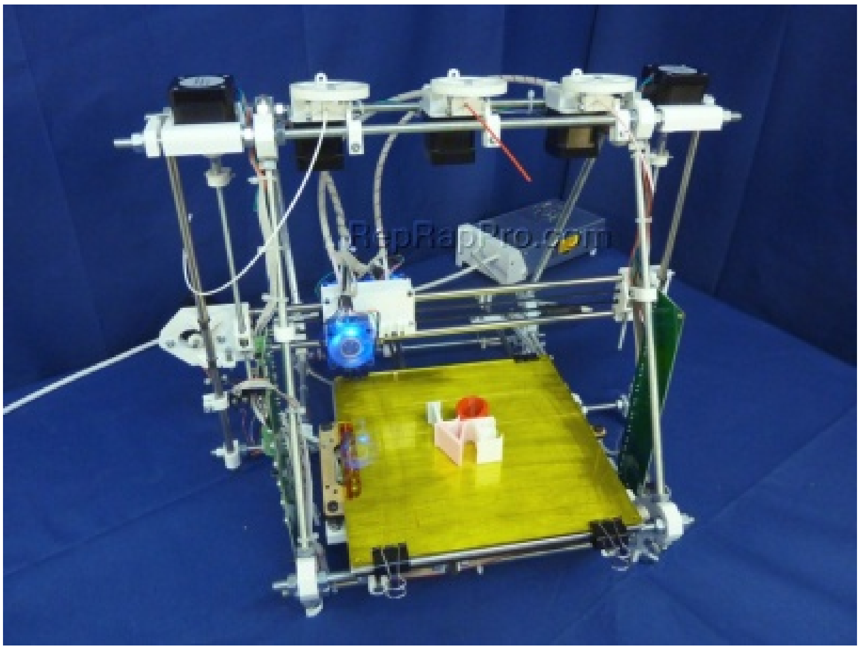
Mendel and Mendel Tricolour

Introduction

These pages are the complete instructions for building, commissioning and using the RepRapPro Ltd Tricolour Mendel and Mono Mendel. They are mirrored on the RepRap Wiki here.



Like all RepRap machines, RepRapPro Mendels are fully open-source. They are licenced under the GPL. All the design files and software are available from the RepRapPro Ltd Github repository. If you want to print the plastic parts for a RepRapPro Mendel, see the appropriate section of that repository. RepRapPro Tricolour Mendel is based on the previous RepRapPro Mono Mendel with many alterations and additions. It was designed in order to further simplify assembly and to increase build volume when using multiple extruders.

These instructions document the assembly of a single material/colour “Mono” Mendel. The extra Tricolour instructions follow the Mono instructions.

It is recommended that Tricolour machines are initially assembled as Mono Mendels, before being extended to Tricolour machines after commissioning, and you have gained some experience using the Mono. You are building a complex machine - the skills required and the rate at which you learn mean that troubleshooting when you have built it all at once is much more challenging.

For the most part, the construction of the Tricolour is the same as for the Mono. At various points there are small tasks that you need to do for the Tricolour. These sections are highlighted in green on the relevant pages.

General notes

Give yourself plenty of space and ensure your work area is clean. Dust and dirt are a 3D printer's worst enemy. All printed parts have been printed on various RepRap machines from suppliers within the RepRap community. Despite the fact that these machines are highly tuned RepRap 3D printers, some holes and features may need a little fettling to get the best performance from your machine. This is especially true for the Igus bushings used for the Z axis. There is a video how-to on fettling 3D printed parts here on Vimeo.

Before you start the build, please ensure you have all the components as listed on the packing list included in the kit. If anything is missing, please contact us via email:
support@reprappro.com

BEFORE YOU ATTEMPT TO ASSEMBLE ANY PART OF THE RepRapPro Mendel 3D PRINTER, PLEASE READ THESE BUILD INSTRUCTIONS FULLY AND ENSURE YOU UNDERSTAND THEM. Although all parts are covered by warranty, this will be invalidated by your not following these build instructions. If anything is unclear please get in contact with support prior to assembly in order to ensure no damage caused to your machine.

