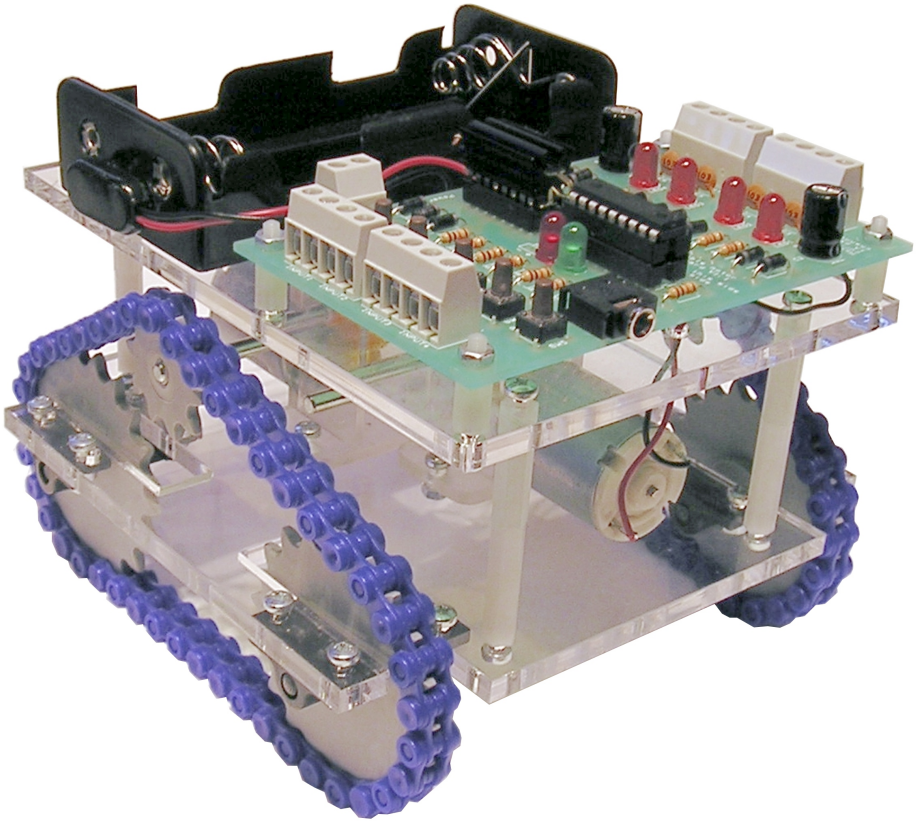
Laser cut tank



Teaching Notes

Issue 1.4

Product information: www.kitronik.co.uk/quicklinks/2125/

Index of sheets

Introduction

About the project kit

This project kit has been carefully designed for use by teachers in KS3 design and technology. It is designed such that even teachers with a limited knowledge of electronics should have no trouble using it as basis around which to form a scheme of work.

It is intended that the tank and motor board will be built up and reused. These notes detail the manufacture of the tank kit and wiring it to the motor controller board. Possible tasks using the motor controller as a sequence controller as well as PC programming tasks using sensor inputs are detailed.

Please note the instructions explaining how to use the sequence controller are in the motor controller teaching material and not repeated in these notes.

Using the booklet

This booklet is intended as an aid for teachers when planning and implementing your scheme of work.

Please feel free to print any pages of this booklet to use as student handouts in conjunction with Kitronik project kits. There are no page numbers in this booklet. This means you can pick and choose which sheets you use whilst still retaining a feeling of continuity.

Support and resources

You can also find additional resources at www.kitronik.co.uk There are component fact sheets, information on calculating resistor and capacitor values, puzzles and much more.

Kitronik provide a next day response technical assistance service via e-mail. If you have any questions regarding this kit or even suggestions for improvements please e-mail us at: support@kitronik.co.uk Alternatively phone us on 0845 8380781.

Build instructions

The first section of the teaching notes details how to build up your tank.

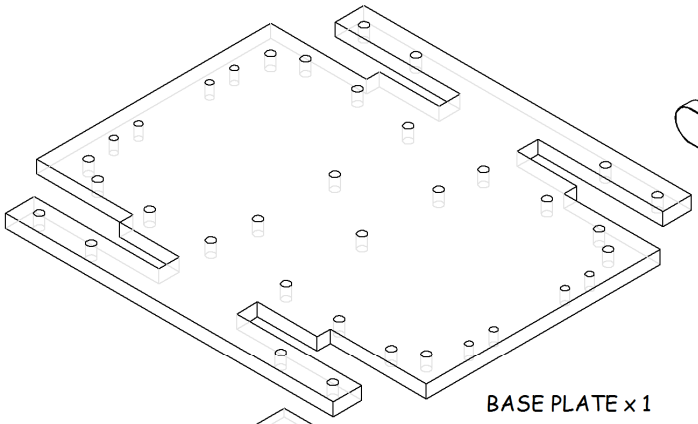
Before you start building up the tank you will need:

- A built & tested motor controller board.
- A top & base plate cut from 5mm acrylic.

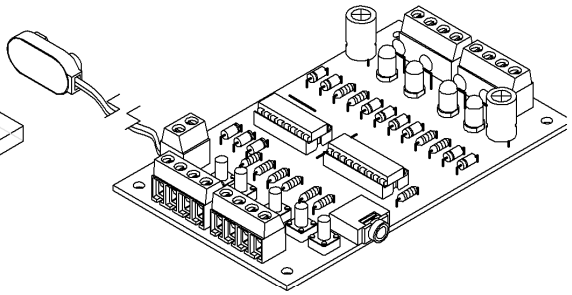
The DXF files, which can be imported into any laser cutter software, are available on the Kitronik website at: www.kitronik.co.uk/laser_cut_tank.htm or on the 'Teaching notes and resources CD'.

It is important that the material that you cut from is 5mm thick. The way the chain tracks are connected between the two wheels and the drive wheel has been set-up to the right tension for 5mm material. If a different thickness of material is used the chain will be loose or tight and the tank won't work correctly.

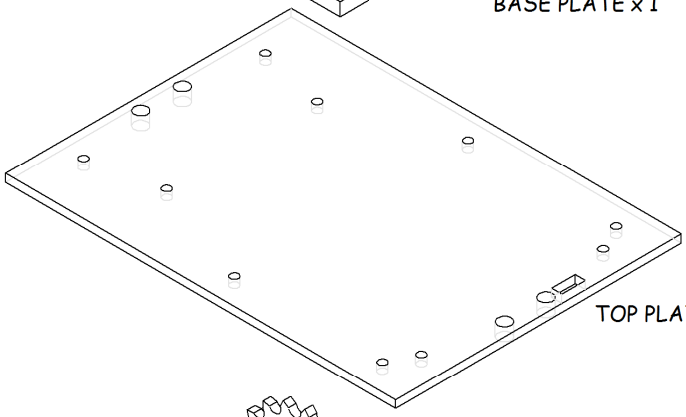
Following the details on the mechanical assembly are the instructions for wiring up the motors and wiring up sensors.



