Disegna3D V4

Assembly and Operating

Instructions

Contents

Introduction

These assembly and commissioning instructions will enable you to construct and set-up your Disegna3D V4 printer. The instructions take the form of a series of sequential steps, after some initial preparation you proceed with the assembly of the frame and then construct each sub-assembly and attach it to the frame. The steps are in a logical sequence which should ensure that there is easy access when attaching the sub-assemblies. I recommend that you read through the entire instructions before you start, this should give you a clear understanding of the context of each step.

The Disegna3D V4 has been designed to avoid a lot of complex assembly operations, like frame alignment and hot end assembly, therefore it should be possible to complete the printer and produce your first print in a weekend build! The key is to be organised before you start and work methodically.

The Printer and its Major Components
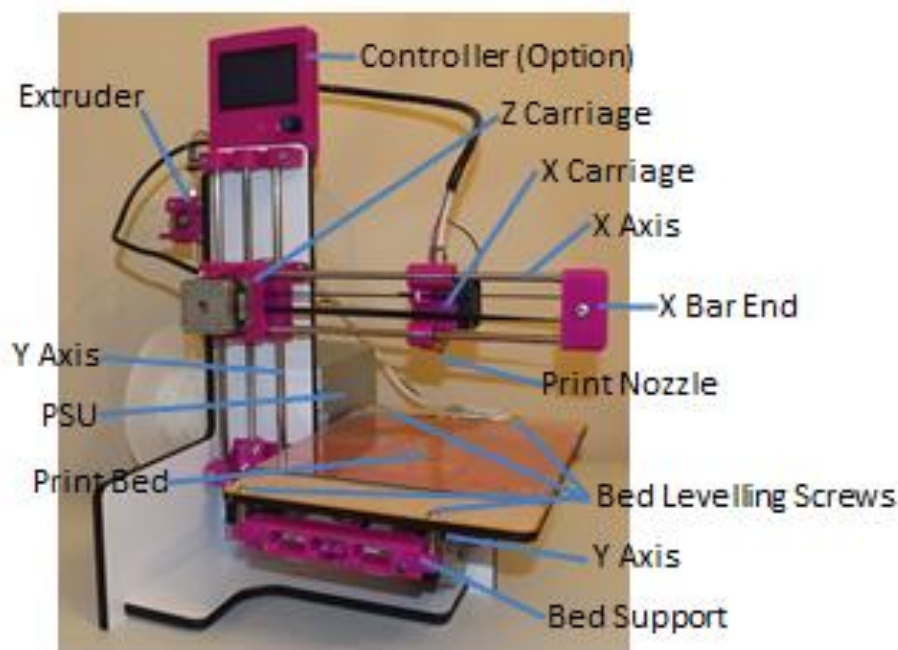
Safety

Assembly:

Be aware that to correctly assemble the printer and work safely while doing so requires a level of technical competence. Read through the instructions before you start, do not attempt to assemble the printer if you are not confident in your ability to do so. If any element of the instructions is unclear then please email for clarification.

High Voltage:

The printer kit uses a CE marked ATX power supply (PSU) to reduce the mains supply down to a maximum of 12v which poses no shock hazard. The PSU is capable of supplying a high

current though so care should be taken when building the printer to ensure that there are no short circuits.

Under no circumstances should the power supply be opened, nothing should be poked into it and the printer should not be operated outdoors or in a high humidity environment e.g. kitchen or bathroom.

Mind your fingers:

There are exposed moving parts on the printer so keep fingers (and everything else) clear when it is in operation.

Hot parts:

When the printer is operating the bed of the printer can reach temperatures of 110 deg C and the print head 250 deg C. These parts will remain hot for 20 minutes after the printing has finished and power has been removed, you should wait for this time to elapse before making adjustments / modifications to the printer. The bed / hot end temperature are displayed in pronterface / on the lcd display.

Glass:

The print bed surface is glass. Care should be taken to ensure that the glass is not damaged, if it is, it should be disposed of carefully and correctly (in accordance with local authority rules / guidance). The printer should not be operated if the glass is damaged or missing.

PLA and ABS

The V4 is designed for use with 1.75mm PLA and ABS filaments. Operation with other filaments is not guaranteed.

There is contradictory information concerning the safety of the fumes and particulates emitted into the surrounding environment when printing ABS and PLA. There is consensus that PLA has lower particulate emissions and its chemical emissions are less likely to be harmful. However when printing either filament the printer should be used with adequate ventilation, fume extraction or air filtration.

Before you start building

Collect together the tools that you will need:

Soldering iron	Metric Allen keys
Wire cutters	Electric / Hand drill
Wire strippers	Drill bits (2,3,4,8,10mm)
Heatgun (for heatshrink, lighter can be used)	Spanners 4 & 7mm
Narrow nose pliers	Craft / Stanley knife
G Cramp	Small hammer
Slotted and Pozidrive screwdrivers	Digital Calliper (or similar to measure filament dia)
Digital Multimeter	Needle files

Prepare the plastic parts:

All the parts in the kit have been printed in ABS on another 3D printer. ABS is a very durable plastic but is prone to warping during printing. To counter this, a lot of the larger parts have "ears" included in the design to improve bed adhesion and counter the effects of warping. The ears need to be trimmed off with a craft / Stanley knife. The exception being the x-pulley spacers, where the flange is functional and should be left in place. At this point also clean up the plastic parts of any printing artefacts, the odd blob or string is difficult to avoid, although usually these will only affect aesthetics. But in some places, such as the pulley bores which contain the bearings a careful clean-up here will aid assembly. Generally any artefacts are loosely attached and can be scraped away with the tip of a craft knife or the judicious use of a needle file.

The x-pulley has support material around the outside. This needs to be trimmed away carefully and any jagged edges cleaned with a small file. Note: this operation will not change the colour of the part!

All of the through holes in the plastic parts should be drilled through to ensure clearance. There are 3 sizes used: 4mm, 3mm and 2mm (for the endstop switches). Some of the through holes in parts will have a very thin plastic web crossing the bore. This is needed when printing a narrower hole on-top of a wider hole (usually the nut trap), the printer cannot print plastic in thin-air so a one layer thick web is included in the design. The webs need to be drilled through prior to commencing assembly.

Finally a lot of the plastic parts include captive nuts and these can all be fitted in advance to allow you to speed through the later assembly stages. It is purely personal preference whether you wish to do this now or during each step. If you do wish to carry it out now all the plastic parts require nyloc nuts except the bed supports, where the M4 Nuts are plain.

bed support showing plain nut positions

Rods:

The rods used in the Disegna3D V4 are 316 Grade Stainless steel, sometimes referred to as marine grade stainless. This grade of steel is harder and more corrosion resistant than "standard" 303 and 304 grades of stainless steel. Ensure that the ends of the rods are de-burred, any sharp edges should be lightly filed to remove them. Additionally I have found that lightly polishing the rods with t-cut, Silvo or similar reduces the bearing friction and is something that I would recommend.
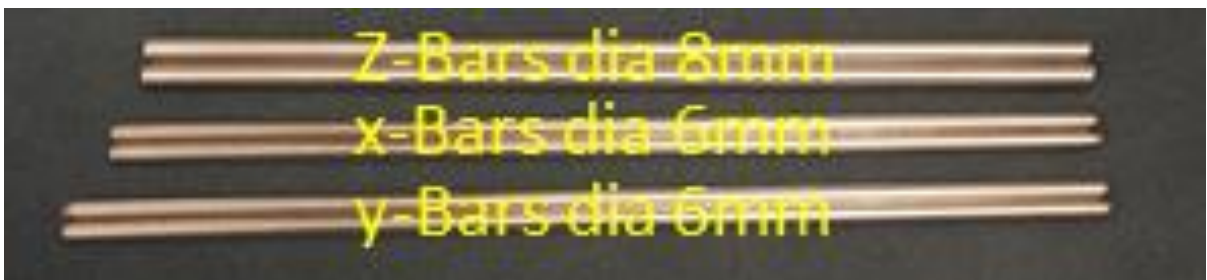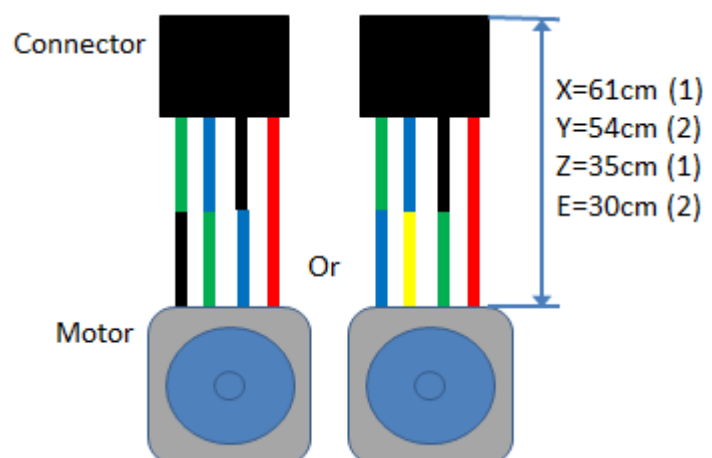

Soldering

In this one section you'll perform all the soldering needed for the assembly. Move on to the next part if you've bought the no solder kit.

Motor Wiring:

In this step you will extend the wires on the motors and fit the plugs at the same time. Start with the X-Motor, cut one of the cables with the 4 pin plugs at each end so that when connected to the existing motor wire the overall length will be 61cm (leaving a plug at one end). Strip back 6mm of insulation from the ends of the wire, connect these wires to the existing motor wires, the colours being consistent with the diagram.

X=61cm (1)
Y=54cm (2)
Z=35cm (1)
E=30cm (2)

Join the wires by twisting the ends together, soldering and then covering the individual connections with approx. 15-20mm of the 3mm heatshrink. Be sure to slide the heatshrink

onto the wire before you solder them and when soldering ensure that the heatshrink is kept a good distance from the soldering iron. Repeat these steps for each of the 4 motors, with the cable lengths shown in the diagram. Label each motor with its axis designation as you go. Each of the cables with the 4 pin connectors at each end can be used to extend the wires of 2 motors, one cable for the X & Z motor and one for the Y and E motors, this is indicated by the numbers in brackets in the diagram.