The RepRapPro Mendel is a robust RepRap machine once assembled; however it does require a certain amount of care during assembly. If in doubt, force is usually not the answer! There are many ways to get support and advice, see the Get Support section below.

If you can't see clearly from the pictures, they can be enlarged by clicking on them

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Get support

If you find you need help or advice with assembling, commissioning or using your RepRapPro Mendel 3d printer, you can use the following channels:

- Check the troubleshooting pages for common issues like connection, extrusion, sticking and printing problems.
- Our Forum. This sub-forum deals with the RepRapPro Mendel. Other sub-forums on the site deal with other eMaker and RepRapPro models.
- RepRapPro channel on freenode irc

support@reprappro.com

Tool List

Mechanical

Tools required for the mechanical build of the RepRapPro Mendel 3D printer:

- Drill bits including 2mm, 3mm, 6mm and 8mm

- Precision screwdriver set
- A set of metric allen keys including:
    - 2mm (M2.5 size)
    - 2.5mm (M3 size)
    - 4mm (M5 size)
- 13mm spanner (M8 nut)
- 8mm spanner (M5 nut)
- 5.5mm spanner (M3 nut)
- 5mm spanner (M2.5 nut)
- 15cm adjustable spanner
- Half round needle file
- Craft knife
- Fine tweezers
- 300mm rule
- Vernier or digital calipers
- Square
- Fine nosed pliers
- Pliers
- Side cutters
- A small amount of superglue (for securing the hobbed insert)

Electrical

Tools required for the electrical build of the RepRapPro Mendel 3D printer:

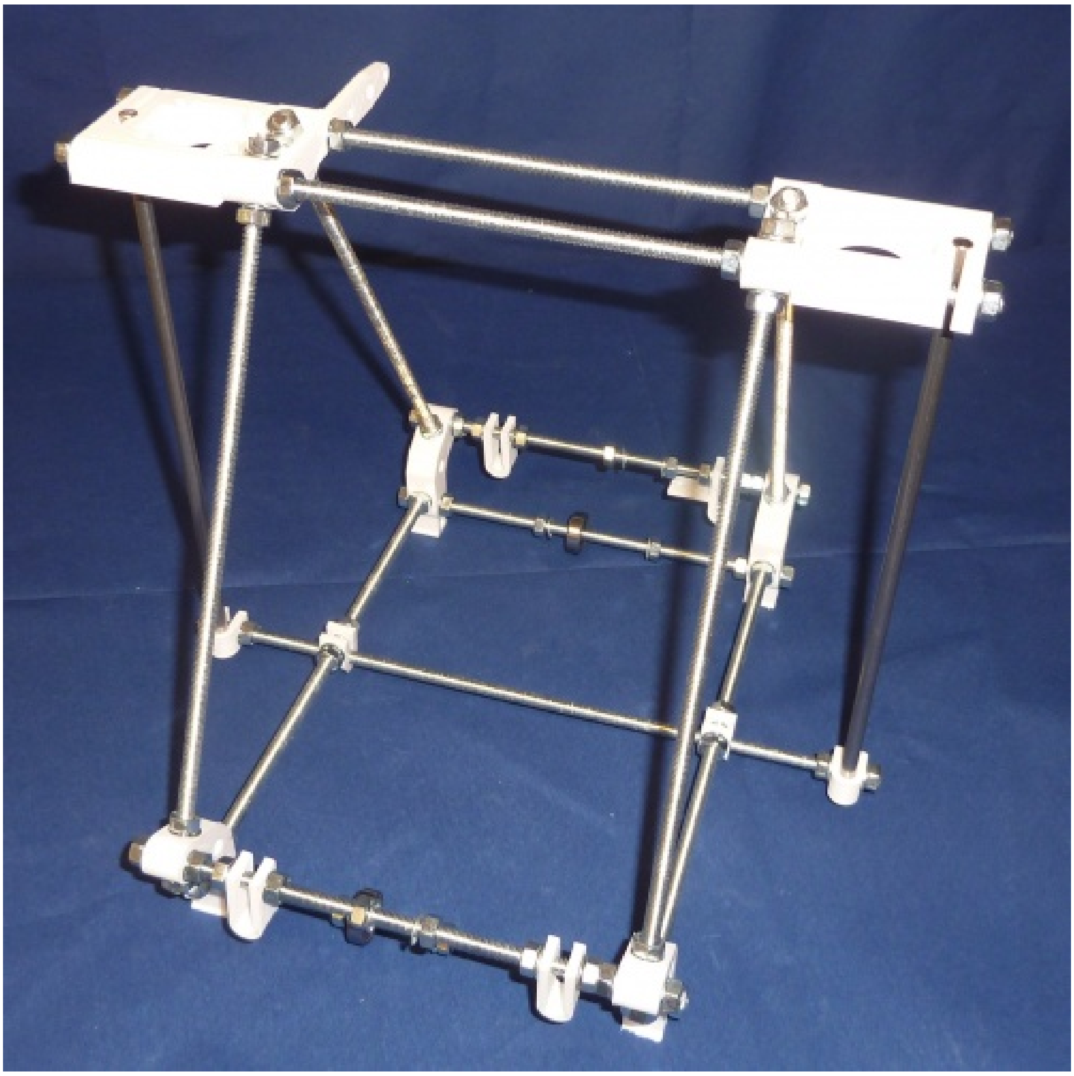
- Digital Multimeter
- A fine-tipped soldering iron

