Vehicle Assembly

This section describes the assembly of a vehicle. Firstly, lists with necessary materials and useful tools are given. Afterwards, the assembly is described step by step devided into the following 7 parts:

0. Bill of Materials
1. Underframe Preparation
2. Adhesive Preparation
3. XRAY M18 PRO Assembly
4. Servo Configuration
5. Soldering
6. LED Holder
7. Final Assembly

These instructions do not include PCB soldering. For instructions on PCB assemly, see PCB Assembly.

For questions regarding assembly, please contact:

- Patrick Scheffe

Contents

0. Bill of Materials

The following tables show the quantities of the components needed for *one* vehicle. *Note*: The elements needed for PCB-Assembly are not given here.

Mechanical Components		Quantity
XRAY M18 Pro LiPo Kit		1
NF113LG-011 DC motor		1
Motor Magnet (6x2.5 mm, diametrically magnetised)		1
Battery Holder (.stl file for 3D printing)		1
LED Holder (.stl file for 3D printing)		1
Screws	M2x6mm	2
	M2x5mm	2
	M2x10mm Countersink	2
	M2.5x6mm	3
	M3x10mm	2
Nuts	M2	6
	M2.5	5
	M3	4
Washers	M2.5	2
	inner diameter: 2.2mm outer diameter: max. 4.5mm	2

Electrical Components	Quantity
Vehicle Main Board	1

Odometer Board			1
Female DSUB 9 connector			1
HiTEC D89MW servo			1
Banana connector 4mm			2
Banana connector 2mm			1
100nF capacitor			2
Fuse holder 0031.8201.G			1
Fuse 521,027			1
Red 1.0 wire end ferrule			4
4-Pole connector			1
LED NSDW570GS-K1			4
IDC Ribbon cable 10 POL (AWG 28-10G 10M)			11 cm
IDC Socket 10 POL			2
Heat shrinks			
Silver wire			
	Color	**Gauge**	
Wires	Red	1mm2	31 cm
	Black	1mm2	25.5 cm
	Blue	0.5mm2	8.2 cm
	Red	0.14mm2	35 cm
	Black	0.14mm2	35 cm

Tools
2-Part epoxy adhesive
HiTEC DPC-11 Software
Servo Programmer incl. necessary harnesses
Soldering iron
Crimper
3D-Printer
Diverse drills, screwdrivers and allen keys

Contents

1. Underframe Preparation

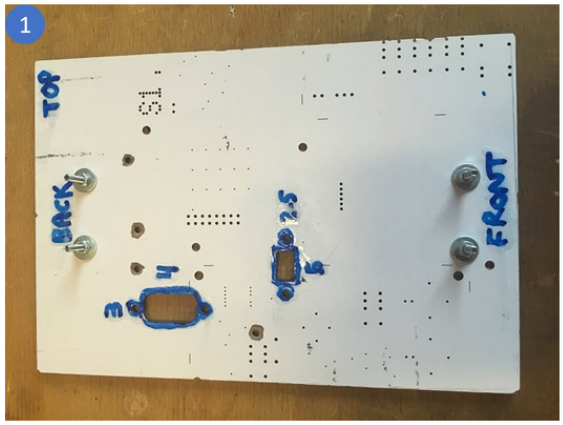
The CPM Lab's vehicles are based on the XRAY M18 Pro LiPo Kit. However, for using it in the Lab, several adaptations have to be applied to it.

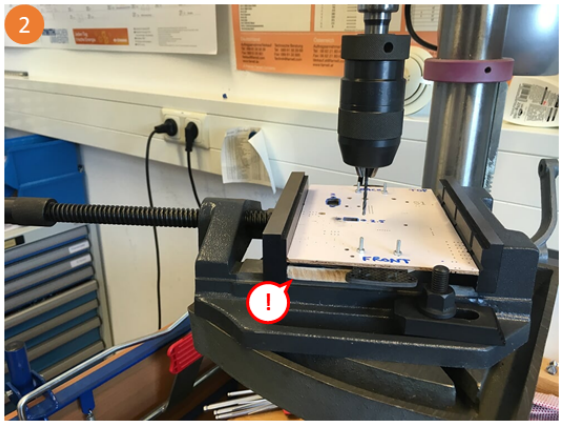
In this step, additional holes will be added to the underframe of the M18 to provide mounts for the charging connection, the fuse, and the switch. For this, a wooden template is used onto which even multiple underframes can be attached.

1. Car Underframe Preparation

Part	Quantity
XRAY M18 PRO Underframe	1

Tool
XRAY M18 PRO Drill Template, 4x M2.5mm screws and nut
Wood Drill Underlay





Step	Instructions
1	Attach template to top of underframe NOTE: take note of orientation
2	Mount underframe+template to drill with wood underlay beneath NOTE: without wood underlay, underframe will bend and drilling will not work

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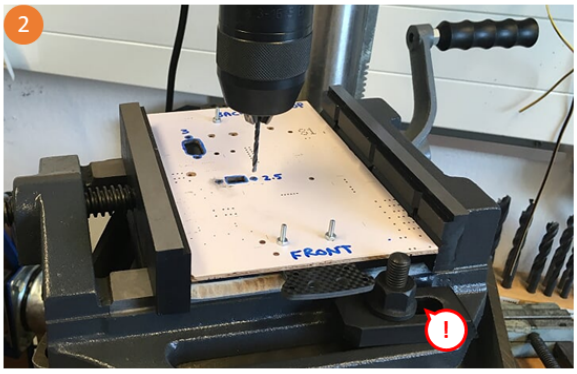
2. Car Underframe Drilling

Part	Quantity
XRAY M18 PRO Underframe	1

Tool
2.5mm, 3mm, 4mm, 5mm Drill Bit



Step	Instructions
1	Drill 3mm DSUB holes NOTE: make sure to secure vice to ensure proper hole placement
2	Drill 2.5mm switch holes NOTE: make sure to secure vice to ensure proper hole placement
3	Use 4mm drill to drill out DSUB port
4	Use 5mm drill to drill out switch port

---

3. Car Underframe Filing

Part	Quantity
XRAY M18 PRO Underframe	1
XRAY M18 PRO Drill Template	1

Tool
Files
Vice

Step	Instructions
1	Using vice and square file to file final switch shape, check results with switch NOTE: consider removing template towards end to avoid damaging
2	Using vice and a combination of files to file out DSUB port, **check results with male DSUB** NOTE: consider removing template towards end to avoid damaging

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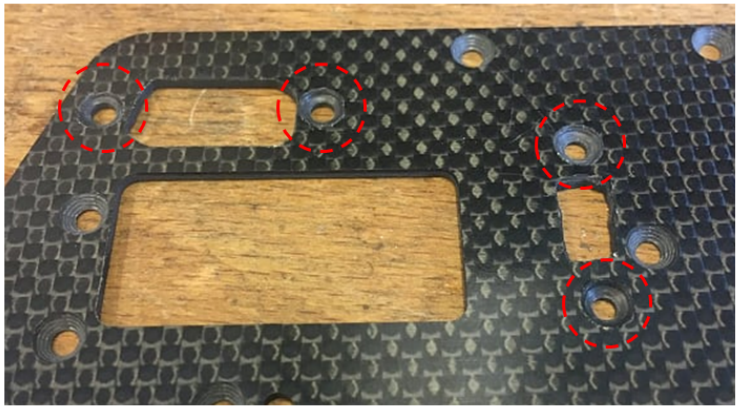
4. Car Underframe Post

Part	Quantity
XRAY M18 PRO Underframe	1

Tool
6mm Drill Bit or M3 Countersink
Wood Drill Underlay



Step	Instructions
1	If not already removed, remove template
2	Use 6mm drill bit or M3 Countersink to countersink 3mm and 2.5mm holes NOTE: countersink holes on bottom of underframe

Contents

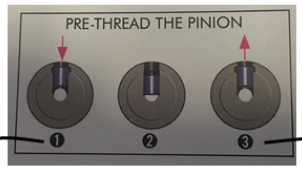
2. Adhesive Preparation

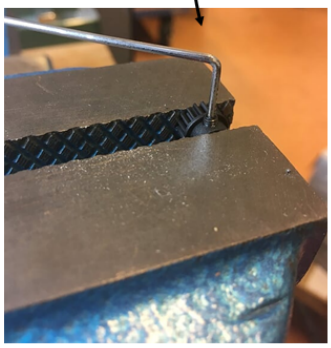
Since the adhesive needs some time for drying, this step is done now. On the one hand, the magnet must be adhered to the cog to allow distance measuring by the odometer. On the other hand, two nuts fixed to the Flex Piece will allow an easier fastening of the Main Board in the end.

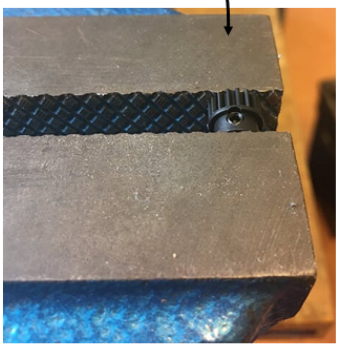
1. Magnet Motor Cog Pre-Thread

Part	Quantity
17T Cog from XRAY M18 Pro Kit (tooth count written on back)	1
Threaded Insert	1

Tool
1.5mm Allen Key





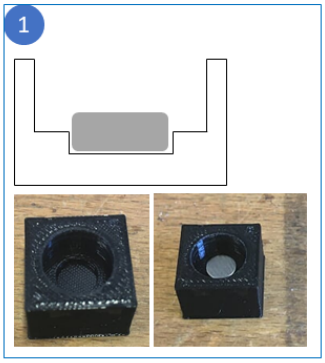


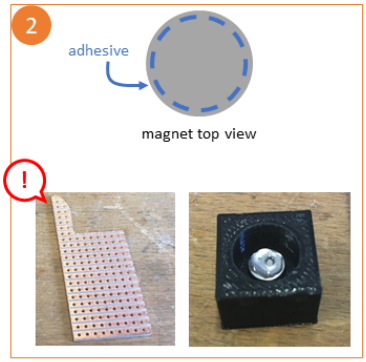
Step	Instructions
1	Use 1.5mm Allen Key to pre-thread cog per manufacturers instructions (p. 26) TIP: clamping cog in vice facilitates steps

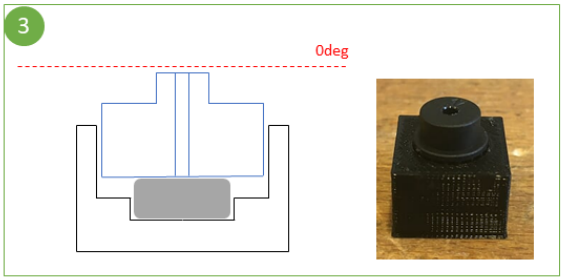
2. Magnet Motor Cog Mating

Part	Quantity
17T Cog from XRAY M18 Pro Kit (tooth count written on back)	1
Bipolar magnet	1

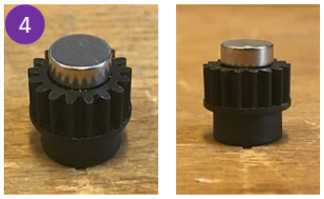
Tool
Cog Magnet Mating Tool (3D Printed)
2-Part Epoxy Adhesive
Blunt tipped drill







Step	Instructions
1	Place magnet into bottom of tool
2	Apply mixed Epoxy to top of magnet using **NON-MAGNETIC TOOL/TIP** NOTE: apply glue on perimeter of top to avoid shaft hole
3	Slowly and carefully slide cog into tool until it has settled onto magnet. **Ensure cog is level**. NOTE: do not excessively press on cog to prevent glue spread
4	Allow glue to harden according to specifications. If necessary, use blunt-tipped drill to clear shaft hole.