Endstop (microswitch) Wiring:

In this step you will attach the wires / connectors to the enstops. Start with the X Endstop. Cut one of the cables with the 2 pin plug so that it is 65cm long (leaving a plug at one end). Strip back 4mm of insulation from the ends of the wire and tin the ends. Solder these wires to the micro-switch as shown, covering the terminals with 3mm heatshrink. Repeat these steps for the Y and Z Endstops. Label the switches as you go to aid assembly later.
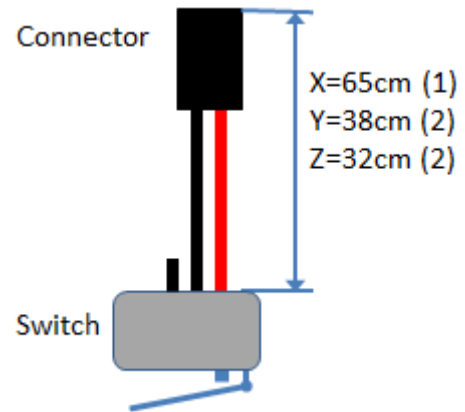
Bed Thermistor:

Take one of the wires with the 2 pin dupont connectors on the end. Cut one of the connectors off, leaving 1.5cm of lead attached to it, keep the short length, it will be used for the thermistor on the hot-end.

Now, take the long length, slide a 30mm length of 3mm heatshrink down each conductor then remove 5mm of insulation from one conductor and 25mm of insulation from the other. Cut the 25mm of exposed conductor back to 5mm. Slide the 25mm of removed insulation down one of the legs of the thermistor and then solder the thermistor to the lead as shown in the picture. Cover the bare connections with heatshrink.

Hot end thermistor:

Solder the 2 pin dupont connector / 1.5cm lead from the previous step to the white leads from the hot end thermistor. Insulate the connections with approx. 15mm of the 3mm heatshrink.

Fan wiring Extension:

Cut the connector off the 40mm fan and extend the wires by soldering on 1m of the 0.35mm^2 wire. Insulate the connections with 20mm of the 3mm heatshrink. Note that unlike the thermistors the polarity is important for the fan so maintain consistency with the fan wire colours. Strip back 6mm of insulation from the other end and twist and tin the ends. This will make it easier to insert the wires into the power connector.

Heated Bed:

Strip the ends of the 500mm long 1.5mm^2 bed power cable and solder them to the bed heater as shown. Ensure that the PCB tracks (you can feel / see them, the other side is flat) are uppermost. Also ensure that when attaching the wires to the board that no solder flows onto the other side, this needs to be flat. Strip 5mm of insulation from the free ends and tin the copper core. At this point it is worth checking the resistance across the heater, it should be approximately 1.8 ohms.

Power Supply:

The PSU supplied in the kit is a PC ATX power supply. Only the 12v output is used all other outputs are left unconnected. Additionally ATX power supplies have an enable (green) line which needs to be connected to 0v to enable operation.

Identify all the 12V (yellow wires) at the ATX (large) connector and cut them as close to the connector as possible. Identify the 12V (yellow wires) at the CPU and Auxillary (all the other) connectors and cut them to the same length as the ones removed from the ATX Connector. Cut 10mm of insulation from the end of the wires. Take a short length of red wire cut from one of the other leads and strip 10mm of insulation from each end. Make 2 bunches from the yellow wires and twist the ends of each bunch together along with one end of the red wire. Now tin the ends.

Identify an equal number of 0v (Black) leads (as yellow leads) from the PSU and cut them to the same length as the yellow leads. In the same way as the yellow leads cut back the insulation, make two bunches. Connect a short length of black wire between the 2 bunches and tin the ends.

Identify the green, enable pin on the ATX connector, cut this to approx. 50mm long. Identify an additional black, 0v wire and cut this to the same length. Solder these 2 wires together. Cut the remaining black wires back to 50mm long and cover the ends with heatshrink (include the green wire in this bundle).

Cut the red wires back to 50mm long and cover the ends with heatshrink. Repeat for the orange wires and individually the grey, brown, blue and purple/violet wires.
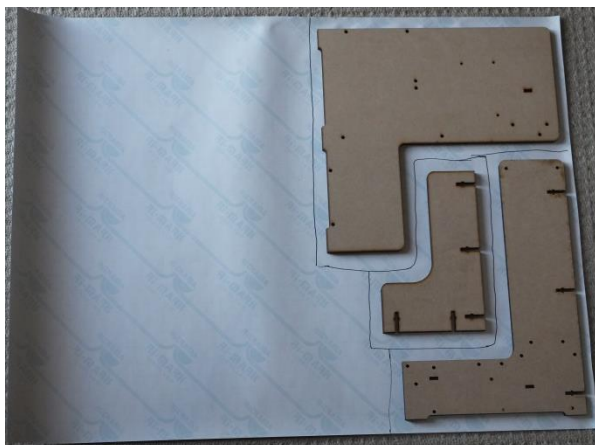
Frame Assembly

The picture on the right shows how the frame should look at the end of this step.

Parts Required:

| Qty	Component	Sub Assy
8	M4x35 Button Hex	Frame
8	M4 Square Nut	Frame
8	M4 Plain Washer	Frame
1	Side (MDF) -001	Frame
1	Main (MDF) -001	Frame
1	Brace (MDF) -001	Frame
0.8m	Vinyl	Frame

Instructions:

Turn the parts over and repeat the process.

Note that the 6mm MDF used to support the bed is not covered in vinyl.

If any of the MDF parts have a label attached (as shown in the picture to the right) carefully remove it before applying the vinyl. Cut out all the vinyl pieces and apply to the

Applying the vinyl to the frame parts:

Lay out the frame parts on the backing side of the vinyl and mark around them, leave approximately 1cm clearance around each part. You may find that the vinyl comes in 2 pieces to assist packing but the process is the same.

appropriate frame parts. Start by covering one side of the parts only. When the vinyl has been applied turn the piece over and carefully trim around the edge using a craft / Stanley knife. **Insert the captive (square) frame nuts at this point** and then apply the vinyl to the other side.
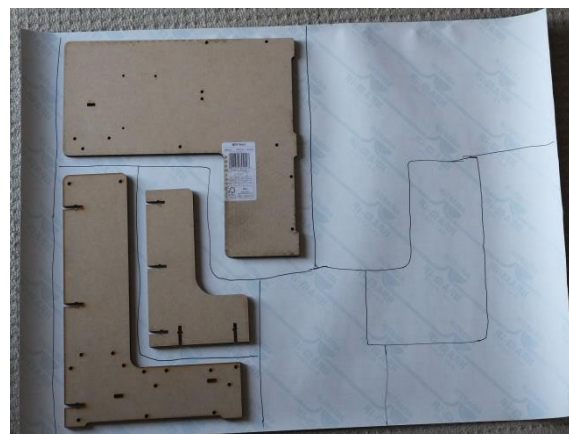
Tips on applying vinyl: Ensure that the surface of the frame part is clean and free from dust. Line up the vinyl on the piece to familiarise yourself with the clearances you are working

with. Start to apply the vinyl along a short edge, peel the backing paper off as you work, rub the vinyl down firmly with a sponge or a piece of cardboard. Work from the middle outwards to exclude any air bubbles. Try to avoid putting too much tension on the vinyl as you apply it / remove the backing as this will stretch it and cause wrinkles. The porous surface of the MDF means that bubbles are less likely to occur. If you do get a bubble or wrinkle the vinyl can be pulled back off the surface, be extremely careful to apply gentle pressure when doing this or the vinyl will stretch.

Cutting out the holes:

Gently press with your finger to identify the holes in the panels beneath the vinyl. Rectangular holes should be neatly trimmed around using a craft knife. For round holes you have 2 options, trim around using a craft knife or with your fingers, twist a sharp oversize drill bit in the hole to cut away the vinyl (in the way you would remove a burr from the edge of a hole). Do not use a power tool to turn the drill bit, this path leads to disaster! The first option is neater, the second is quicker. The edges of the holes are always covered so either method results in the same overall finish. Cut out all the features under the vinyl apart from where the square captive M4 nuts are.

Assembling the frame:
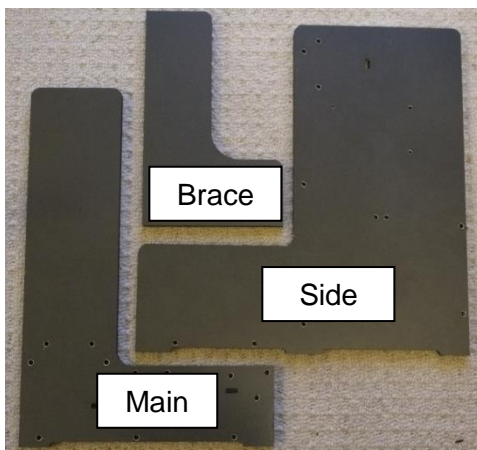
When all the frame parts are covered the frame can be assembled using the M4x35 Button headed M4 screws with a plain washer under each head. Insert all the screws so the frame is held together loosely. Then align the side piece and tighten it up. There are cut marks in the top and bottom of the side piece to allow it to be aligned to the main piece. Then align and tighten the brace piece. The brace piece is aligned by ensuring that the bottom of it is level with the cut-out along the bottom of the Side and Main pieces and ensuring it is flush with the sides (and firmly into the corner) of the side and main pieces.

You should now have a square and stable frame.

