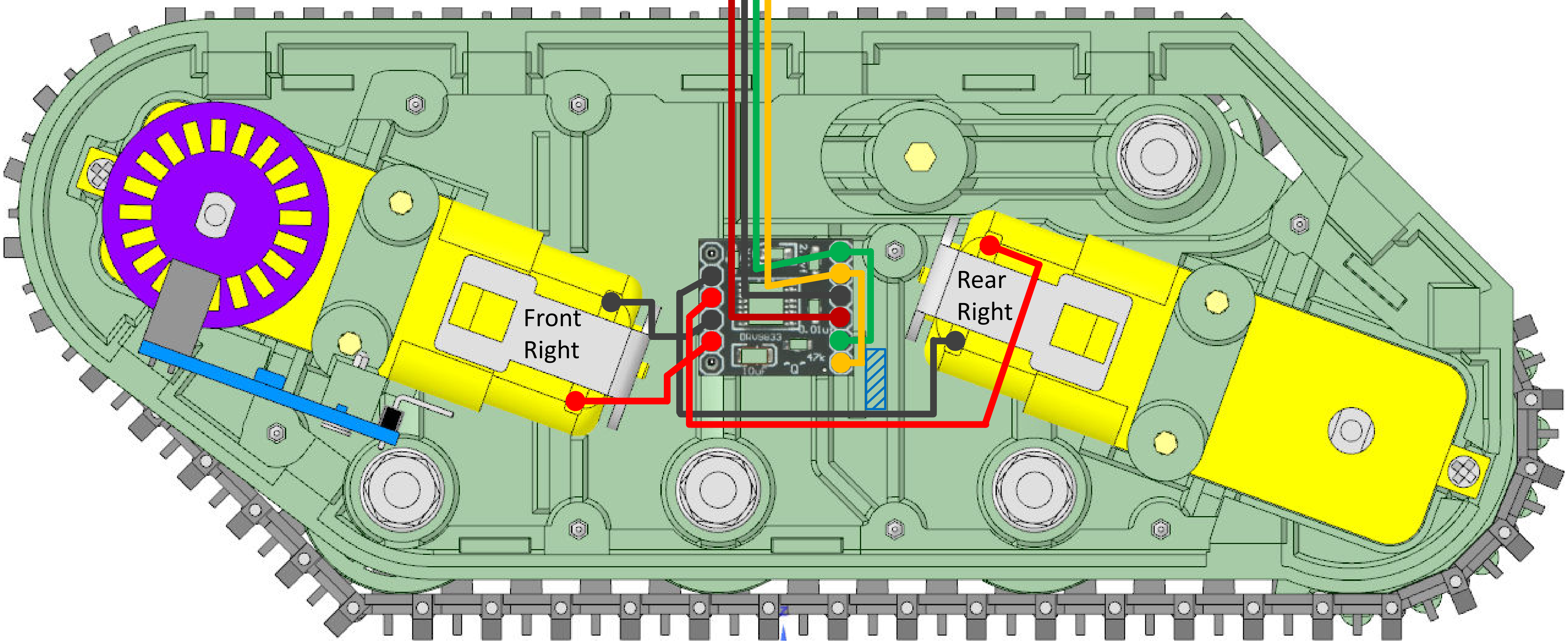
## Right-hand Motor Wiring

As the front and rear motors are physically connected via the track, it is essential that they are driven in the same direction, to prevent damage. Follow this diagram carefully.

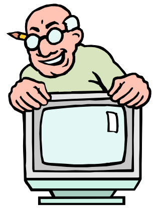
If in doubt, split the track before testing, so that you can observe correct operation before re-connecting the track.





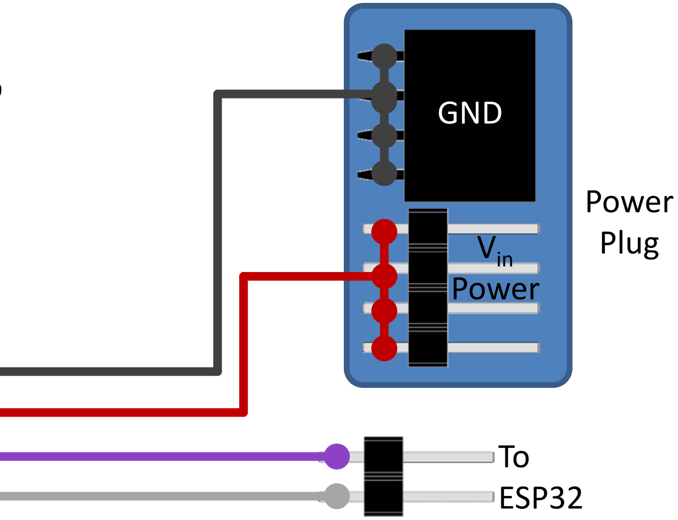



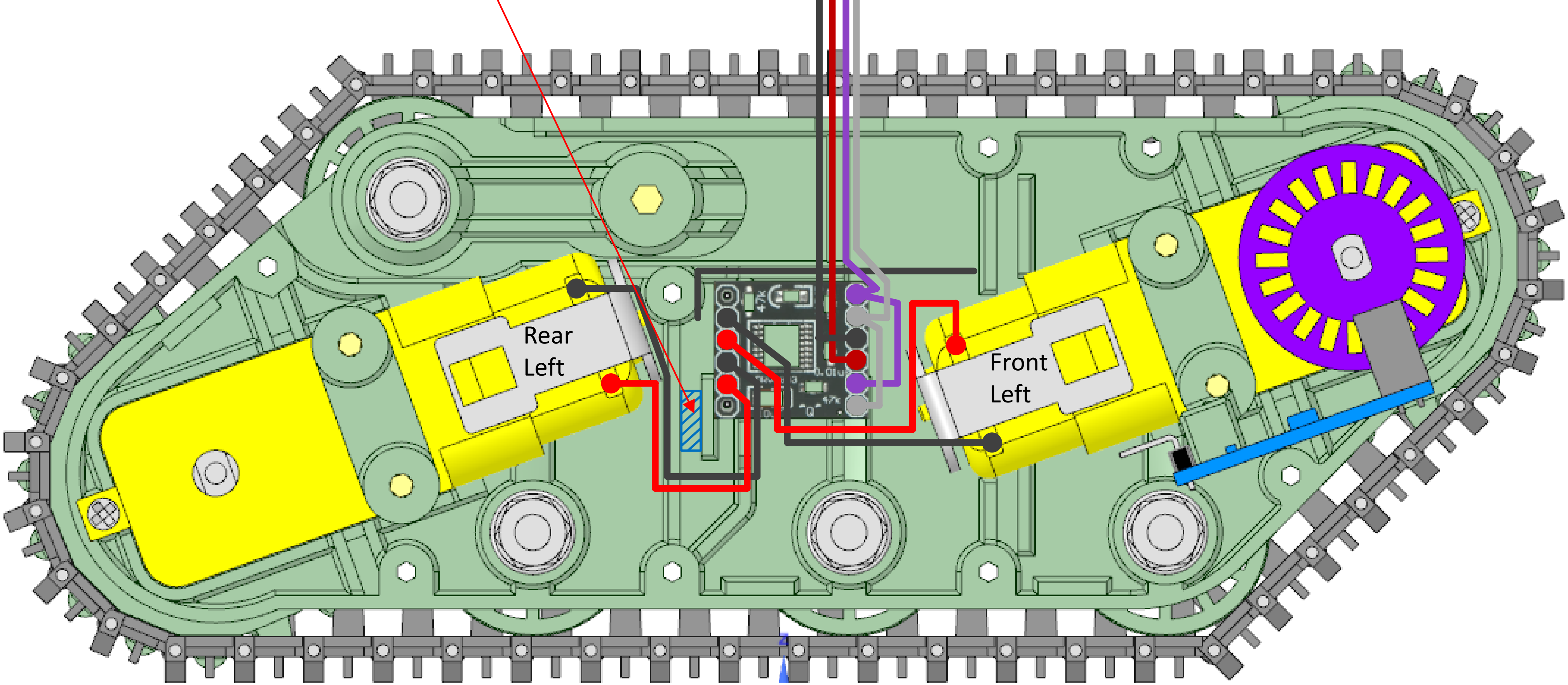
## Left-hand Motor Wiring



The same applies to this side. As the front and rear motors are physically connected via the track, it is essential that they are driven in the same direction, to prevent damage. Follow this diagram carefully. If in doubt, split the track before testing, so that you can observe correct operation before re-connecting the track.

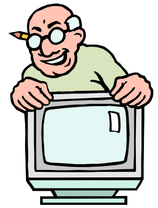
When wiring the motors avoid this shaded area, as it is occupied by the cross plate, which passes through the body of the vehicle.

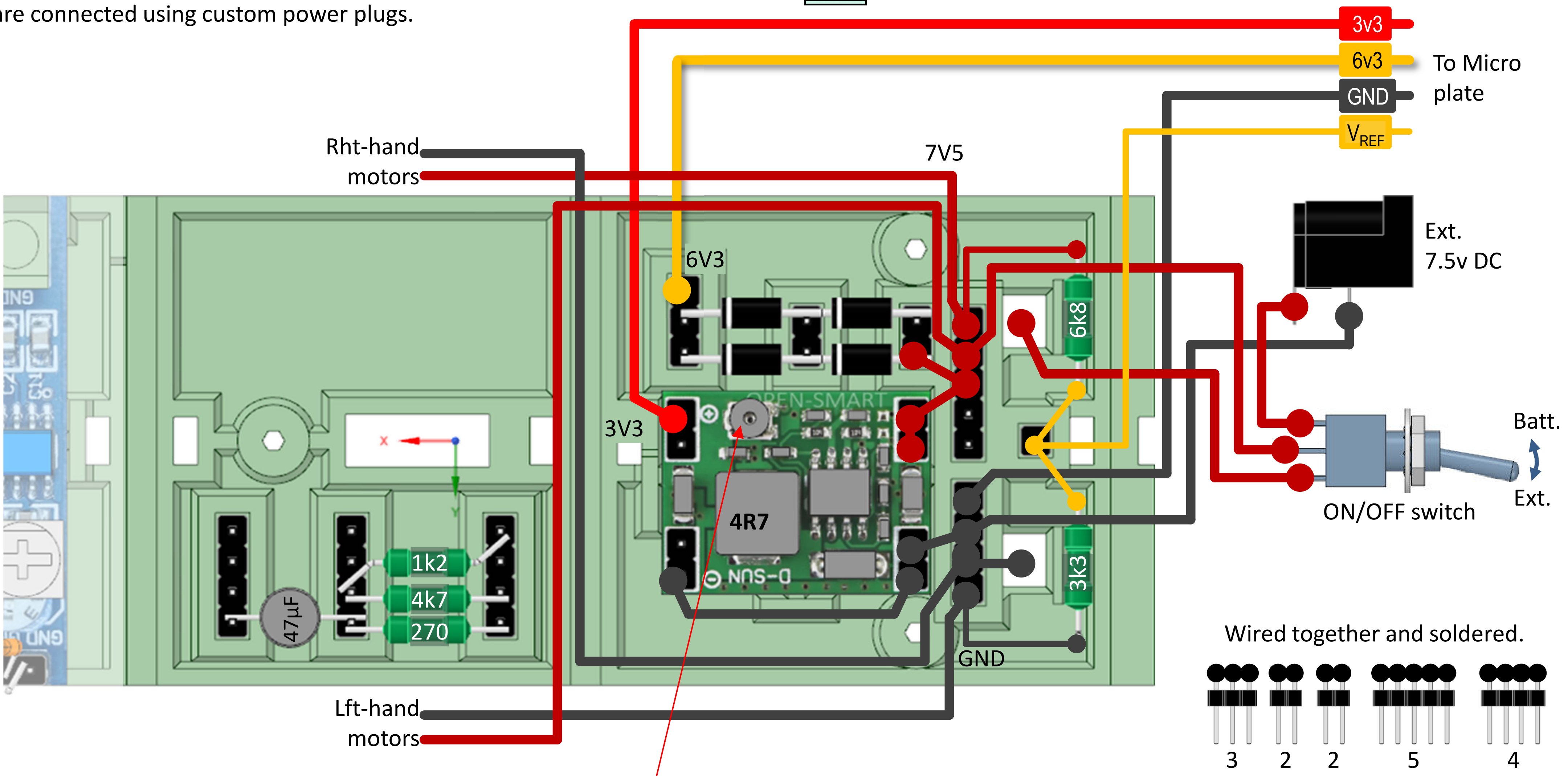


## Battery Plate Wiring

This internal plate is mounted above the battery box, using cable ties. It is the key distribution point for all power wiring. The H-bridge motor drivers are connected using custom power plugs.

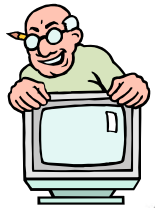





Set voltage regulator output to 3.3v **before** connecting its output to the rest of the system.

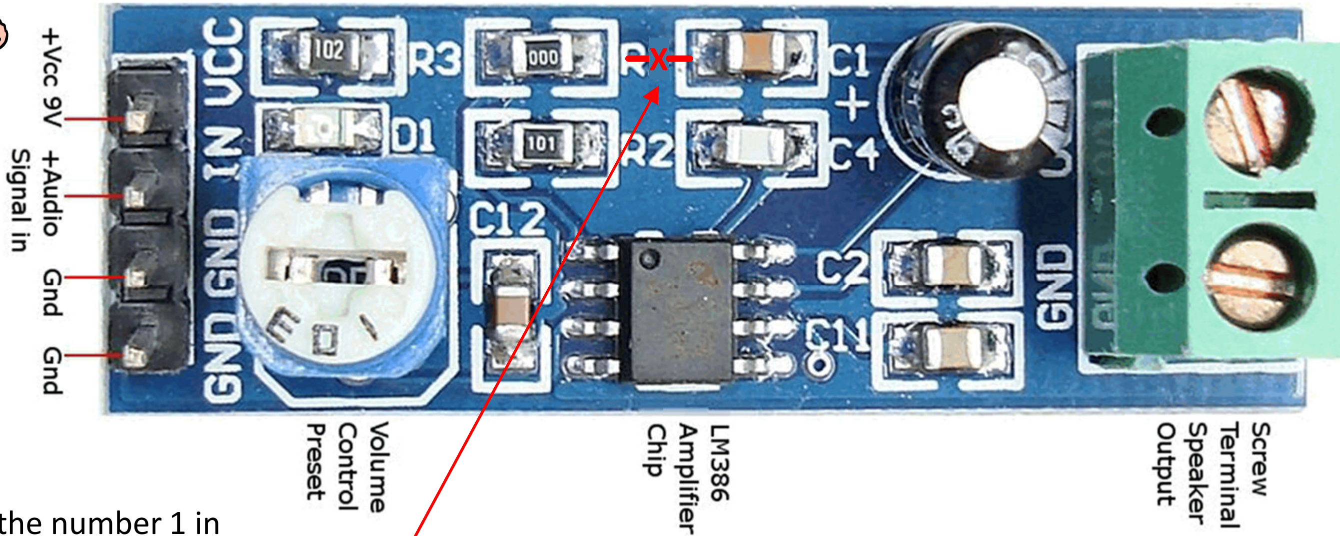
Pin strip connection points are pre-wired as connected pins, before gluing into the battery plate.

## LM386 Amplifier Board

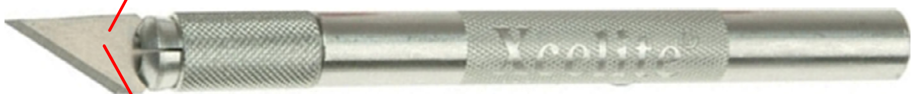


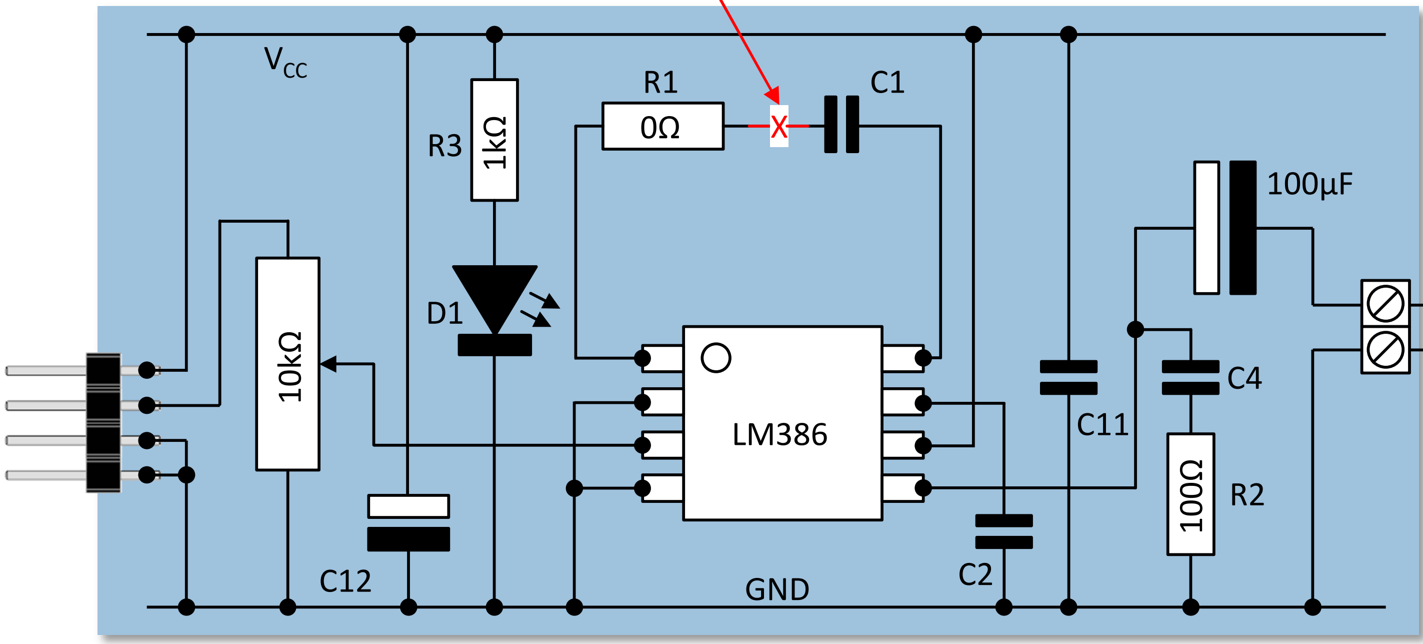
The LM386 audio amplifier is configured as having a Gain = 200. Which is much too high for our application!!!.

Fortunately, we can cut a track on the pcb, which will reduce the gain to 20, and the layout of the pcb makes this relatively simple to do. The capacitor C1 has been inserted to increase the gain, and it is connected in series with a 0-ohm resistor R1, to keep the pcb single sided.



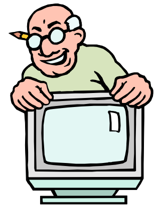

Using a sharp craft knife, cut into the board where the number 1 in the R1 legend is. Then check for a connection between the two components. Repeat this until there is no longer a connection.

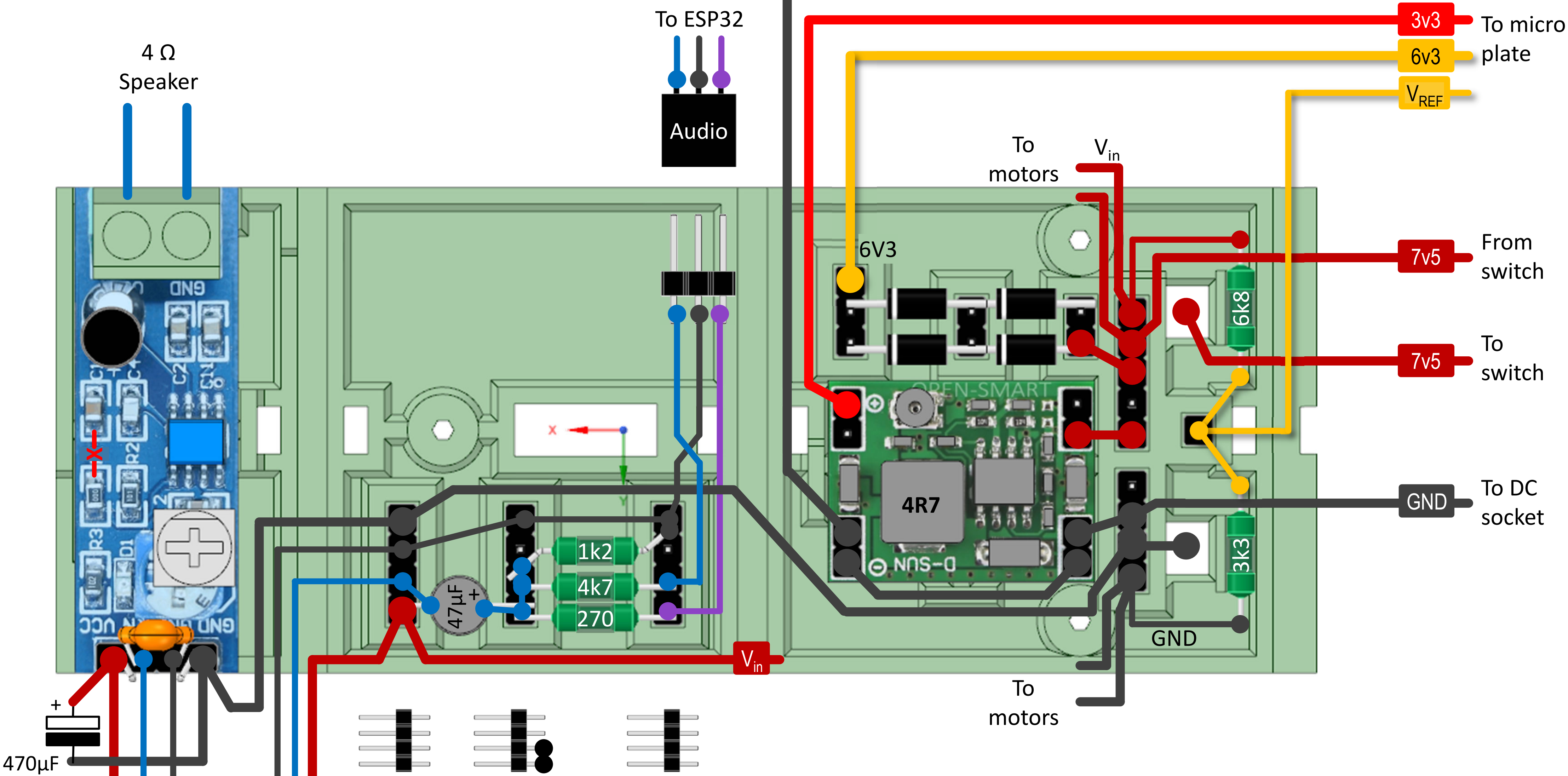




# Battery Plate Audio Wiring

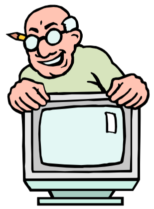
The audio amplifier is mounted on the end of the Battery plate, using a cable tie. Which also retains a 470µF capacitor beneath it. This acts as a power rail smoothing capacitor.