- Precision screwdrivers
- Solder
- Hair dryer or cigarette lighter (or other heat source for heating heatshrink wire sleeving; the barrel of a soldering iron works OK)
- Wire strippers/cutters
- Crimping tool (very useful, but not absolutely necessary; you can do it by hand)
  - EITHER Ratchet crimp tool Such as this one, which we use
  - OR Molex crimp tool (such as the 63811-1000, you may also want the extraction tool 11-03-0044, Molexkits.com)
- Scissors

Frame Assembly

Goal

By the end of this stage, your machine should look like this:

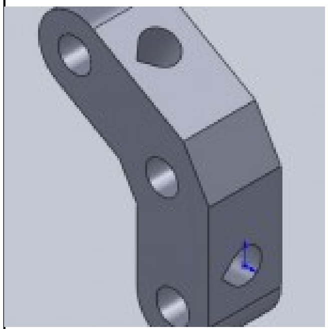
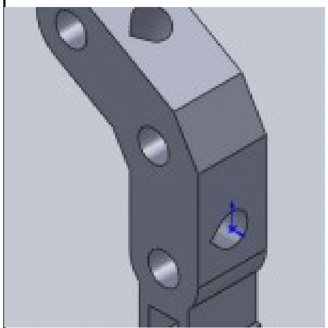
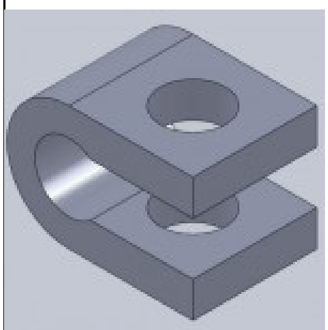


Tools

You will need the following tools

- Laser-cut measurement template (provided with your kit)
- M6 (10mm) spanner
- Adjustable spanner
- Set-square
- 300mm Rule

Step 1: Frame triangles

RP parts	**Quantity**	
	2	
	4	
	2	
Hardware	**Quantity**	
M6 threaded bar x 250mm	6	
M6 nuts	28	
M6 serrated washers	28	

Building 2 sets of triangles (5 min each)

Split the above 6x plastic V shape RP components into two equal sets of 3x (1x left part with foot/leg, 1x right part with foot/leg and 1x top part), start with two legs ones, make sure you slide a belt clamp (U shaped plastic part) along the bottom M6 threaded 250mm long bar, with a serrated washer and nut either side, then **loosely screw just with force of fingers** rest of 250mm rods into each of 3x V shape RP components to finally form a triangle.