X-Axis Assembly

Appearance at the end of this step:

Note that the x-motor will have a plug fitted (not shown in this photo).
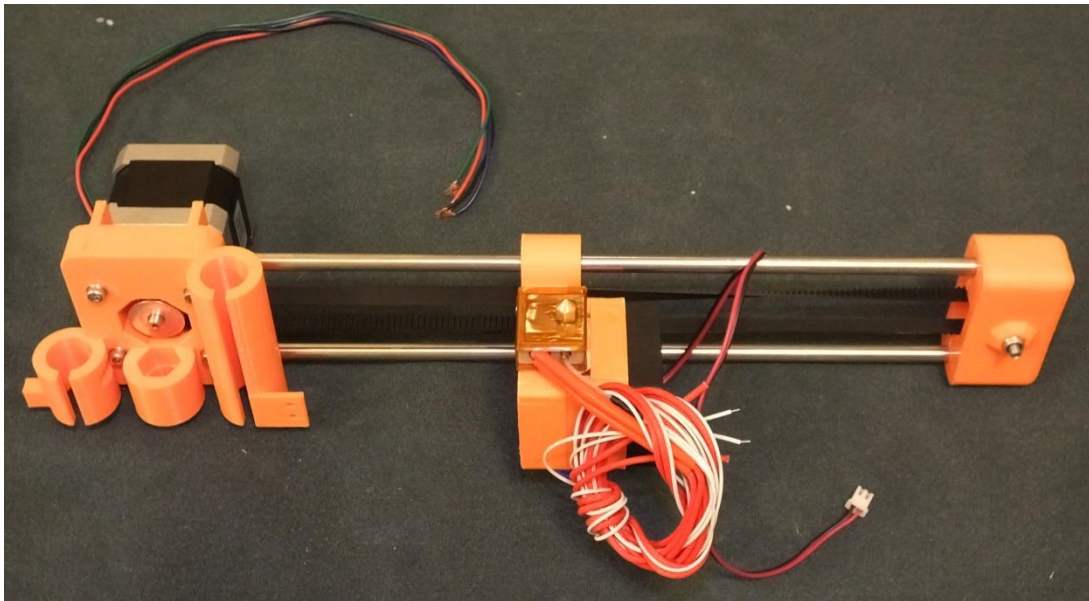
Parts Required:

Qty	Component	Sub Assy
1	M4x30 Hex	X Bar End
1	M4 Nyloc	X Bar End
1	M4 Plain Washer	X Bar End
1	X Pulley -001	X Bar End
2	X Bearing Spacer -001	X Bar End
1	624ZZ	X Bar End
4	M3x40 Hex	X Carriage
4	M3 Nyloc	X Carriage
1	X Carriage -001	X Carriage
1	Hot End Clamp -001	X Carriage
1	Hot End E3D Type 1.75/0.4mm	X Carriage
1	Fan 40x40x10 12v 2pin	X Carriage
1	LM6LUU	X Carriage
1	LM6UU	X Carriage
4	M3x30 Hex	Z Carriage
2	M2x10 Pan	Z Carriage
2	M2 Full Nut	Z Carriage
4	M3 Plain Washer	Z Carriage
2	M2 Plain Washer	Z Carriage
2	M2 Shakeproof Washer	Z Carriage
1	Z Carriage -001	Z Carriage
2	306x6mm T316 Stainless	Z Carriage

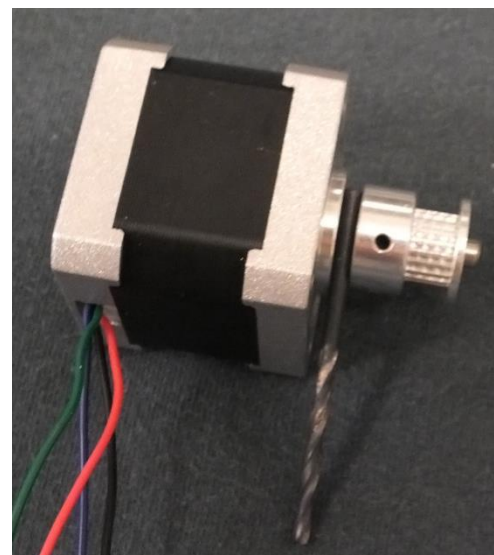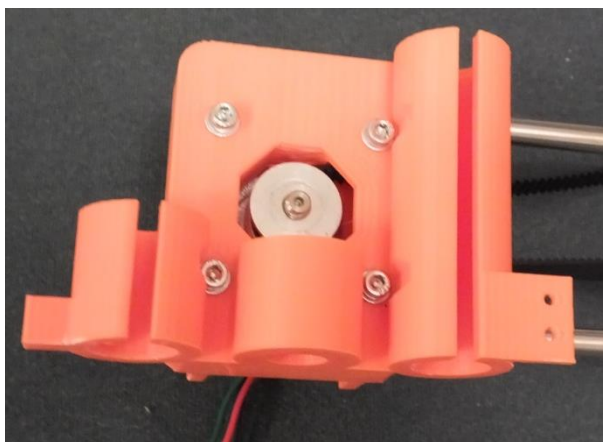|		
70cm	GT2 Belt	Z Carriage
1	GT2 Pulley	Z Carriage
1	Nema 17 1.7A	Z Carriage
3	LM8UU	Z Carriage
1	Microswitch	Z Carriage
1	X Bar End -001	Z Carriage
2	287x8mm T316 Stainless	Z Carriage

Instructions:

X-Bars:

The first step is to insert the X-axis bars into the z-carriage. Prepare the bars, remove any burrs from the ends, put a small chamfer on the ends to be inserted into the z-carriage (with a small file), this will make the assembly easier. The x-bars are an interference (very tight) fit. Ensure that the z-carriage is supported on the middle part, not on the bearing housing. Gently tap the bars into the z-carriage with a small hammer. Repeated light taps as opposed to fewer heavier blows is the correct method, this will minimise the chances of damage to the bars or z-carriage. The z-carriage has 2 small windows so you can see when the x-bars are fully inserted.
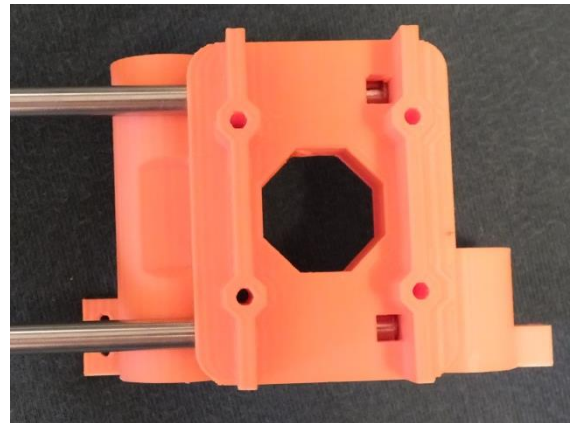
Z-Carriage:

Attach the GT2 Pulley to the shaft of the motor, its position is important. The flange of the pulley should be towards the end of the motor shaft and the gap between the pulley and the motor should be a fraction over 3mm. Use a drill shank bit to set this gap.
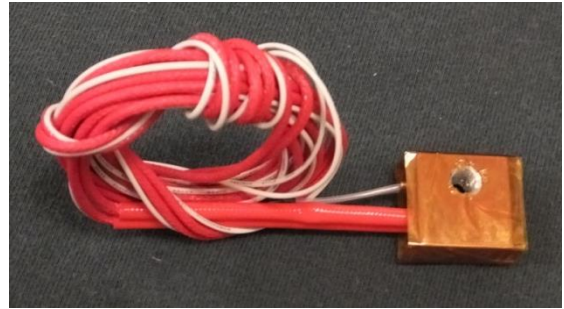
Push a loop of the GT2 belt into the z-carriage (into the gap between the x-rods). The teeth should face inwards. Now place the motor onto the Z-axis such that the GT2 pulley goes through the loop. Attach the motor to the z-carriage using the 4-off 30mm hex screws with

plain washers under their heads. Ensure that the motor is oriented so that the wire points upwards.
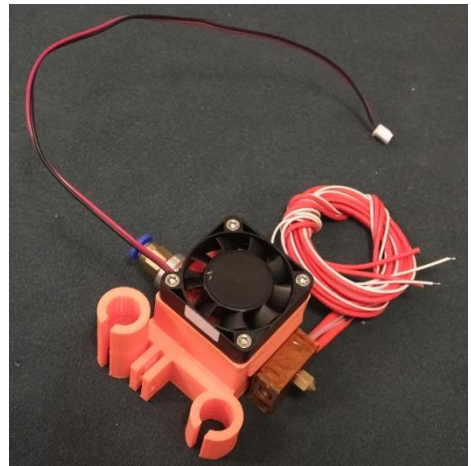
X-Carriage:

Firstly you need to insulate the heater block of the hot-end using polyamide tape. Remove the brass nozzle and then unscrew the heater block from the stainless steel threaded tube. If the heater block has a set screw retaining the heater, remove this too. Wrap 9/10 layers of polyamide tape around the heater block then carefully cut away the tape covering the tapped m6 hole (and allen screw hole) using a sharp craft knife. Re-assemble the hot-end, ensure that the stainless tube is screwed tightly into the ribbed heatsink. Screw the other end into the heater block so that there is a 2mm gap between the heater block and heatsink. Now screw the nozzle into the heater block tightly against the stainless tube.

The nozzle should be re-tightened when hot-end is first heated; this will prevent leaks. Ensure that the heater and thermistor are centred in the heater block and their cables are oriented correctly (see the picture to the right).

If you have not done so already fit the 4 M3 nyloc nuts into the nut traps of the x-carriage. Now assemble the x-carriage, hot-end, hot-end clamp and fan (ensure this is the right way round with the impeller on the outside) using the 4x40mm M3 bolts. Note that the heads fit in the recesses of the fan body so washers should not be used. If the hot end is not clamped tightly then wrap polyamide tape around the top to increase the diameter slightly. Do not wrap tape around the finned part of the hot end.

From the fan end of the x-carriage push a LM6UU and LM6LUU bearing into the x-carriage. These are a tight push fit but it should be possible to push them in by hand.