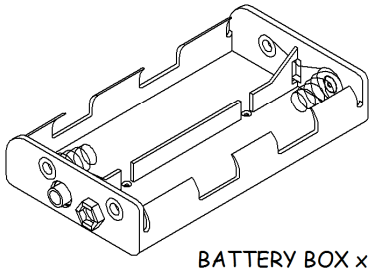
BASE PLATE x 1



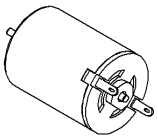
CONTROL BOARD x 1



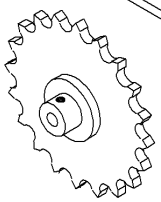
TOP PLATE x 1



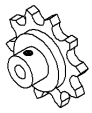
BATTERY BOX x 1



MOTOR x 2

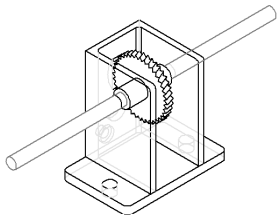


MAIN WHEEL x 4

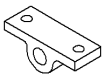


DRIVE COG x 2

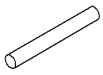
WORM DRIVE x 2



GEARBOX x 2

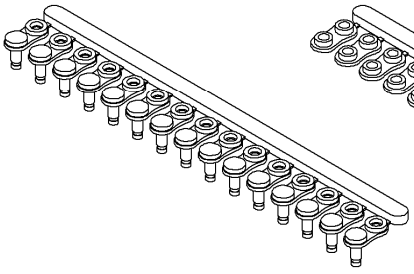


AXLE MOUNTS x8



AXLE x 4

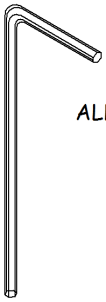
SWITCH x 1



LINK STRIP ONE x 6

LINK STRIP TWO x 6

M3 x 25MM STAND-OFFS x 4



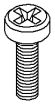
ALLEN KEY x 1

GRUB SCREW x 6

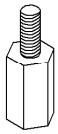
M3 NUT x 26

M3 x 20MM STAND-OFFS x 4

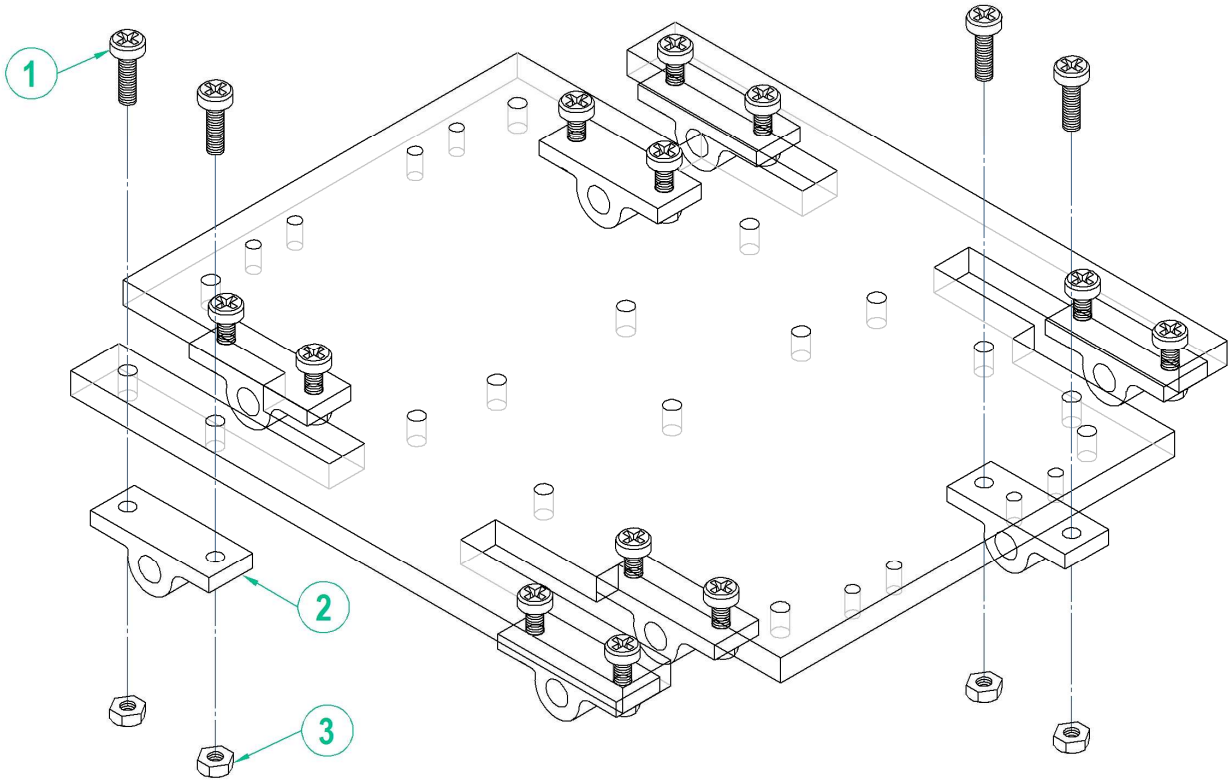
M2.5 x 6MM SCREW x 4



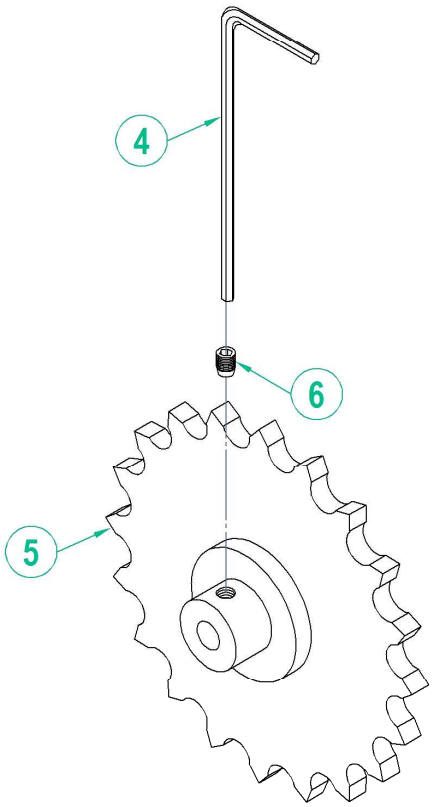
M3 x 10MM BOLTS x 34



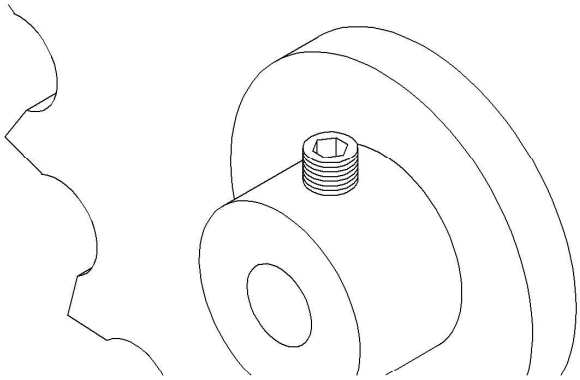
M3 x 10MM STAND-OFFS x 4



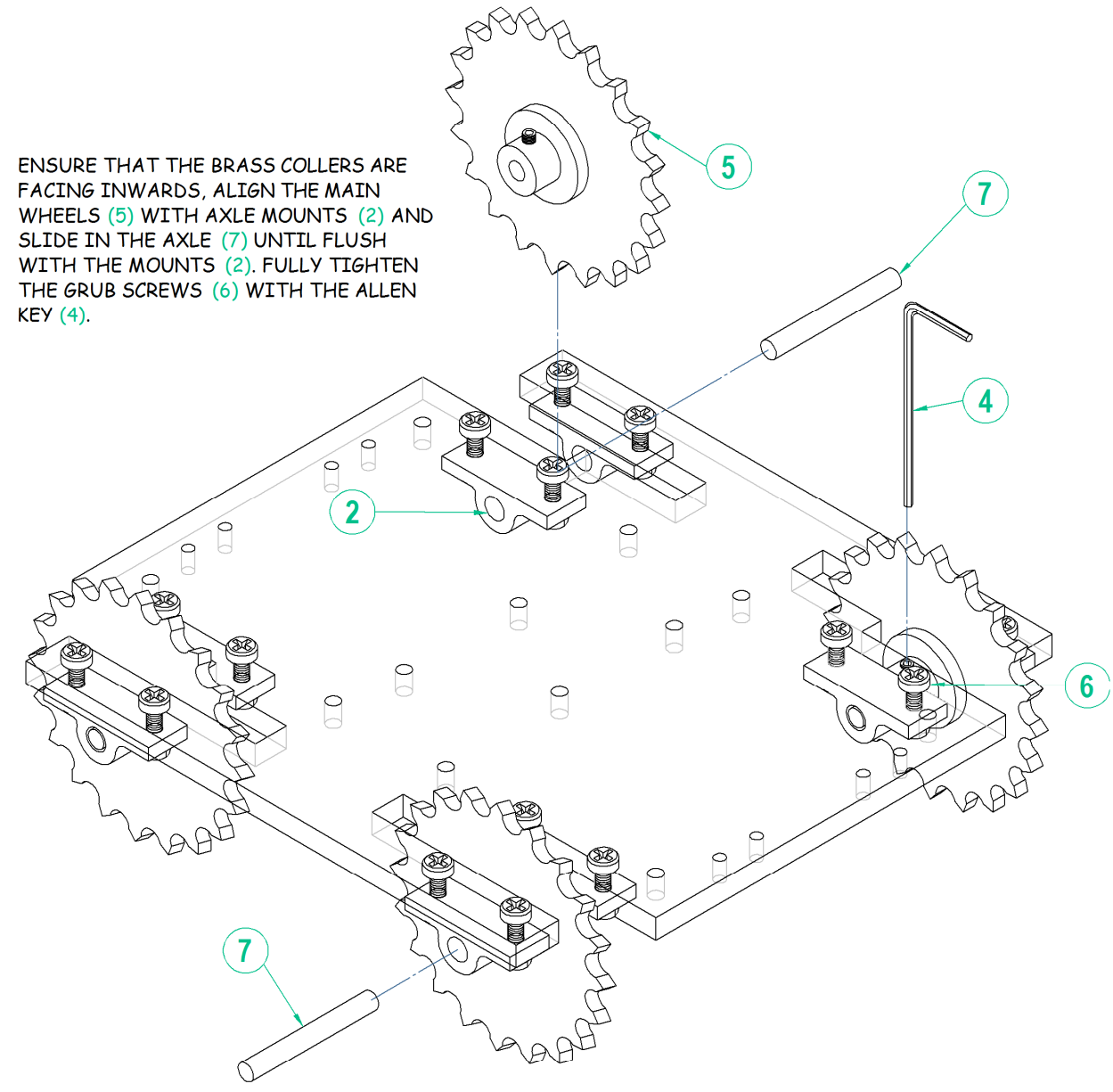
USING SIXTEEN M3 x10MM BOLTS (1) AND SIXTEEN M3 NUTS (3) FIX THE EIGHT AXLE MOUNTS (2) TO THE BASE PLATE AS SHOWN

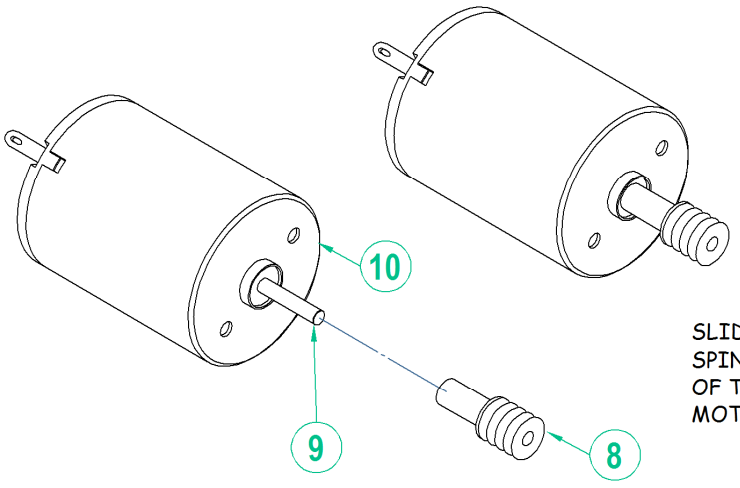


USING THE ALLEN KEY (4) SCREW IN THE GRUB SCREW (6) INTO THE BRASS COLLER OF THE MAIN WHEEL (5) A ¼ OF THE WAY IN AS SHOWN BELOW. REPEAT FOR ALL FOUR WHEELS