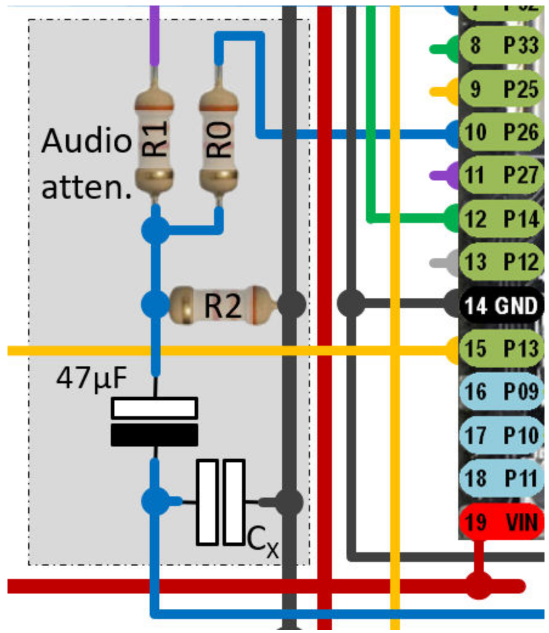



Some pin strip connection points are pre-wired as connected pins, before gluing into the battery plate.

## Audio Attenuator Wiring



The audio output signal can be developed in code by either PWM signals, or from the DAC2. A simple attenuation function is provided by a pin connected to R1. If this pin is configured as an input, it will have no affect; but if it is set to an output and driven LOW it will significantly reduce the output fed to the amplifier.




R0 = 4k7Ω
R1 = 270Ω
R2 = 1k2Ω

In all cases the audio waveform will have fast edges and high frequency noise, which needs to be removed before feeding it into the LM386N audio amplifier. So we need to filter that HF noise using a simple low pass RC network. The audio signals also have a DC offset on them, centred around the mid-rail voltage, which needs to be removed via a in-line series capacitor, as the amplifier input expects signals to be centred on GND.

As the attenuation method used effectively changes the impedance of the circuit we will select a capacitor to suit the high output condition, when R1 is effectively out of the circuit, and the pin is an input.

The 3dB cut-off frequency of the RC network occurs when the impedance Xc == R, where the value of R is R0 in parallel with R2. This value is 956 ohms.

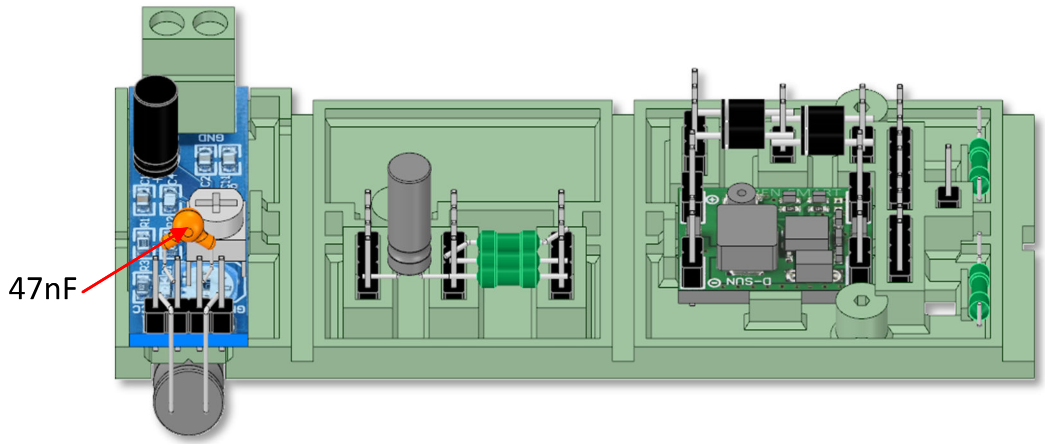
We calculate impedance of a capacitor as: $Xc = 1 / (2 \times \pi \times F \times C)$

Re-arranging this gives: $C = 1/(2 \times \pi \times F \times Xc)$

Using a cut-off frequency of 4 kHz, calculating capacitance gives us:

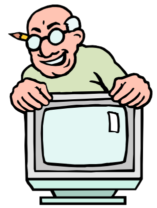
$C = 1 / (2 \times \pi \times F \times Xc) = 1 / (2 \times 3.142 \times 4E3 \times 956) = 41.6\ E\text{-}9$

We will therefore use Cx = 47 nF, as the HF audio attenuation option, and this will be attached at the terminals of the amplifier.

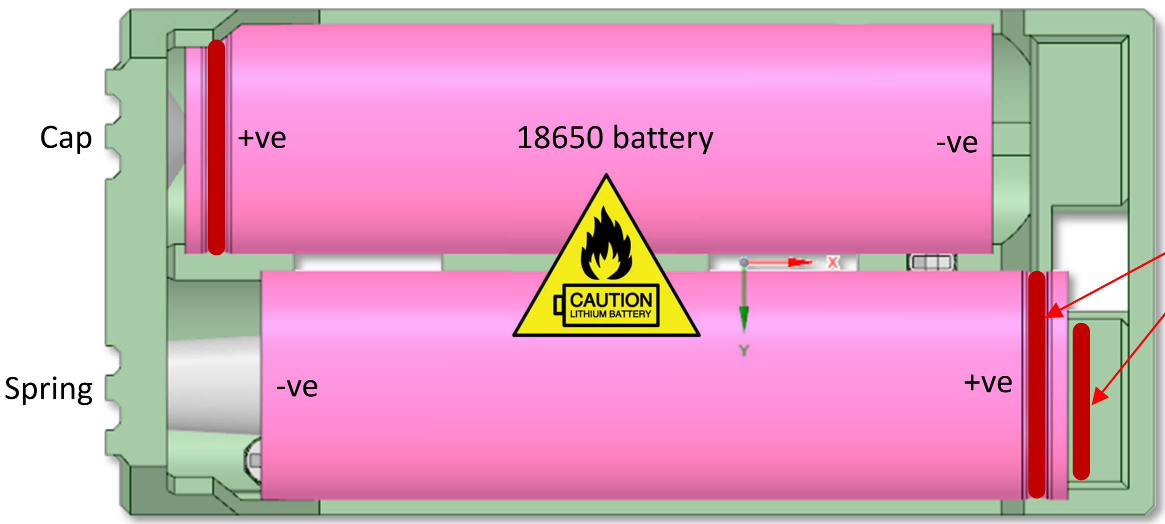


# Battery Box Wiring

The cap and spring clips are glued into the base of the battery box, so that their leads protrude through the base into the battery plate. Where as the cap and spring clips in the cover are first soldered together, before being glued into the cover as one piece.

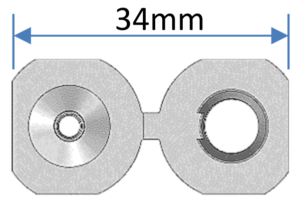




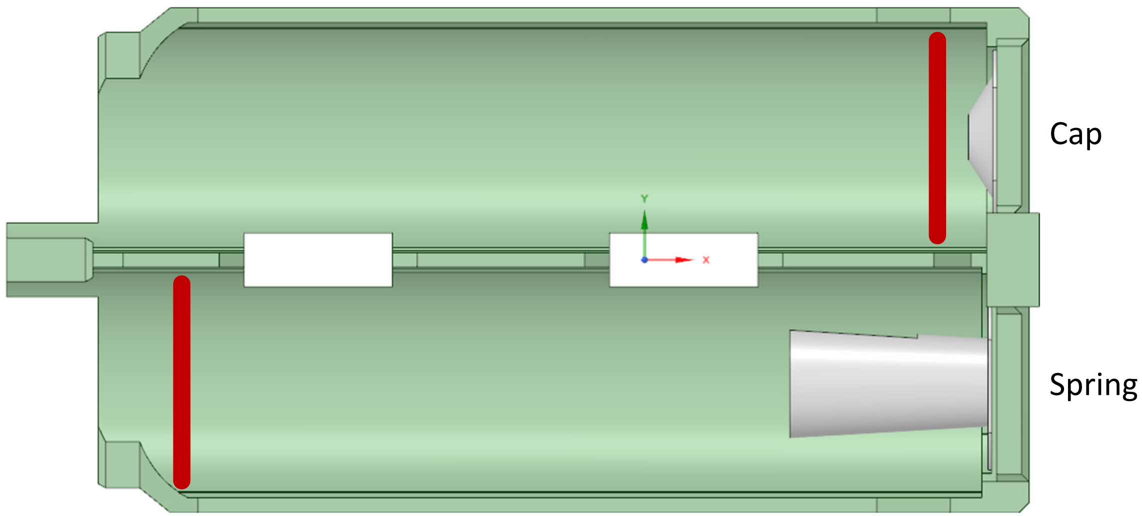



Base

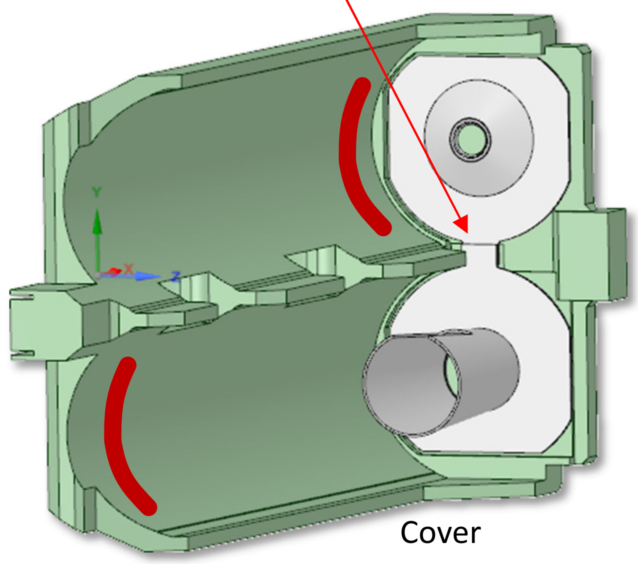
Mark the positive ends of each battery and the corresponding case surface with a red indelible marker, for easy reference.




Crop, smear on flux, and solder the two connectors together **before** gluing them into the cover. Note that the spring is on top of the cap.




Cover



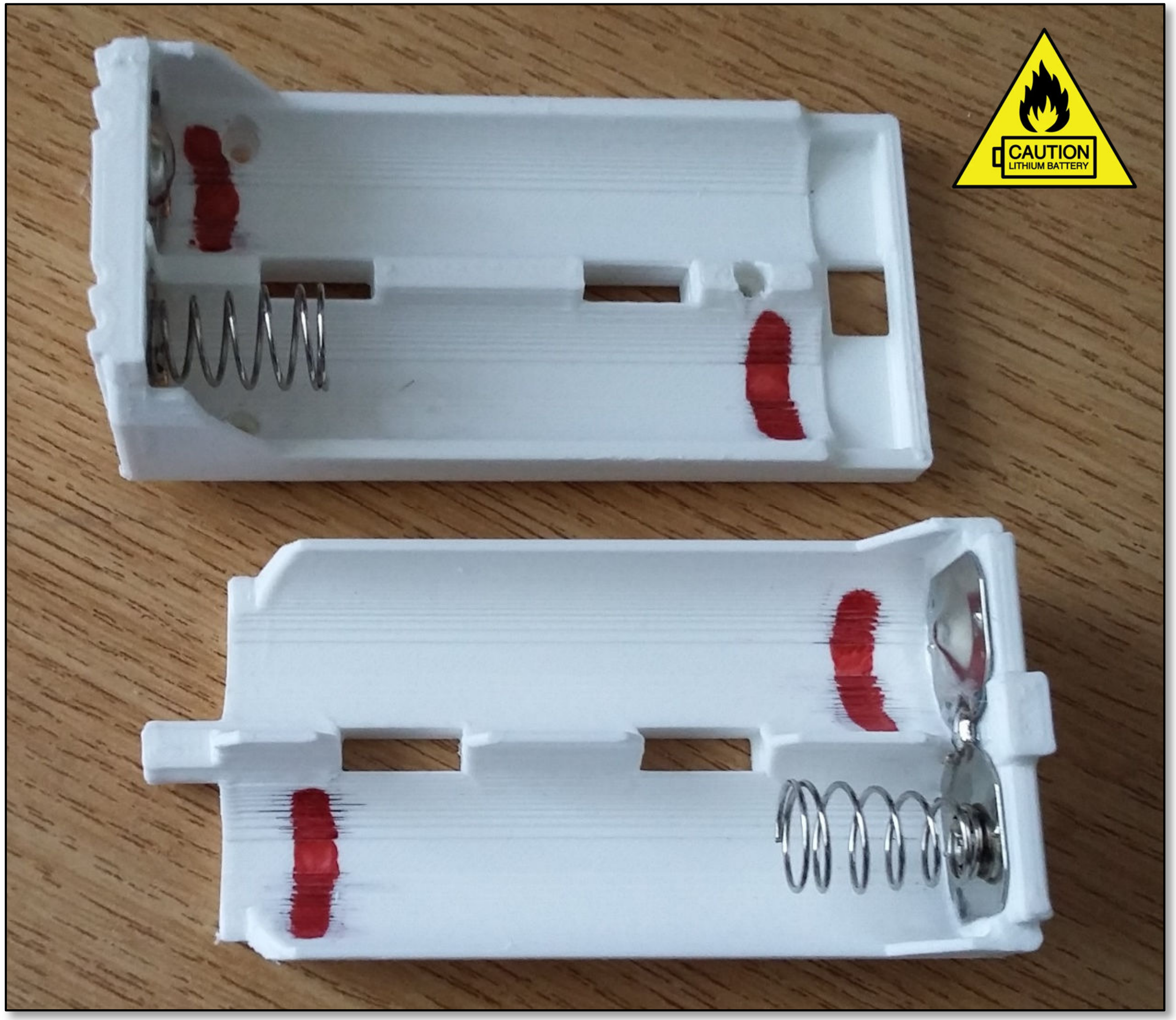
Cover

# Battery Box Wiring

Crop and solder the spring and end cap together, ensuring that the space between them matches that of the battery holder.

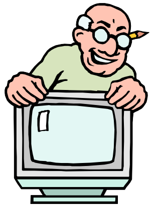
The use of soldering flux will help to reduce oxidation and make the soldered joints easier. Tin both parts separately, then place one over the other and apply heat to melt them together.

Note the markings in red, using a felt tipped pen, to ensure that you always insert the batteries the correct way round. There is no current protection in this system, so always take extreme care.



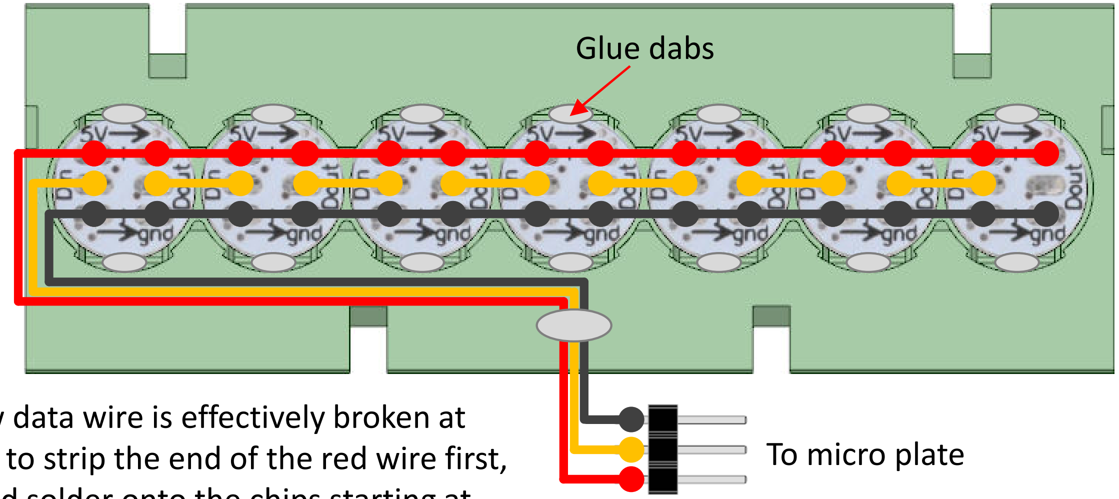


## Nose Plate LED Wiring



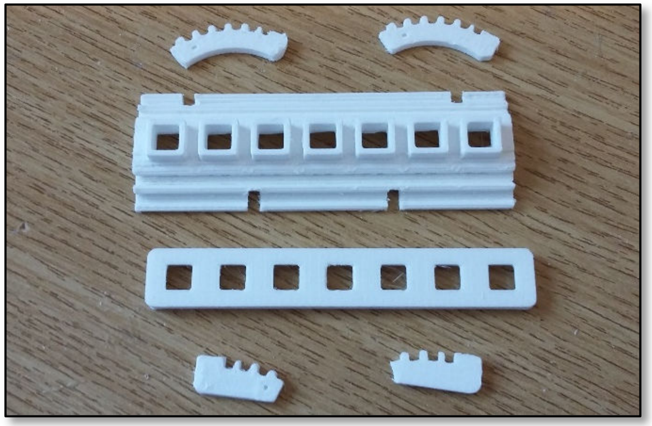
The RGB LED strip mounted in the Nose Plate is made up of individual WS2812B LEDs, glued into the mounting plate.

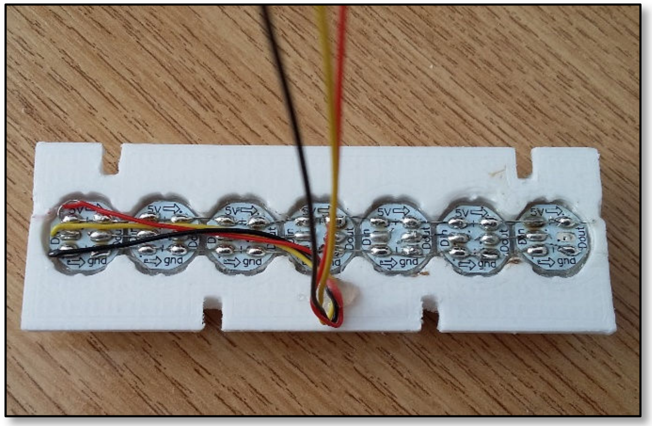
Glue the LEDs into their respective positions first, noting their polarity and orientation. Insert all of the LEDs first, before applying small dabs of glue top and bottom, to each one. Ensure that you do not get any glue on the contact pads.

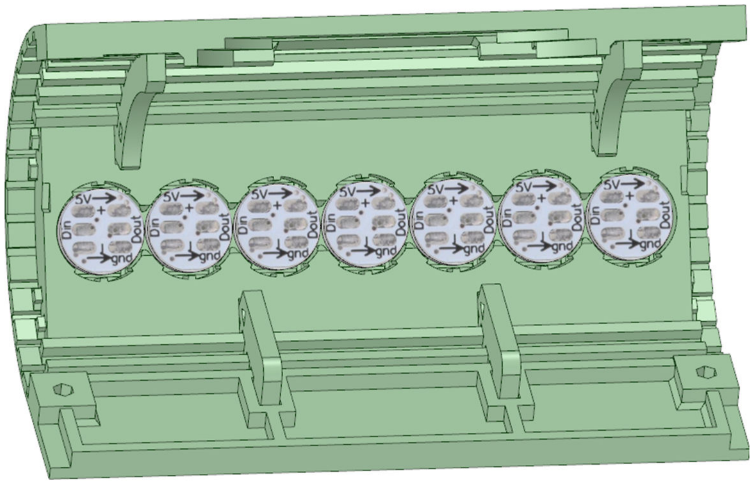



Use wire wrap wire to make the solder connections. Note that the yellow data wire is effectively broken at each chip, to form an input and an output. The easiest way to wire this is to strip the end of the red wire first, to run the full length of the strip. Lightly smear the chip pads with flux and solder onto the chips starting at the insulated end. The data wire is attached in a similar manner, but the stripped section is longer, and after each input pad is soldered the wire is raised up, then down again to form a small loop, prior to soldering it onto the next output pad. Once all data pads have been soldered, you can then cut out the looped wire in the centre of each chip, effectively breaking the in/out connections. The black GND wire is attached in the same way as the red wire. Red and black wire length >= 27cm, yellow wire length >= 32cm, allowing for loops in the data wire.

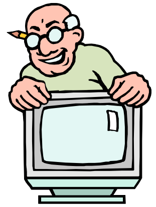
Once soldered, you can test the strip by temporarily wire wrapping it to your ESP32 micro, and running the code in TEST = true mode. Then fold down the loose wires and group them together, either by twisting or using heat shrink sleeving. Wire the free ends to a 3 pin strip as shown. This will later connect to a plug from the Micro Plate wiring.