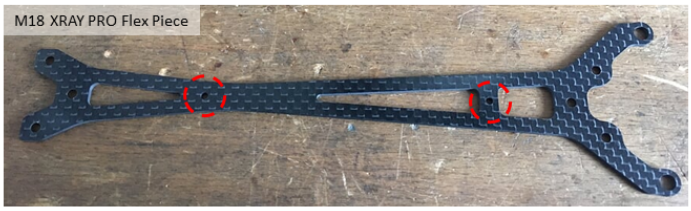


Recommended 2-Part Epoxy Adhesive

3. PCB Nut Fixation (1/2)

Part	Quantity
M2 Nut	2
M2x6mm Screw	2
M18 XRAY PRO Flex Piece	1

Tool
2-Part Epoxy Adhesive



Step	Instructions
1	Use screws to fixate M2 Nuts to Flex Piece NOTE: make sure Nuts are on bottom (see images for orientation)

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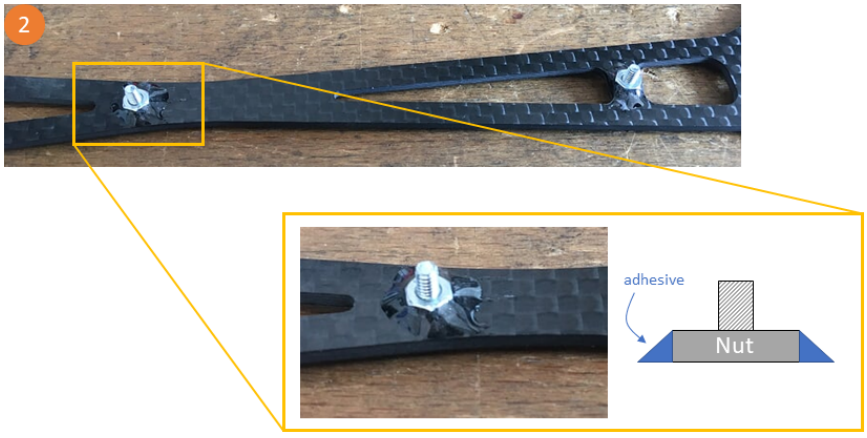
3. PCB Nut Fixation (2/2)

Part	Quantity
M2 Nut	2
M2x6mm Screw	2
M18 XRAY PRO Flex Piece	1

Tool
2-Part Epoxy Adhesive



Step	Instructions
2	Apply mixed adhesive to perimeter of screw (as fillet) NOTE: make sure to not get adhesive on screw because it can then no longer be removed

Contents

3. XRAY M18 PRO Assembly

In the next part, the M18 Pro is built according to its manual, mostly. Consequently, this section focuses on tips and indicates deviations from the original.

XRAY M18 PRO Assembly

Part	Quantity
XRAY M18 Pro Set	1

Tool
M18 Assembly Manual

Step	Instructions
1	Follow assembly instructions NOTE: each section contains slides with notes and tips for assembly IMPORTANT: read slide to each section before proceeding with section

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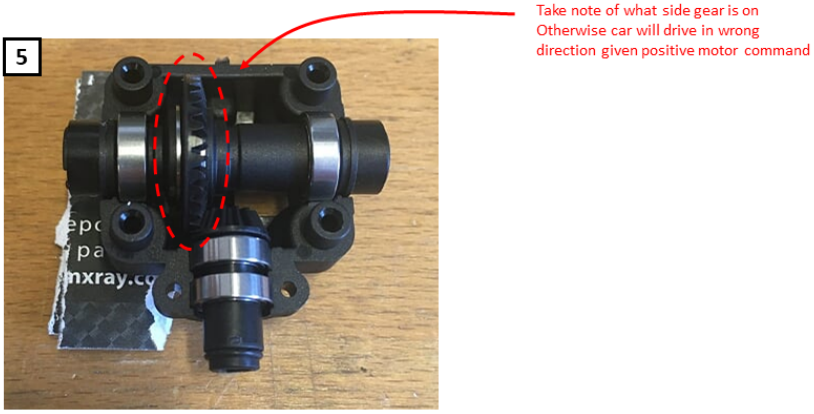
1. Front Differential



Step	Note
5	Take note of differential orientation
	Differential break-in done post vehicle assembly

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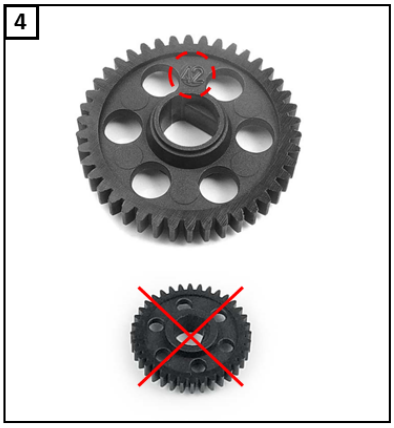
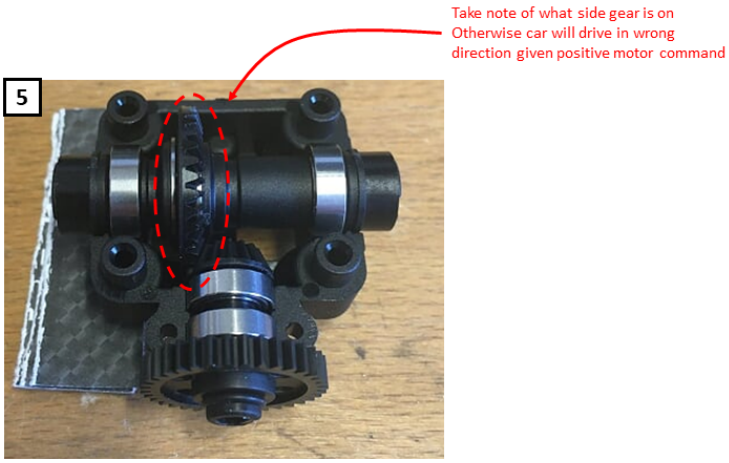
2. Rear Differential





Step	Note
4	Note that for this vehicle the cog wheel with 42 cogs instead of the common one with 36 cogs has to be used.
5	Take note of differential orientation
	Differential break-in done post vehicle assembly

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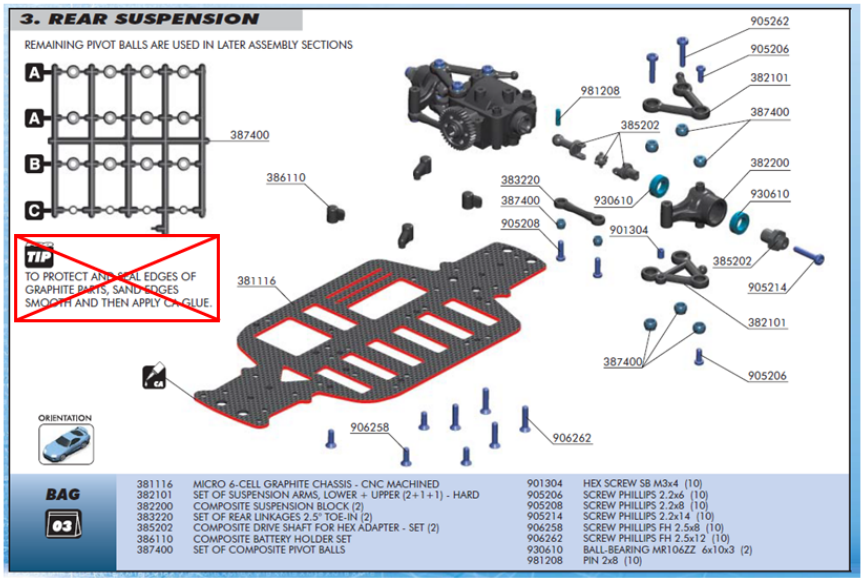
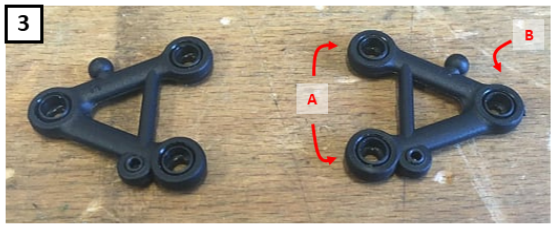
3. Rear Suspension (1/3)



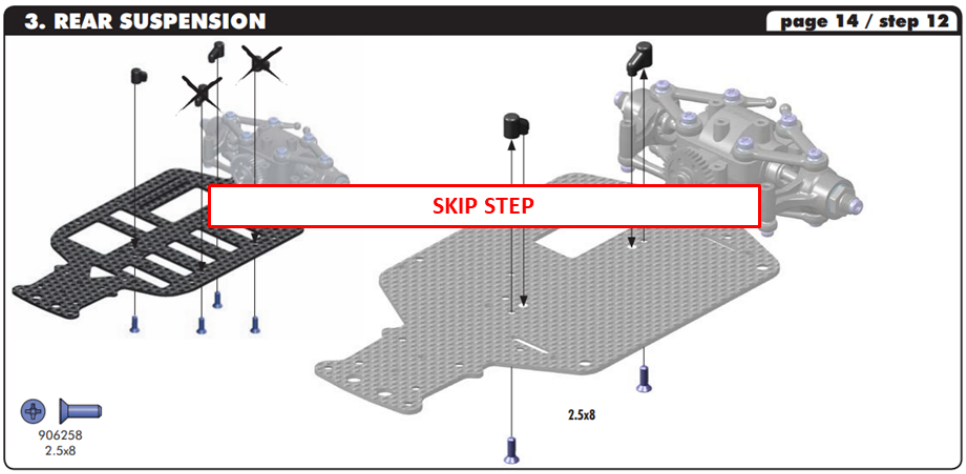
Step	Note
INTRO	Not necessary to seal edges with CA Glue given indoor use of vehicles

3. Rear Suspension (2/3)



Step	Note
3	Take note of different types of pivot balls Take note of orientation of pivot balls and direction from which downstop screw is inserted
4	Take note of different types of pivot balls Take note of orientation of pivot balls
6	Use vice to clamp tool to facilitate step

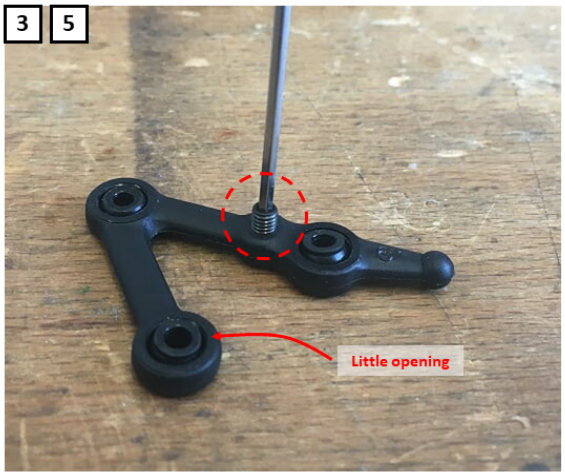
3. Rear Suspension (3/3)



Step	Note
12	Skip step because we have our own battery holding, which will be installed later.