Slide the x-carriage onto the x-bars. The fan should face away from the z-carriage, the longer bearing should be at the top. Be careful when sliding the x-carriage onto the x-bars, do not use excessive force. If everything is not aligned the bars will push the individual ball bearings out of the LM6UU/LM6LUUs.

X-Bar End:

Insert an M4 nyloc nut into the nut trap on the x-bar end.

Push the 624ZZ bearing into the X-pulley, use the printed plastic drift provided. The drift is shaped to ensure that the bearing is not damaged during this exercise. The bearing will be a tight fit, you may have to clean up the inside of the bore in the pulley with a needle file before it will seat correctly.
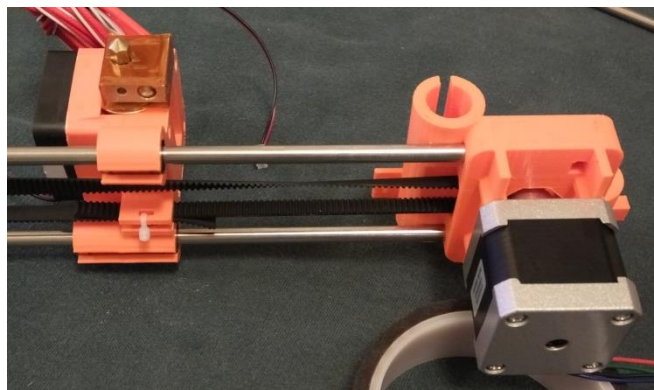
A G cramp is a good way of gently seating the bearing.
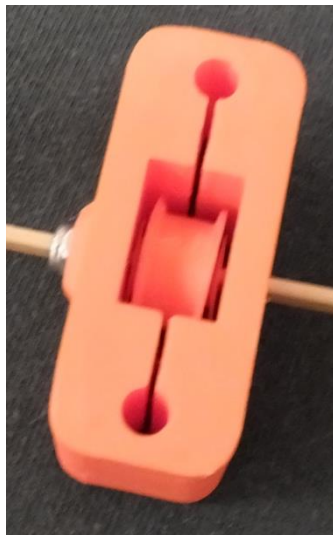
Place a bearing spacer each side of the pulley (flange facing outwards) and manoeuvre this "bearing sandwich" into the space on the x-bar end. Insert an m4 x 30mm hex bolt, with a plain washer under the head through the x-bar end to secure the pulley in place. Do not tighten the bolt at this point. Use a bamboo skewer or similar to align the pieces of the "bearing sandwich" if you have difficulty inserting the bolt.

Slide the x-bar end onto the x-bars. The head of the m4 bolt should be on the same side as the motor on the Z-axis.

Put a half twist into the lower part of the GT2 belt, push it through the x-bar end, round the pulley and back towards the z-carriage. With the correct half twist in the lower section of the belt the flat side of the belt should pass over the pulley.

The two ends of the belt should be placed flat side to flat side and pushed into the belt retainer on the x-carriage. The length of overlap should be such that when the x-bar end is pulled to the end of the x-bars there is a working tension in the belt. When you have adjusted the belt such that this is the case, tighten the bolt in the x-end to secure its position and maintain the tension. Cut off the excess belt and fit a cable tie through the belt retainer on the x-carriage and trim the end.

X-Endstop:

Attach the endstop to the z-carriage using the 10/12mm M2 screws and nuts, with a plain washer under the head and a crinkle washer under the nut.

Z-Bearings:

Push LM8UU linear bearings into the bearing housings of the z-carriage. One bearing goes in the short housing and two bearings in the long housing, one in each end.

This completes the assembly of the X-axis, place it to one side for use in the next step.

Z-Axis Assembly

Parts Required:

X-Axis Assembly plus:

Qty	Component	Sub Assy
2	M4x45 Hex	Z Bar Bottom
2	M4x20 Hex	Z Bar Bottom
2	M3x20 Hex	Z Bar Bottom
2	M3x8 Pan	Z Bar Bottom
4	M4 Nyloc	Z Bar Bottom
4	M4 Plain Washer	Z Bar Bottom
1	PSU Corner -001	Z Bar Bottom
1	Nema 17 1.7A	Z Bar Bottom
20mm	PVC Tube 5/8mm	Z Bar Bottom
1	M8 Threaded Rod 255mm	Z Bar Bottom
1	M8 Full Nut Brass	Z Bar Bottom
4	M3 Plain Washer	Z Bar Bottom
1	Z Bar Bottom -001	Z Bar Bottom
2	M4x45 Hex	Z Bar Top
2	M2x10 Pan	Z Bar Top
2	M4 Nyloc	Z Bar Top
2	M2 Plain Washer	Z Bar Top
2	M4 Plain Washer	Z Bar Top
2	M2 Full Nut	Z Bar Top
2	M2 Shakeproof Washer	Z Bar Top
1	Z Bar Top -001	Z Bar Top
1	Microswitch	Z Bar Top
4	M3x20 Hex	Z Coupling
4	M3 Nyloc	Z Coupling
4	M3 Plain Washer	Z Coupling
2	Z Coupling -001	Z Coupling

Instructions:

If you are fitting the optional Graphical Controller, read the "Graphical Controller (Option)" section of the instructions before proceeding.

If you have not done so already fit the M4 nyloc nuts into the nut traps of the Z-Motor bracket and the z-bar bracket and fit the M3 nyloc nuts into the nut traps of the Z-Motor coupling pieces.

Attach the Z-Motor to the Z-Motor bracket using 2off m3x8 screws with plain washers under their heads at the front and 2off M3x20 screws with plain washers under their heads at the back. Ensure that the motor shaft is free from grease and place the 20mm length of PVC tube over it so that it is flush with the top of the shaft.
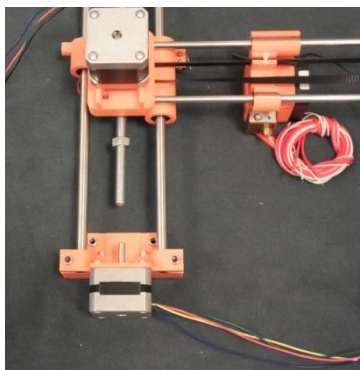
Push the 8mm z-rods into the Z-Motor bracket. Carefully place the Z-Carriage onto the Z-Rods.

Pass the M8 threaded rod through the Z-Carriage from the top then run an M8 nut onto it from the bottom, about 75mm.
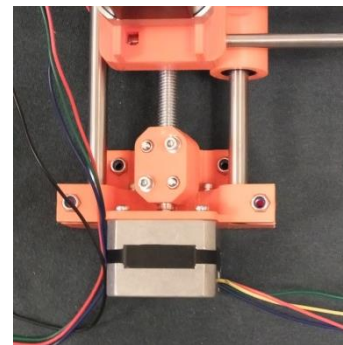
Move the Z-Carriage such that the Z Threaded Rod aligns with the motor shaft. Join the threaded rod and motor shaft together using the z-motor coupling. Tighten the M3x20mm hex screws evenly to ensure that the connection is tight without distortion.

Push the Z-Bar Top Bracket onto the top of the Z-Rods.

Now attach the Z-Axis to the frame using 2off M4x45 bolts at the top plus 2off M4x45 and 2off M4x20 bolts at the bottom. Fit the PSU corner bracket on the back, right side of the Z-Motor Bracket.
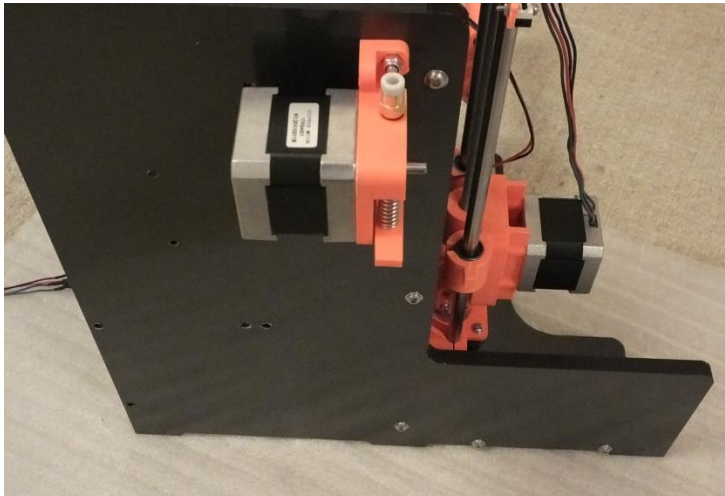

Z – Endstop:

Attach the endstop to the Z-Bar Support using the M2 screws and nuts, with a plain washer under the head and a crinkle washer under the nut.

Extruder Assembly

Appearance at the end of this step:

Parts Required:

Qty	Component	Sub Assy
2	M4x20 Hex	Extruder
3	M3x16 Hex	Extruder
1	M3x8 Pan	Extruder
2	M4 Nyloc	Extruder
2	M4 Plain Washer	Extruder
2	M3 Plain Washer	Extruder
1	Extruder Lever -001	Extruder
1	Extruder Body -001	Extruder
1	Extruder Cover -001	Extruder
1	Nema 17 1.7A	Extruder
1	Spring 1.2x7.5(5ID)x20	Extruder
1	Pneumatic Fitting 4mm/6mm	Extruder
1	624ZZ	Extruder

Instructions:

Fit the extruder gear to the stepper motor shaft. The placement does not have to be precise but it must grip the filament. Use a 3 or 4mm drill bit to set a space between the motor flange and the gear and tighten the grub screws.

Attach the back plate of the extruder to the stepper motor using 2x M3x16mm hex headed screws with washers under their heads and 1x M3x8mm screw with no washer under the head. Ensure the alignment of the motor so that the cable exits on the same side as the mounting bracket.

Fit the 624zz bearing to the extruder arm and clip the cover in place to secure it.

With the extruder spring in place squeeze the extruder arm so that the pivot hole aligns with the remaining screw hole in the motor. Secure the extruder arm in place with an m3x16mm hex headed screw (no washer under the head).