## Display & Micro Power Wiring

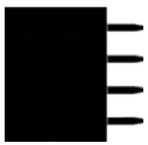


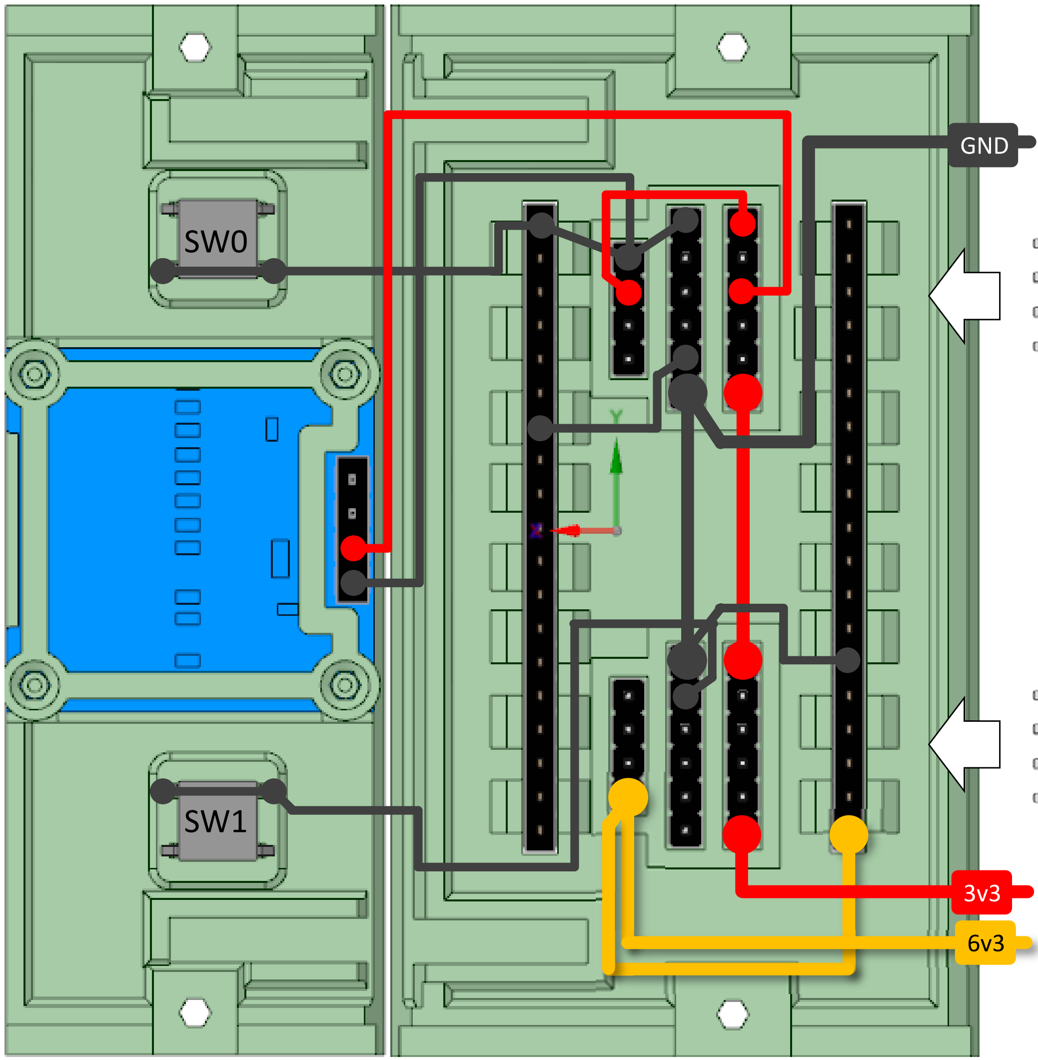
Pre-wire and solder the pin strips as shown, then glue them into the plate, along with the socket strips for the ESP32, and the button switches. Attach the OLED display using the small strap and 2x10mm screws.

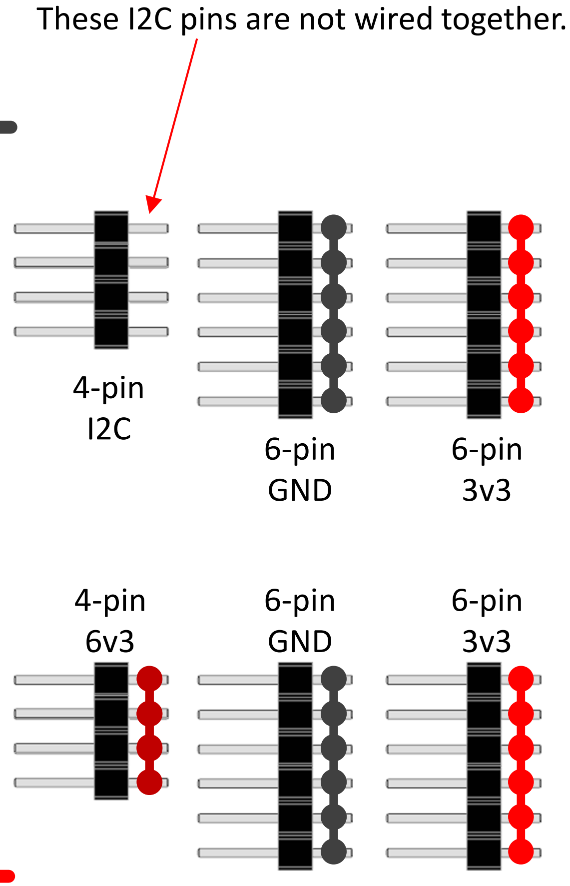
The pre-wired pin strips act as common connection points, which are easy to wire wrap to.

Start by running in these wires. The power feed in wires are soldered onto the pins, where as the other wires can be wire wrapped initially, and tested functionally, before finally soldering those connections.

A 4-pin socket is used to connect to the display, to ease maintenance tasks.

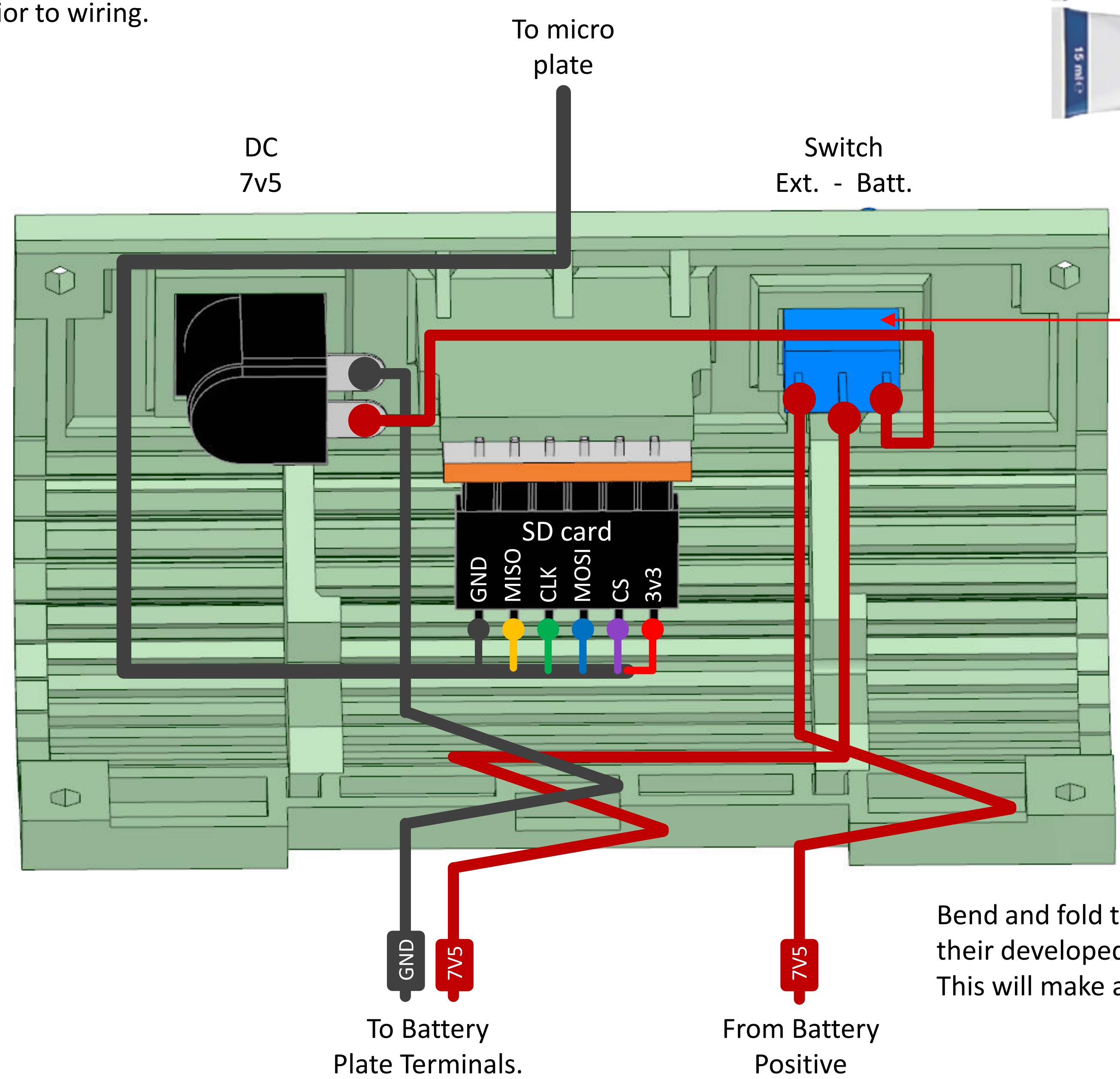




## Heal Plate Wiring

The DC power socket, toggle switch and micro-SD card reader at glued into the heal plate, prior to wiring.

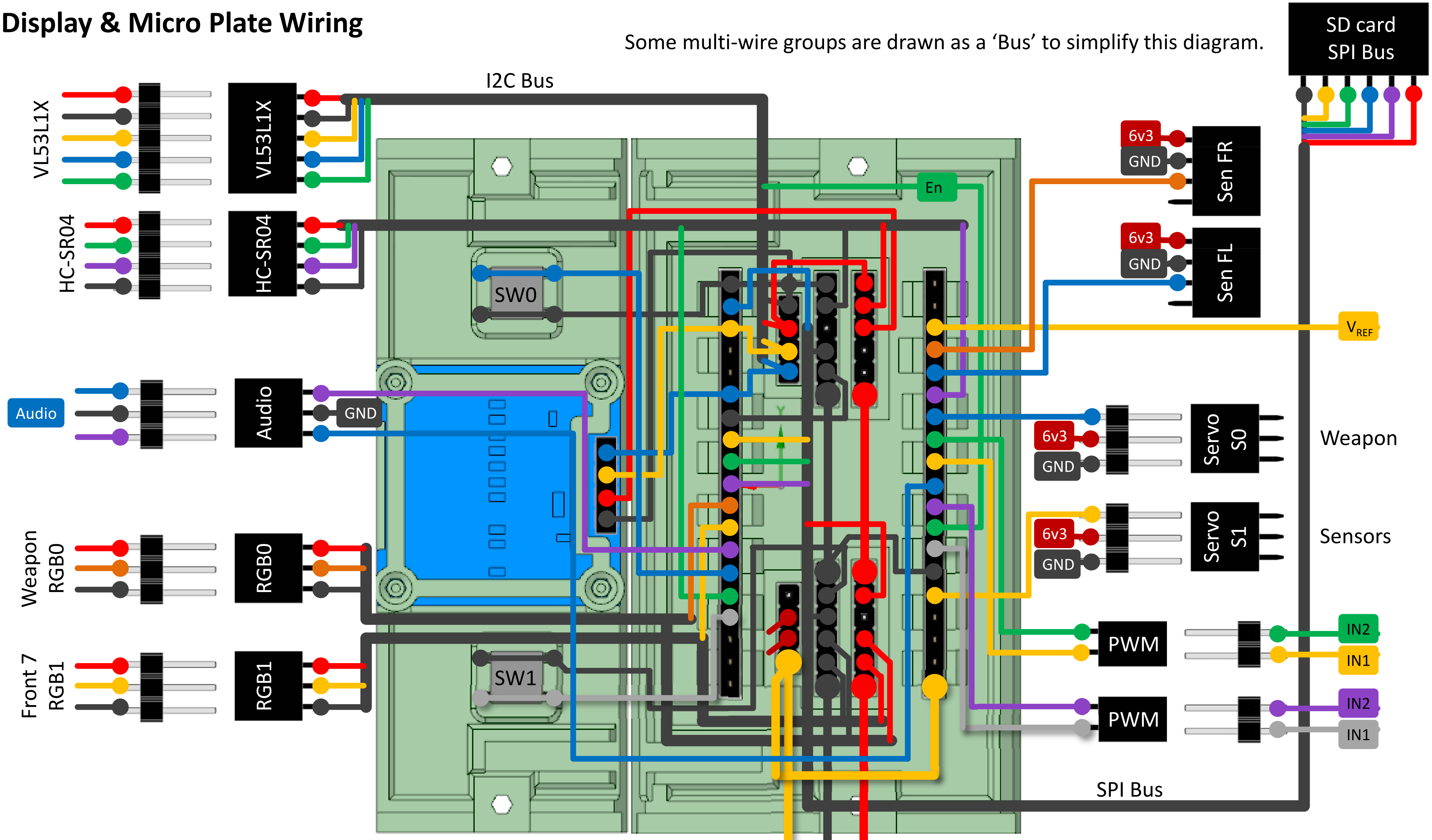




The toggle switch enables power to be taken from either the DC power socket or the battery pack. This is useful when operating the TankBot on a stand, during software changes and testing.

Bend and fold the battery wires, so that their developed length can be extended. This will make assembly easier.

# Display & Micro Plate Wiring

Some multi-wire groups are drawn as a 'Bus' to simplify this diagram.

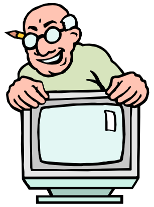



This diagram shows the use of floating plugs and sockets, which are important for assembly and future maintenance. Wire to the micro plate first, then trim wires to length before connecting to plugs, etc



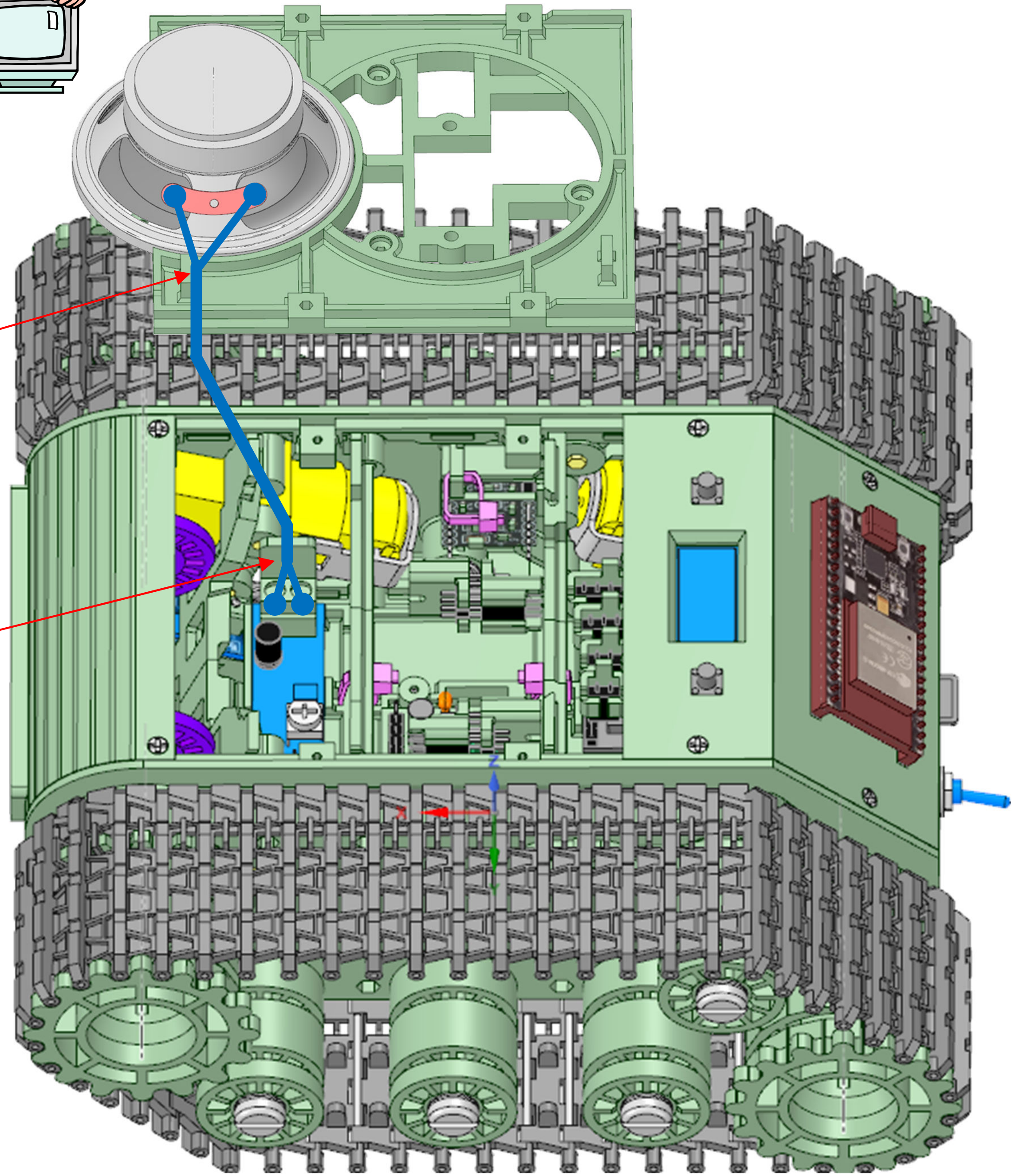
Issue: 1.1 Released: 08/12/2025 TechKnowTone

## Speaker Wiring



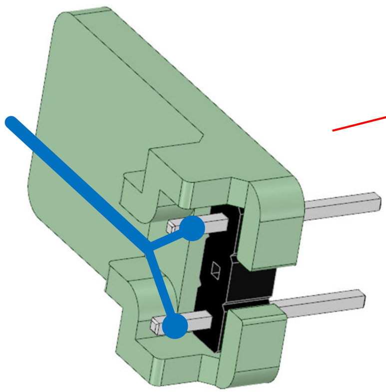
Glue the speaker into the Top Plate, with the connections orientated as shown. Allow the glue to set fully.

Wire the speaker as shown, to a 2-pin strip, which is actually 3-pin, with the centre pin removed. Solder the connections and glue the pin strip into the Amplifier Connector. This component makes it much easier to insert the pin strip connections into the amplifiers screw terminal block.



Cable tie

Wire wrap the modified 3-pin strip, and solder the connections. Then glue the strip and wires into the custom holder, which is designed to make it much easier to insert the terminals into the amplifiers terminal block.

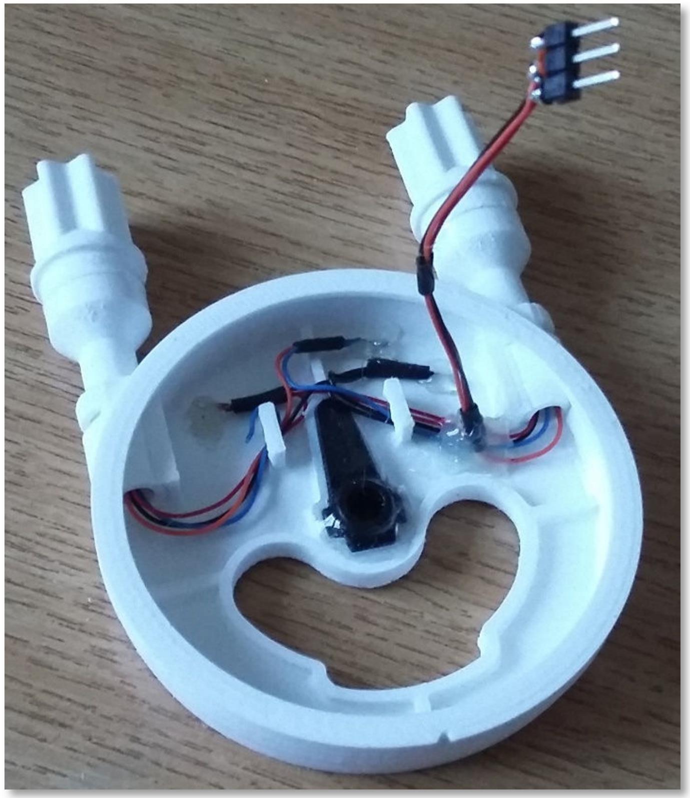


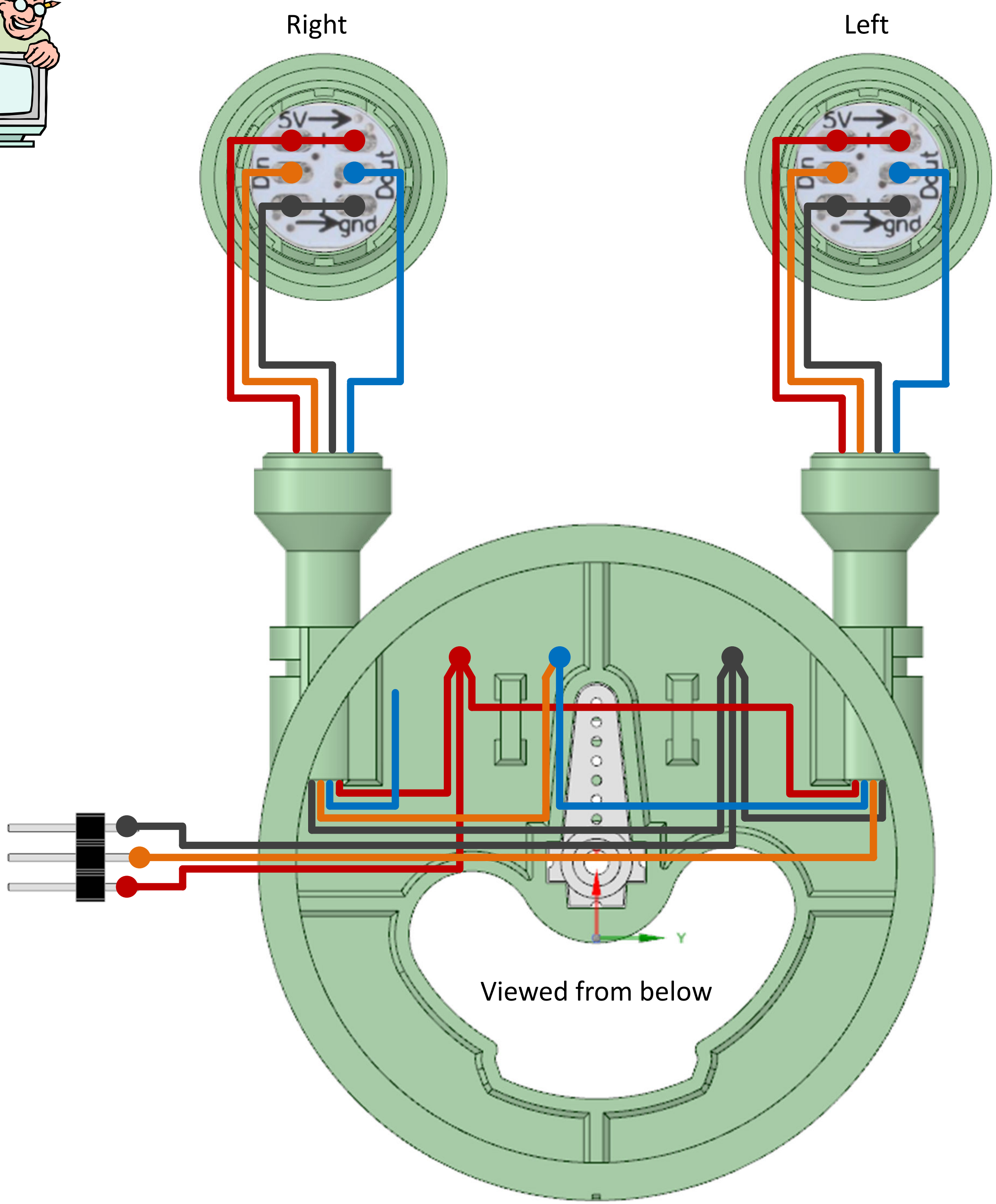
# Turret LED Wiring

The weapon LEDs are wired in the same manner, as shown here, but connected inside of the turret such that the data out of the left LED (blue) is fed into the data in of the second LED (orange) on the right.