4. Front Suspension (1/2)

3 5



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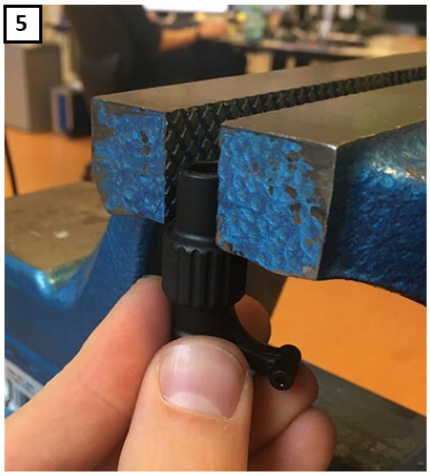
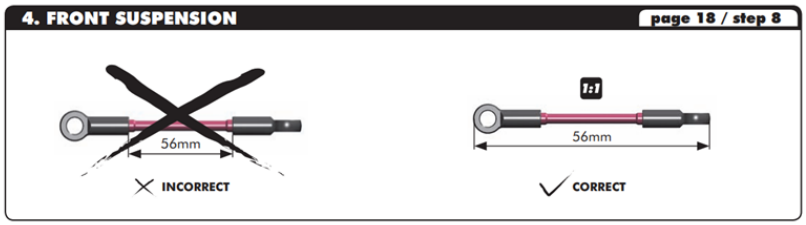


Step	Note
3	Take note of different types of pivot balls Take note of orientation of pivot balls
5	Take note of orientation of pivot balls and direction from which downstop screw is inserted
5	Use vice to clamp tool to facilitate step

4. Front Suspension (2/2)



Step	Note
8	Step wrong, see supplemental instruction sheet NOTE: exact length set during servo setup procedure (see next section)

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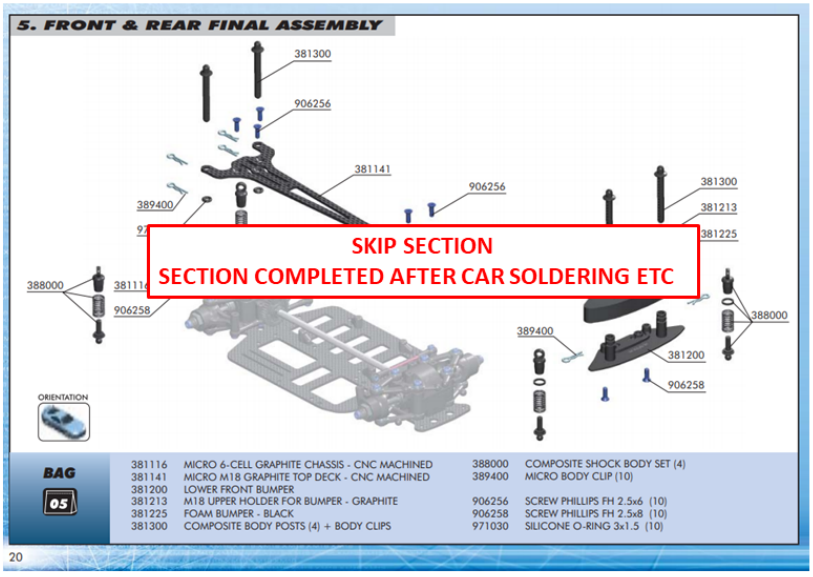
5. Front & Rear Final Assembly



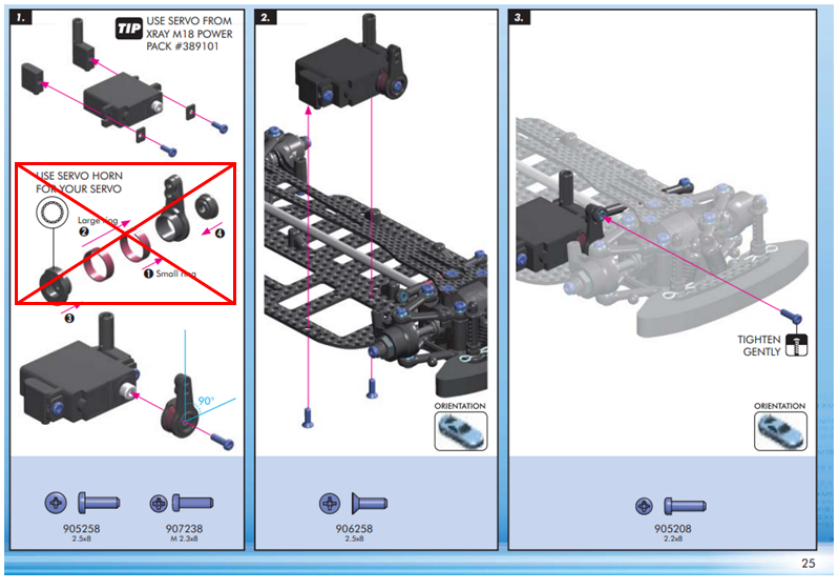
Step	Note
ALL	Skip section for now Modifications and steps to come easier done prior to Section 5

Contents

4. Servo Configuration

The assembly of the M18 Pro ends with the configuration of the servo and the wheels. In order to configure the HiTEC D89MW Servo, the HiTEC DPC-11 software is used. For the current configuration of all vehicle's servos look here.

1. M18 Pro Final Assembly: Servo (1/2)

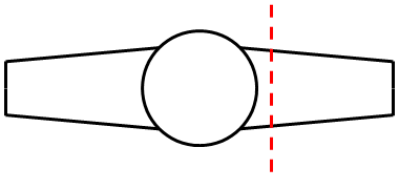


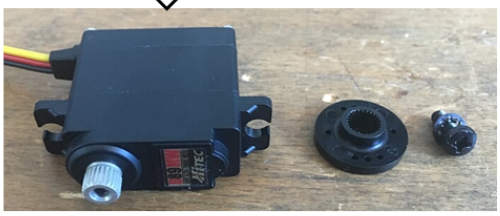
Step	Note
1-3	Follow Custom Servo Preparation and Installation Steps in following slides e.g. different servo horn will be used

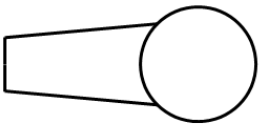
2. Servo Prep (1/2)

Part	Quantity
HiTec D89MW Servo	1
180deg Servo Arm	1

Tool
Saw, File







Step	Instructions
1	Remove currently installed servo arm
2	Trim one side of 180deg servo arm (see images above)

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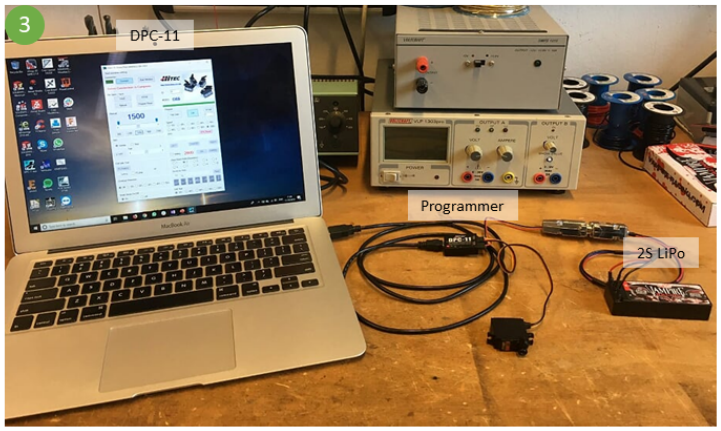
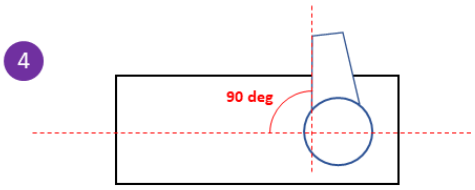
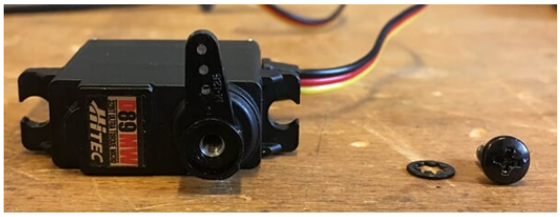
2. Servo Prep (2/2)

Part	Quantity
HiTec D89MW Servo	1
180deg Servo Arm	1

Tool
Servo Programmer, 2S LiPo, necessary Harnesses







Step	Instructions
3	Using Arduino, HiTec DPC-11 Software, or existing vehicle, power servo and command to 0deg (1500) NOTE: use manual position test, **0deg corresponds to 1500**
4	Attach modified servo arm as shown in the figure. Note: servo arm should be located on **right side of servo** : given splines on servo cog, side of servo arm may not be at exactly 90deg; this will be accounted for later

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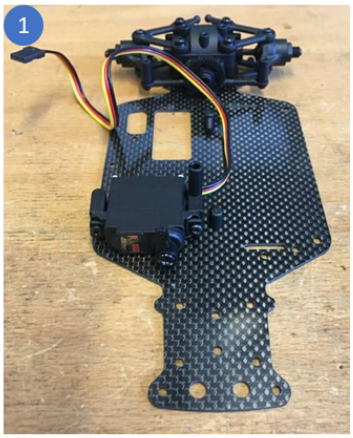
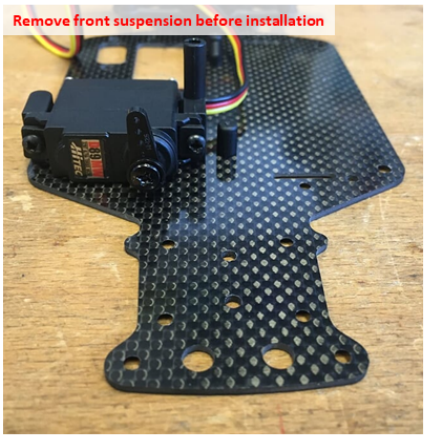
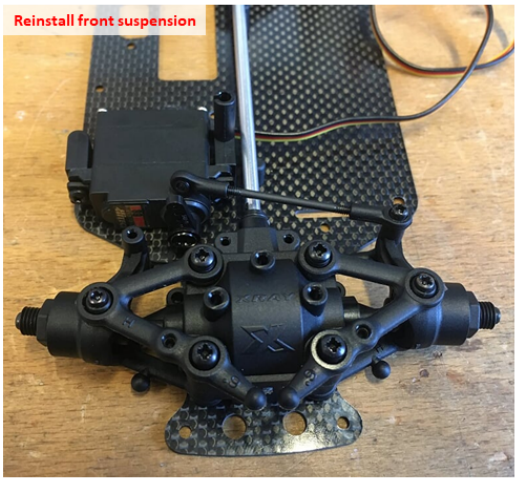
3. Servo Installation

Part	Quantity
HiTec D89MW Servo	1

Tool
M18 Assembly Manual







Step	Instructions
1	Attach servo to vehicle according to manual instructions (p. 25 Steps 1-2) Note: try to install servo in the center of servo mounting posts; inconsistencies will be accounted for later **TIP: consider removing front suspension to facilitate access**