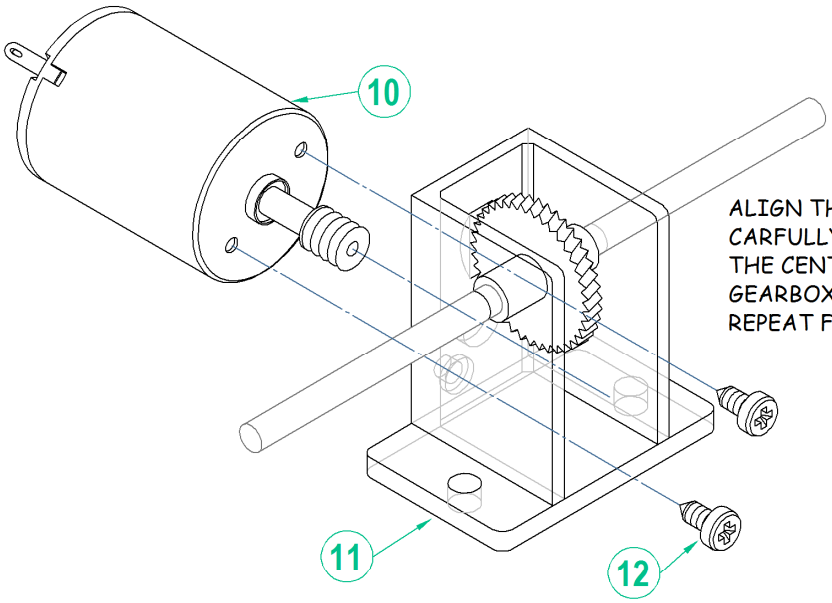


ENSURE THAT THE BRASS COLLERS ARE FACING INWARDS, ALIGN THE MAIN WHEELS (5) WITH AXLE MOUNTS (2) AND SLIDE IN THE AXLE (7) UNTIL FLUSH WITH THE MOUNTS (2). FULLY TIGHTEN THE GRUB SCREWS (6) WITH THE ALLEN KEY (4).

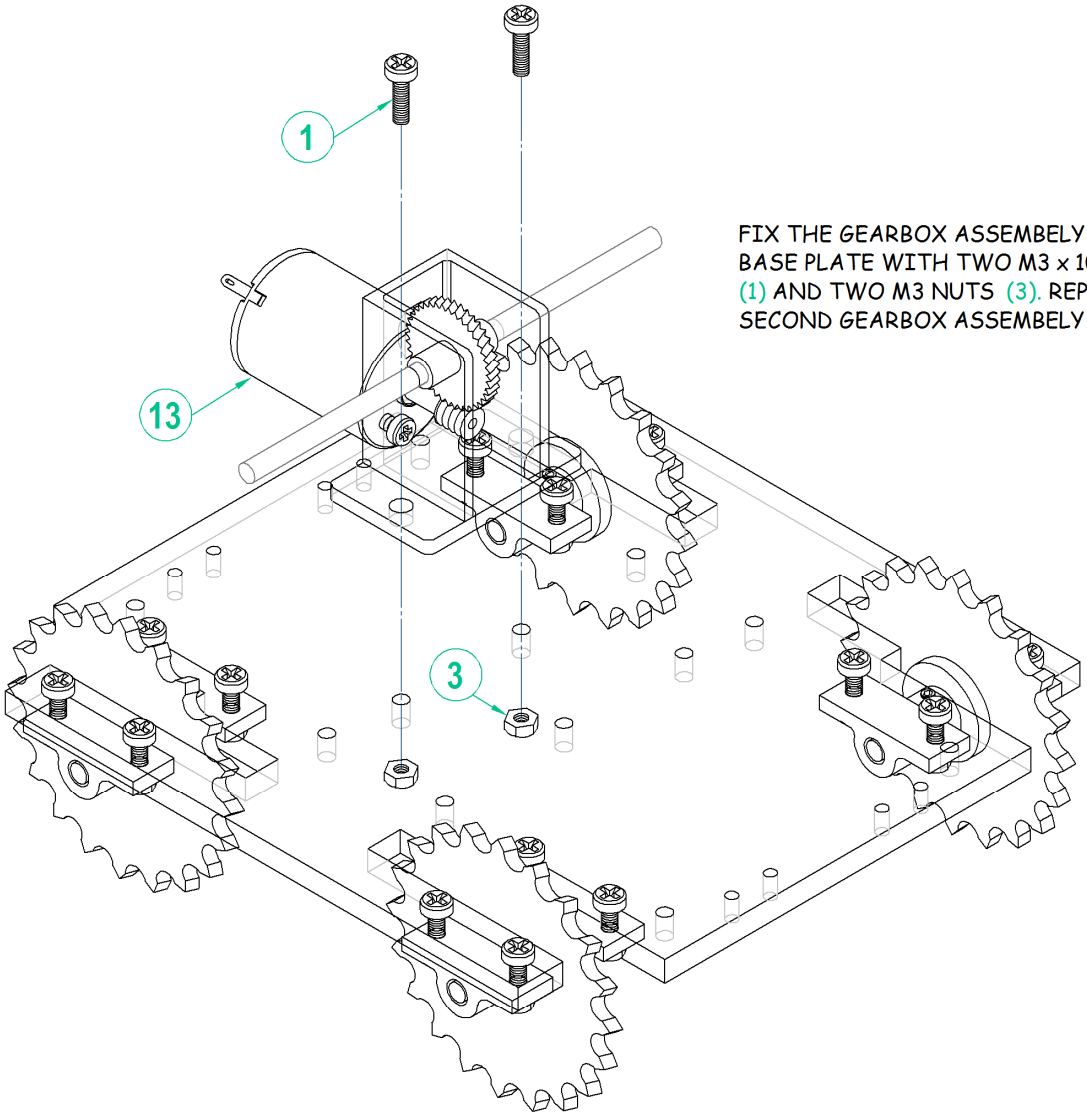




SLIDE THE WORM DRIVE (8) ONTO THE MOTOR SPINDLE (9) UNTIL IT'S FLUSH WITH THE BODY OF THE MOTOR (10). REPEAT FOR SECOND MOTOR.