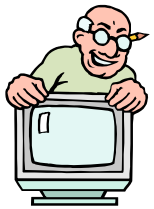
A separate lead, with a 3-pin plug, is then used to make these connections with the micro plate.

As the weapons are a glued assembly, make sure that all connections are good, as it will be impossible to access the LED wiring once the parts have been glued together.





# Turret Sensor Wiring



The range sensors are mounted in the turret, and connected to the main chassis via two multi-core cables.

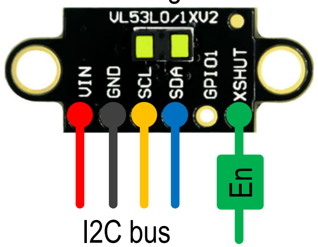
Wire-wrap the 4-pin and 6-pin sockets first then feed their wires through the turret plate apperature.

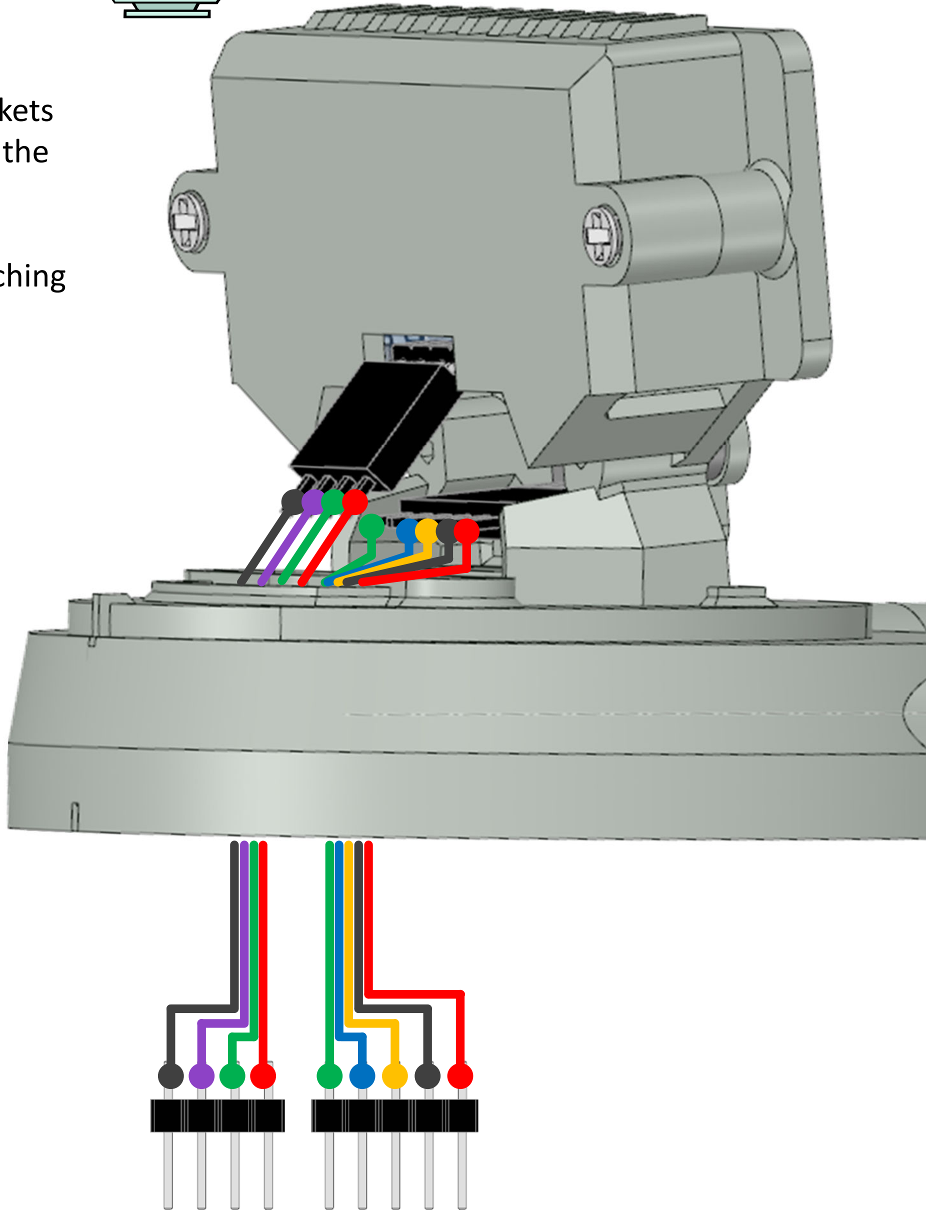
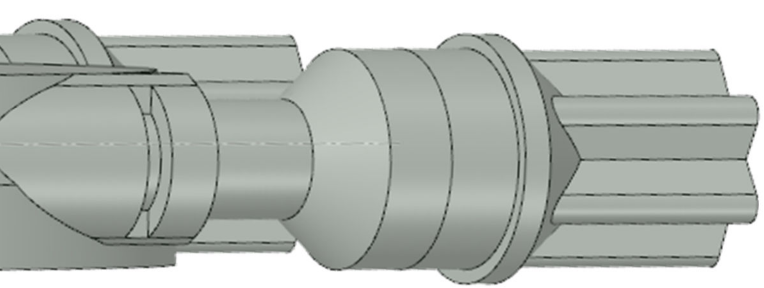
Then complete each cable by attaching a 4-pin and 5-pin plug.

HC-SR04

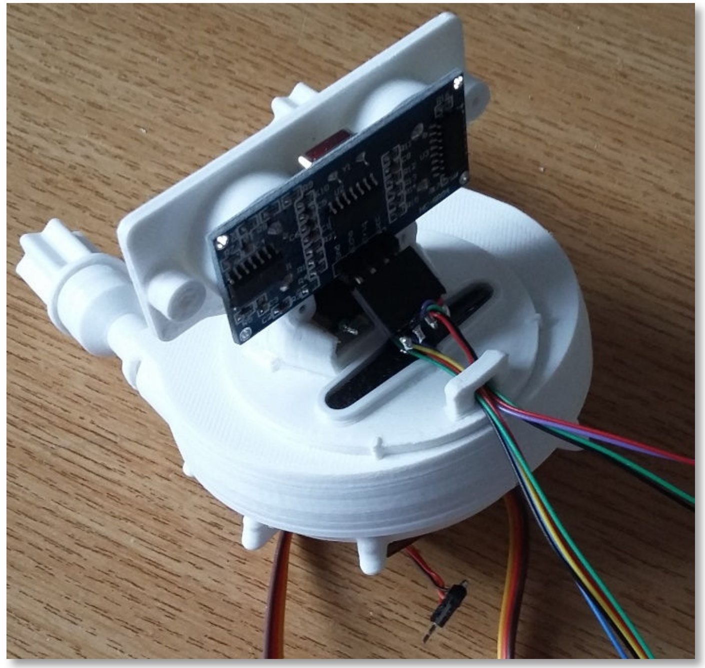

Viewed from the front

VL53L1X
Laser range finder

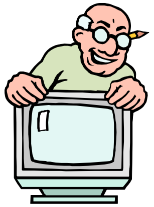


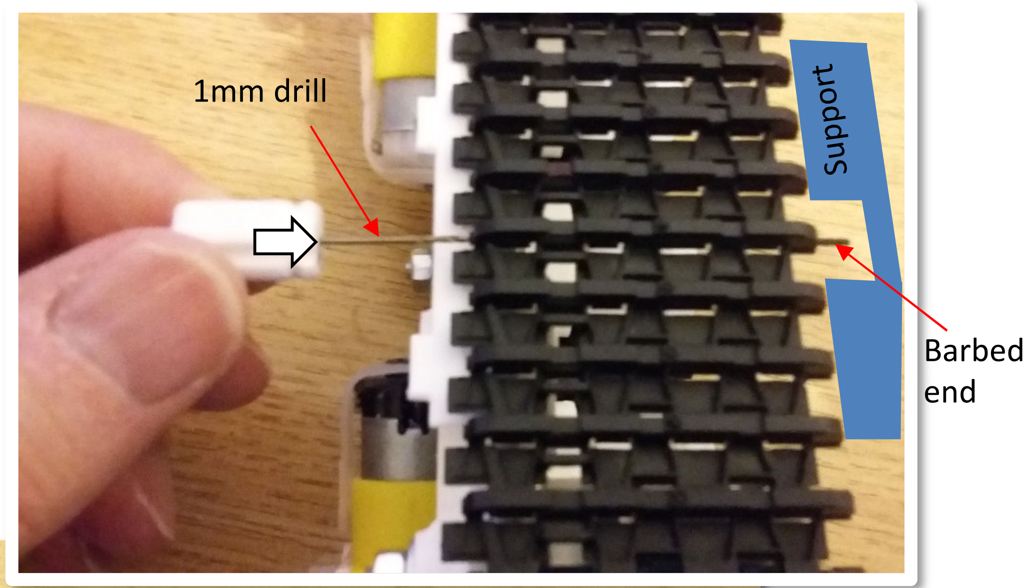
HC-SR04 VL53L1X



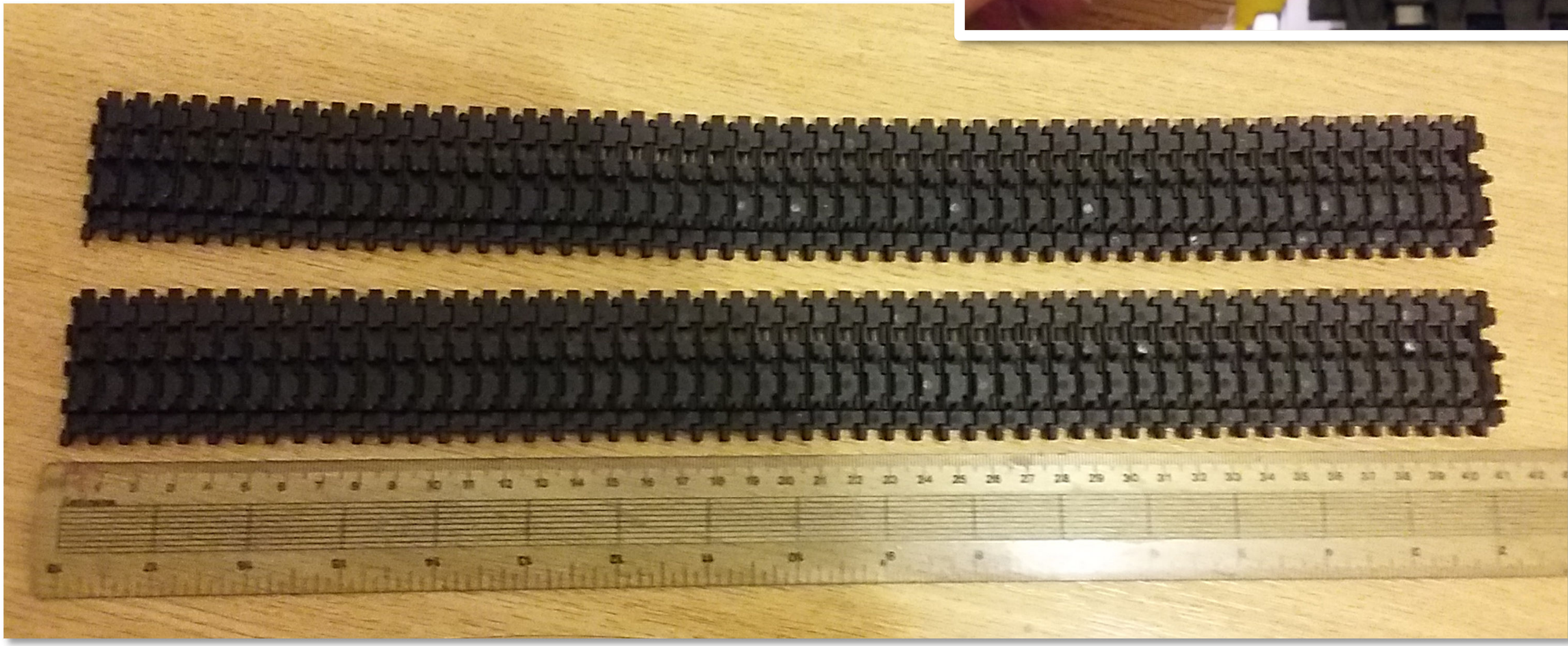
## Track



To get two tracks of the required length I had to buy two sets, and split them. The fitted tracks have 52 links each, and are 405mm in length. This gives sufficient slack to connect up the track, and then tension it with the sliding adjuster. It does not need to be too tight.

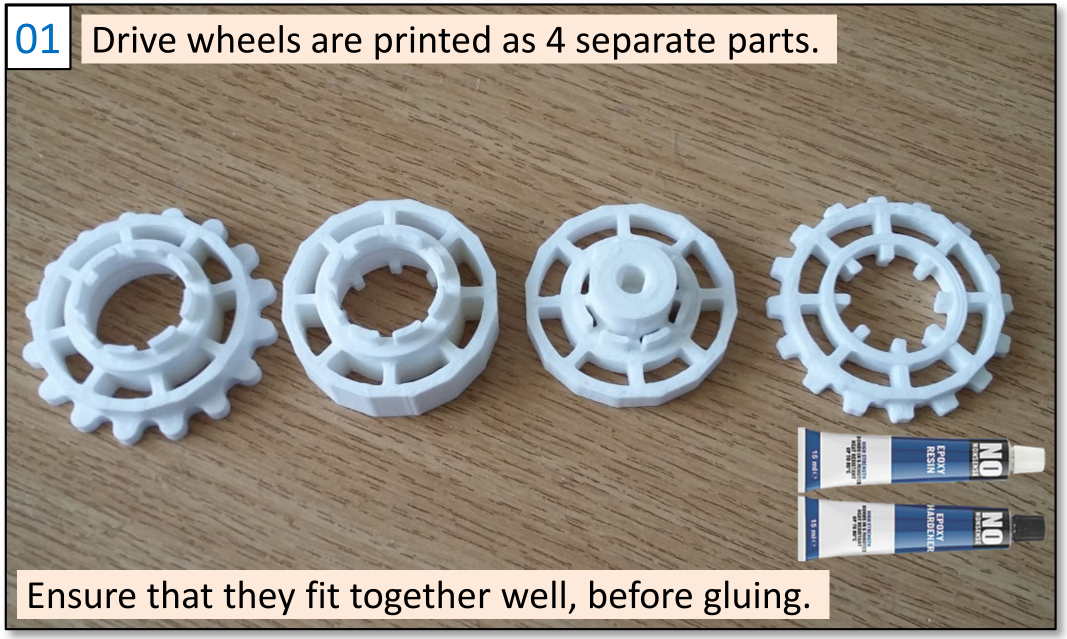



To remove a track pin, to separate the track, support it either side of the link as shown. Then apply pressure to the pin using a 1mm drill or Alen key. It is a good idea to mark the link from which the pin was removed in some way, so that in future a different pin can be removed. Thus reducing the wear caused by removing and re-inserting the same barbed pin.



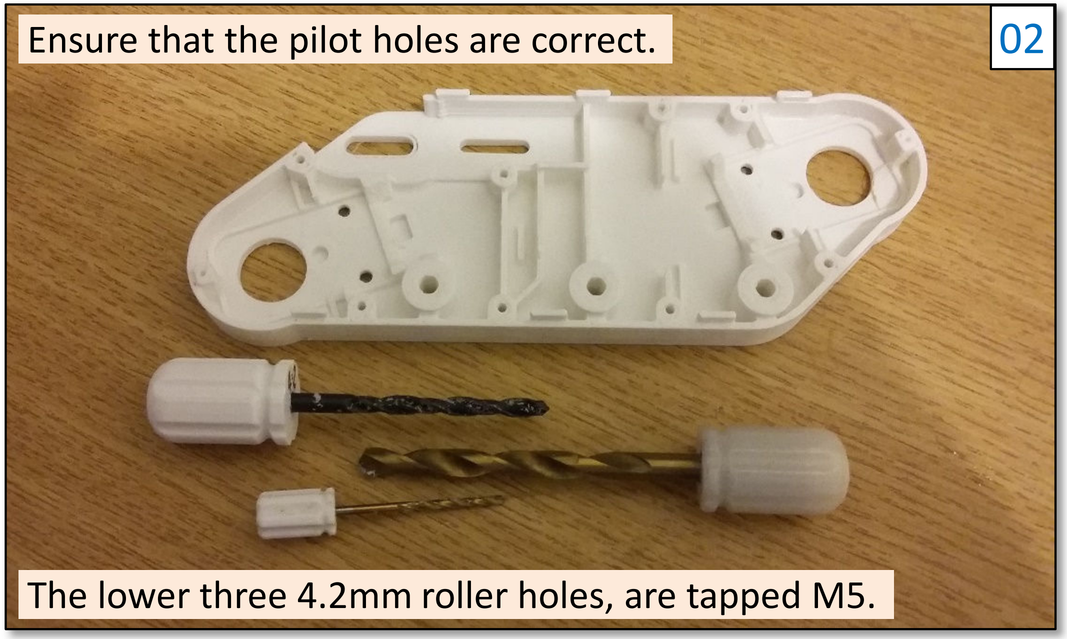
## Build Sequence Photos

01 Drive wheels are printed as 4 separate parts.



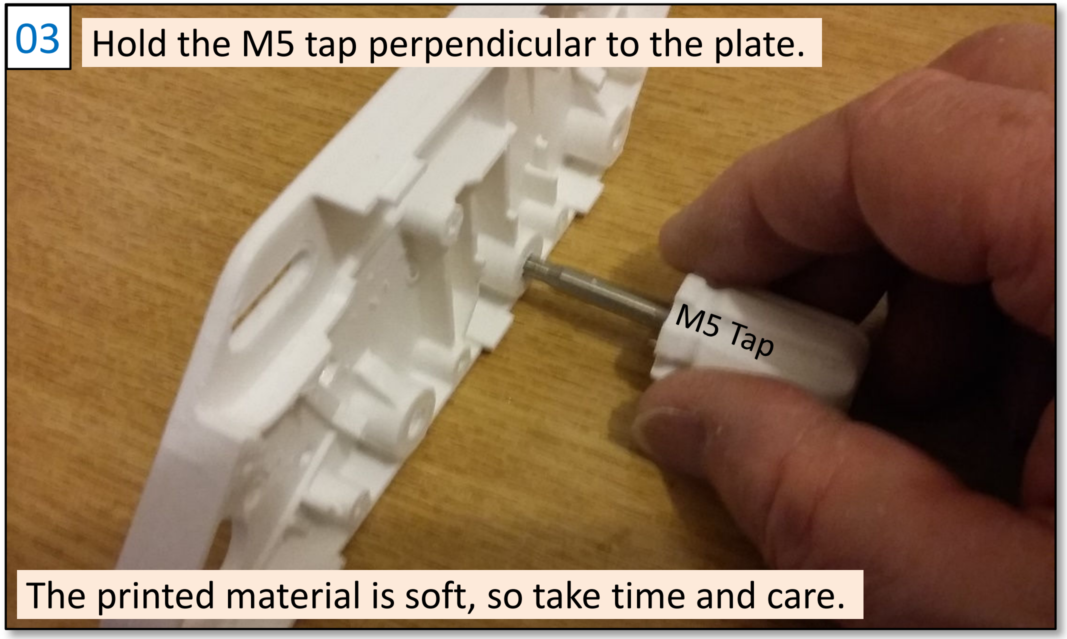
Ensure that they fit together well, before gluing.

02 Ensure that the pilot holes are correct.



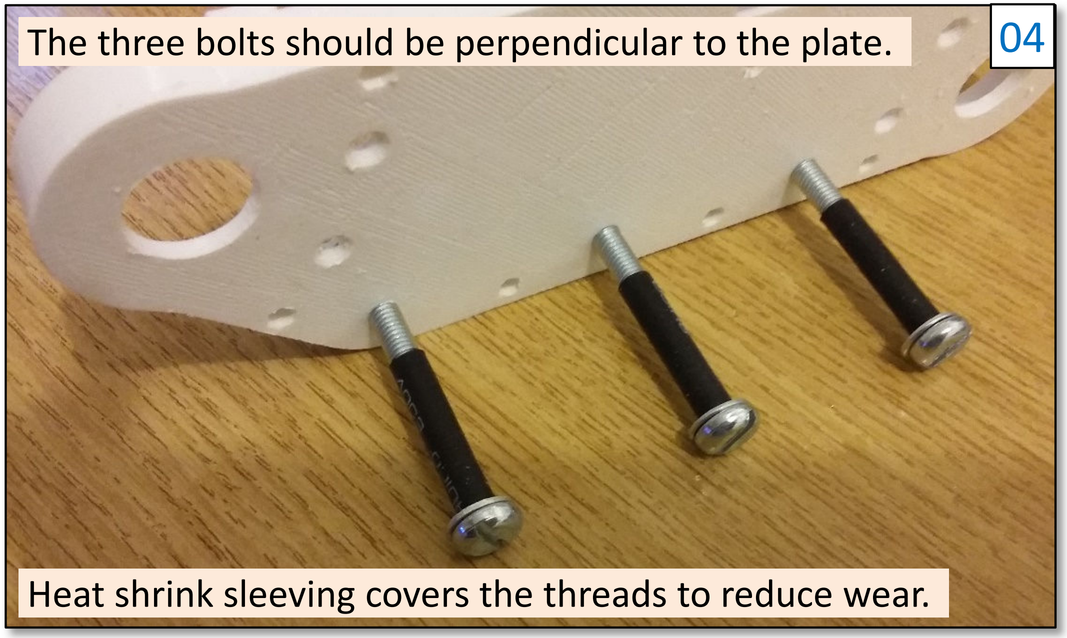
The lower three 4.2mm roller holes, are tapped M5.