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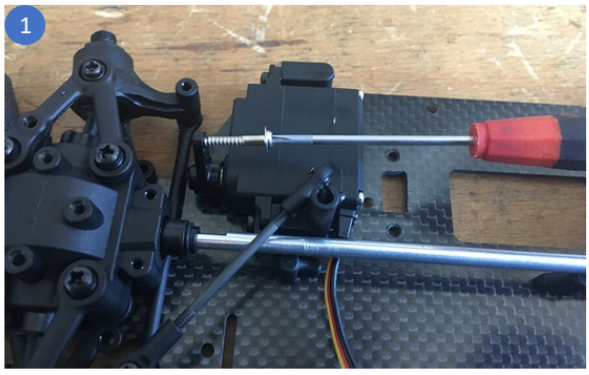
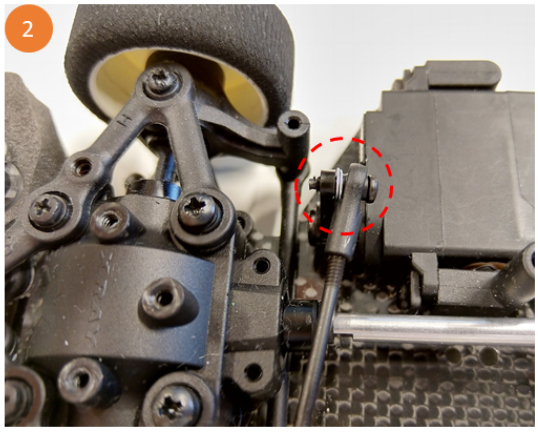
4. Servo Arm Attachment

Part	Quantity
HiTec D89MW Servo	1
Washer (inner diameter: 2.2mm; outer diameter: 4.5mm)	2

Tool
M18 Assembly Manual





Step	Instructions
1	Use screw included with servo (shown on the left) to pre thread uppermost servo arm hole
2	Attach steering arm to servo arm so that steering arm is behind servo arm (see image) and the two washers are in between. Note: The wheels don't have to be attached here. That will be the next step.

5. Attach Wheels

Part	Quantity
M18 PRO Wheels	4

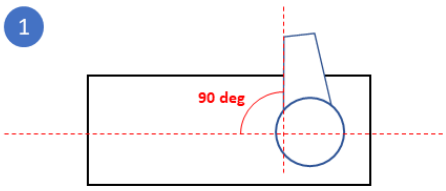
Tool
M18 Assembly Manual

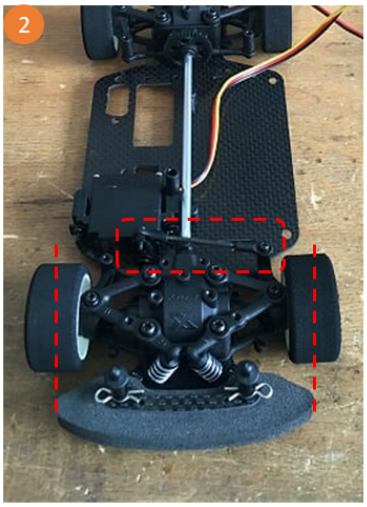
Step	Instructions
1	Attach wheels per manual; instructions (p. 29 step 11) Note: the smaller wheels must be attached on the front axis

6. Servo Arm Adjustment

Part	Quantity

Tool



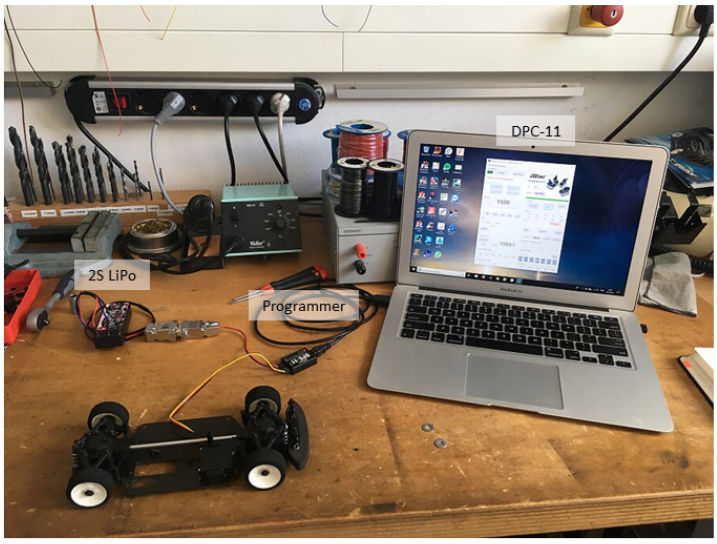


Step	Instructions
1	Move servo arm to the given position.
2	Adjust length of steering arm by turning thread in or out until front wheels are straight when servo arm stays at the shown position.

7. Servo Flashing (1/3)

Part	Quantity
HiTec D89MW Servo	1

Tool
Servo Programmer, 2S LiPo, necessary Harnesses



Step	Instructions
1	Connect Servo to 2S Lipo and Programmer Connect Programmer to computer and start DPC-11 Software.

7. Servo Flashing (2/3)

Part	Quantity
HiTec D89MW Servo	1

Tool
Servo Programmer, 2S LiPo, necessary Harnesses

1. Start DPC-11, select D-Series

2. Connect to Servo

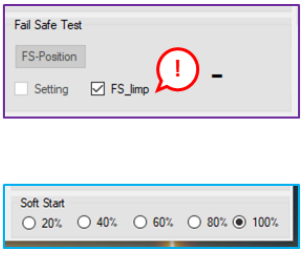
Step	Instructions
2	Start DPC-11 software Select D-Series Connect to Servo

---

7. Servo Flashing (3/3)

Part	Quantity
HiTec D89MW Servo	1

Tool
Servo Programmer, 2S LiPo, necessary Harnesses

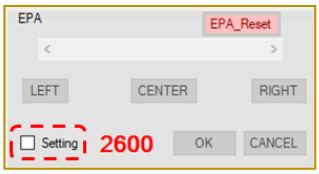


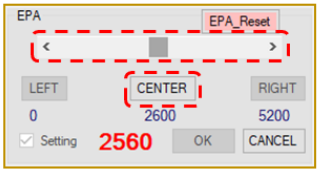
Step	Instructions
3	Only set/change following Settings: 1. Soft Start: 100% (was 20%) 2. FS_LIMP: checked (was unchecked) NOTE: do not set FS-Position, simply check FS_Limp

8. Servo End Point Adjustment (1/3)

Part	Quantity
HiTec D89MW Servo	1

Tool
Servo Programmer, 2S LiPo, necessary Harnesses





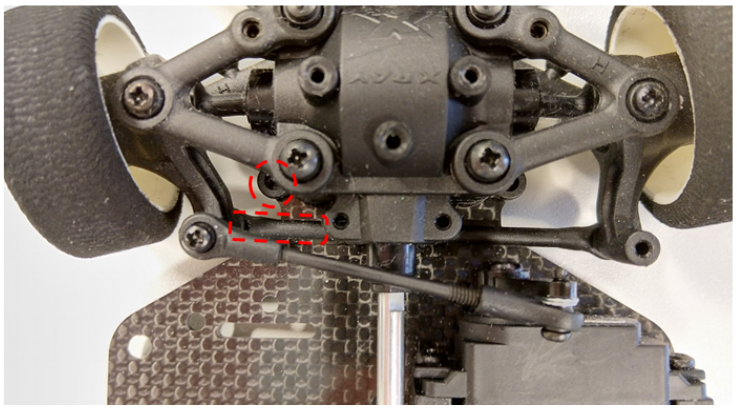
Step	Instructions
1	Activate the End Point Adjustment Setup by setting the hook.
2	Use the scrollbar to find the value at which the vehicle moves completely straight. Confirm this value by hitting “CENTER”.

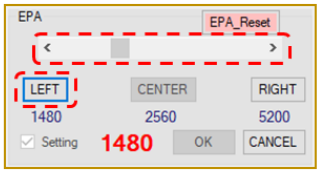
---

8. Servo End Point Adjustment (2/3)

Part	Quantity
HiTec D89MW Servo	1

Tool
Servo Programmer, 2S LiPo, necessary Harnesses



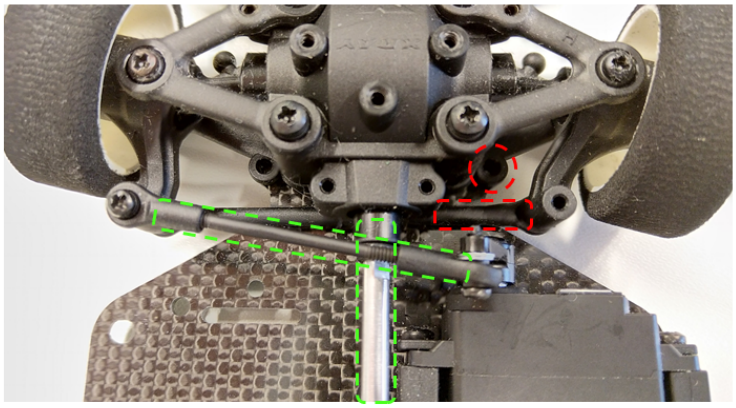


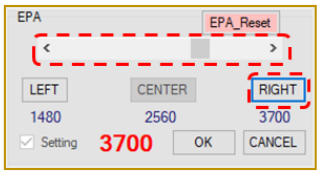
Step	Instructions
3	Steer further and further to the left until the two red marked components hit each other. Confirm this maximum by hitting “LEFT”. Note: There should be no mechanical limits for the steering until this point is reached. If that isn’t the case, adjust the steering arm accordingly and repeat the process.

8. Servo End Point Adjustment (3/3)

Part	Quantity
HiTec D89MW Servo	1

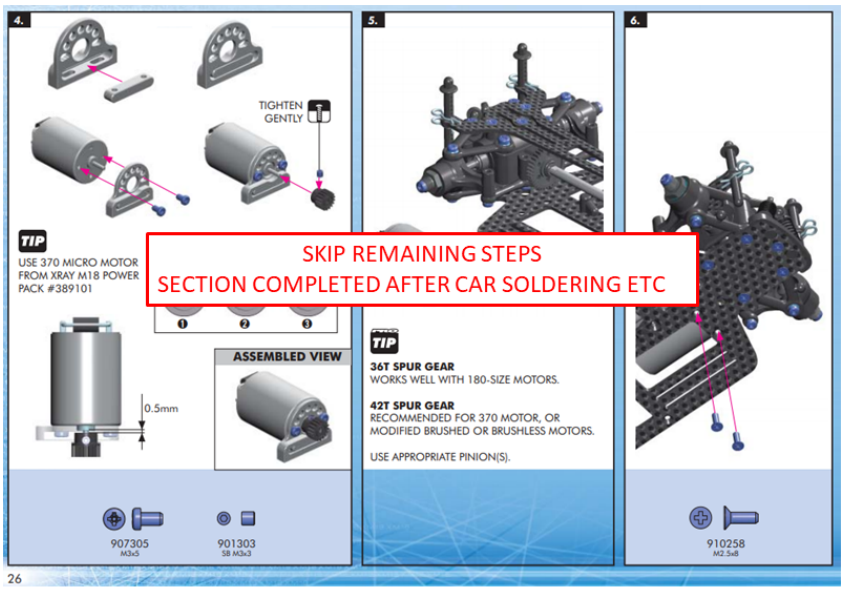
Tool
Servo Programmer, 2S LiPo, necessary Harnesses





Step	Instructions
4	Steer further and further to the right until the two red marked components hit each other. Confirm this maximum by hitting "RIGHT" (and finish the EPA by hitting "OK"). Note: There should be no mechanical limits for the steering until this point is reached. Especially the green components should NEVER hit each other. If that isn't the case, adjust the steering arm accordingly and repeat the process. Alternatively, it can also be helpful to reduce the suspension of the front wheels.