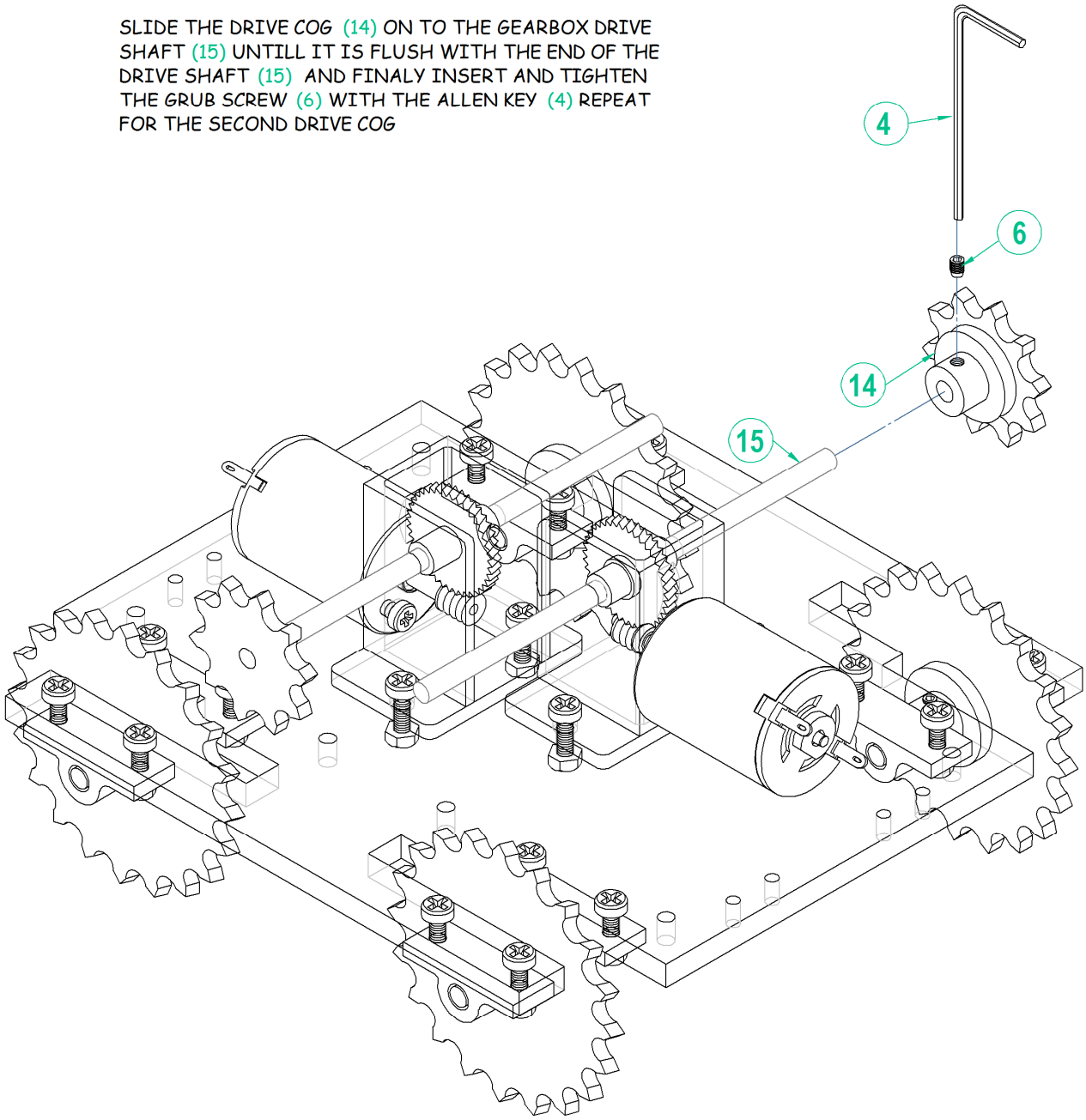


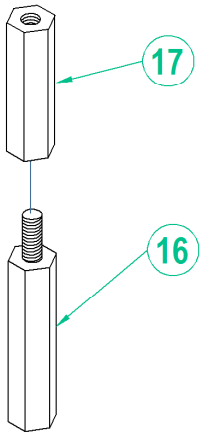
ALIGN THE MOTOR (10) WITH THE GEARBOX (11 CARFULLY THREAD THE WORM DRIVE THOUGH THE CENTRE HOLE. FIX THE MOTOR TO THE GEARBOX WITH TWO M2.5 x 6MM SCREWS (12). REPEAT FOR 2ND MOTOR AND GEARBOX.

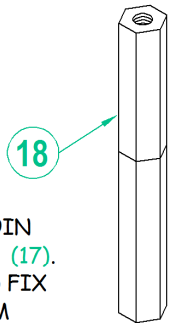


FIX THE GEARBOX ASSEMBELY (13) TO THE BASE PLATE WITH TWO M3 x 10MM BOLTS (1) AND TWO M3 NUTS (3). REPEAT FOR THE SECOND GEARBOX ASSEMBELY

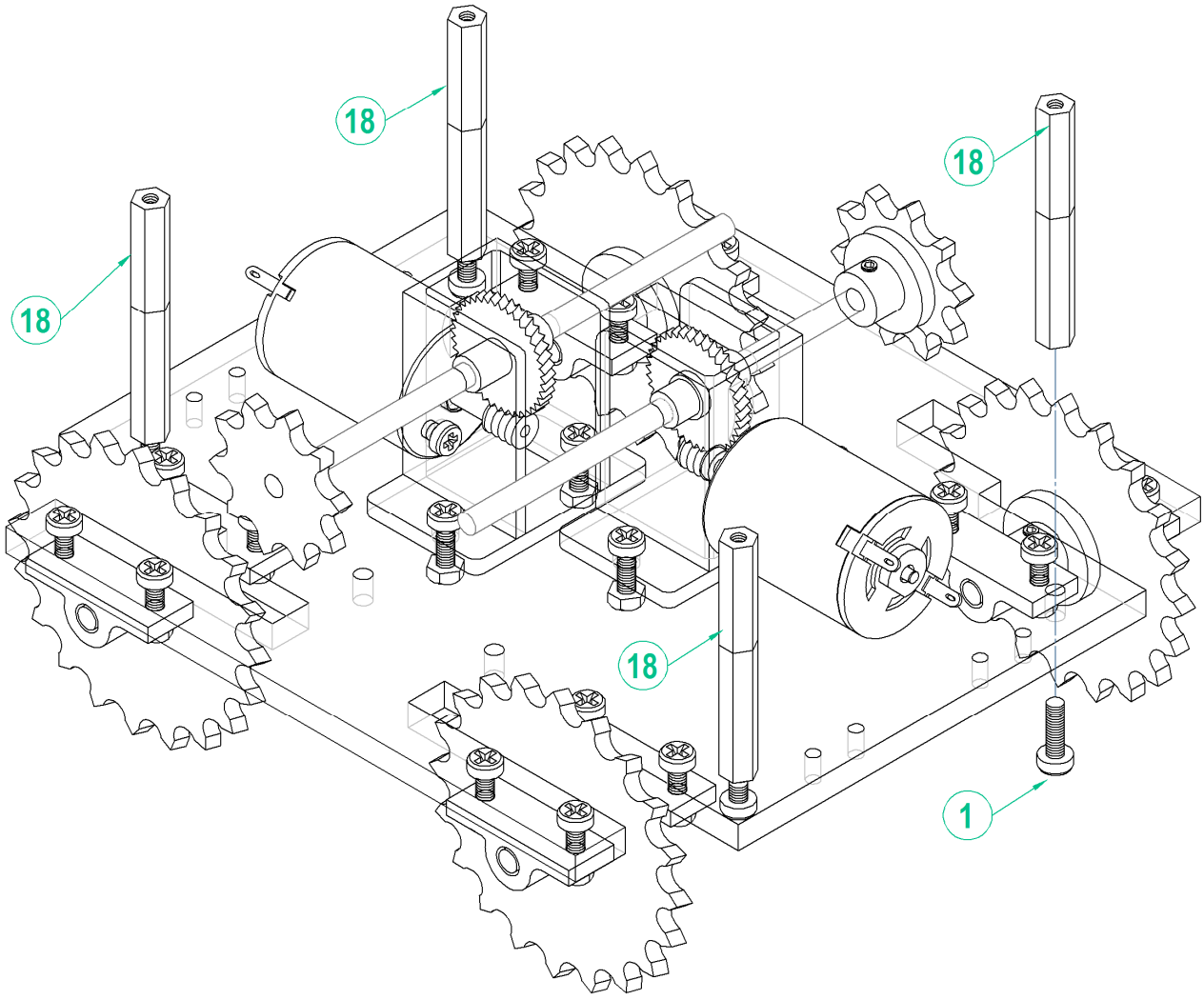
SLIDE THE DRIVE COG (14) ON TO THE GEARBOX DRIVE SHAFT (15) UNTILL IT IS FLUSH WITH THE END OF THE DRIVE SHAFT (15) AND FINALY INSERT AND TIGHTEN THE GRUB SCREW (6) WITH THE ALLEN KEY (4) REPEAT FOR THE SECOND DRIVE COG