Screw the Bowden Tube fitting into the extruder body. There is a lot of pressure on the thread and it can work loose over time. The best way to avoid this is to place a small amount of superglue on the thread before screwing it into the extruder body.

Attach the extruder to the frame using 2x M4x20mm hex head screws with washers under the heads and M4 nyloc nuts in the extruder body.

Spool Holder

Appearance at the end of this step:
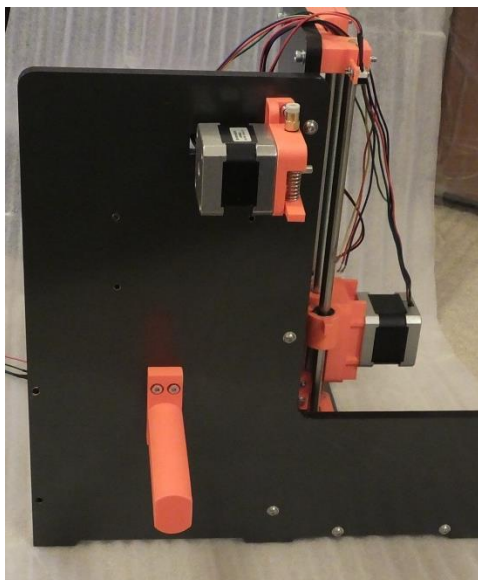
Parts Required:

Qty	Component	Sub Assy
2	M4x20 Hex	Spool Holder
2	M4 Full Nut	Spool Holder
2	M4 Shakeproof Washer	Spool Holder
2	M4 Plain Washer	Spool Holder
1	Spool Holder -001	Spool Holder

Instructions:

Attach the spool holder to the frame using 2off M4x20 hex head screws. Note that the hex heads fit flush in the spool holder with a plain washer underneath. On the other side fit the plain M4 nuts with shake-proof washer under them.

Electronics Assembly

Appearance at the end of this step:
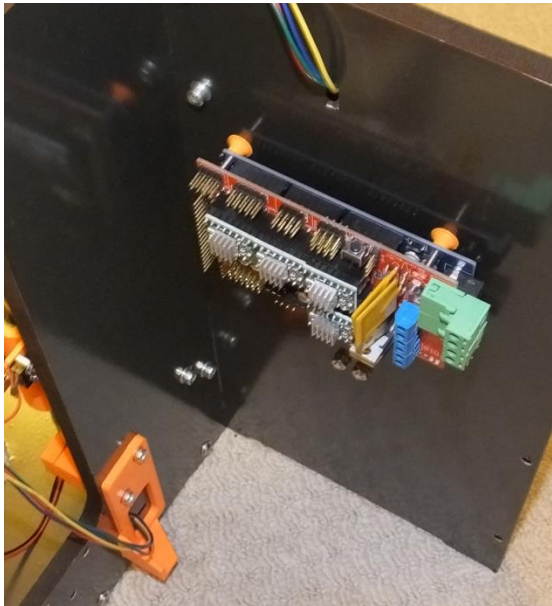
Parts Required:

Qty	Component	Sub Assy
3	M3x35 Button Hex	Electronics
3	M3 Full Nut	Electronics
3	M3 Plain Washer	Electronics
3	M3 Fibre Washer	Electronics
3	Electronics Spacer -001	Electronics
1	RAMPS 1.4	Electronics
1	ATMega2560	Electronics
4	A4988 Motor Driver Module	Electronics
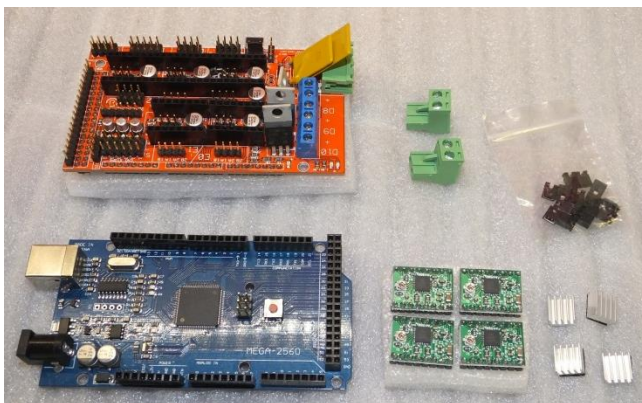
Instructions:

At this point you are just assembling the electronics boards and mounting them to the frame, connecting everything together will take place in later steps.

There are 3 types of components which make up the electronics assembly:

- The Mega 2560 board, this is the heart of the system and is based on an Arduino development board. It is the board which will connect to your computer.
- The RAMPS 1.4 electronics board. This provides the interface between the Mega and electrical components of the printer.
- The A4988 motor drivers (x4). These boards convert the logic signals from the Mega into the correct current drives for the stepper motors.

Before doing anything else check that all the pins on the boards are straight, straightening them if necessary, sometimes they can get knocked in transit.

On the RAMPS board fit 3 shorting pins under each of the stepper drivers, note that E1 is not used.

Now fit the motor drivers to the RAMPS board ensuring that you get the orientation correct. There is a small potentiometer on each of the drivers and this should be at the end of the driver board

away from the RAMPS power connector.

Press the RAMPS and the Mega boards together to form the electronics assembly. At this point fit the heatsinks to the top of the driver chips on the motor drivers. In the V4 only the extruder uses enough current to need a heatsink on the driver, so you only need to fit a heatsink in position E0 if you wish.

The electronics assembly mounts to the frame with 3off M3x35 button head screws. Ensure that there is a plain washer under each of the screw heads. After passing through the frame an electronics spacer should be placed on each of the bolts before mounting the electronics. The position of the bolts should indicate which of the mounting holes in the electronics are used; the power and PC connector face the back of the printer. Place a fibre washer under each of the nuts. Do not overtighten the nuts or the electronics PCB will be bent and potentially damaged.
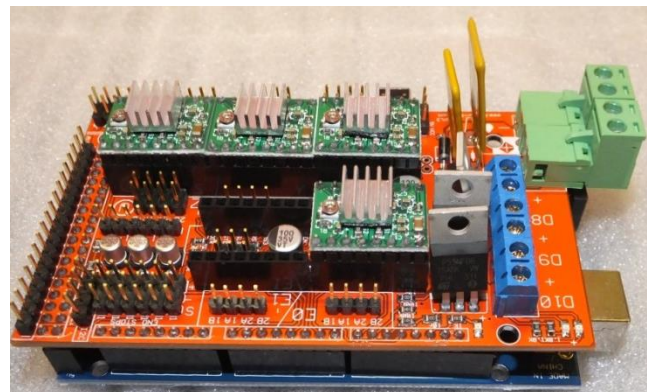
Y-Axis Assembly

Appearance at the end of this step:
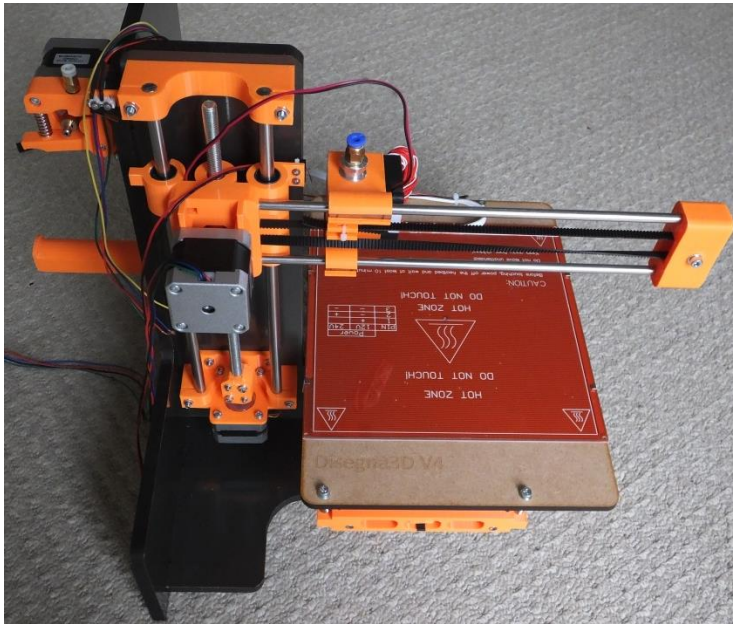
Parts Required:

Qty	Component	Sub Assy
4	M4x35 Button Hex	Bed Assy
4	M4 Full Nut	Bed Assy
12	M4 Plain Washer	Bed Assy
4	Spring 1.2x7.5(5ID)x20	Bed Assy
1	Heated Bed MK2B	Bed Assy
1	Bed Support (MDF) -001	Bed Assy
1	Glass (214x200x2mm)	Bed Assy
1	Thermistor	Bed Assy
4	Glass Clips	Bed Assy
8	M3x16 Hex	Bed Supports
4	M3 Plain Washer	Bed Supports
2	Bed Support -001	Bed Supports
2	294x6mm T316 Stainless	Bed Supports
8	M3 Nyloc	Bed Supports
2	Y Belt Clamp -001	Bed Supports
50cm	GT2 Belt	Bed Supports
5	M4x20 Hex	Y Bar Motor
3	M3x10 Pan	Y Bar Motor
5	M4 Nyloc	Y Bar Motor
5	M4 Plain Washer	Y Bar Motor
3	M3 Plain Washer	Y Bar Motor
1	Y Bar Support (motor) -001	Y Bar Motor
2	Y Pulley -001	Y Bar Motor

1	Nema 17 1.7A	Y Bar Motor
2	624ZZ	Y Bar Motor
1	LM6LUU	Y Bar Motor
1	GT2 Pulley	Y Bar Motor
2	M2x10 Pan	Y Bar Supports
3	M4 Nyloc	Y Bar Supports
2	M2 Plain Washer	Y Bar Supports
3	M4 Plain Washer	Y Bar Supports
2	M2 Full Nut	Y Bar Supports
2	M2 Shakeproof Washer	Y Bar Supports
1	Y Bar Support (front) -001	Y Bar Supports
1	Y Bar Support (back) -001	Y Bar Supports
1	Microswitch	Y Bar Supports
4	M4x25 Hex	Y Bar Supports
2	LM6UU	Y Bar Supports

Instructions:

If you have not done so already fit the captive nuts into the plastic parts.