9. M18 Pro Final Assembly: Motor (2/2)



Step	Note
4-11	Skip steps for now Modifications and steps to come easier done prior to Steps 4-11

Contents

5. Soldering

This section describes the mounting of most electrical components, i.e., the soldering and mounting of

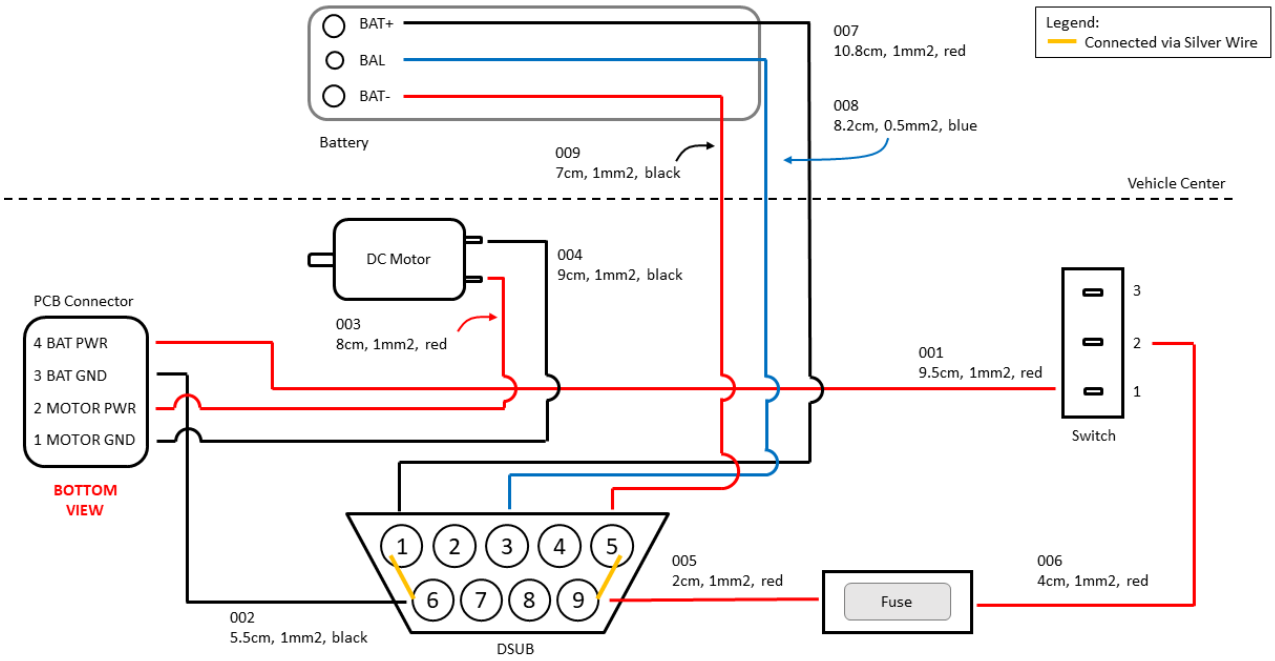
- the motor,
- the fuse,
- the switch,
- the charging connection (DSUB), and
- the battery.

1. Cut Wire (1/2)

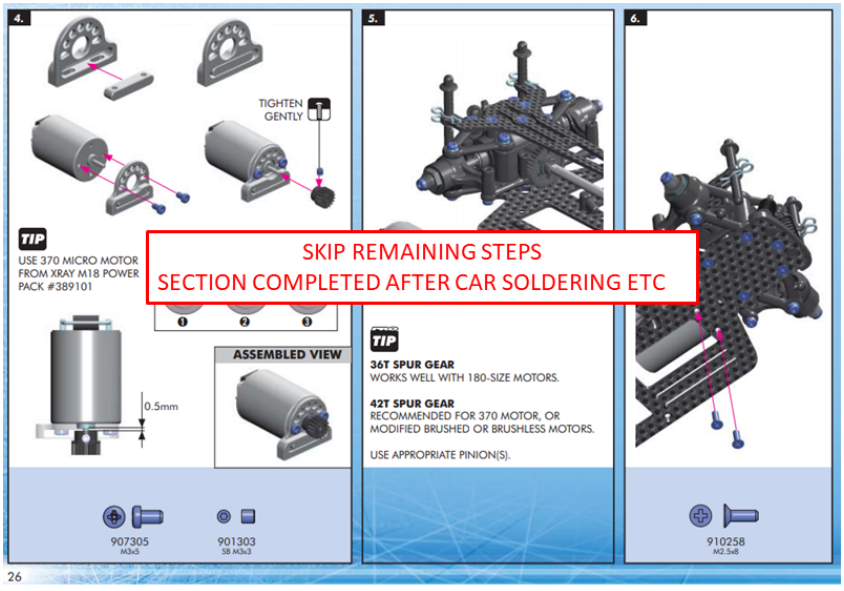
Wire PN	Length [cm]	Color	Gauge	Description	Location/Use
001	9.5 +0.25	Red	1mm2	Battery Power	Switch to PCB Connector
002	5.5 -0.25	Black	1mm2	Battery Ground	DSUB to PCB Connector
003	8.0 +0.25	Red	1mm2	Motor Power	Motor to PCB Connector
004	9	Black	1mm2	Motor Ground	Motor to PCB Connector
005	2	Red	1mm2	Vehicle Power	DSUB to Fuse
006	4	Red	1mm2	Vehicle Power	Fuse to Switch
007	7 -0.25	Red	1mm2	Battery Power	DSUB to Battery
008	8.2	Blue	0.5mm2	Battery Balance	DSUB to Battery
009	10.8 -0.25	Black	1mm2	Battery Ground	DSUB to Battery

Step	Instructions
1	Cut wire to correct length Note: take note of color and gauge

1. Overview Diagram (2/2)



9. M18 Pro Final Assembly: Motor (2/2)



Step	Note
4-11	Skip steps for now Modifications and steps to come easier done prior to Steps 4-11

3. Aderenden Huelsen

Part	Quantity
Red 1.0 Aderenden Huelsen	
Wire 001, 002, 003, 004	

Tool
Crimper

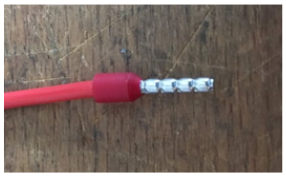
001
9.5cm, 1mm2, red

002
5.5cm, 1mm2, black

003
8cm, 1mm2, red

004
9cm, 1mm2, black

1



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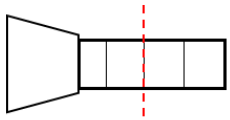


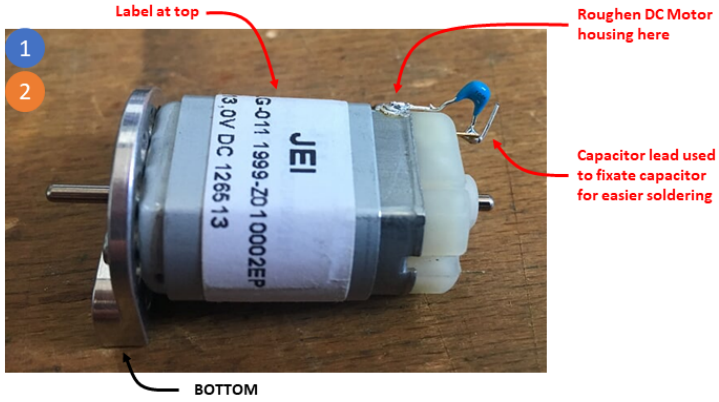
Step	Instructions
1	Crimp red 1.0 aderenden huelsen to PCB connector wires
2	Shorten aderenden huelsen in half (see image) NOTE: otherwise huelsen won't fit into connector

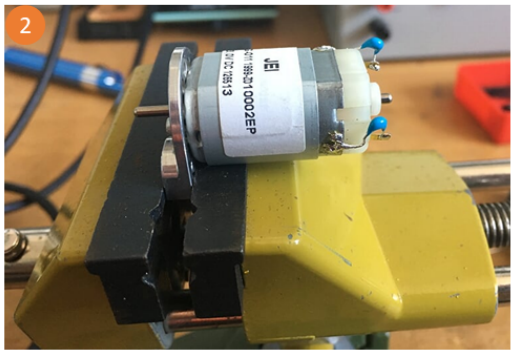
---

4. DC Motor Prep

Part	Quantity
DC Motor	1
100nF Capacitor (104)	2

Tool
M18 Assembly Manual
Soldering Iron





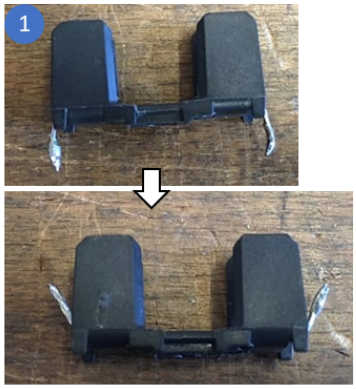
Step	Instructions
1	Attach Aluminum Motor Holder to DC Motor according to manual (p. 26 Step 4), **DO NOT INSTALL MOTOR** **WARNING: use max M2x5 screws to attach motor** NOTE: check polarity of motor i.e. spin direction (**usually correct when label/sticker on top**)
2	Solder 100nF Capacitors to motor leads and housing NOTE:100nF cap usually labelled as 104 (104 = 10*10^4pF) TIP 1: use sandpaper to slightly roughen motor housing surface for better soldering Tip 2: fixate cap by wrapping capacitor lead wire through motor lead hole

5. Fuse Prep

Part	Quantity
Fuse Holder	1
Wires 005, 006	1
M2.5x6mm Screw; M2.5 nut	1; 1

Tool

1



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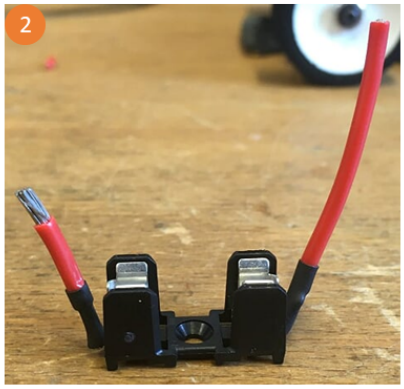
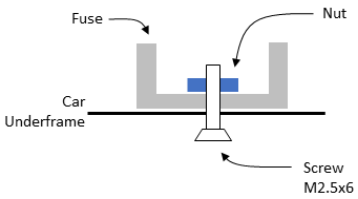