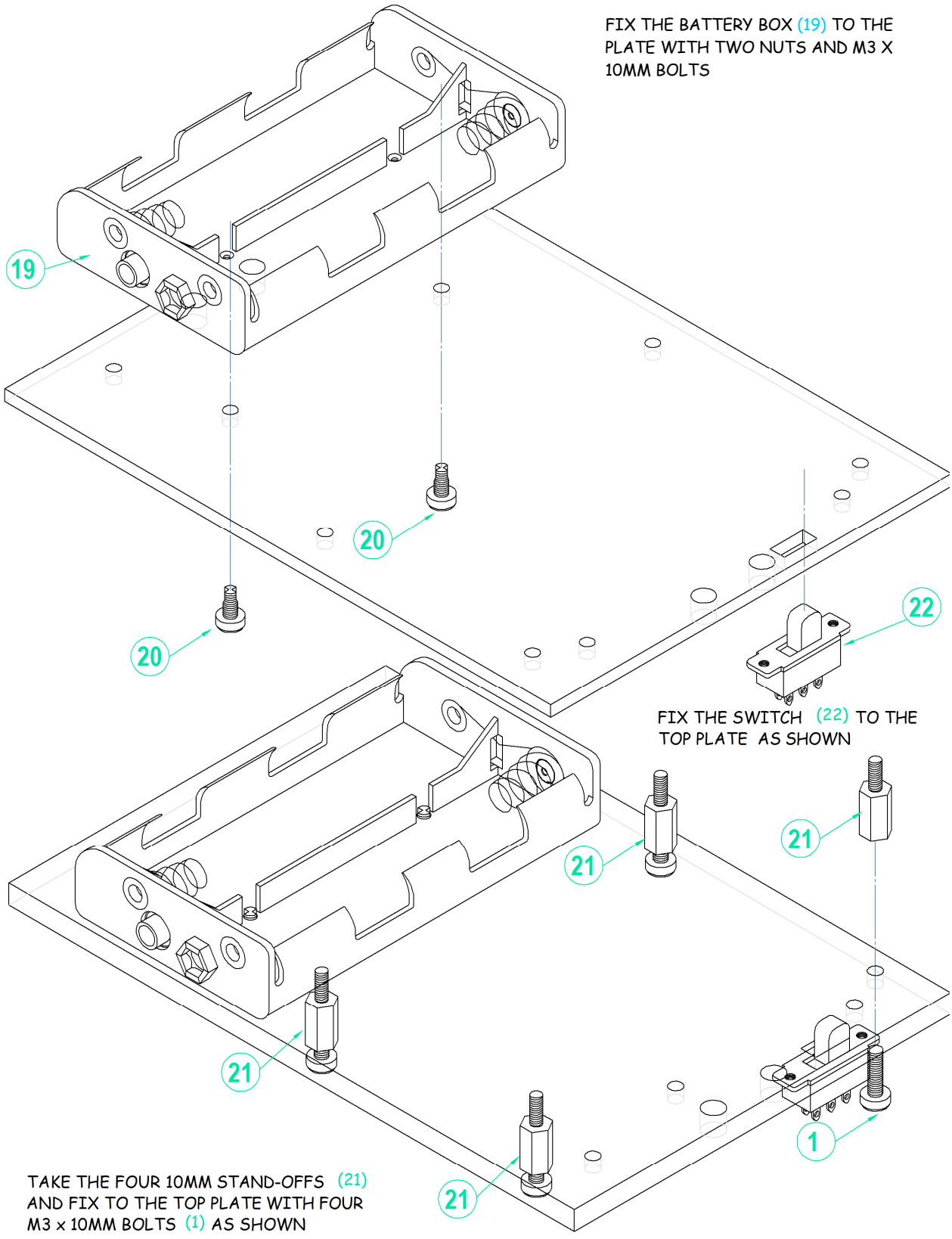


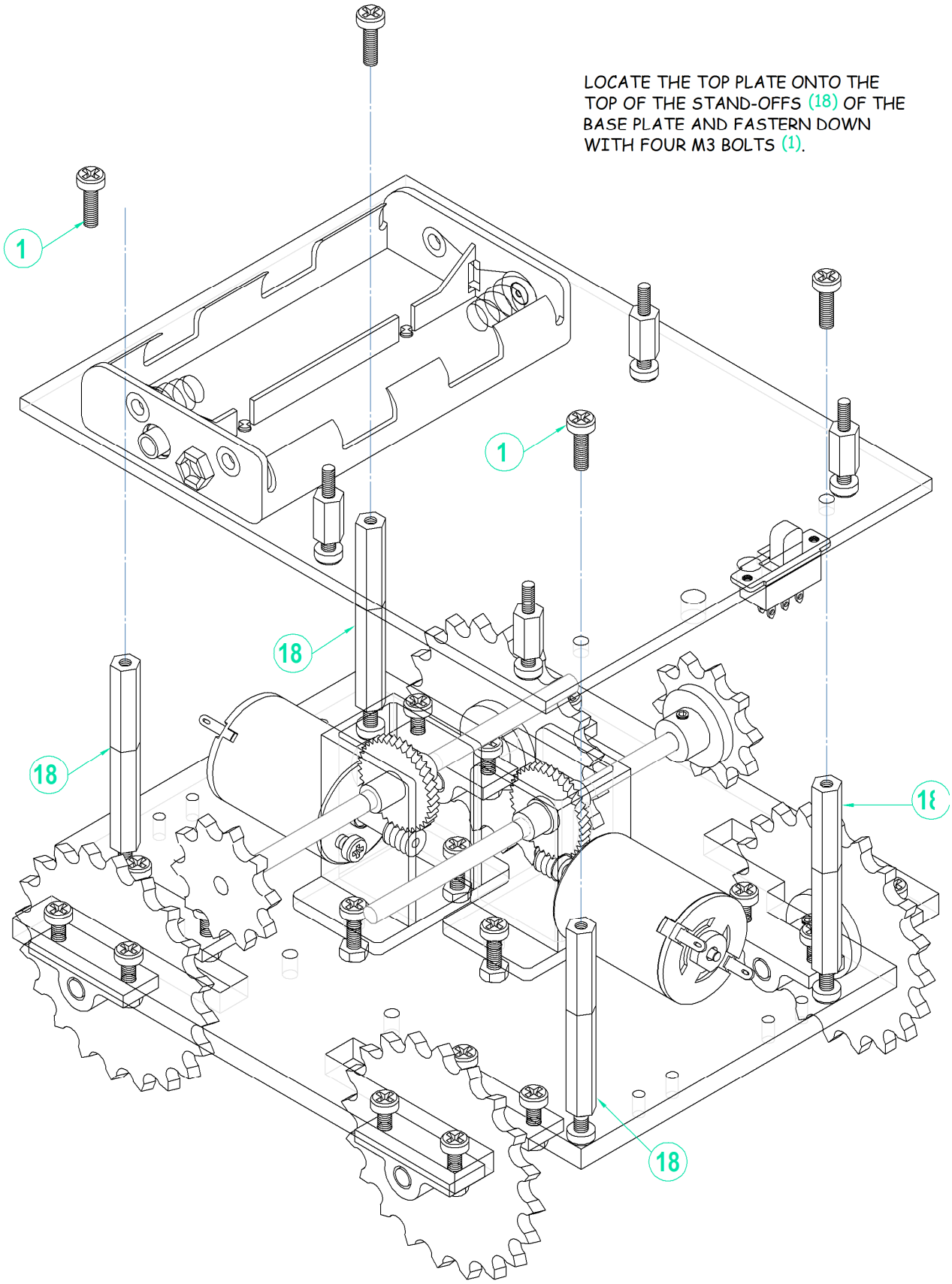


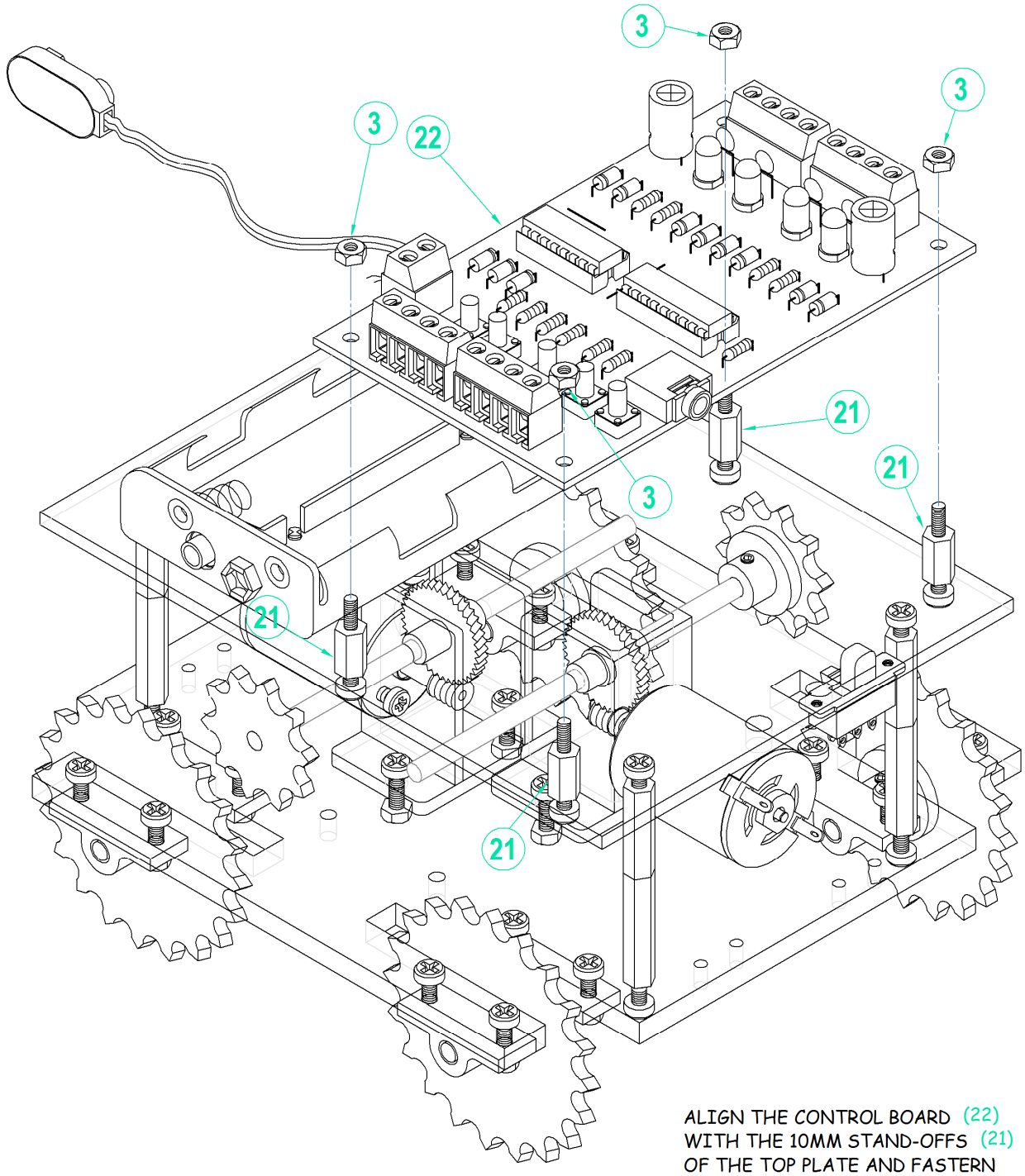


TAKE THE FOUR 25MM STAND-OFFS (16) AND JOIN THEM TO THE FOUR 20MM FEMALE STAND-OFFS (17). TAKE THE FOUR PAIRS (18) OF STAND-OFFS AND FIX THEM TO THE BASE PLATE WITH FOUR M3 x 10MM BOLTS(1) AS SHOWN