03 Hold the M5 tap perpendicular to the plate.



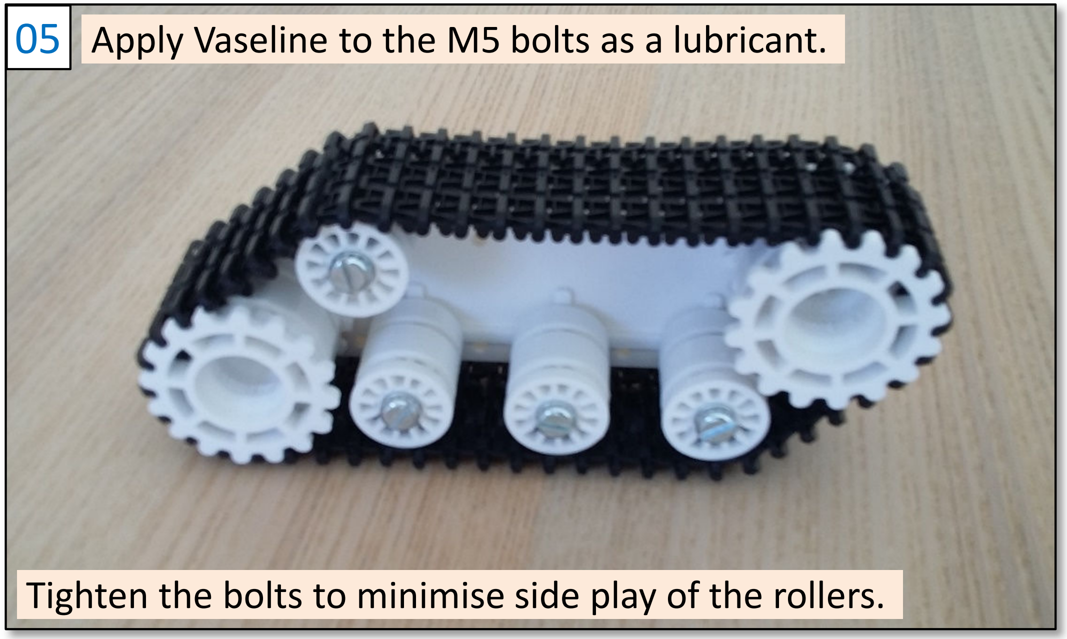

The printed material is soft, so take time and care.

04 The three bolts should be perpendicular to the plate.



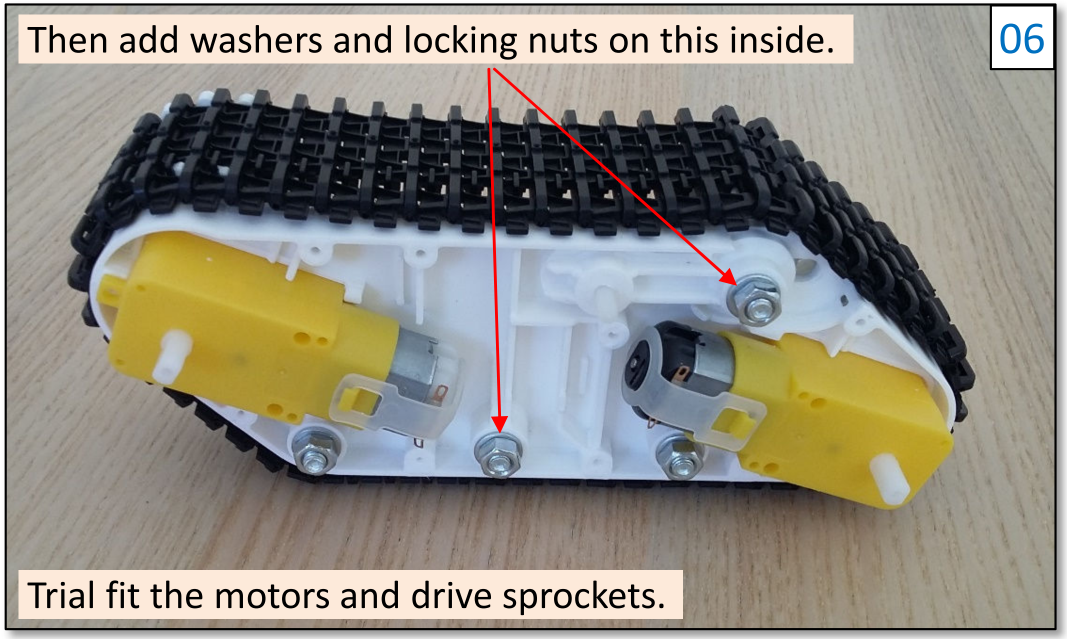
Heat shrink sleeving covers the threads to reduce wear.

## Build Sequence Photos



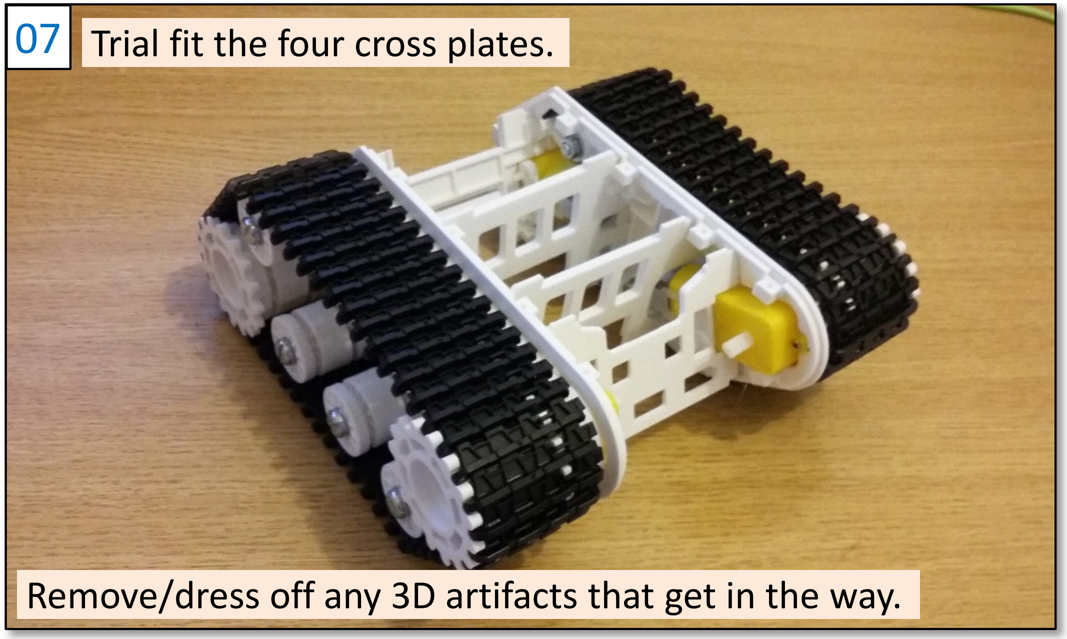
05 Apply Vaseline to the M5 bolts as a lubricant.

Tighten the bolts to minimise side play of the rollers.



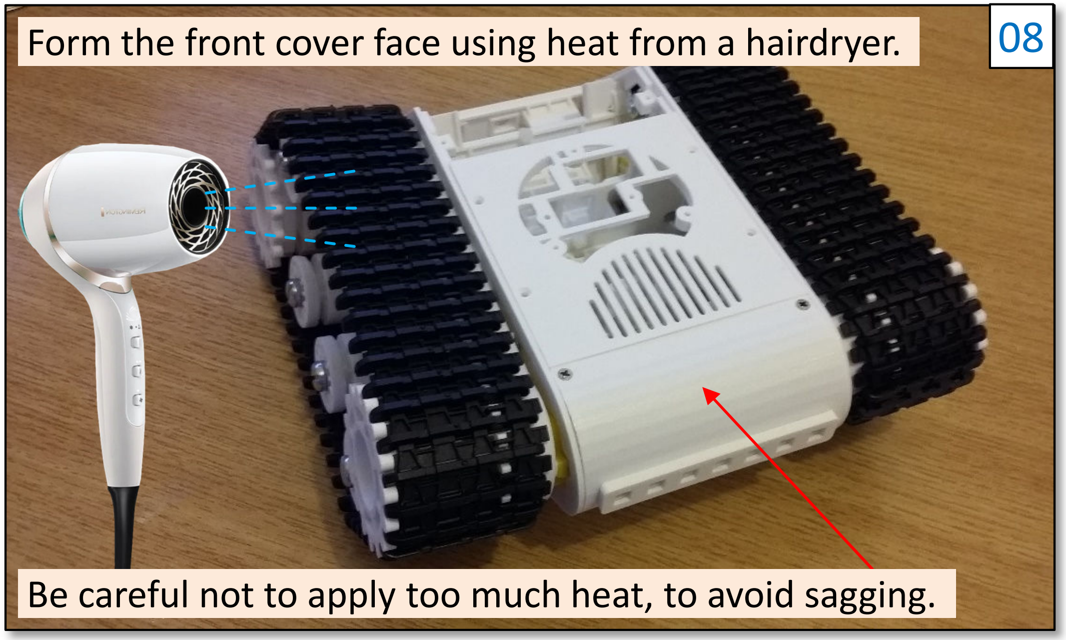
06 Then add washers and locking nuts on this inside.

Trial fit the motors and drive sprockets.



07 Trial fit the four cross plates.

Remove/dress off any 3D artifacts that get in the way.

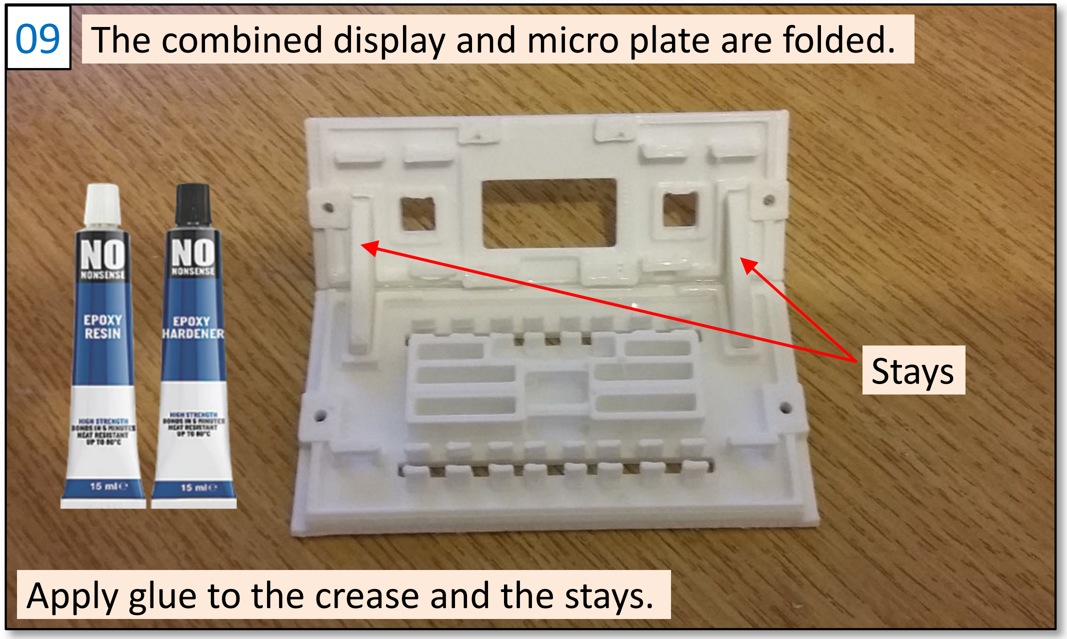


08 Form the front cover face using heat from a hairdryer.

Be careful not to apply too much heat, to avoid sagging.

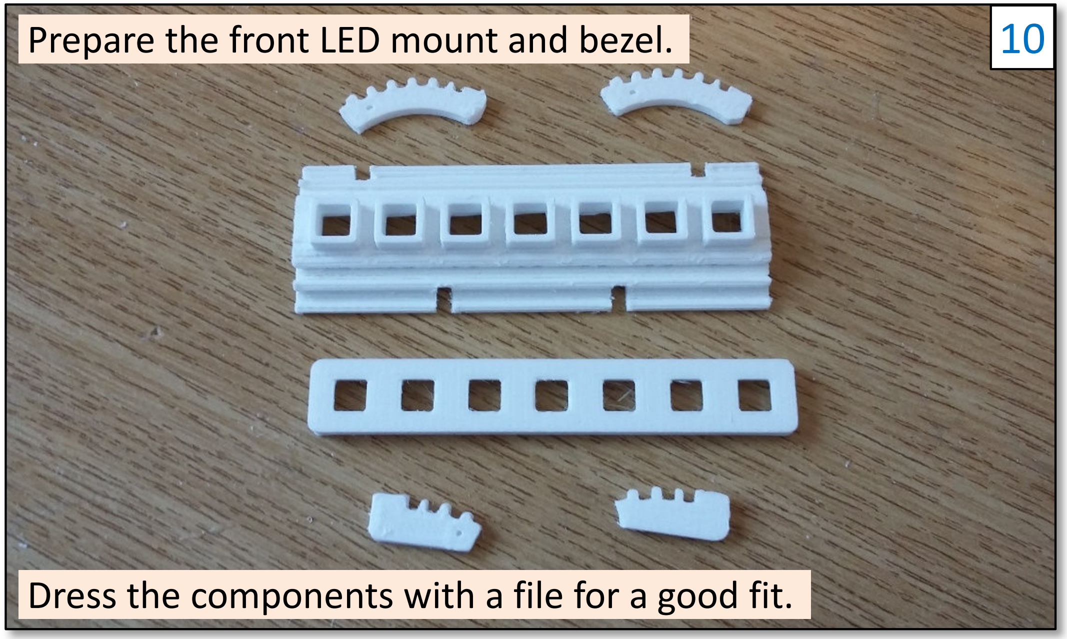
## Build Sequence Photos

09 The combined display and micro plate are folded.



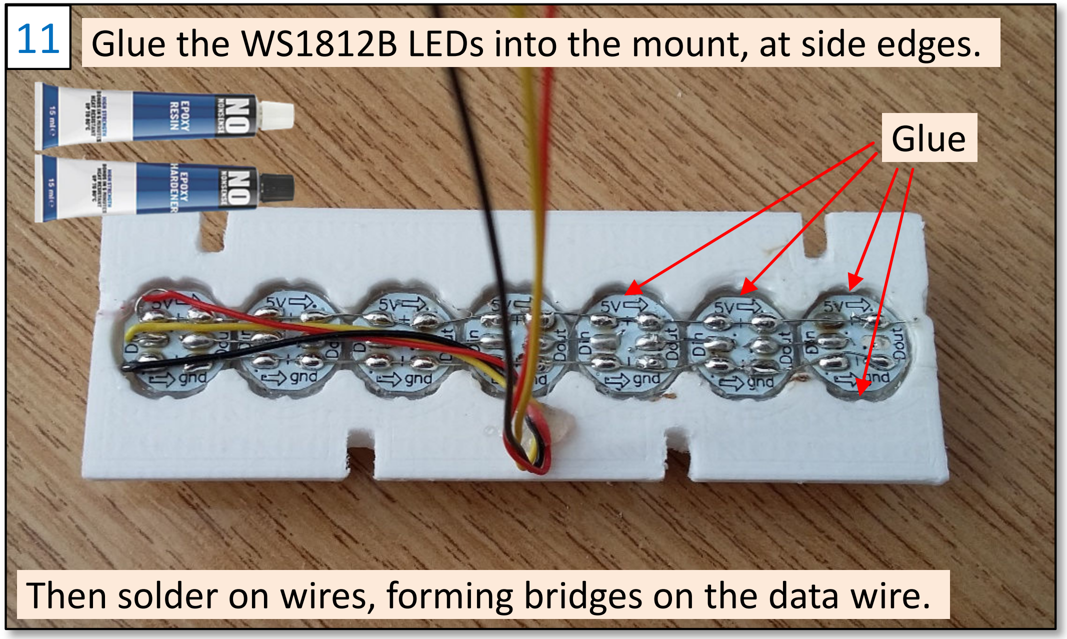

Apply glue to the crease and the stays.

10 Prepare the front LED mount and bezel.



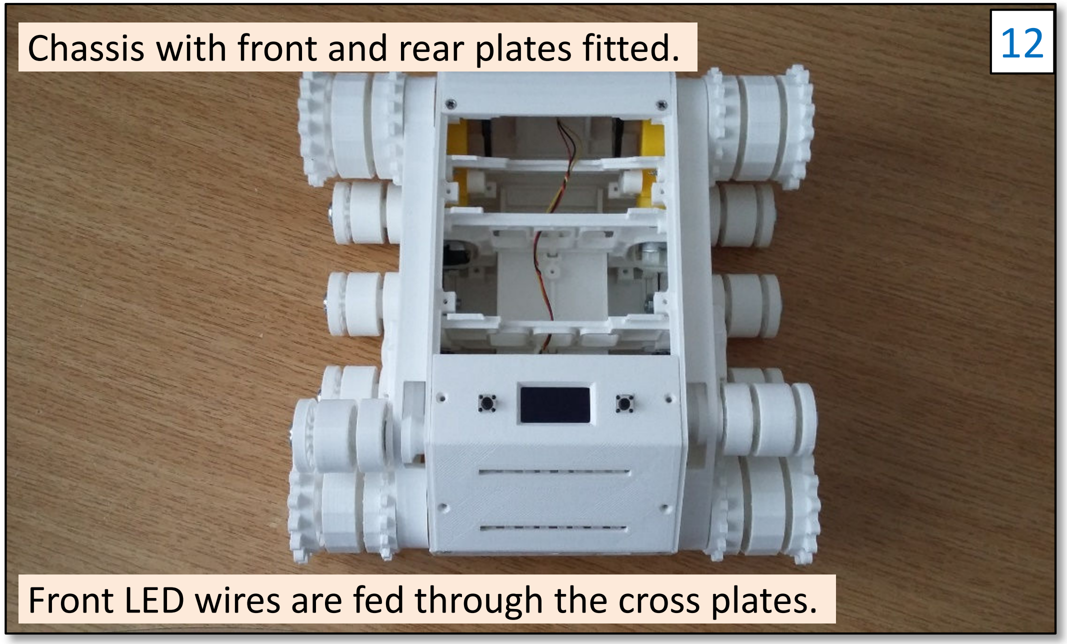
Dress the components with a file for a good fit.

11 Glue the WS1812B LEDs into the mount, at side edges.



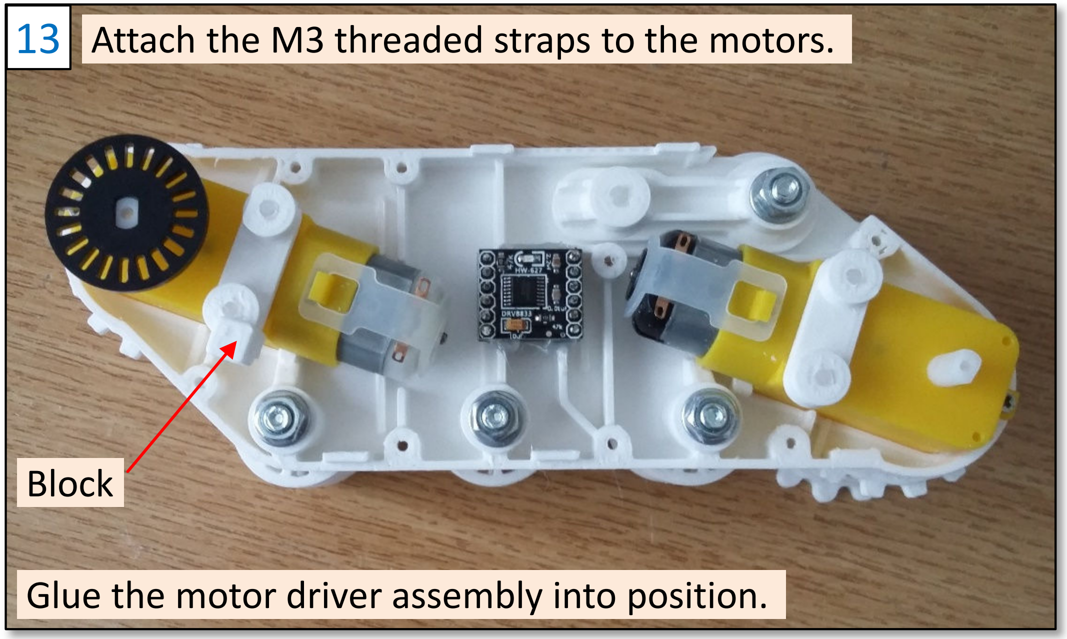

Then solder on wires, forming bridges on the data wire.

12 Chassis with front and rear plates fitted.



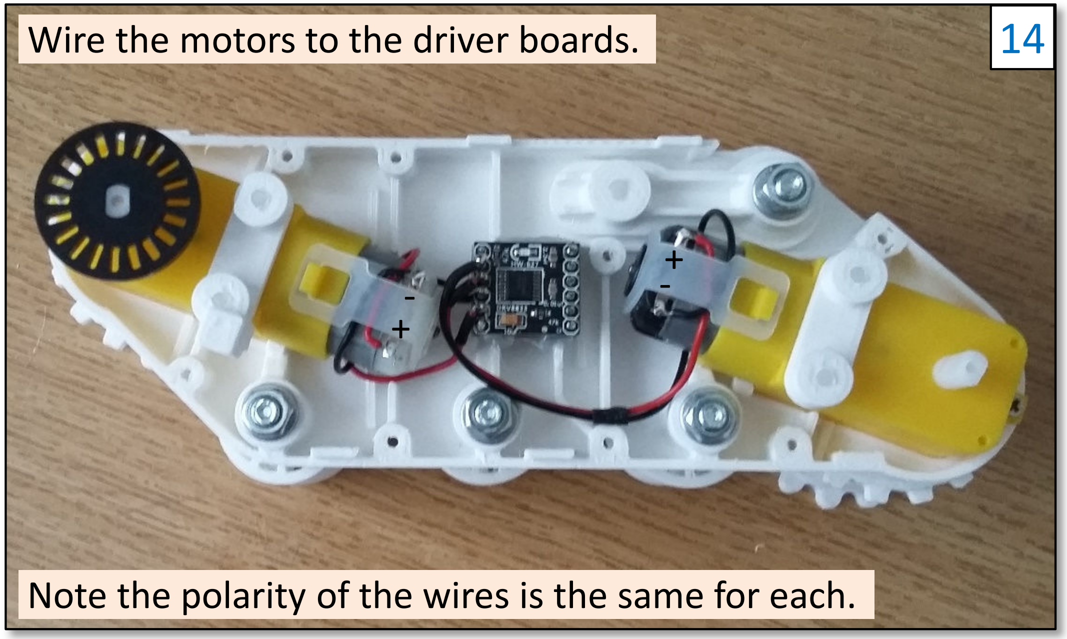
Front LED wires are fed through the cross plates.