3



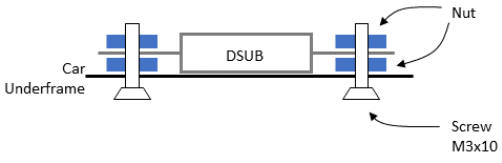
Step	Instructions
1	Bend up fuse leads
2	Solder wires 005 and 006 to fuse leads Add heat shrink
3	Attach fuse holder to frame using M2.5x6mm screw and M2.5 nut NOTE: see CPM Toolbox for pre-cut M2.5x6mm screws. Else, shorten M2.5 screw to 6mm using double nut technique

6. Install Connector/Switch

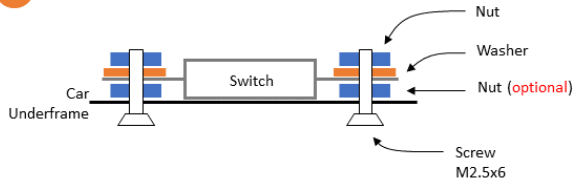
Part	Quantity
Female DSUB 9 Connector	1
On/Off Switch	1
M2.5x6mm Screw; M2.5 Nut; M2.5 Washer	2; 4; 2
M3x10mm Screw; M3 Nut	2; 4

Tool

1



2

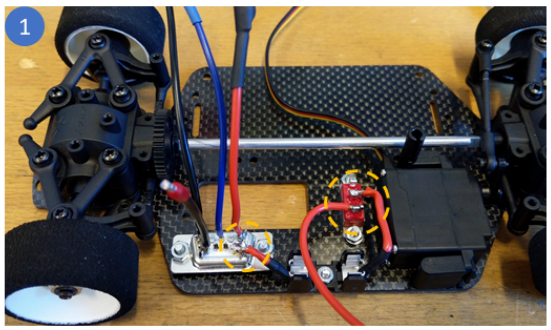


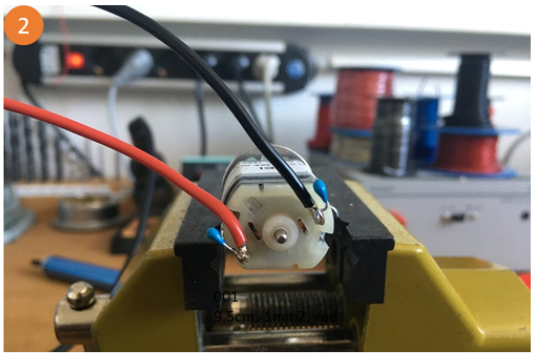
Step	Instructions
1	Attach DSUB to frame using **M3** Screws, Nuts and Washers Order: Nut, DSUB, Nut
2	Attach Switch to frame using **M2.5** Screws, Nuts and Washers Order: Nut, Switch, Washer, Nut Note: The lower two nuts are optional dependent on the length of the switch's arm. Normally, the nuts can be left out but the arm should not protrude too far.

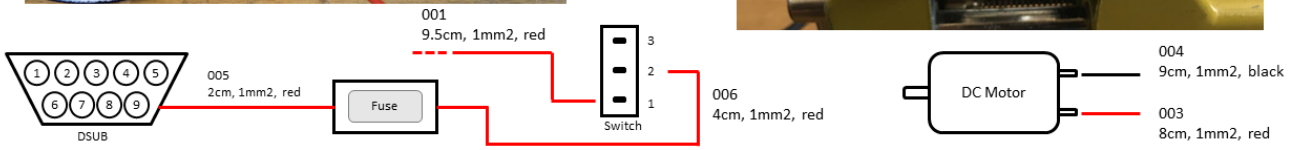
7. Solder (1/2)

Part	Quantity
Wire 001, 005, 006,	

Tool
Soldering Iron





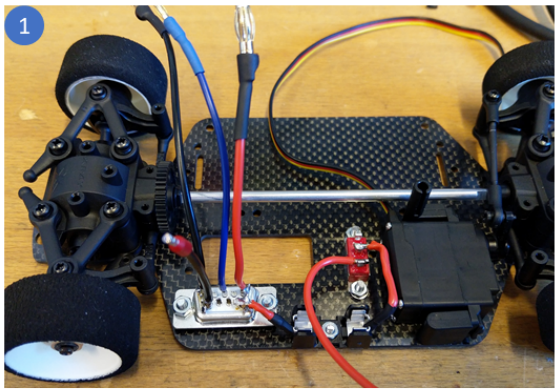


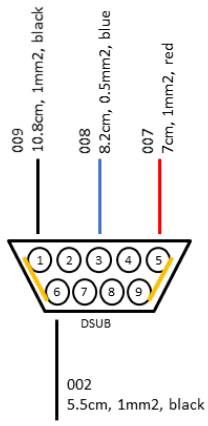
Step	Instructions
1	Solder fuse wire 005 to DSUB pin 9 Solder fuse wire 006 to Switch Pin 2 (middle) Solder wire 001 to Switch Pin 1
2	Solder wires 003 and 004 to DC motor, **DO NOT install motor yet** NOTE: solder wires slightly slanted, take note of polarity

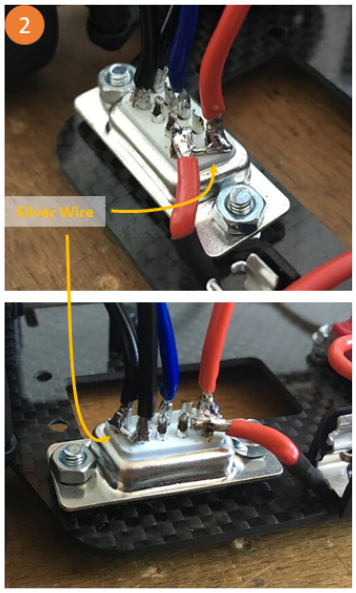
7. Solder (2/2)

Part	Quantity
Wire 002, 007, 008, 009	1

Tool
Soldering Iron, Silver Wire







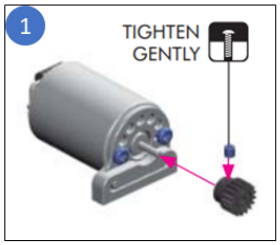
Step	Instructions
1	Solder Wire 007 to DSUB Pin 5 Solder Wire 008 to DSUB Pin 3 Solder Wire 009 to DSUB Pin 1 Solder Wire 002 to DSUB Pin 6
2	Add silver wire to connect Pin 1 and 6 Add silver wire to connect Pin 5 and 9 TIP: leave silver wire long -> spot solder to rear pin (1 & 5) -> then solder to front properly -> then re-solder back properly -> shorten wire

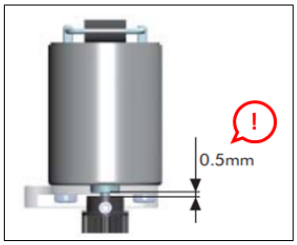
---

8. DC Motor Installation

Part	Quantity
DC Motor	

Tool
M18 Assembly Manual





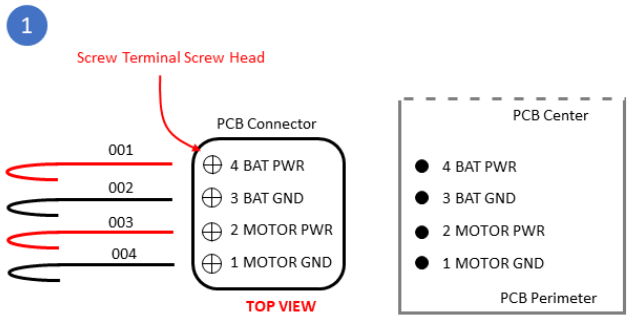
Step	Instructions
1	Install cog (pinion) onto motor shaft per manual instructions (p. 26 Step 4) NOTE: gap should be between 0.5-1mm (exact distance may be adjusted later to ensure proper distance to odometer board hall sensors)
2	Install DC Motor onto vehicle per manual instructions (p. 26-27 Step 6 and TECH TIP)

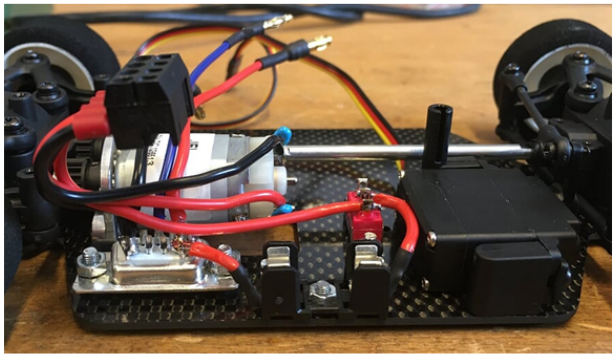
---

9. Connector

Part	Quantity
4-Pole Connector	1

Tool
M18 Assembly Manual





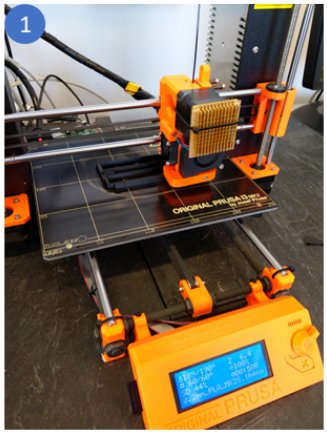
Step	Instructions
1	Attach Wire 001 to Port 4 (top view furthest left on connector) Attach Wire 002 to Port 3 Attach Wire 003 to Port 2 Attach Wire 004 to Port 1 (top view furthest right on connector NOTE: orientation is important, check PCB pin labels to verify correct connections

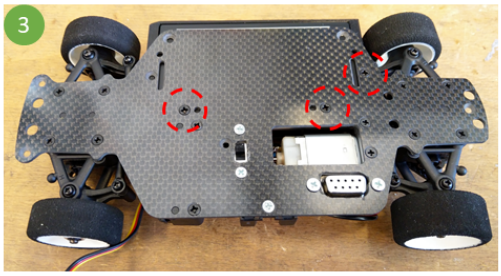
---

10. Battery Holder (1/2)

Part	Quantity
Battery Holder	1

Tool
Prusa i3

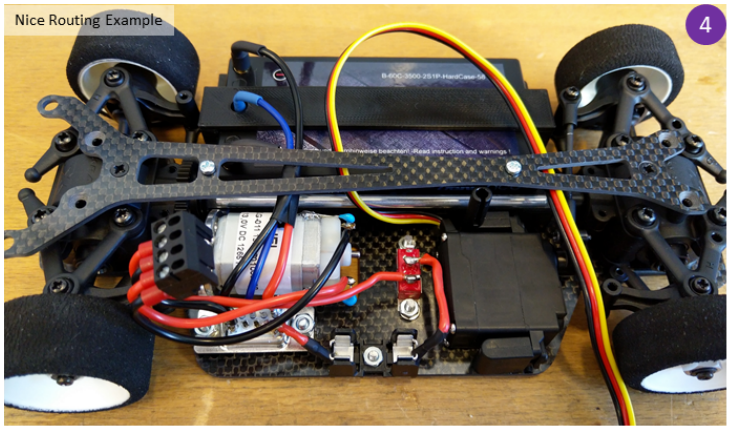


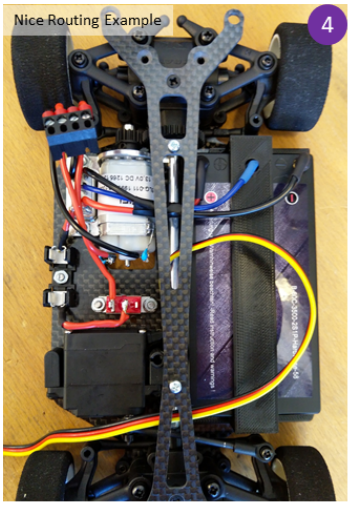


Step	Instructions
1	Print Battery Holder with 3D Printer File: lab\docs\Vehicle\Version2\cad\Batterie_Halterung\Battery_Holder_1v13_0.2mm_PLA_MK2S_1h46m.gcode
2	Put the battery into the holder.
3	Use 3 2.5x8 screws to attach the battery holder and the battery to the underframe. TIP: The screws can be found in bag 3 and bag 6.