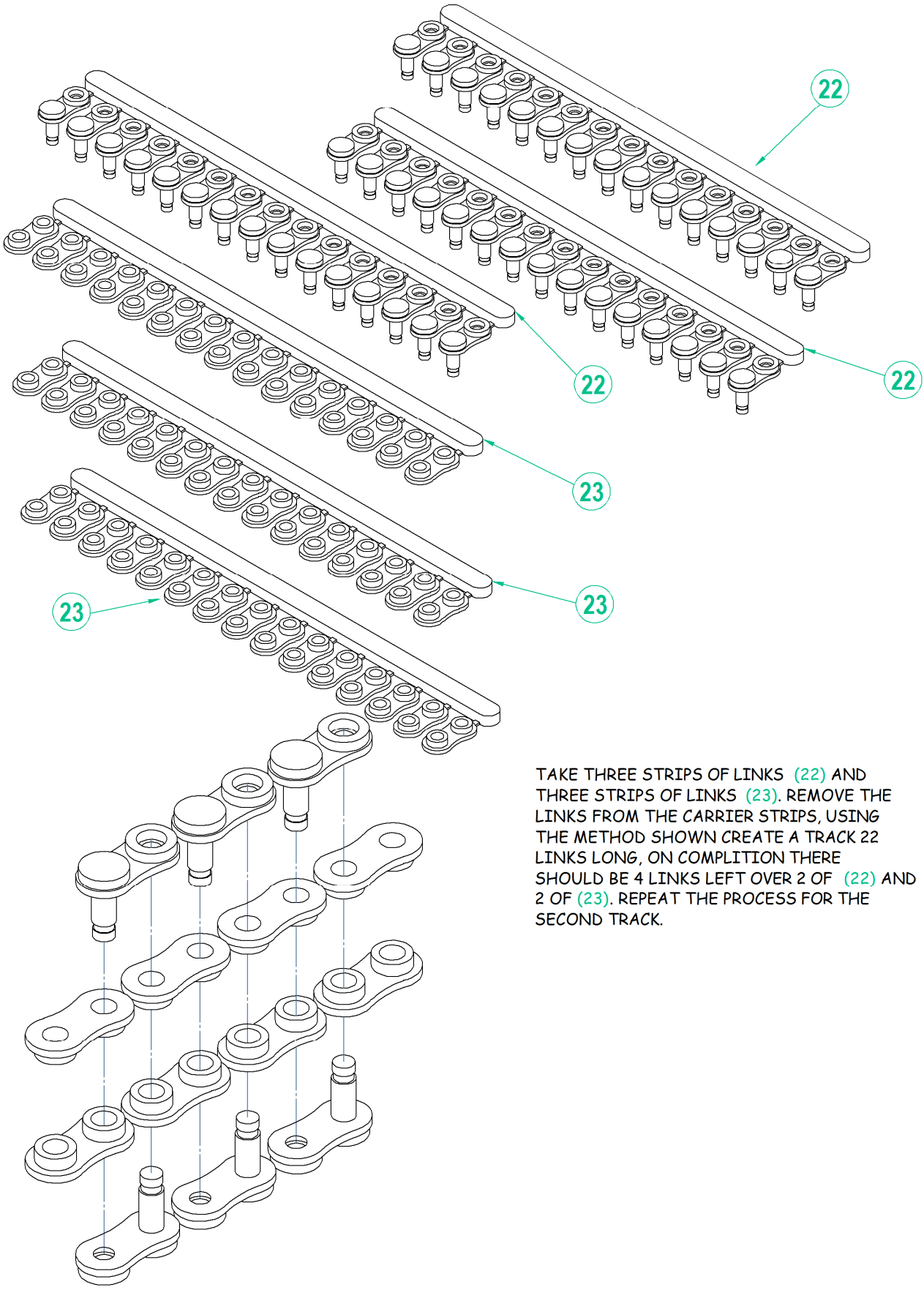



FIX THE BATTERY BOX (19) TO THE PLATE WITH TWO NUTS AND M3 X 10MM BOLTS
19
20
20
22
FIX THE SWITCH (22) TO THE TOP PLATE AS SHOWN
21
21
21
1
TAKE THE FOUR 10MM STAND-OFFS (21) AND FIX TO THE TOP PLATE WITH FOUR M3 x 10MM BOLTS (1) AS SHOWN


LOCATE THE TOP PLATE ONTO THE TOP OF THE STAND-OFFS (18) OF THE BASE PLATE AND FASTERN DOWN WITH FOUR M3 BOLTS (1).
1
1
18
18
18
18



ALIGN THE CONTROL BOARD (22)
WITH THE 10MM STAND-OFFS (21)
OF THE TOP PLATE AND FASTERN
WITH FOUR M3 NUTS (3)

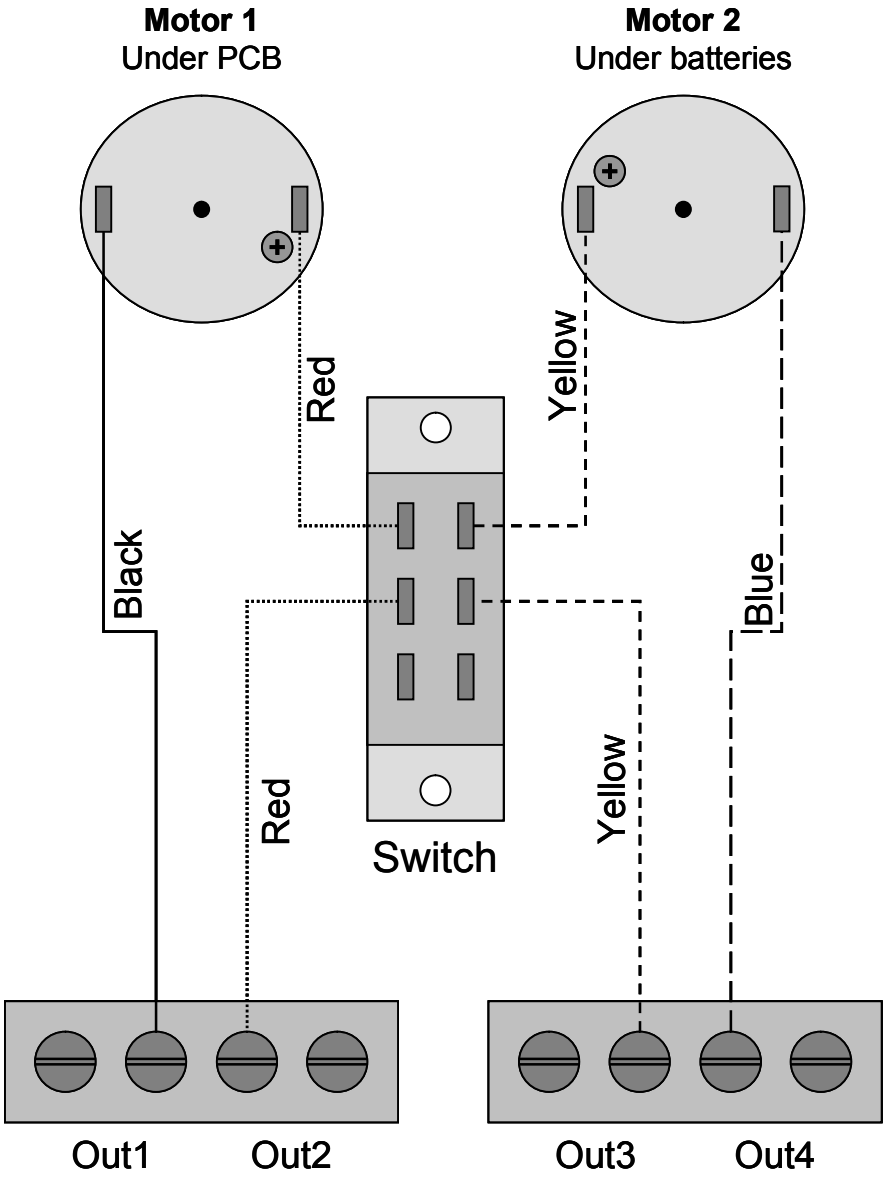


TAKE THREE STRIPS OF LINKS (22) AND THREE STRIPS OF LINKS (23). REMOVE THE LINKS FROM THE CARRIER STRIPS, USING THE METHOD SHOWN CREATE A TRACK 22 LINKS LONG, ON COMPLITION THERE SHOULD BE 4 LINKS LEFT OVER 2 OF (22) AND 2 OF (23). REPEAT THE PROCESS FOR THE SECOND TRACK.