Y-Motor Assembly:

Push the 624ZZ bearing into the y-pulleys using the same method and drift used to fit the bearing in the x pulley. They will be a tight fit, you may have to clean up the inside of the bores in the pulleys with a needle file before they will seat correctly. Now attach the y-pulleys to the y-motor bracket using 2off m4x20mm hex screws, the assembly order is screw, pulley, washer, y-motor bracket, nut. Ensure that the pulleys are mounted the correct way around; the open side of the pulley should face away from the bracket.

Attach the GT2 Pulley to the shaft of the y-motor, its position is is important. The flange of the pulley should be towards the end of the motor shaft and the gap between the pulley and the motor should be 4mm. Use a drill shank bit to set this gap.


Attach the y-motor to the y-motor bracket with 4 off m3 x 10mm screws with plain washers under the heads. The holes to attach the motor are slotted, this is to allow the y-belt to be tensioned, for now ensure the motor is at the highest position (closest to the pulleys).

Y Carriage Assembly:

Fit the y-belt clamps into place on the bed supports using 4 off M3x16mm hex screws with plain washers under the heads. But do not tighten them. Fit LM6UU bearings in the Y-bar front and back supports and an LM6LUU bearing in the y-motor bracket. Slide the y-bar

front and back and y-motor brackets onto their respective y-bars. Push the bars into the bed supports. Insert the M3 screws which lock the bars but do not tighten them at this point. Use the paper template provided to square up the y-carriage and when it is; then tighten the y-bar clamps.
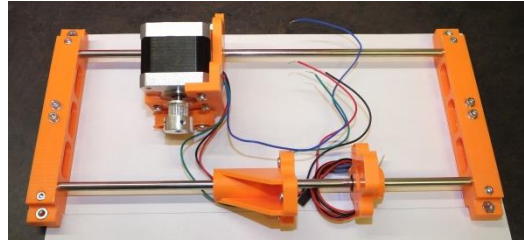
Y-Endstop:

Attach the endstop to the y-bar back support using the M2 screws and nuts, with a plain washer under the head and a crinkle washer under the nut.

Attach the Y-axis to the frame:
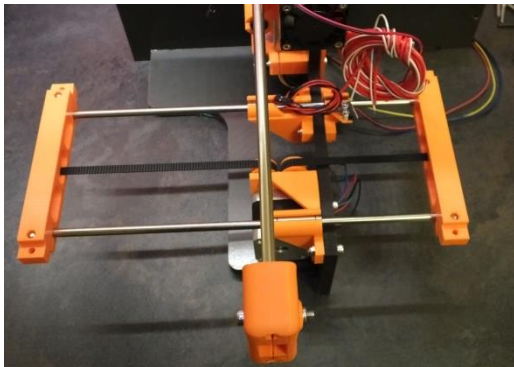
Now attach the Y-axis to the frame using 3off M4x20 bolts with plain washers under the heads for the motor assembly plus 3off M4x25 bolts with plain washers under the heads for the Y-bar front and back supports.

Ensure that the y-motor wiring is passed through the hole in the frame during assembly.

Tighten the mounting bolts so they just grip and then slide the bed over its full travel to ensure that it doesn't bind. Then slowly tighten the mounting screws. Alternate tightening the screws and sliding the bed back and forth to ensure that everything remains square. If the bed does stick then slacken the screws and repeat.

Fitting the y-belt:
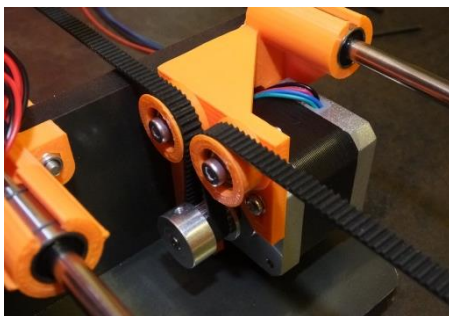
Take the GT2 belt left over from the X-axis. Pass it around the y-motor pulley and over the plastic pulleys. Secure each end in the clamps on the bed supports. If necessary adjust the belt tension by slackening the motor mount screws and pulling the motor downwards, before re-tightening. Trim off the excess belt.

Bed Assembly:

Place the bed heater onto the 6mm MDF bed support, the connection to the bed heater should be at the back. There are lines etched into the MDF bed support to align the bed heater. Place the 2mm glass on top of the bed heater so it is flush with the front. Now fasten this sandwich together using the 4off swiss (glass) clips.

Pass the thermistor through the hole in the MDF bed support and the heated bed so that it is in good contact with the glass. Pack some kitchen towel or other tissue paper around the thermistor to hold it in place. Then tape the lead to the bed support with heat resistant tape.

Secure the heated bed lead and thermistor lead to the MDF Bed Support using a cable tie.

At this point you can insulate the bottom of the heated bed. If you are only going to print PLA then this is not necessary but if you are going to print ABS then it will help the bed reach and maintain the higher temperature needed to prevent the ABS from warping. PLA needs a bed temperature of around 60°C, ABS needs a temperature of around 105°C. Using the template provided cut out the insulator from corrugated cardboard and then attach the insulator to the bed assembly using heat resistant tape. Make sure to leave clearance around the glass clips so the glass can be removed if necessary.

Attach the bed assembly to the bed supports using M4x35 button head screws with plain washers under their heads and 20mm springs between the bed assembly and the bed supports.

PSU Assembly

Parts Required:

Qty	Component	Sub Assy
2	M4x20 Button Hex	PSU
2	6-32 x 3/8 UNC Slotted	PSU
2	M4 Nyloc	PSU
4	M4 Plain Washer	PSU
1	PSU Bracket -001	PSU
1	PSU ATX 450W	PSU

Instructions:

Put the 2 M4 nylock nuts into the nut traps on the PSU bracket and attach the PSU Bracket to the PSU using the 2off 6-32x3/8 UNC screws (note the picture shows these screws as hex headed but the ones supplied in the kit are slotted).


Now attach the PSU to the frame using 2off m4x20mm screws. Check that the back corner of the PSU is seated correctly in the bracket which you fitted at the same time as the Z-axis. Also ensure that the wires for the Y-Endstop, Y-Motor and Z-Motor pass behind the power supply, secure them together with a cable-tie to ensure they stay in place.

Wiring

It's now time to wire everything together.

Fit the Bowden tube then cable tie the hot-end wires around the Bowden tube at the hot-end end. Now wrap the cables with the Bowden tube using the 8mm spiral wrap. Next clip together the wires from the X-Motor and X-Endstop near the x-motor and then wrap the cables using the 4mm cable wrap. It should look something like these pictures.
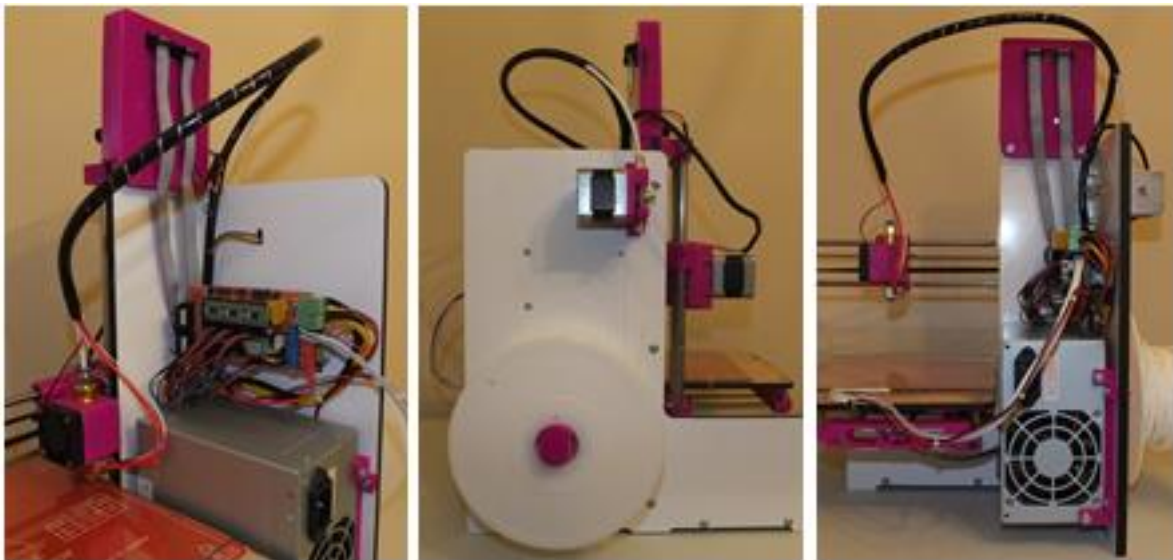
Now connect everything to the electronics, in accordance with the following diagram. Double check that everything is connected correctly, **pay particular attention to the endstops, ensure that they are not connected to the top row of pins.** Doing this will short circuit the 5v power supply when the switch is pressed, this **will** damage the Mega 2560 processor board.
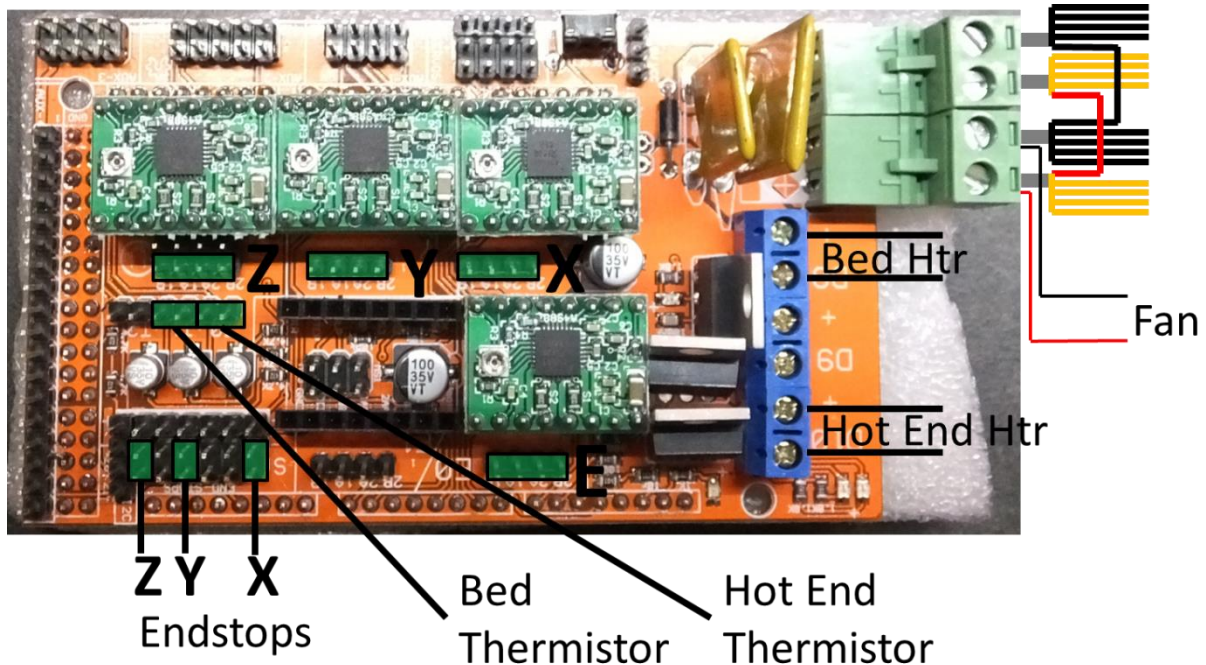
Commissioning the Printer