10. Battery Holder (2/2)

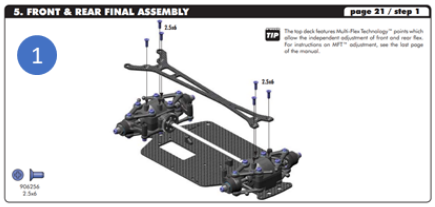
Tool
Electrical Tape

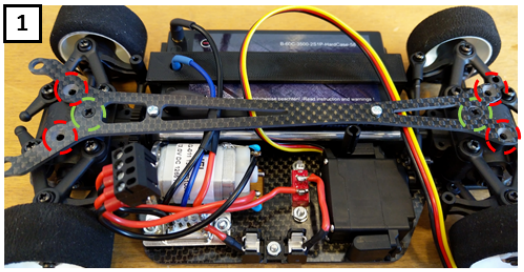




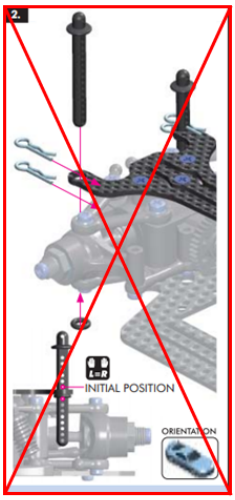
Step	Instructions
4	Install Battery and attach banana connectors wires 007, 008, 009 NOTE: route and bundle battery wires 007, 008, 009 nicely

11. Front & Rear Final Assembly





2



Step	Note
1	Go back in the manual to *front & rear final assembly* and follow the instructions on pages 20-23 by respecting the following changes.
1	Top deck differs from manual (reference Supplementary Manual) NOTE: only install 1/3 screws, remaining will be installed with LED Holder (following section)
2	**Omit**. Step 2 is not necessary since car body will NOT be installed

Contents

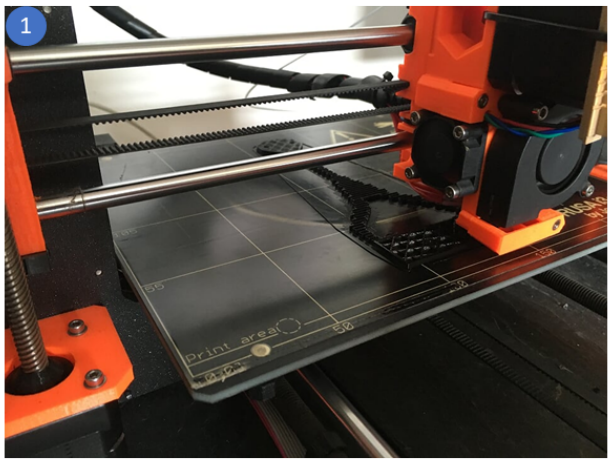
6. LED Holder

This section now describes the soldering and mounting of the LED Holder, which is needed for the IPS. For the assembly of the odometer board, look here.

1. 3D Print LED Holder

Part	Quantity
LED Holder	

Tool
Prusa i3



Step	Instructions
1	Print LED Holder with 3D Printer File: lab\docs\Vehicle\Version2\LED_Halterung\003-001_ledholder.stl

2. Cut Wire (1/2)

Wire PN	Length [cm]	Color	Gauge	Description	Location/Use
001	9	1X Red, 1X Black	0.14mm2	Ground and Power for LED	LED1
002	4	1X Red, 1X Black	0.14mm2	Ground and Power for LED	LED2
003	4	1X Red, 1X Black	0.14mm2	Ground and Power for LED	LED3
004	18 +0.25	1X Red, 1X Black	0.14mm2	Ground and Power for LED	LED4

Step	Instructions
1	Cut wire to correct length Note: take note of color and gauge **Note: 1X red and 1X black wire per LED**

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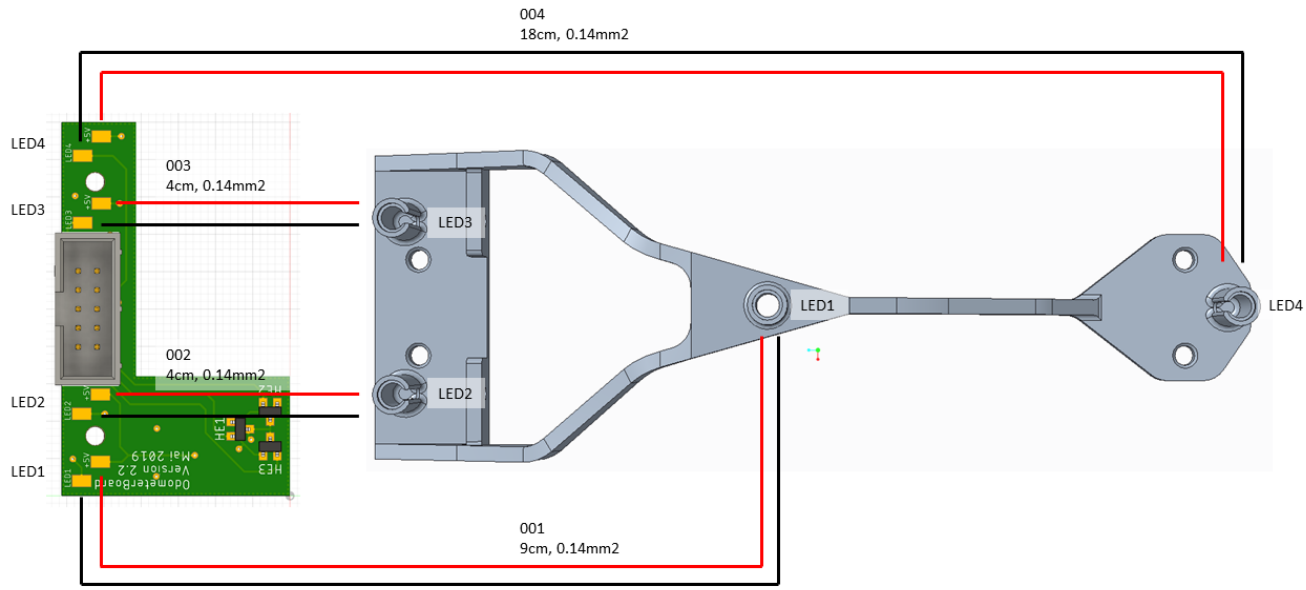
2. Overview Diagram (2/2)



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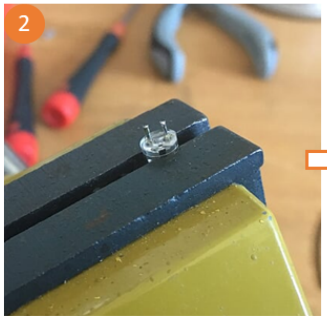
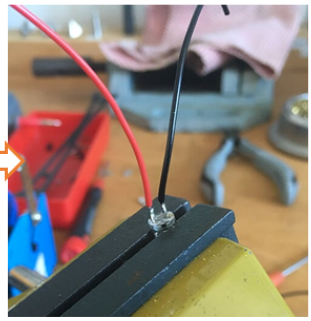
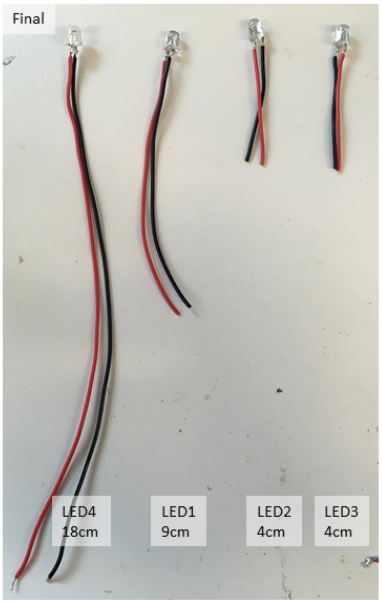
3. LED Prep and Soldering

Part	Quantity
LED	4

Tool
Soldering Iron, Wire Stripper





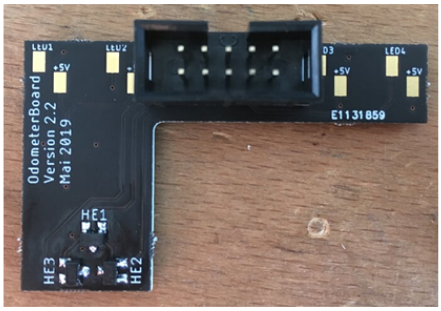


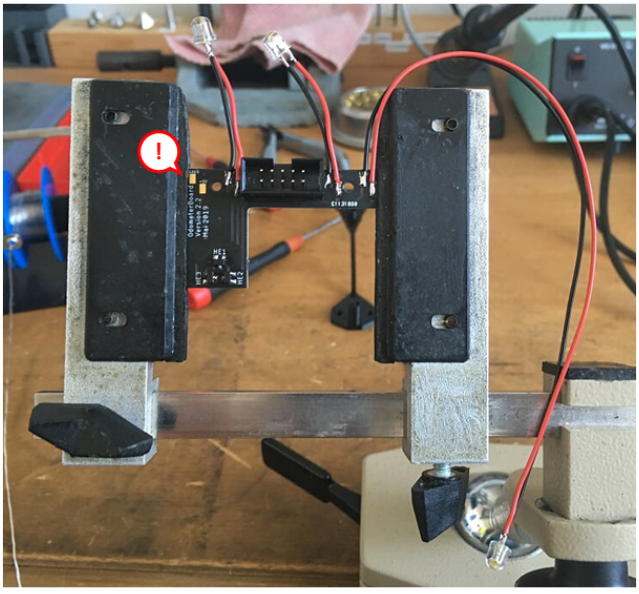
Step	Instructions
1	Short LED leads Note: remember polarity
2	Solder black and red wire to respective lead Note: if necessary, check polarity of LED with multimeter