Connecting motors to the controller board

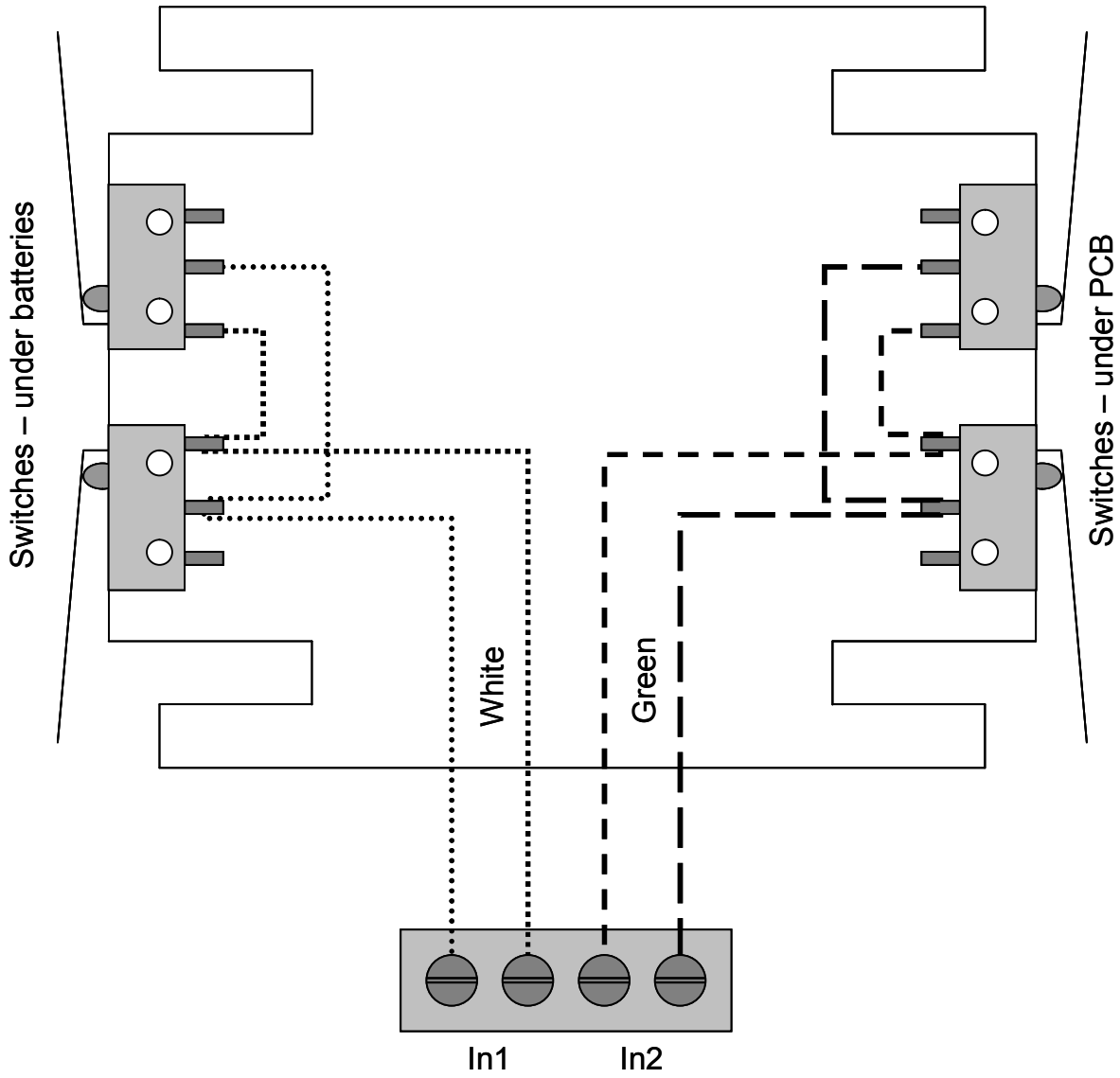
The tank kit is supplied with four lengths of wire in different colours; there is also a switch that has not yet been fitted. This switch will allow the motors to be stopped but without disconnecting power to the controller board. As the switch is mounted from the bottom of the plate you will find it easiest to solder the wires first and fix it in place afterwards.

The following wiring diagram shows which colour wire should be used to connect the motors, switch and terminal blocks together. There are holes in the chassis to keep the cables tidy and away from the moving parts, these are located above the motors and next to the switch. You may need to feed the wires through these holes before soldering them. Watch out for the '+' mark when you connect the motors.



Connecting switches to the controller board

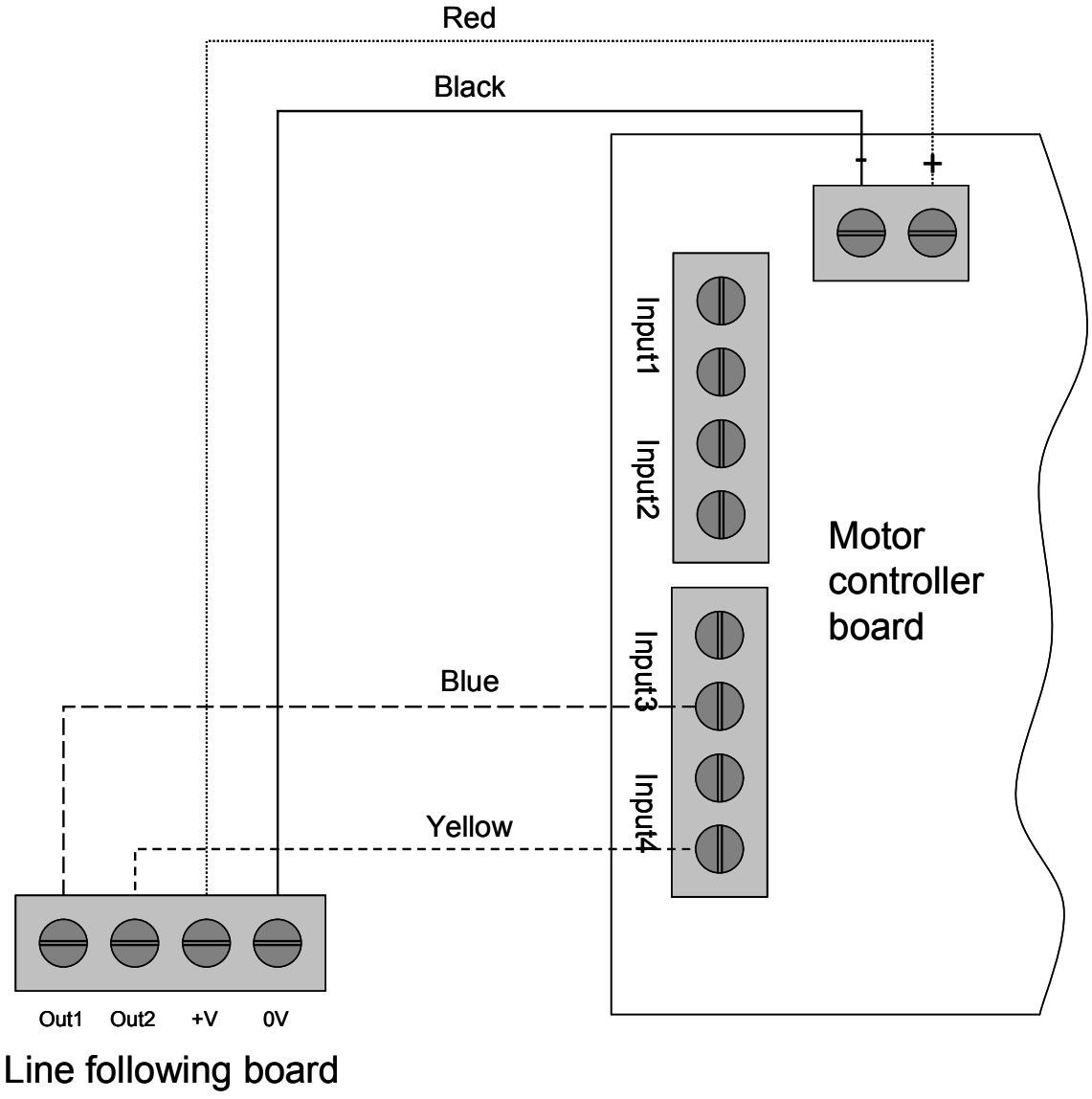
The laser cut tank kit can be enhanced with the addition of 'bump' detection micro switches. The 'switch add on kit' comprises four micro switches with fixing and some white & green cable. The following wiring diagram shows how the switches should be wired together. You should connect the wires to the common (COM) and normally open (NO) connections on the switch (these are the two connections nearest the hinge end of the switch, as indicated below). You will need to connect two 10nF capacitors to the terminal block as shown below. These are required as the wire connecting the control board to the switch can pick up spikes when the motors are running. The capacitors remove these spikes and prevent the software misinterpreting the state of the switch. This could also be done in software by checking the port pin more than once.



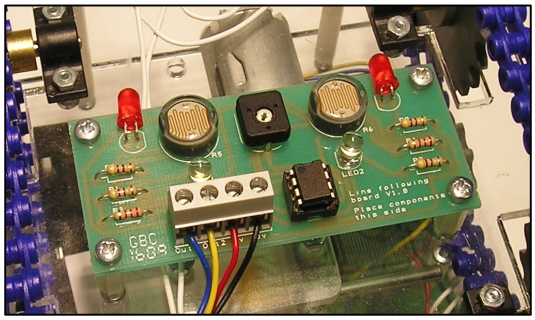
Connecting up a line following board

The four way terminal block on the line following board should be connected to the motor controller board as follows:

Care should be taken when wiring the two inputs to the motor controller board, to ensure that the correct half of the connecter is used. i.e. the one towards the bottom of the board (as shown).



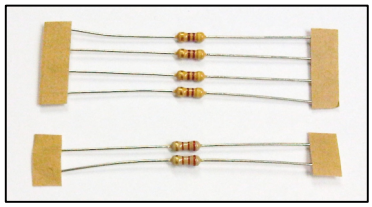
Build Instructions (line follower)



Before you put any components in the board or pick up the soldering iron, just take a look at the Printed Circuit Board (PCB). The components go in the side with the writing on and the solder goes on the side with the tracks and silver pads.

You will find it easiest to start with the small components and work up to the taller larger ones. If you've not soldered before get your soldering checked after you have done the first few joints.

Step 1



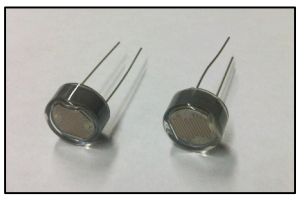
Start with the six resistors (shown right):
The text on the PCB shows where resistors R1, R2 and so on go. Make sure that you put the resistors in the right place.

R1, R2, R8, R9 are 470Ω (yellow, purple, brown coloured bands)
R3 & R4 are 2.2K (red, red, red coloured bands)

Step 2
Solder the Integrated Circuit (IC) holder in to U1. When putting this into the board, be sure to get it the right way around. The notch on the IC holder should line up with the notch on the lines marked on the PCB.