## Build Sequence Photos



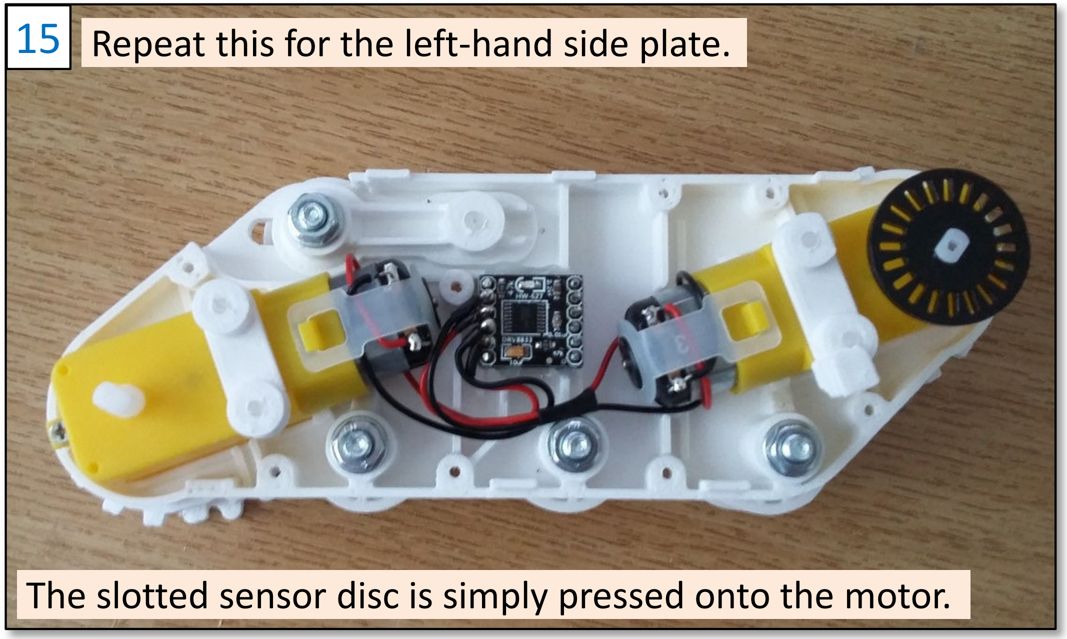

13 Attach the M3 threaded straps to the motors.

Glue the motor driver assembly into position.



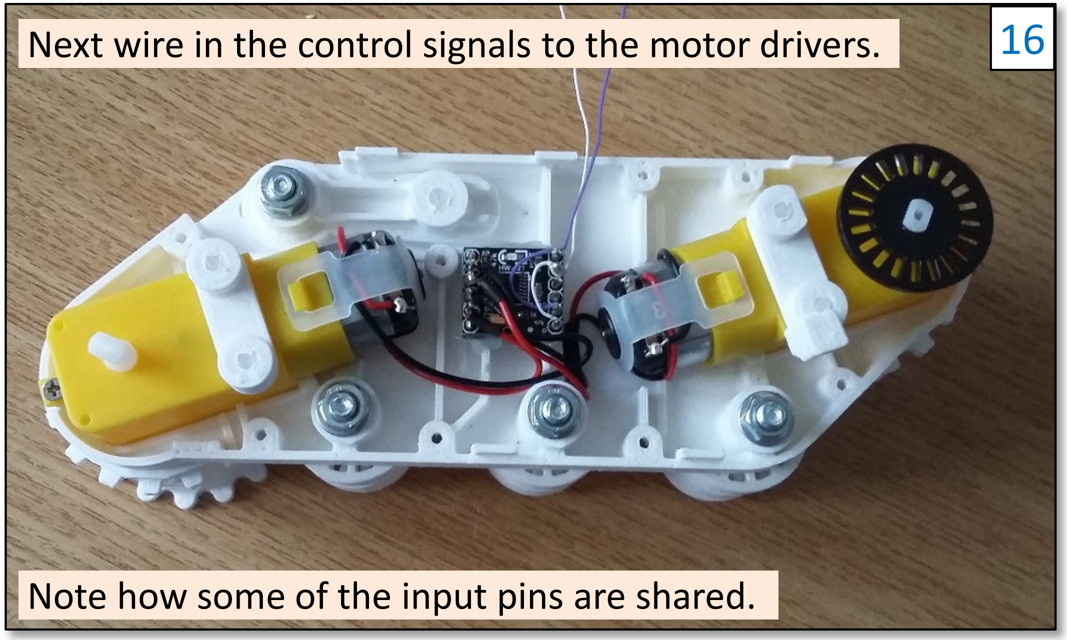

14 Wire the motors to the driver boards.

Note the polarity of the wires is the same for each.



15 Repeat this for the left-hand side plate.

The slotted sensor disc is simply pressed onto the motor.

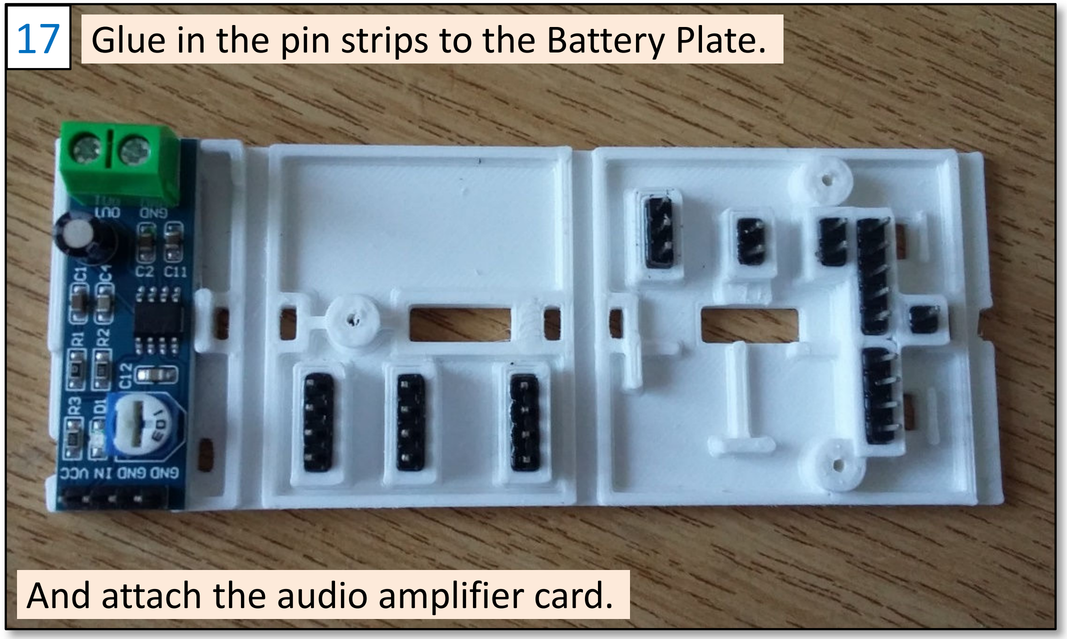


16 Next wire in the control signals to the motor drivers.

Note how some of the input pins are shared.

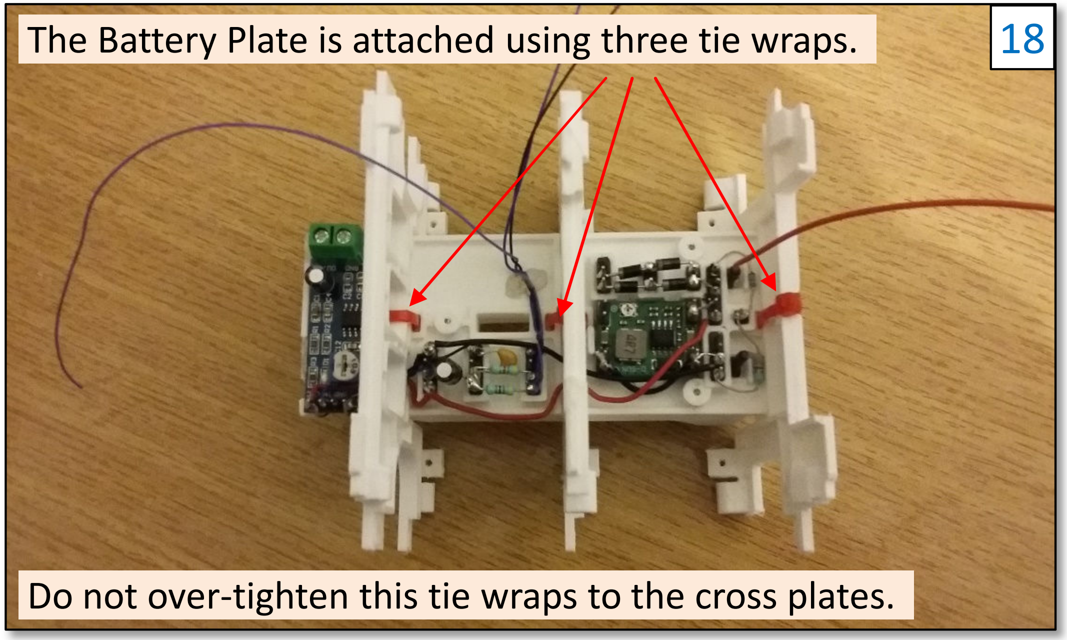
## Build Sequence Photos

17 Glue in the pin strips to the Battery Plate.



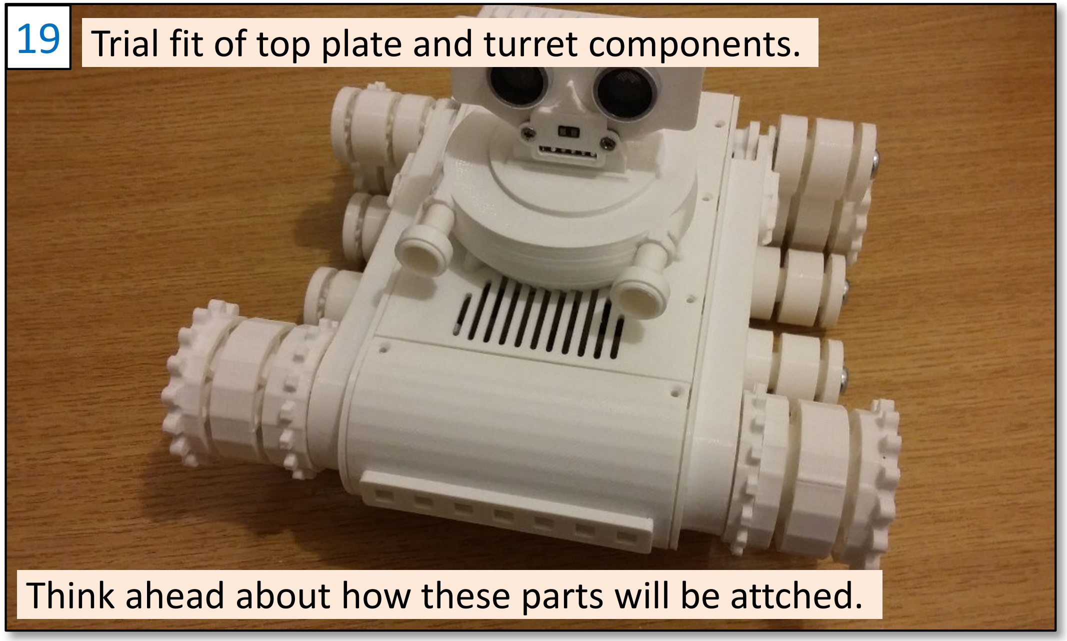
And attach the audio amplifier card.

18 The Battery Plate is attached using three tie wraps.



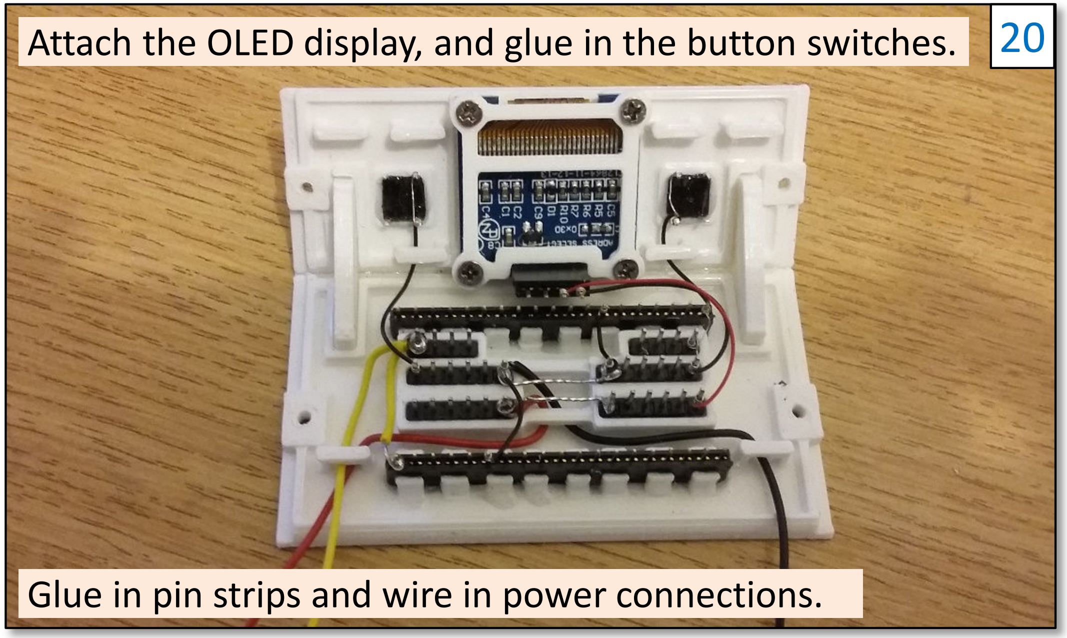
Do not over-tighten this tie wraps to the cross plates.

19 Trial fit of top plate and turret components.



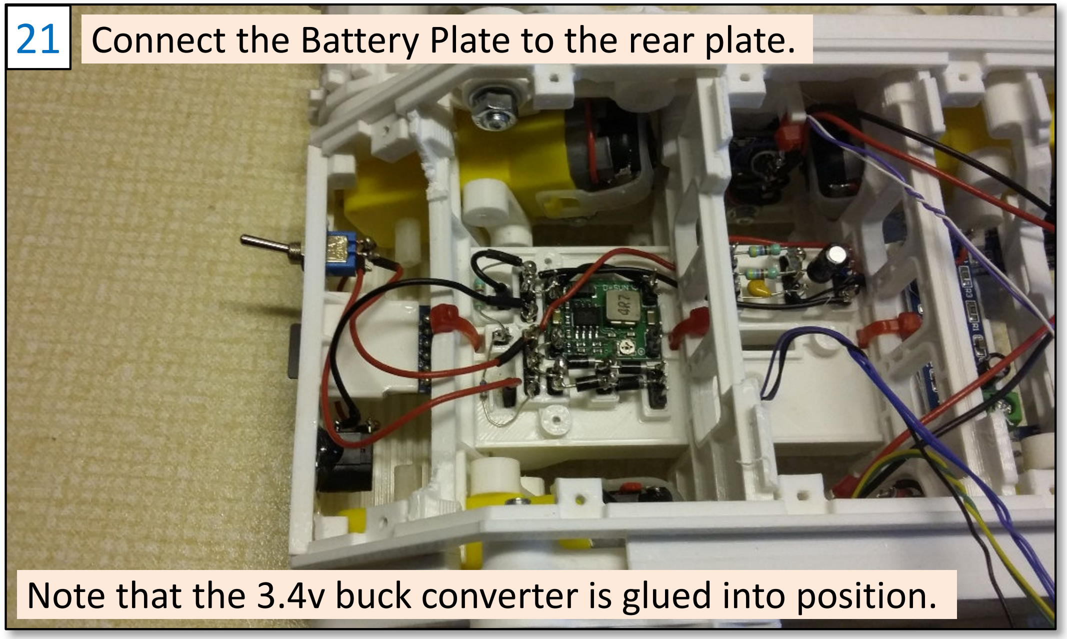
Think ahead about how these parts will be attched.

20 Attach the OLED display, and glue in the button switches.



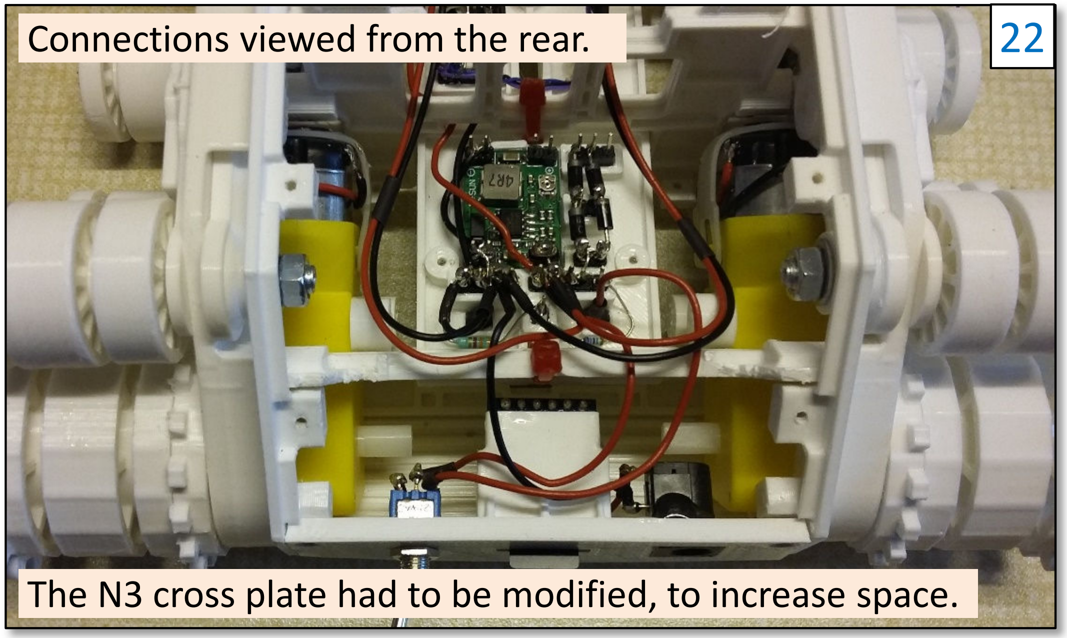
Glue in pin strips and wire in power connections.

## Build Sequence Photos



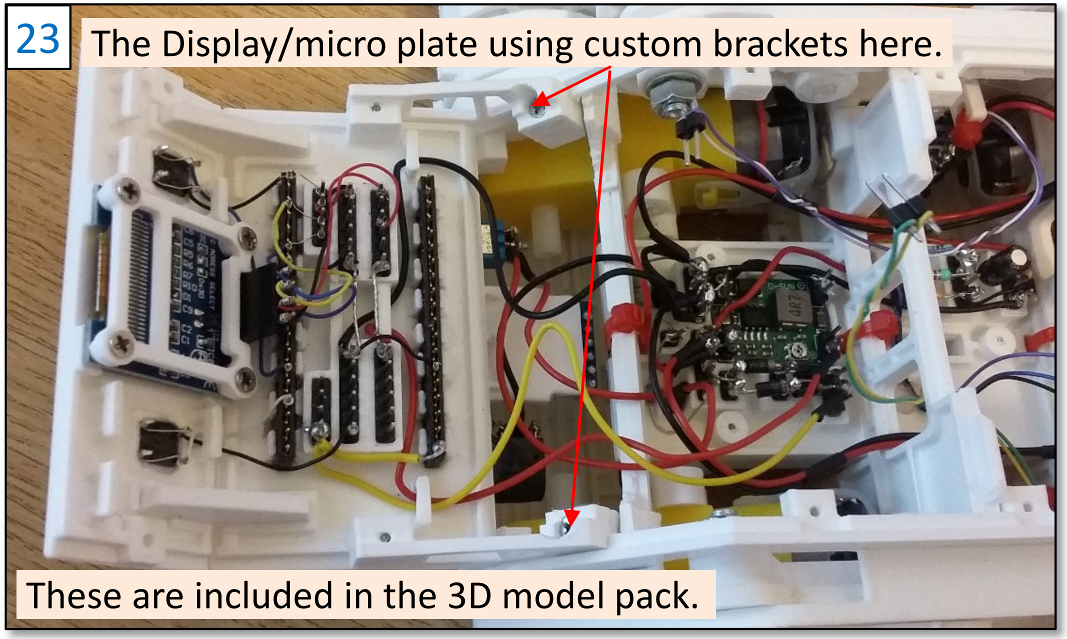
21 Connect the Battery Plate to the rear plate.

Note that the 3.4v buck converter is glued into position.



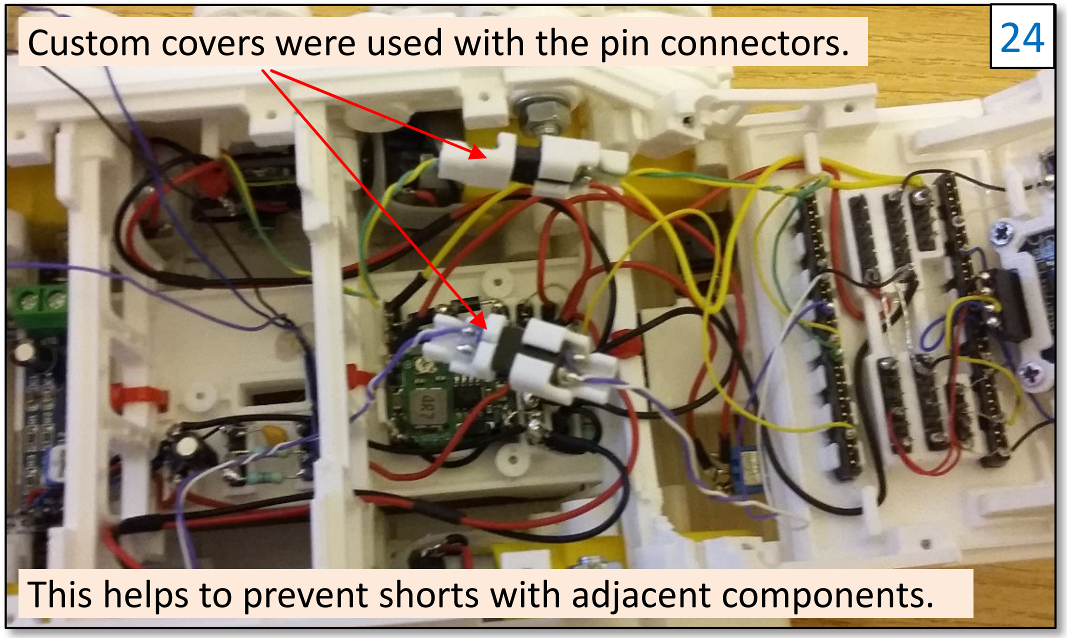
22 Connections viewed from the rear.

The N3 cross plate had to be modified, to increase space.