4. Odometer PCB Soldering

Part	Quantity
LED2, LED3, LED4	1

Tool
Soldering Iron, Wire Stripper



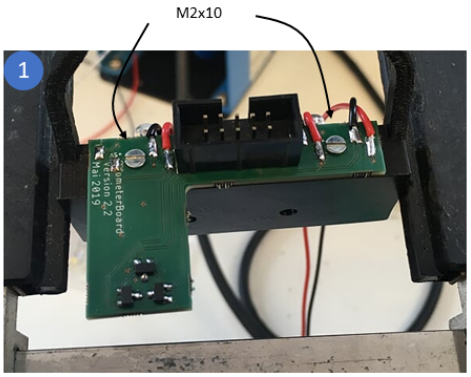


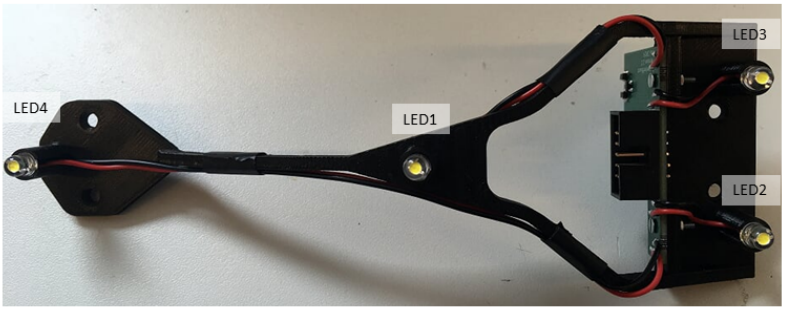
Step	Instructions
1	Solder LED2, LED3, and LED4 wires directly to PCB Open design of LED holders allows LED2-4 to be soldered prior to PCB attachment **NOTE: LED1 needs to be soldered after wired are inserted through thru-hole**

5. Odometer PCB Attachment (1/2)

Part	Quantity
M2x10 Countersink Screw, M2 Nut	2

Tool
Soldering Iron, Wire Stripper





Step	Instructions
1	Attach Odometer PCB to LED Holder using **M2x10 Countersink** Screws and M2 Nuts
2	Route LED2-4 wires to appropriate holders

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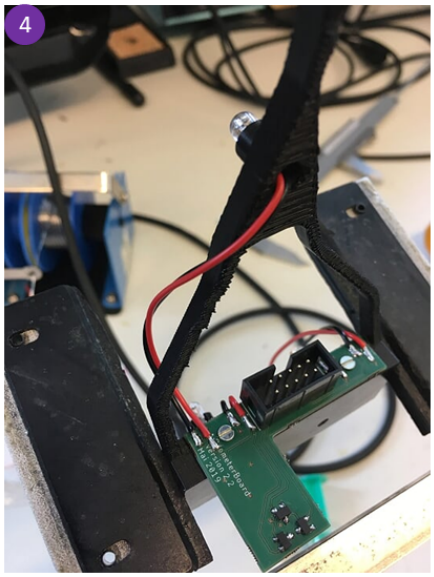
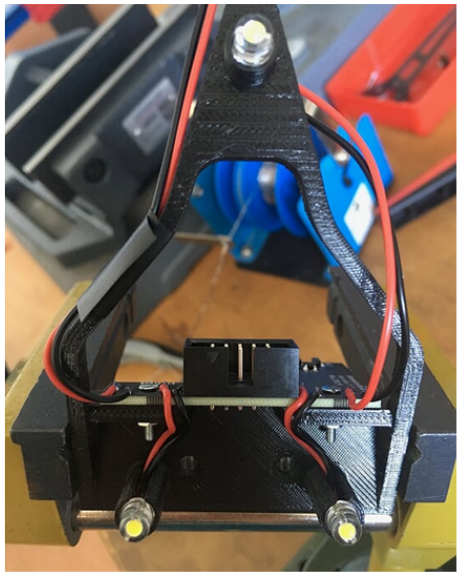
5. Odometer PCB Attachment (2/2)

Part	Quantity
LED1	1

Tool
Soldering Iron, Wire Stripper



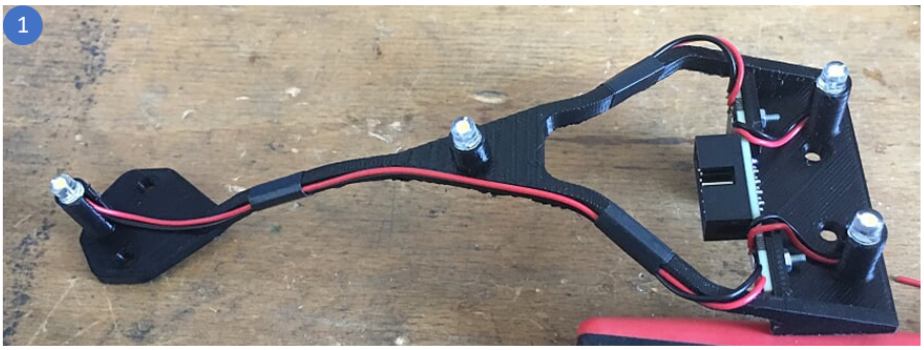


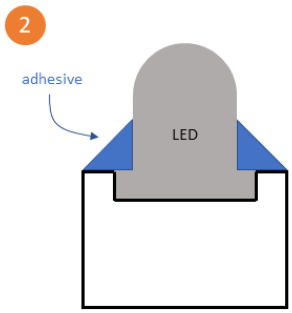
Step	Instructions
3	Route LED1 through thru-hole
4	Solder LED1 to Odometer PCB

7. LED Adhesive

Part	Quantity

Tool
2-Part Epoxy Adhesive





Step	Instructions
1	Use electrical tape or adhesive to fixate/route LED wires nicely
2	Use adhesive to glue LEDs into holder

Contents

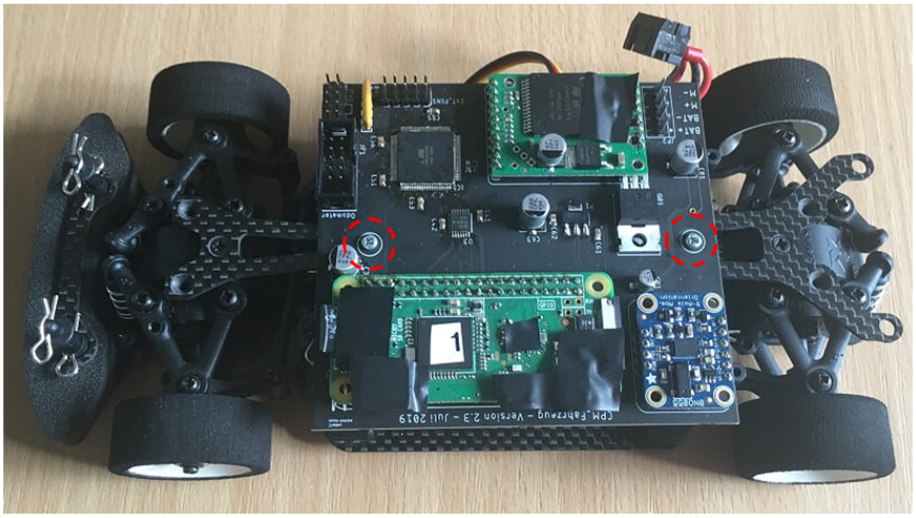
7. Final Assembly

In this last section, the Main Board and the LED Holder will be attached and wired to the chassis. If the Main Board is not soldered yet, see here.

1. Attach PCB

Part	Quantity
M2x6 Phillips Screw	2

Tool



Step	Instructions
1	Attach PCB to flex board using M2x6 Phillips screws

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2. IDC Ribbon Cable

Part	Quantity
IDC Ribbon Cable, IDC Connector	1; 2

Tool

Step	Instructions
1	Cut IDC Cable to 10.75cm + 0.25cm
2	Attach connectors using vice **Note: connector orientation important**

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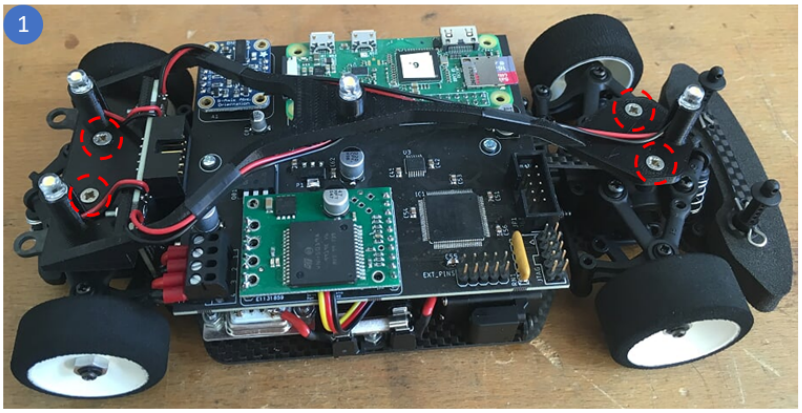
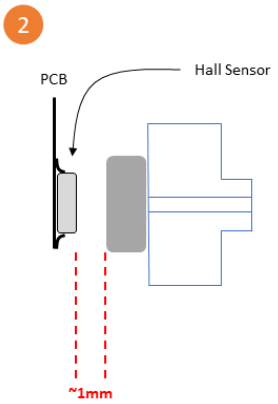
3. LED Holder Sub Assembly Attachment

Part	Quantity
2.5x10 SPAX	4

Tool
M18 Assembly Manual





Step	Instructions
1	Attach LED Holder using 2.5x10 SPAX screws
2	Check that distance between motor cog magnet and hall sensors **~1mm**
3	If necessary, loosen motor cog fixation screw to adjust distance Note: may need to remove LED Holder, PCB and Flex Plate to adjust distance

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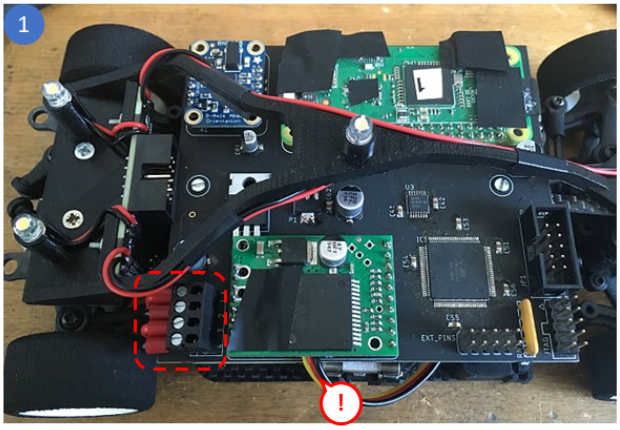
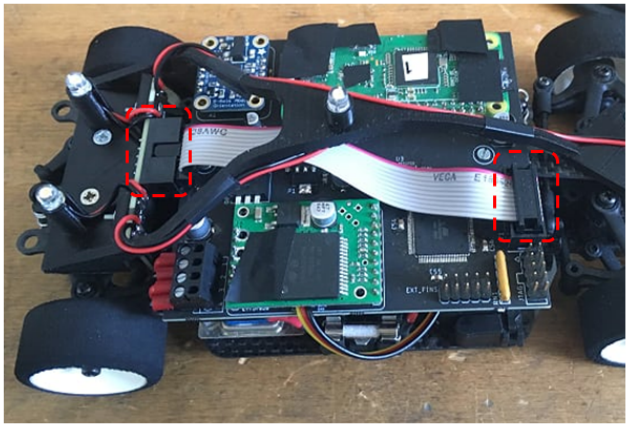
4. Connect PCB

Part	Quantity
IDC Ribbon Cable	1

Tool





Step	Instructions
1	Connect battery connector and servo connector to PCB **Note: take note of servo connector direction: yellow left -> black right**
2	Connect ribbon cable to PCB and LED Holder

Contents