Setting the motor currents:

In this step you will adjust the potentiometer on each of the motor drivers to set the current for each of the stepper motors.

Connect power to the printer.

For the X,Y,Z motor drivers measure the voltage between 0v (where the black wires are connected on the power connector is a good point to access 0v) and centre of the potentiometer. Adjust the potentiometers so that the voltages are 0.60v. For the E motor set the voltage to 0.70v

Installing the software:

Windows:

The SD card provided contains a copy of Printrun (which combines Pronterface, the printer interface software and Slic3r, used to convert 3D models to a printable form). This software does not need to be installed, simply copy the "printrun-…." directory to a convenient location and then create desktop shortcuts for the pronterface.exe and slic3r.exe (contained in the slic3r sub-directory) on your desktop.

The SD card also contains a copy of the Arduino IDE. You only need to install this if you have to change the z max height in firmware, so hold off on doing this now. The Arduino IDE should be installed using the installer provided.

Mac and Linux:

Mac versions of the programs are also provided on the SD. Linux versions of these programs are available online.

Printer drivers:

Connect the printer to your computer using the USB lead provided. The computer should recognise the processor board on the printer and install the correct driver for it. If for some reason the driver does not install then drivers for Windows, Mac and Linux are contained on the SD Card.

Communicating with the printer:

Run Pronterface. Select the Com Port that the printer is connected to and a baud rate of 250,000. Press "connect" The printer should connect and return some diagnostic information on the right hand side of the display.
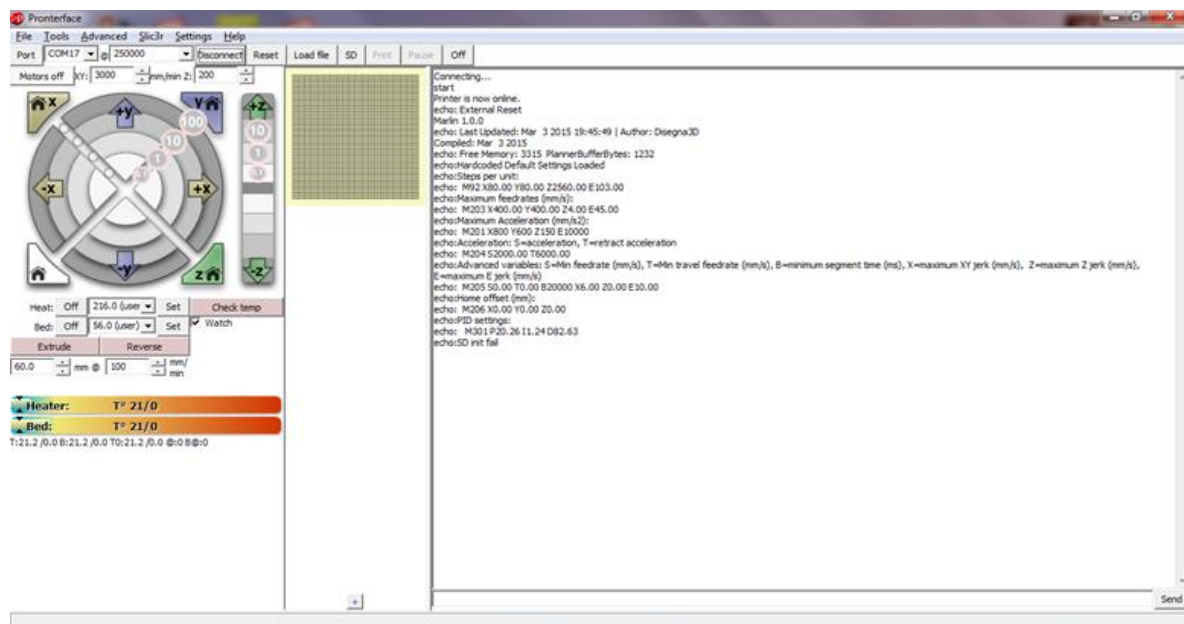
Check that none of the axes are near the end of their travel and then move each of them +10mm using the control wheel on the left of the display. If any of the motors run in the wrong direction then their direction can be reversed by turning the plug into the RAMPS board through 180 degrees. **Ensure that the power is off and the computer disconnected before you do this.** Also remember that for the Y-axis increasing Y should result in the bed moving towards the front of the printer. If any of the motors vibrate noisily but do not move then the wiring is incorrect, turn the power off and check it.

Now home each of the axes in turn by pressing the symbol on the control wheel. Get ready to cut the power if the axis doesn't stop at the endstop. If there is a crash carefully check the wiring and operation of the limit switches. Note that the Z-axis homes to the top and the Y-

axis homes with the bed all the way forward (the home position for these axes is maximum z and maximum y).

Now check the heating of the hot end. Click the "Watch" checkbox. Set the nozzle temperature "Heat" to 200 and press "Set". You should see the nozzle temperature climb steeply and settle at the demanded temperature. Now is a good time to tighten the nozzle. But of course **be careful when doing this as the hot end will be hot enough to cause burns.**

While the nozzle is hot check the extruder works. Set the extrusion to 10mm and rate to 100mm/min, click on "extrude" and check that the motor moves in the correct direction. Click the Heat "Off" button. You don't need to load filament into the extruder to do this check.

Now test the bed heating in a similar way to the nozzle heating. The bed heats much more slowly though so set a low target such as 50 degrees. **The bed temperature should never be set above 110 degrees.** When you're happy that the bed heater is working click the Bed "Off" button.

Levelling the Print Bed:

During the levelling you can use pronterface to move the axes in X and Y but it's probably quicker and easier to move then by hand, click "Motors off" in pronterface if the axes won't move by hand. The z axis should not be adjusted by hand during the levelling process as the firmware will "lose track" of its position.

Adjust the bed levelling screws down so that the threads are 3 turns past the bottom of the nuts. Home the z axis and then lower the print head by typing the command "G1 Z8 F400" into the box at the bottom of the console window and pressing "send". Move the print head in X and Y to the positions A,B,C and D and check that the shank of an 8mm drill bit will pass under the nozzle but a 10mm one will not at each point. If the height is not within this range and you are sure that you have 3 turns of thread past the bottom of the nuts then you need to adjust the z-max height in firmware, jump to "Setting the Z-Max Height".
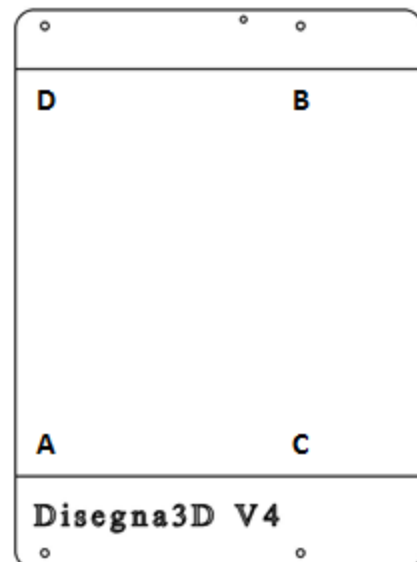
Now lower the head to z0 ("G1 Z0 F400" command). At point A adjust the nearest bed levelling screw so that a piece of paper folded in 2 will just pass underneath it with a little resistance. Repeat this at point B, then C, then D. Go around once more to check that everything is spot on.

Setting the Z-Max Height:

You only need to change the Z-Max height if you could not complete the bed levelling in the previous step and you were directed here from there.

Adjust the bed levelling screws down so that the threads are 3 turns past the bottom of the nuts.

In pronterface home all the axes. Type in "M114" into the terminal input box at the bottom right of the pronterface screen and press "send". In the terminal window above the printer will report the current axis positions. Take a note of the current z position – for reference we'll call this (A). Centre the print head in x and y by typing "G1 X88 Y88 F1600" into the box at the bottom of the console window and pressing "send". Place an 8mm drill bit flat on the bed with the shank roughly in the centre of the bed. Using pronterface (do not do this by manually rotating the z threaded rod) lower the print head until the nozzle just grazes the drill bit shank when it is rolled underneath it. You can adjust the height of the z axis in pronterface using the control wheel or you can type the command G1 Znn F400 into the terminal input box (nn is the height you want in mm). When the nozzle is just touching the drill bit shank enter the M114 command and again take note of the current z position – and for reference we'll call this (B).