When you place a serrated washer between the U shaped RP parts and each M6 nut it will look like this:

Now repeat same for second triangle, you frame triangles should now look like this:

Fine tuning 2 triangle sizes (20 -30 min)

Before moving on to the next step, we need to **tighten the nuts** in rgiht distance on both frame triangles to make them rigid.

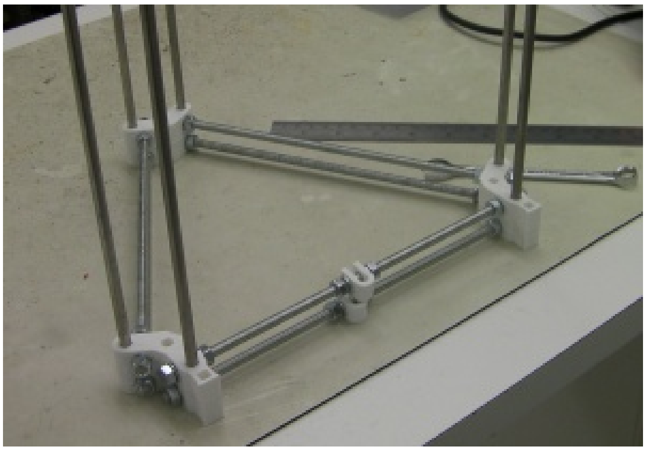
Your kit has a laser-cut measuring template provided. You can use this to make checking the gaps easy. If you do a custom build, best alternative will be to cut a measurement jig 207mm long from 1m long 8mm thick wooden rod.

Please, be patient, give it time, this is very important step.

For each frame, measure the distance between the vertices on all three sides. The distance you should be aiming for is **207mm**. But more important is to make them all six the same. The better aligned your frame is, the better your prints will be when printing large and/or tall objects.

Gently tighten all the M6 nuts ensuring the distance between vertices of **207mm** is maintained.

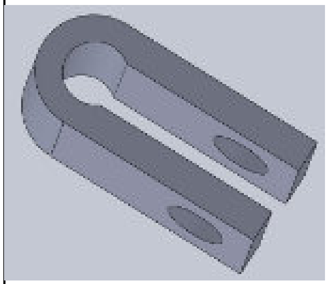
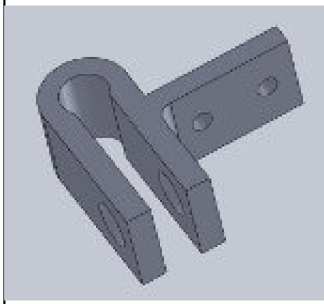
A useful trick once you have one triangle accurately tightened is to use other 6mm rods from the kit to align the second one:



Use the 6 smooth rods rather than the threaded ones for better accuracy, **but be sure then smooth rods can be inserted without any pressure into holes**. In case then you don't prepare holes well enough and you maintain to push smooth rods inside **don't use any tool on them directly to take them out - take a piece of cloth, wrap them and with screwing like motion take them gently out**.

For custom build if you have in hand any M6 hexagon head screws you can use them instead of your expensive smooth rods.

Step2: Cross bars

RP parts	**Quantity**	
	3	
	1	
Hardware	**Quantity**	
M6 threaded bar x 185mm	4	
M6 nuts	24	
M6 serrated washer	24	
626 Bearing	2	

Again split the above components into two equal sets, but with two U-shaped RP bar-clamps in one set, and one U-shaped RP bar-clamp plus the one with the extra tab in the other. (The tab is for the Y axis limit switch.) You will assemble two top bars (identical but for the U/U+extra-tab), and two bottom bars (identical).