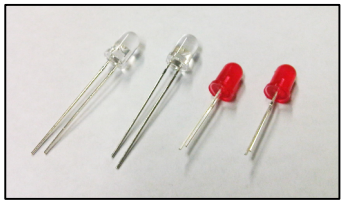
Step 3

Solder R7 - the variable potentiometer (pictured right) in to the PCB where it is labeled R7.

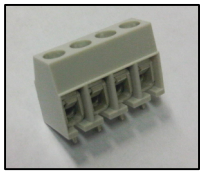


Step 4
Solder the two Light Dependant Resistors or LDRs for short (pictured left) in to the board where it is marked R5 & R6.

Step 5



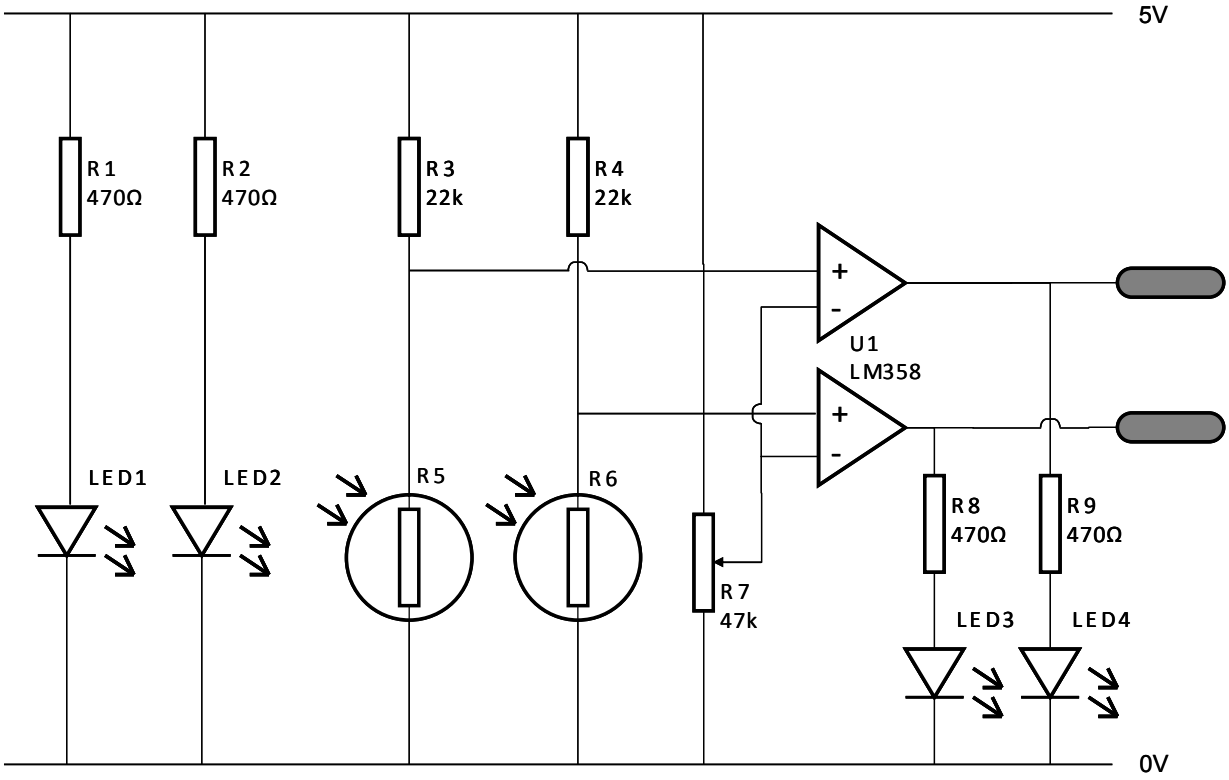
The red LEDs (pictured right) are designed to point out of the back of the board so that you can see them when the board is attached to the tank. The leads of the red LEDs need to be bent by 90° before they are soldered in to the board where it is marked LED3 and LED4. The LEDs won't work if they don't go in the right way around. If you look carefully one side of the LED has a flat edge, which must line up with the flat edge on the lines on the PCB. The two white LEDs go into the board vertically so don't need to be bent, again make sure the flat edge lines up, when soldering them into LED1 & LED2.



Step 6
Solder the 4-way terminal block (shown left) into the board. The terminal block should be placed in to the board so that the wires connect where the Out1, Out2, V+, 0V text is.

Step 7
The LM358 op amp IC can be put into the holder labeled U1 ensuring the notch on the chip lines up with the notch on the holder.

How the Line Following Board Works



The two white LEDs (LED1 & LED2) on the left of the circuit are present to make sure that the light level remains consistent next to each LDR. The resistors (R1 & R2) are included to limit the current in to the LED and control the brightness.

Both LDRs (R5 & R6) work in the same way, in that the LDR with an additional resistor (R3 / R4) make up a potential divider. As the light on the LDR changes, its resistance changes and in turn the voltage at the centre of the potential divider changes. This voltage which changes with light level is then fed in to the op amp. The op amp is set up as a comparator, which means that the voltage from the LDR is compared to voltage set by the trimmer potentiometer (R7). If the LDR voltage is bigger than the pre-set voltage then the output of the op amp goes high, when the LDR voltage is lower than the pre-set voltage the output goes low.

When the output is high the LED (LED3 / LED4) is on and this is signaled back to the main board that controls the tank. Once again a current limit resistor (R8 / R9) is present to control the brightness of the LED.

When a black line is being followed, normally the LDR will be light and the output will be off. When the LDR is over the line it will be dark and the output will be on.

Motor control experiment

Single motor test

Equipment: You will need a laser cut tank kit, with the motor controller board programmed with the sequence controller software.

Test: Using the sequence controller in program mode, press the switches to toggle the outputs on and off to find out what happens to a single motor. Record your observations in the table below:

Output 1	Output 2	Motor direction
Off	Off	
Off	On	
On	Off	
On	On	

Full tank control

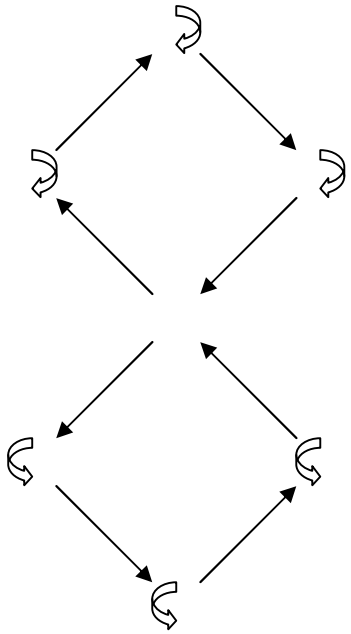
Test: Using all four input switches and your knowledge gained in the first test, work out which outputs should be on and which should be off to get the tank to move. For each output record if it is on or off when the tank is moving as per the left column of the table:

Tank direction	Output 1	Output 2	Output 3	Output 4
Forward				
Backwards				
Spin on the spot left				
Spin on the spot right				
Stopped				

Control program

Using the sequence controller can you program the tank to go forward then turn through about 90° and repeat this again and again? The route of your tank should resemble a square.

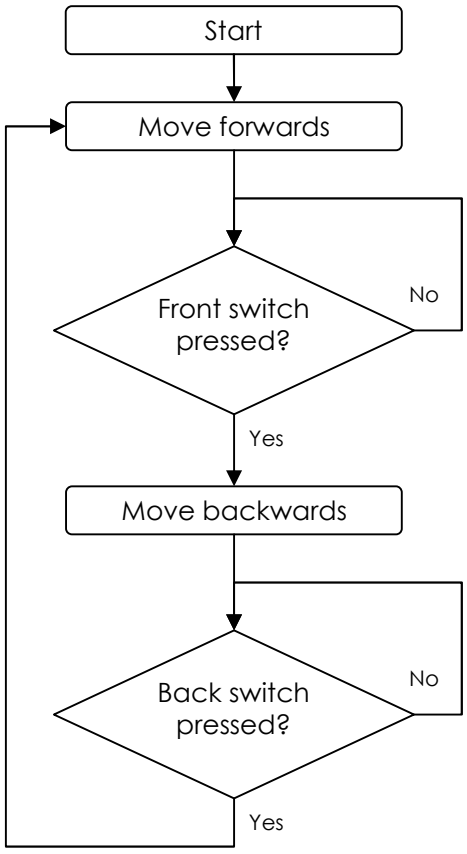
Once you have completed this try to make the tank travel in a figure of eight as shown on the right:



You are currently using the tank without any feedback. What is the main problem with this?

Forward / backwards bump detection

In this task you are going to use a PC to program the tank. The tank has been fitted with micro-switches, these allow the controller to detect when the front or the back of the tank have run into a wall or object. Your software will drive the buggy forward until the front switch detects contact when it will swap directions until the back switch detects contact and repeat. This is shown in the following flowchart:



Inputs

PCB marking	Description	Pin number	Microchip port name
Input1	Back switch	17	RA0
Input2	Front Switch	18	RA1

Outputs

PCB marking	Description	Pin number	Microchip port name
Output1	Motor 1	6	RB0
Output2	Motor 1	7	RB1
Output3	Motor 2	8	RB2
Output4	Motor 2	9	RB3

The front of the tank is the end with the PCB.

Reordering information

Description	*Stock code*
Laser cut tank kit	2125

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