23 The Display/micro plate using custom brackets here.

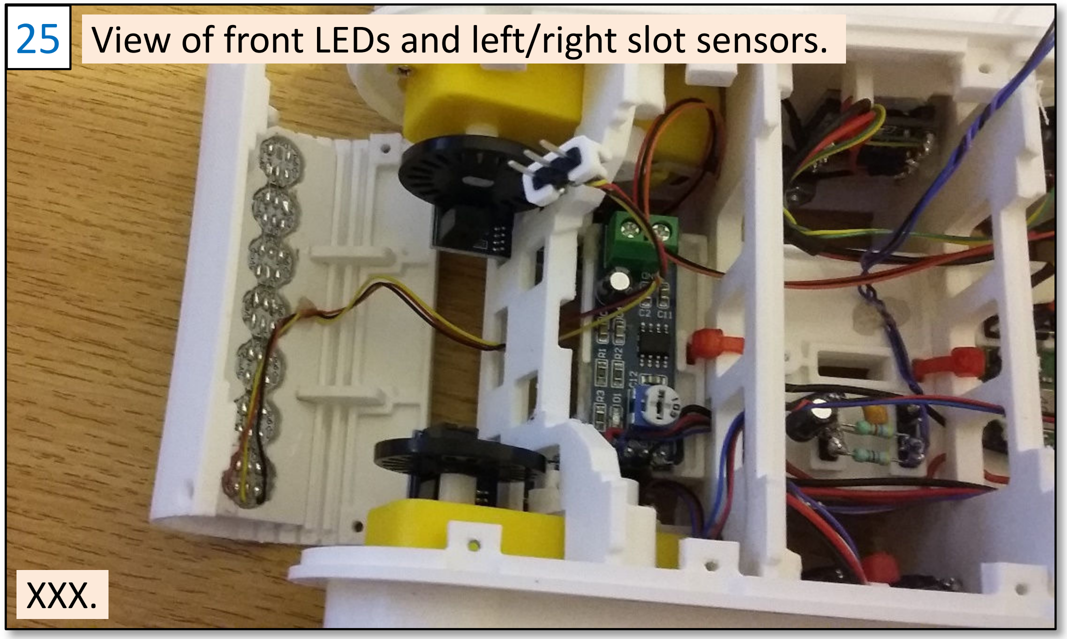
These are included in the 3D model pack.



24 Custom covers were used with the pin connectors.

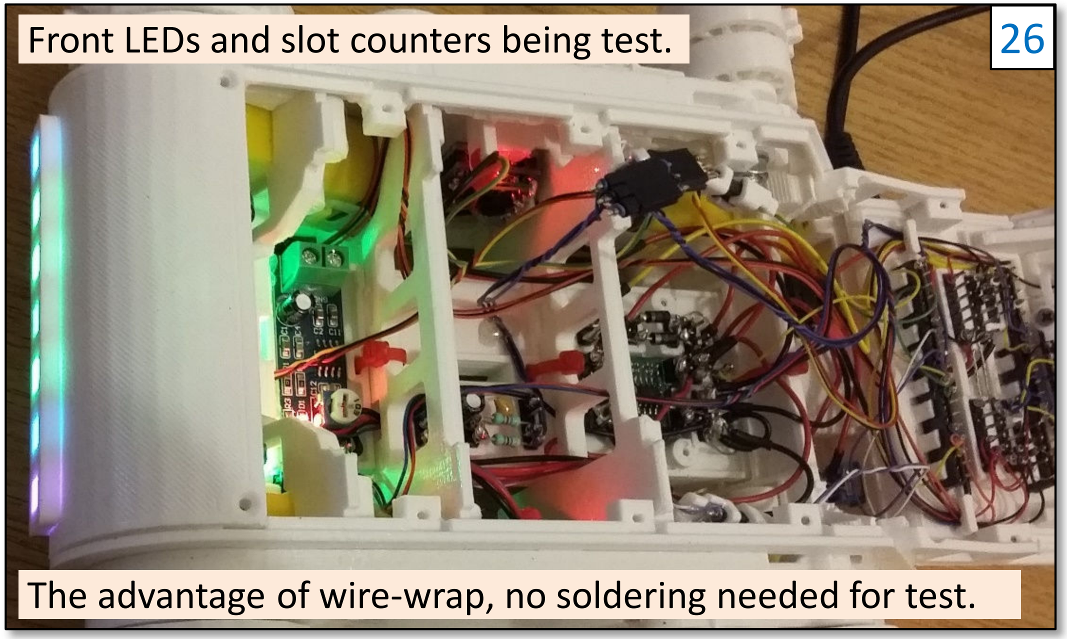
This helps to prevent shorts with adjacent components.

# Build Sequence Photos



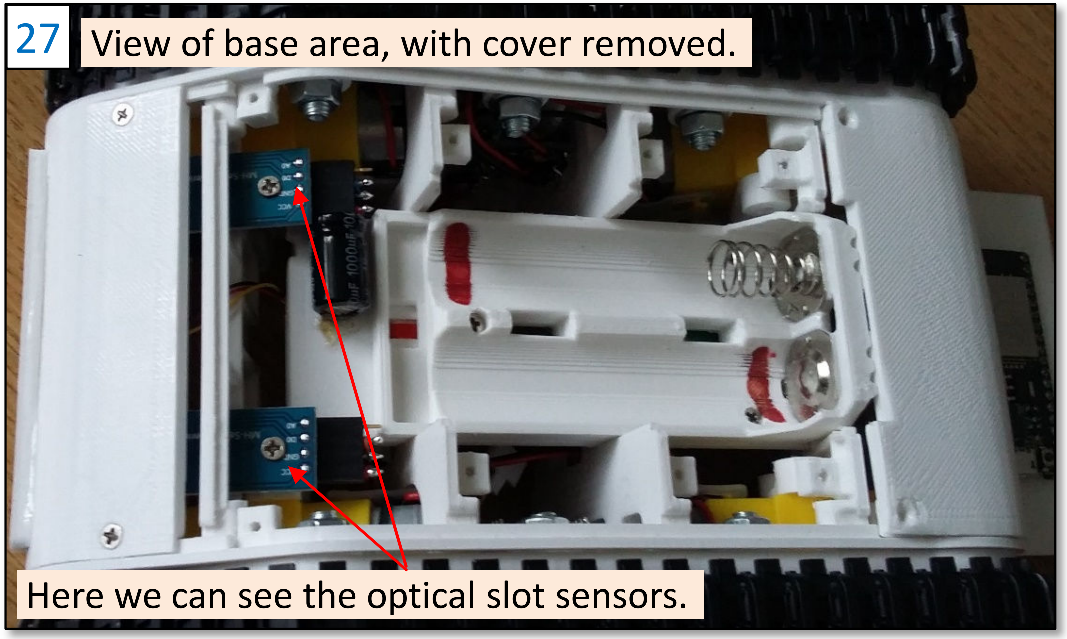
25 View of front LEDs and left/right slot sensors.

XXX.



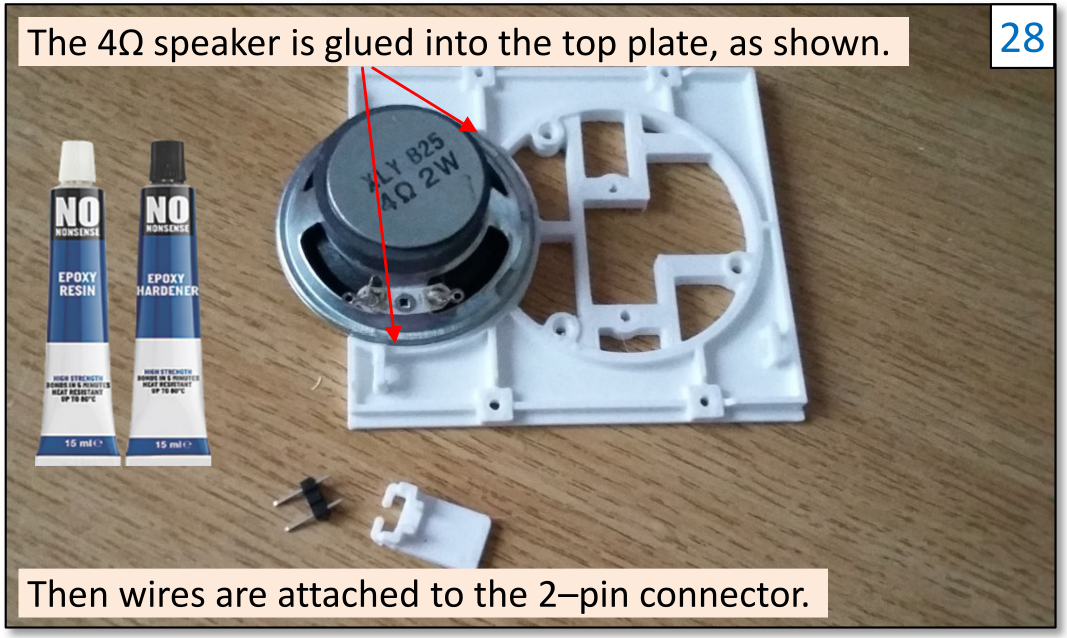
26 Front LEDs and slot counters being test.

The advantage of wire-wrap, no soldering needed for test.



27 View of base area, with cover removed.

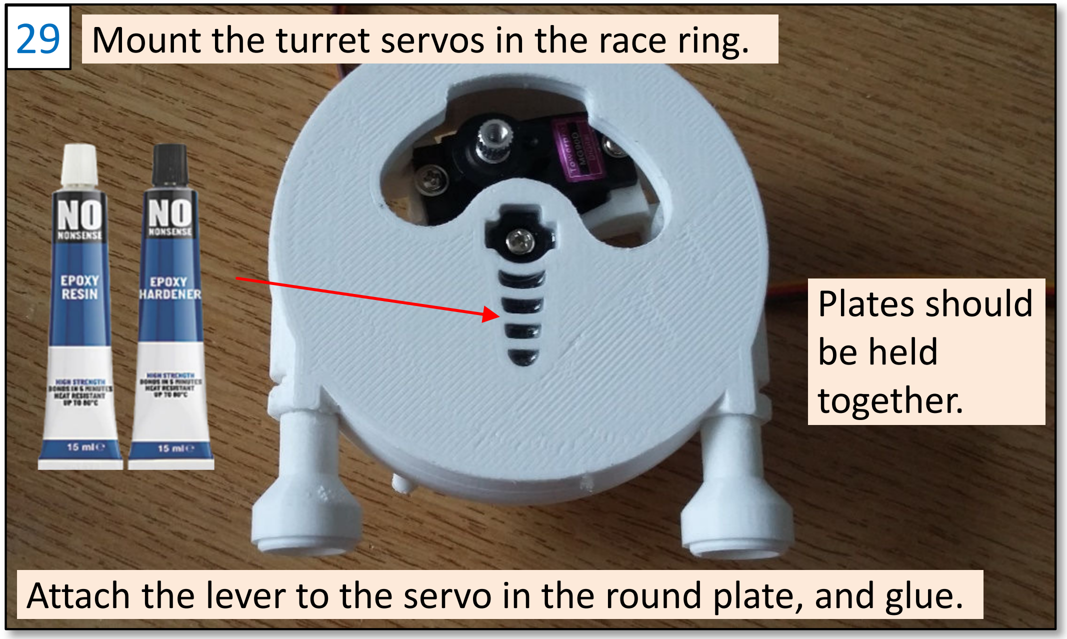
Here we can see the optical slot sensors.




28 The 4Ω speaker is glued into the top plate, as shown.

Then wires are attached to the 2–pin connector.

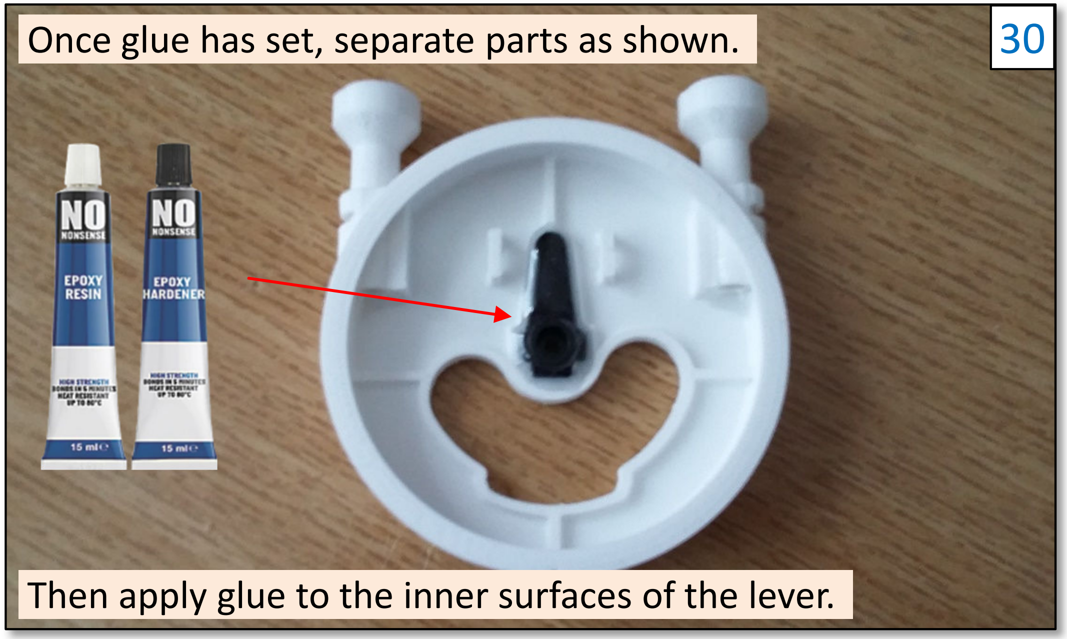
## Build Sequence Photos




29 Mount the turret servos in the race ring.

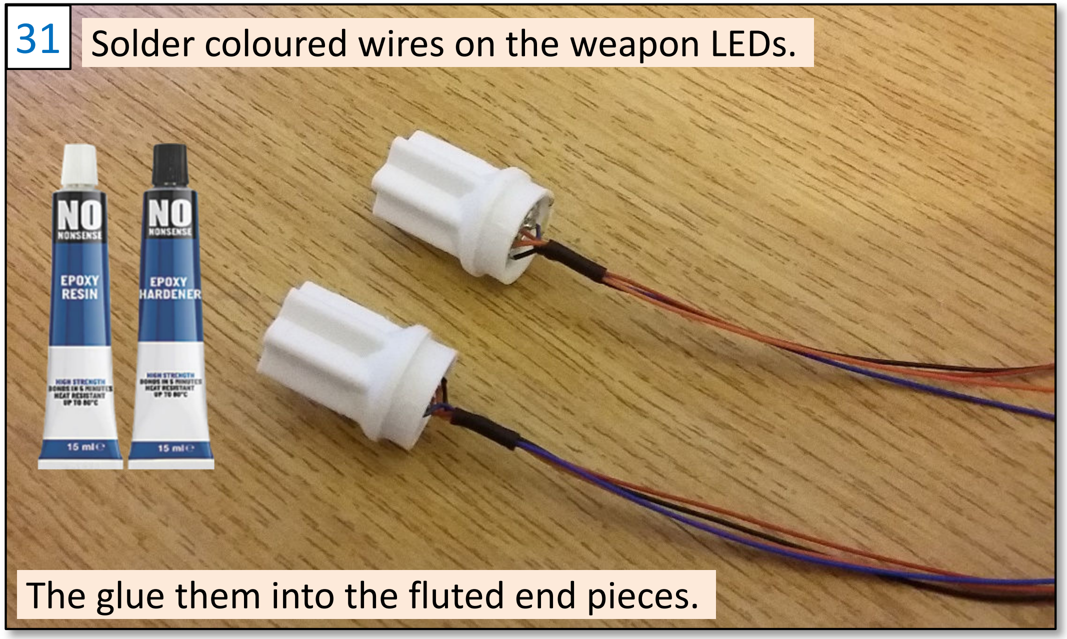
Plates should be held together.

Attach the lever to the servo in the round plate, and glue.



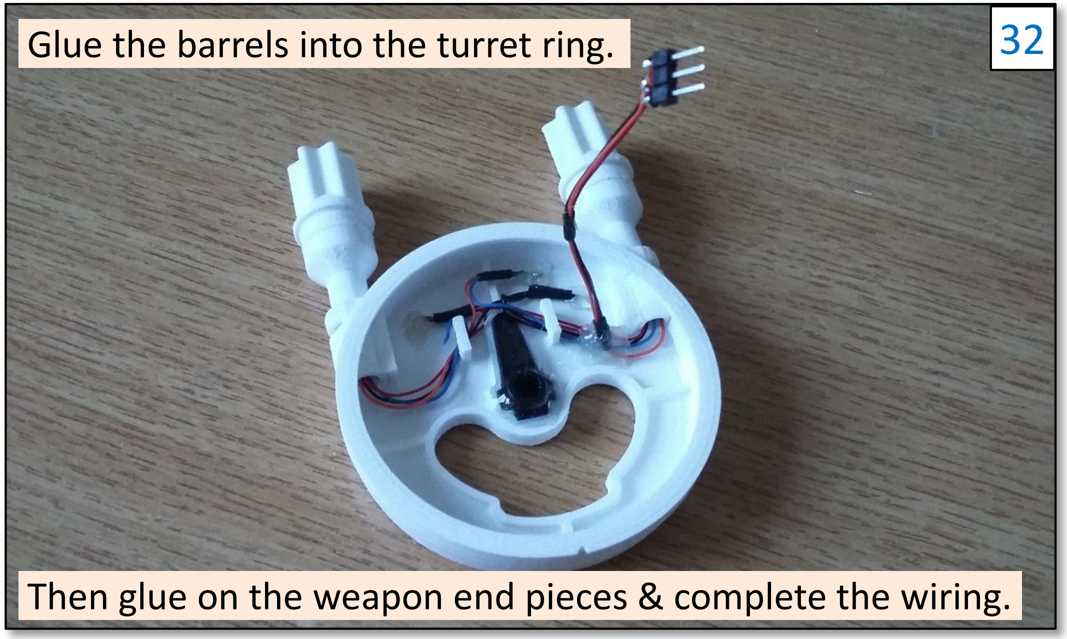

30 Once glue has set, separate parts as shown.

Then apply glue to the inner surfaces of the lever.




31 Solder coloured wires on the weapon LEDs.

The glue them into the fluted end pieces.

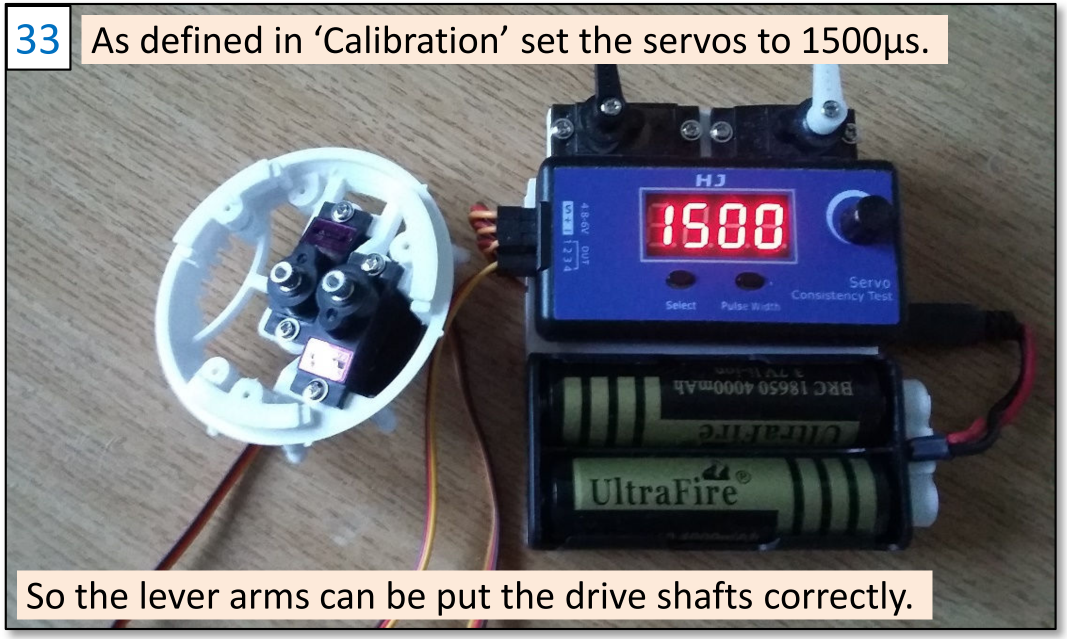


32 Glue the barrels into the turret ring.

Then glue on the weapon end pieces & complete the wiring.

## Build Sequence Photos

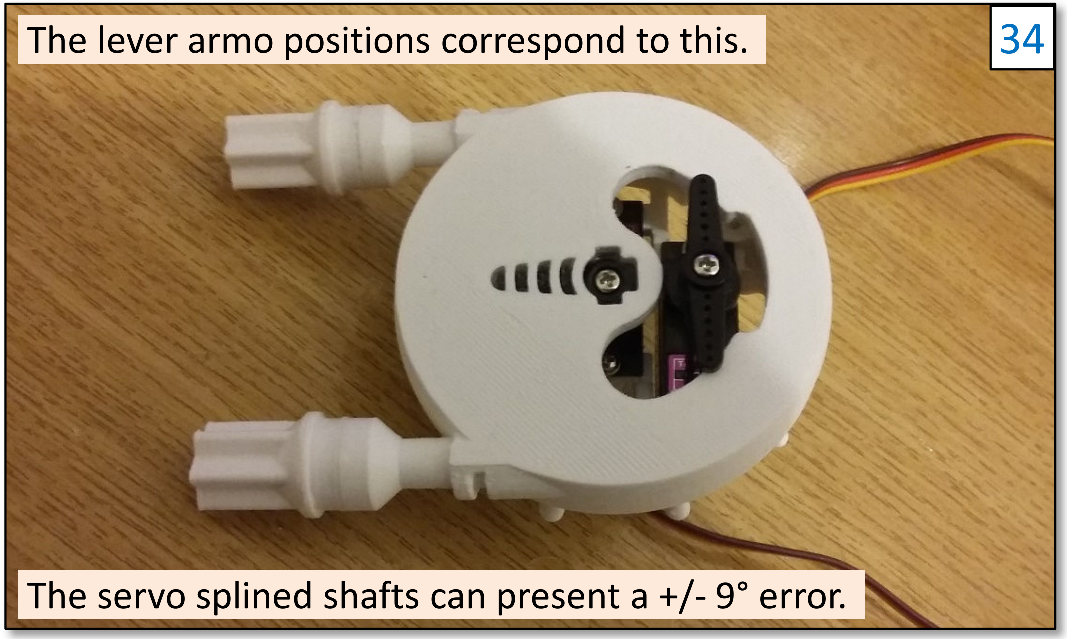
33




As defined in 'Calibration' set the servos to 1500µs.

So the lever arms can be put the drive shafts correctly.