Now press "Disconnect" in pronterface.

At this point you need to make some changes in the printer firmware and then re-upload it to the printer.

Install the Marlin IDE using the installer on the SD card. Copy the directory U8glib folder from the SD card into the Arduino libraries folder. Find the marlin.ino file on the SD card and open it. It should open in the Arduino IDE. In the Arduino IDE you'll see tabs for each of the files that the Marlin file includes. Click on the configuration.h tab. Scroll down to find #define Z_MAX_POS. Change the current value to A-B+7. So if A was 151 and B was 10.4 then enter 147.6. Now find #define MANUAL_Z_HOME_POS and change the value here to the same. In the Arduino IDE under the tools tab ensure that "Serial Port" is set to the right port for the printer and ensure that "Board" is set to Arduino Mega 2560. Now click upload (round symbol of an arrow facing right). Reconnect the printer in pronterface. Home the z axis, type the M114 command and check the Z value returned is the same as you typed in the configuration.h file. You should now be able to level the print bed in accordance with the previous step.

Lubricate the axes:

Apply a couple of drops of 3 in 1 oil or a little light grease on each side of the bearings and also on the threaded rod. Run the axes to each end of their travel to ensure the lubrication is taken into the bearings / distributed.

You are now ready for your first print.

The First Print

Ensure that the print bed is spotlessly clean. Pure acetone makes an excellent degreaser.

Ensure that the printer is connected in pronterface. Home the axes.

Load the filament. Lift the lever on the extruder so that the bearing clears the extruder gear. Insert the filament through the hole in the lever, past the extruder gear and up into the Bowden tube. It can be a bit fiddly to get the filament into the hole after the gear, ensure the filament is straight (cutting the end off at 45 degrees can also assist). Now heat the print

nozzle to 200 degrees. Push the filament until it reaches the print nozzle and starts to extrude out of the nozzle. Turn the heat off.

Ensure that pronterface has the correct print profiles selected, under the slic3r tab ensure that V4 PLA is selected for Print settings, Filament and Printer. If you can't see the slic3r tab then you need to enable slic3r integration under options\settings\user interface ensure "enable slic3r integration" is ticked. You will have to close down and restart pronterface for this to take effect.

Then go to file/open and open the file example.stl from the SD card. Pronterface will call slic3r to convert the 3d model file to something that can be printed. When this is complete pronterface will return estimated print time and filament required. After this has happened press "print", the printer will heat the bed, then the nozzle, then home the axes and finally start the print (after about 7 minutes). You might find it easier to pre-heat the bed for future prints.

Congratulations on your first print!

Slic3r Settings

You can run slic3r directly or you can run it from a shortcut in pronterface by clicking options/slicing settings. The profiles provided for PLA and ABS will provide a very good starting point but Slicer is a very powerful tool and has many options to customise your prints. Full details can be found in the slic3r manual available online at http://manual.slic3r.org. A few parameters that you will want to adjust:

•   Infill : the density of infill for your objects. Higher densities make stronger objects (but increase the probability of warping).

•   Perimeters : the number of solid perimeters around the layers of your objects: more shells = stronger and more likely to be sealed (but take longer to print and again increase the chances of warping)

•   Cooling settings : Settings which allow you to compensate for heat build up in a model which can cause distortion. Normally only relates to small models where layer times are quick. The V4 does not come with a print cooling fan, in my experience fans produce variable results, often resulting in models with poor layer adhesion. But there are other options if you want to print very small models. In slicer you can slow down the print speed to increase the layer time. Alternatively, a strategy I often employ is to include a sacrificial model on the same print bed (just a vertical cylinder or similar) some distance from the target model. This slows the layer time down too. Usually I just print more than one thing I want at the same time! If you want to try out a cooling fan then by all means do, there are a lot of fan duct designs on thingiverse, the fan is enabled in the printer firmware and just needs to be connected across the two screw terminals on the RAMPS board (between the hot and and heated bed connections).

•   Filament diameter: in order to extrude the right amount of filament slic3r nees to accurately know the dimensions of your filament. Filament is nominally 1.75mm but will vary roll to roll. Measure your filament diameter accurately at several points using a pair of callipers and enter the average value.

Printer Tuning

Compared to other 3d printers the V4 needs very little calibration but one parameter that you need to be aware of is e steps per millimetre. This is the number of steps that the extruder (E) stepper motor needs to make to extrude one millimetre of filament. When you get your printer the value is set to something which should be useable but to get perfect prints it needs to be set accurately. The number of e steps per mm varies slightly with filament diameter / rigidity (how far the gear teeth bite into the filament) and the geometry of the extruder so unfortunately it will change from one roll of filament to the next.

You can see the effect of the wrong e steps per mm on your prints, if it is too low there will not be enough plastic extruded, there will be gaps in the layer and poor layer adhesion. If it's too high too much plastic will be extruded, edges of the model will the rough as will the top surface. If severely too high the print nozzle will snag in the excess plastic and the layers will lose registration.

So how do you set it? Take the filament out of the printer. Put 2 marks on the filament 20cm apart. Mark as accurately as you can. Re-insert the filament into the extruder so that the first mark is at the hole in the lever. Type M114 into pronterface and note the E value, call this A. In pronterface extrude filament in small increments until the second mark is at the hole in the lever. Again issue the M114 command and note the E value, call this B. Enter the command M503, this will pull up the printer summary information that you get when you connect to the printer. Near the top you'll see M92 followed by a value, note it down, it's the current e steps per mm value, let's call it C. Now calculate the new e steps per mm value, $D=20/(B-A)*C$. Enter the new e steps per mm with the command E92 D. You can then save the value to the non-volatile memory of the processor card by issuing the command M500. You may need to tweak the e steps per mm slightly to get a print quality you are happy with. Note that you can change the e steps per mm (using the M92 nn) command on-the-fly and the effects will be immediate, even in the middle of a print, so it is possible to tweak the value based on how you see the first layer going down.

3D Models

The most common 3D models used in 3D printing are STL (Stereo Lithography) files, normally having the extension .stl. These files describe the surface of a model using triangles.

In order to get the most out of your 3D printer you will need some 3D models to print, there are online repositories of designs which other people have created (often including source files for the programs used to create them). The most well known online repositories are www.thingiverse.com and www.youmagine.com.

At some point you will also want to create your own 3D Models. There are several free 3D CAD programs available which can be used to do this, the following list is not exhaustive:

- OpenSCAD - www.openscad.org
- 123d Design - www.123dapp.com/design
- Design Spark - www.rs-online.com/designspark/electronics/eng/page/mechanical
- Sketchup - www.sketchup.com
- Blender - www.blender.org

Each has its merits and the one you choose will probably be based on your preferred working style. All of these programs are free and have online tutorials (check on youtube).

Additionally you may need software to view and correct any errors in your .stl models. Netfabb is useful for this and a free (limited functionality) version is available www.netfabb.com/basic.php.

Maintenance

The V4 requires very little periodic maintenance. Periodically check that everything is secure and lubricate the axes and threaded rod. The maintenance period will vary depending on use.

Graphical Controller (Option)

The Graphical Controller is available for the V4 and allows stand-alone operation of the printer. 3D Models processed by Slic3r (into gcode files) can be printed directly from an SD card. The controller does not have to be fitted when the printer is first built, the firmware to support it is included, so it can be added at any time.

Assembly:

Using a craft knife remove the 'ears' from the controller case. Insert the red (emergency stop) button into the aperture in the front of the case and then place the controller onto the back. Secure it in place by snapping the back of the case into place. Then push the knob onto the rotary switch.

The controller is held to the frame using the screws that secure the top of the Z-axis. If building your printer from scratch fit the controller in the section "Z-Axis Assembly" when you attach the Z-axis to the frame.

Connect the controller adaptor to the RAMPS board. Again if building your printer from scratch do this in the section "Electronics Assembly".

Finally connect the 2 ribbon cables between the controller and the adaptor board. When building from scratch do this after all the other items in the "Wiring" section.
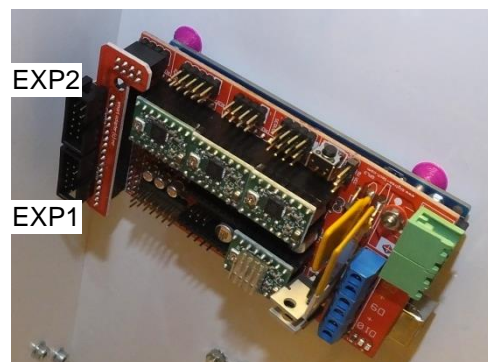
Operation:

The controller allows you to change control the printer and change parameters using a hierarchical menu structure accessed by pushing the knob and then rotating it to select the desired menu item or sub-menu.

The most common items you will need are:

Main / Print from SD:
> Allows you to navigate the SD card and print gcode files stored on it.

Main / Prepare / Auto Home:
> Moves all the axes to their home position.

Main / Prepare / Move Axis:
> Allows you to move the position of each of the axes, note: you cannot move the Z-axis if you choose an move step greater than 1mm. Also you cannot move the extruder E-axis unless the print nozzle is hot.

Main / Control / Temperature:
> Allows you to change the nozzle and bed temperature. This is useful for pre-heating the bed or changing the filament.

Main / Tune / Flow
> The tune menu is only available while printing. Adjust the flow to change the rate at which filament is extruded (equivalent to changing e steps per mm).

If you turn the knob whilst in the home screen the FR (feederate) will change, this speeds up or slows down the speed of the printer. Use this with caution over a small range. Reducing the speed can improve print quality or reduce overheating problems when printing small models. Raising it can save time when quality is not an issue.