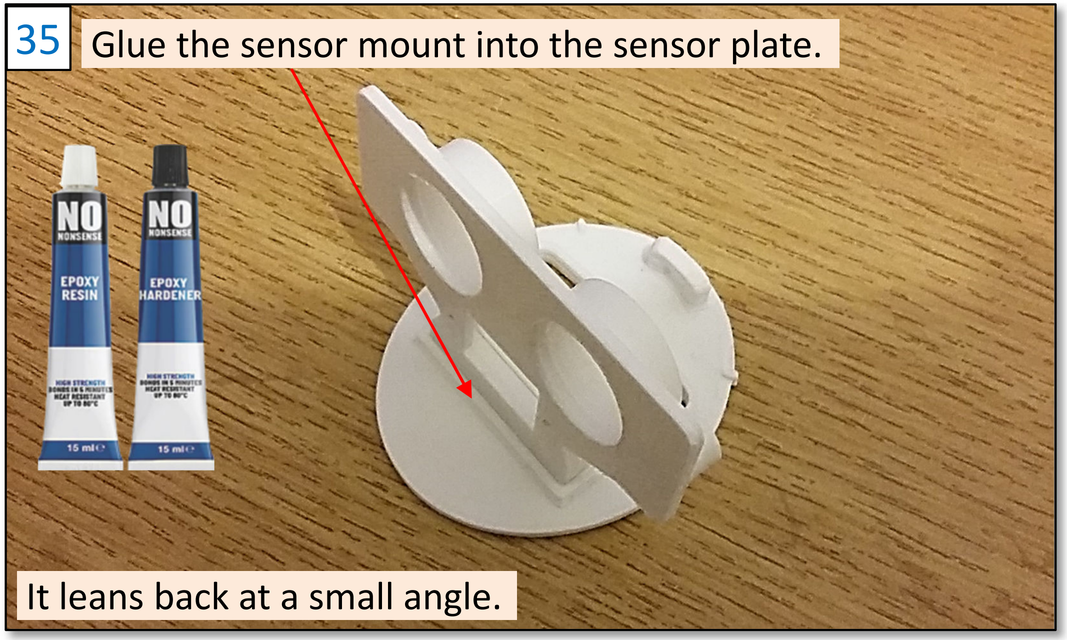
34



The lever armo positions correspond to this.

The servo splined shafts can present a +/- 9° error.

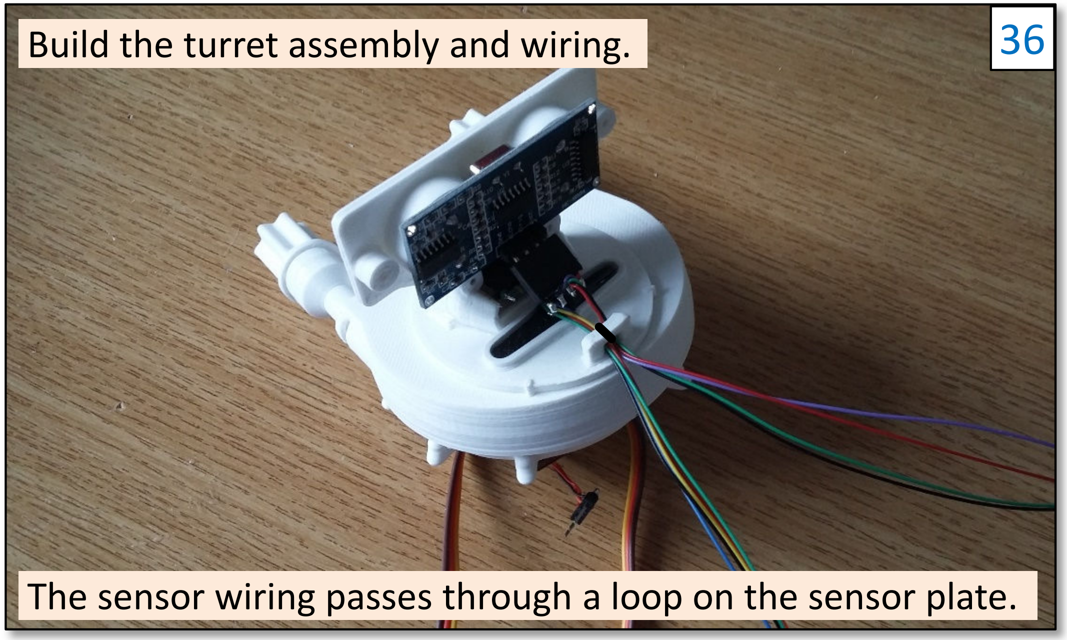
35




Glue the sensor mount into the sensor plate.

It leans back at a small angle.

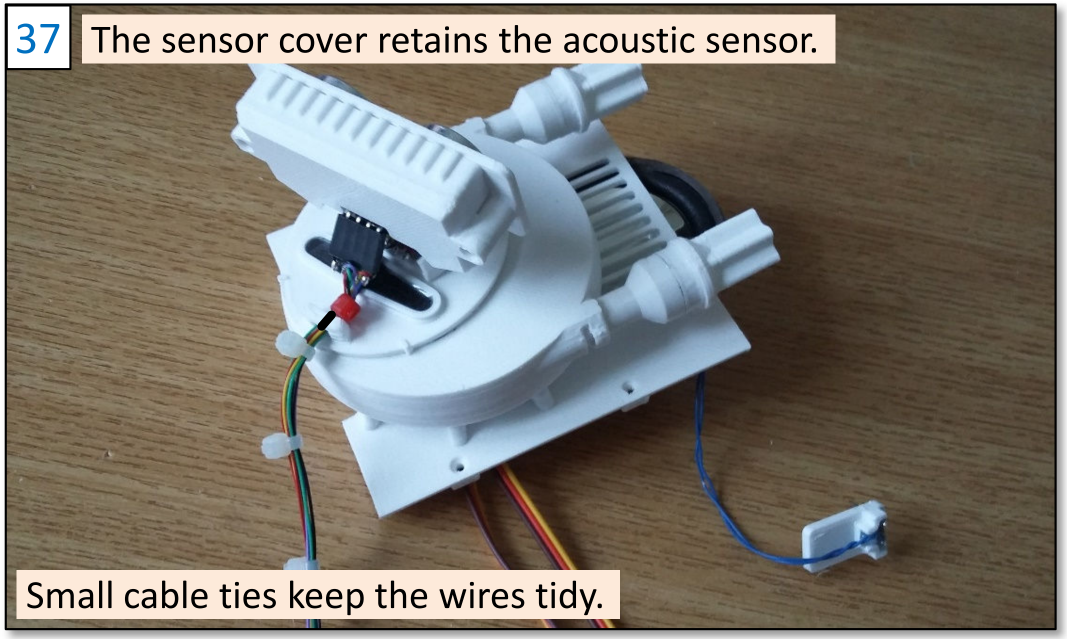
36



Build the turret assembly and wiring.

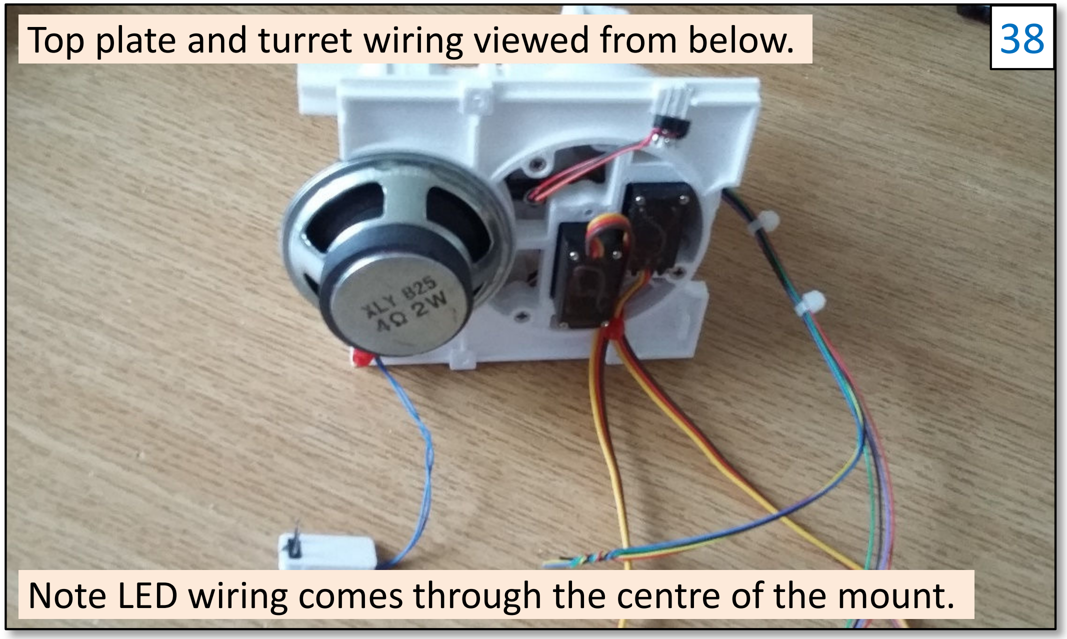
The sensor wiring passes through a loop on the sensor plate.

## Build Sequence Photos



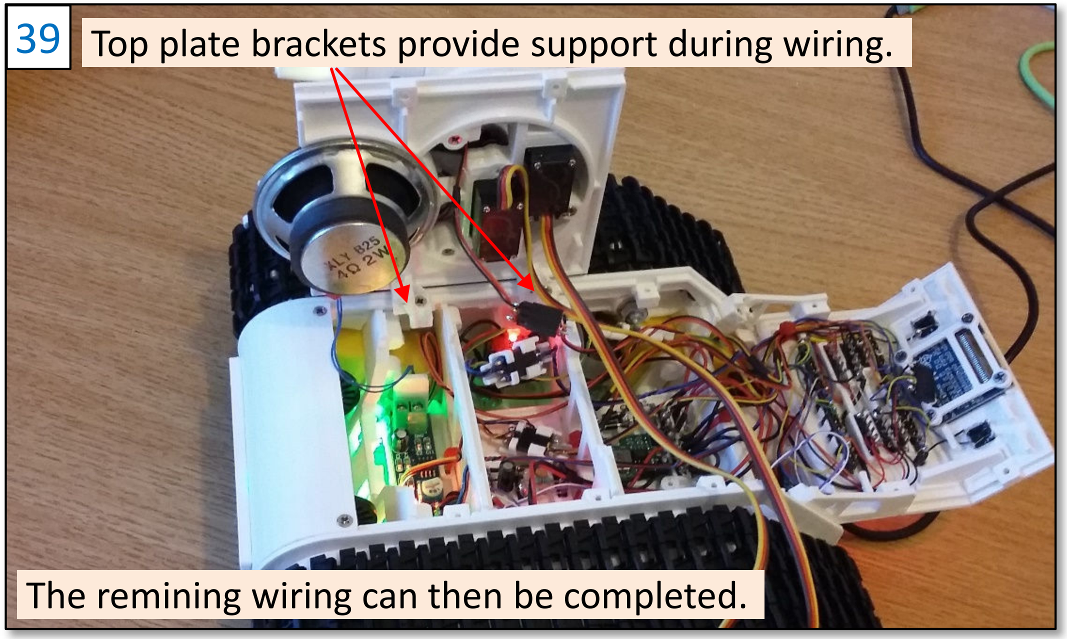
37 The sensor cover retains the acoustic sensor.

Small cable ties keep the wires tidy.



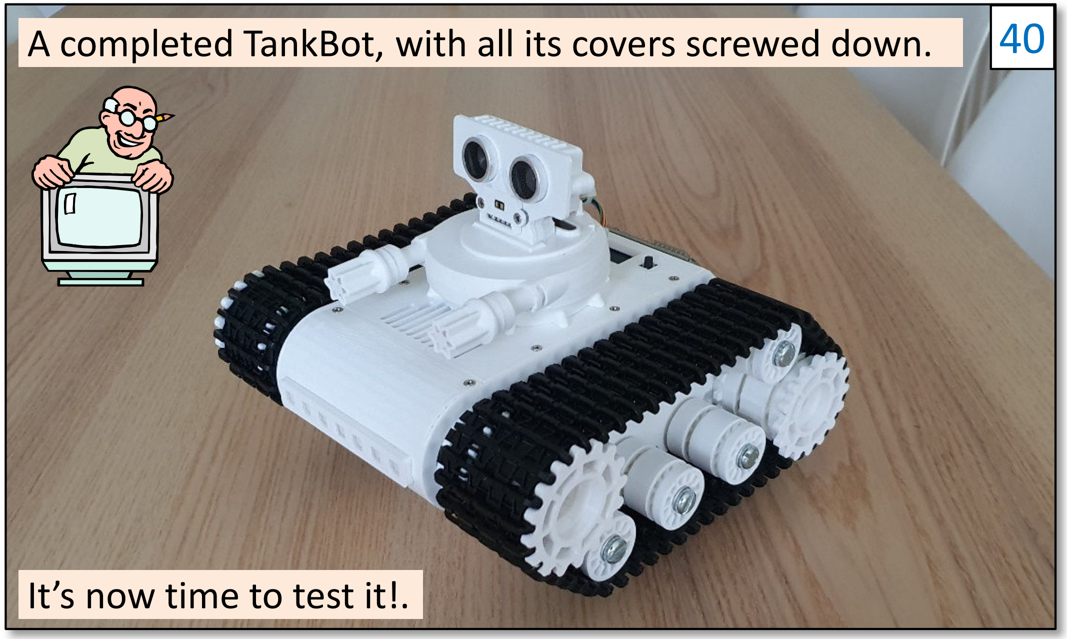
38 Top plate and turret wiring viewed from below.

Note LED wiring comes through the centre of the mount.



39 Top plate brackets provide support during wiring.

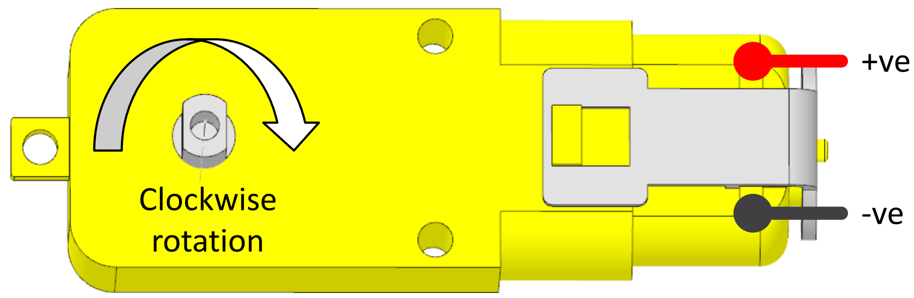
The remining wiring can then be completed.



40 A completed TankBot, with all its covers screwed down.

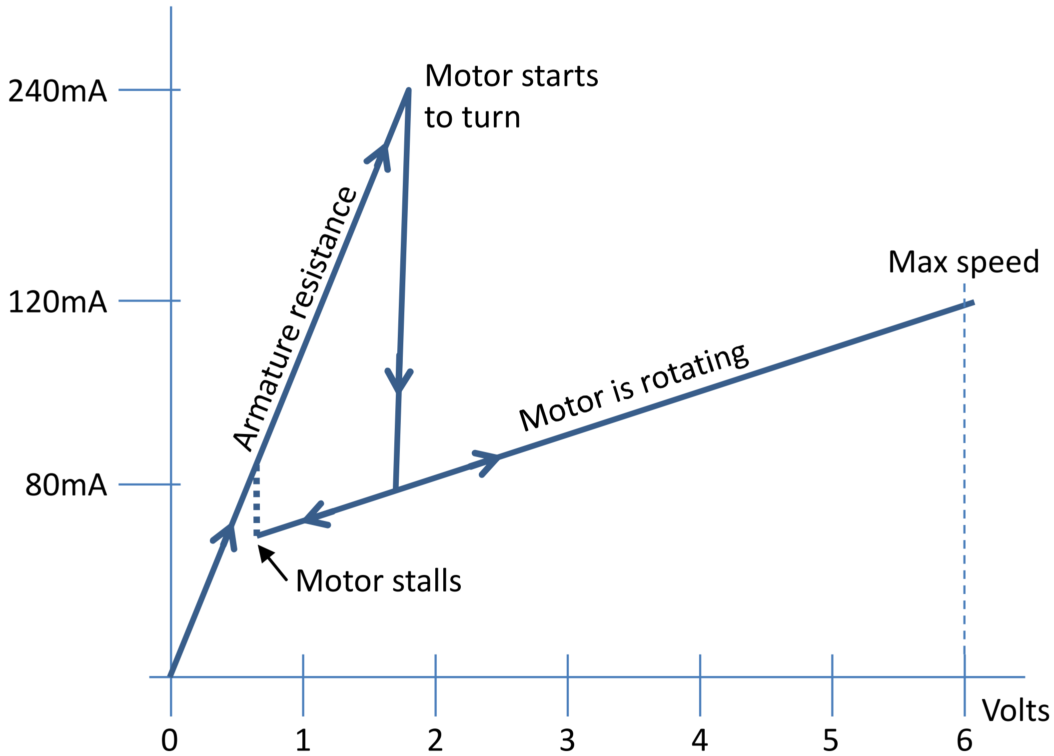
It’s now time to test it!.

## DC Motor Polarity




The direction of rotation of a permanent magnet DC motor is determine by the polarity of the voltage applied to its terminals. Here we see that the motor shaft on the side of the motor which has terminals, is rotating in a clockwise direction when this polarity of the voltage applied.

In an unloaded state the motor will start to rotate at around 1.8 volts. Before getting to the point of rotation, friction in the motors nylon gearbox keeps it stationary, and the stalled motor current is determined by the applied voltage and the armature resistance. Once the motor starts to turn, the current drops rapidly, due to the motors back emf cancelling some of the applied voltage.

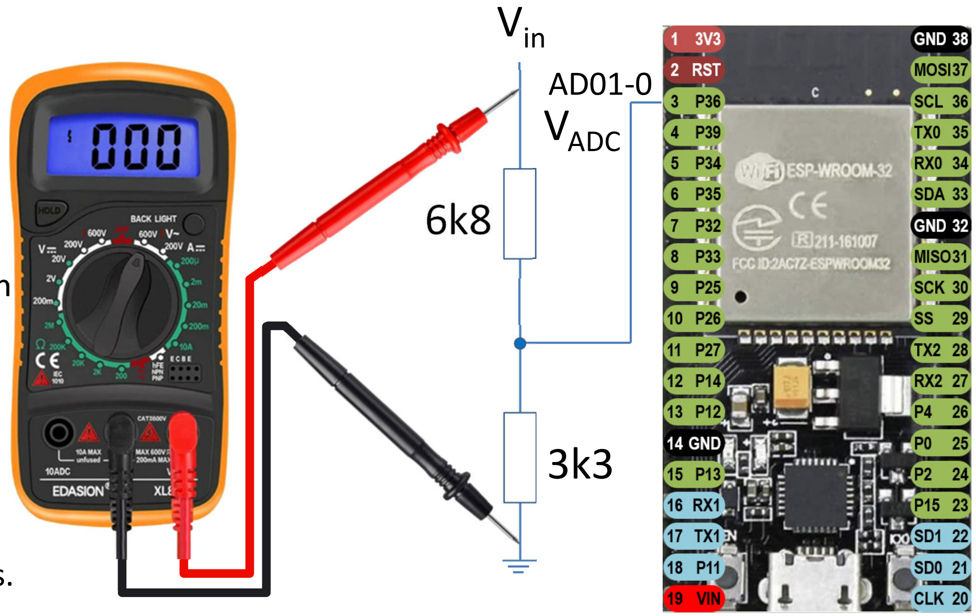



The motor speed will then increase in a manner proportional to the applied voltage. At 6 volts I measured an unloaded current of 120 mA. Reducing the voltage will decrease the motor speed and it will be seen to still turn, below the initial starting point, as the gearbox friction is reduced once the motor is in motion.

As the voltage is further reduced the motor will once again stall, and the current will again be determined by the armatures winding resistance.

# Battery Voltage Health Monitoring

See 18650 discharge curve obtained from the internet below. In this robot both batteries are assumed to be identical, and connected in series. With the robot powered, from either its batteries or external source, and in sleep mode, press SW0 to get the robot to repeatedly display battery readings. Measure the $V_{in}$ voltage with a multimeter; note that and the average $V_{ADC}$ value displayed left on the OLED at that time. I had 7.68 volts for $V_{ADC}$ = 2810.




We determine a constant: BatCal = 2810/7.68 = 365.9 conversion factor.
This conversion constant will be entered in our code for display purposes.

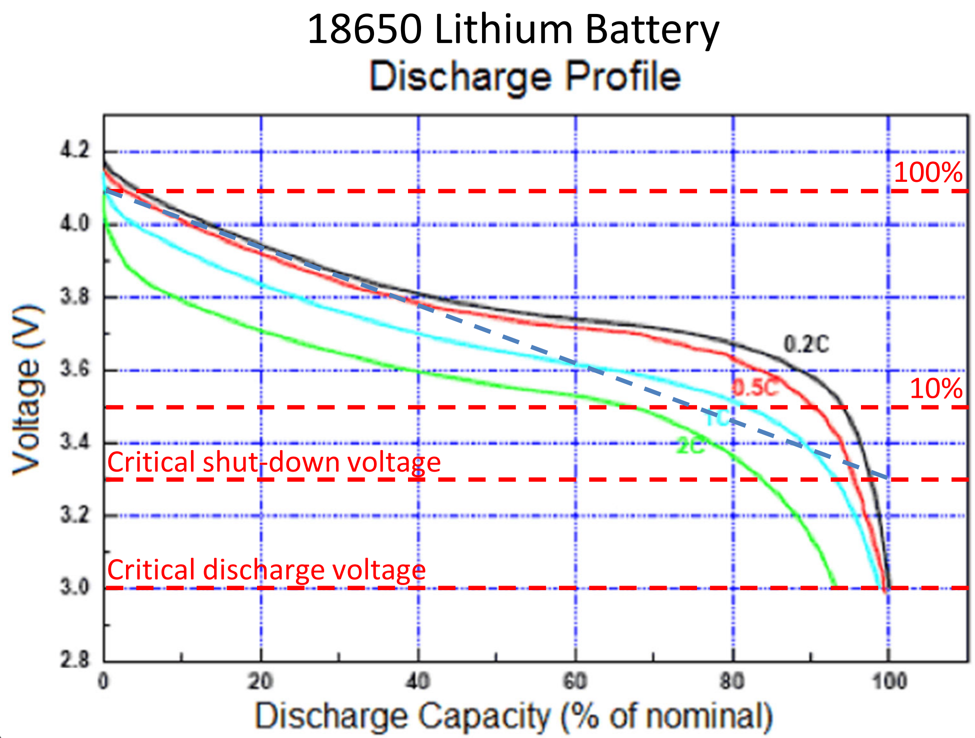
Now that we have the value of BatCal, we can determine $V_{ADC}$ values for each of our limits in the code as follows. Remember that we have two batteries in series.

BatMax 100% is when $V_{in}$ = 8.2v converted gives $V_{ADC}$ = 3000

BatWarn 10% warning point at $V_{in}$ = 7.00v converted gives $V_{ADC}$ = 2561

BatCritical 0% cut-off point at $V_{in}$ = 6.60v converted gives $V_{ADC}$ = 2415

Enter these #define values into your code, and recompile it. You now have a built in calibrated digital voltmeter, and useful warning limits



Discharge: 3.0V cutoff at room temperature.

**Notes:**
The code will sample the battery voltage on power-up to ensure it is sufficient, then at regular interval, calculating an average 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 and display 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.