NOTE : The extra tab on one U-shaped bar clamp is used to maintain the Y-axis end-stroke contact. Install it at this moment (see Wiring - step 5 [1]

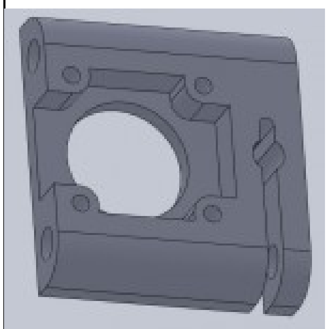
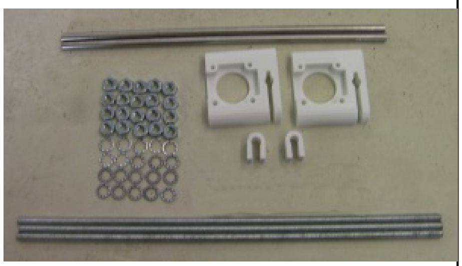
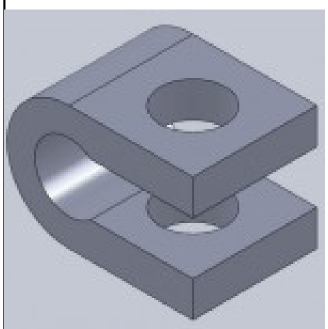
So for one top bar, you will need (starting from the middle of the M6 threaded bar): serrated washer, two M6 nuts, serrated washer, bar-clamp, serrated washer, two M6 nuts, serrated washer. Then, in the other direction: serrated washer, two M6 nuts, serrated washer, bar-clamp+tab (with the tab facing towards the centre of the bar), serrated washer, two M6 nuts, serrated washer.

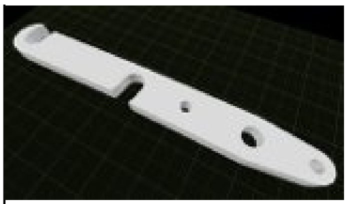
For the other top bar, you will need (starting from the middle of the M6 threaded bar): serrated washer, two M6 nuts, serrated washer, bar-clamp, serrated washer, two M6 nuts, serrated washer. Then do exactly the same in the other direction.

And for the bottom bars: 1 x 626 bearing, serrated washer, 2 x M6 nuts, serrated washer, (and repeat in the other direction, except for the bearing).

Your cross bars will now look like this:

Step3: Put them all together

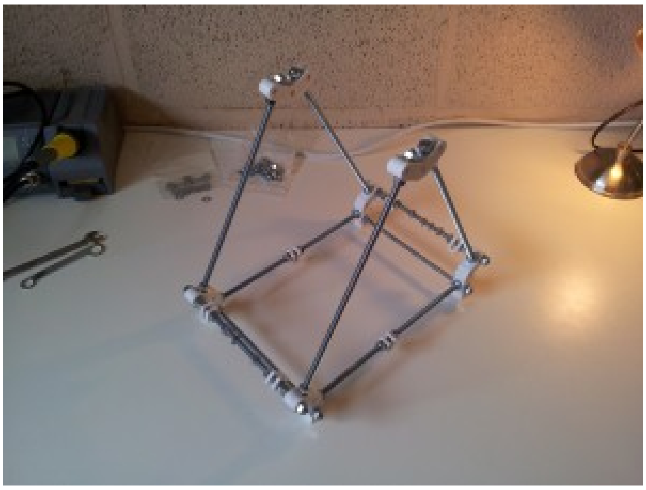
RP parts	Quantity	
	2	 Again, bars aren't really bent, they are straight!
	2	
	1	



Hardware	Quantity
M6 threaded bar x 285mm	3
M6 smooth rods x 235mm	2
M6 nuts	20
M6 serrated washer	20

Firstly screw the cross bars into one of the triangles. The cross bar with the bar clamp with the extra tab should go at the back, with the bar clamp with the extra tab on the right.

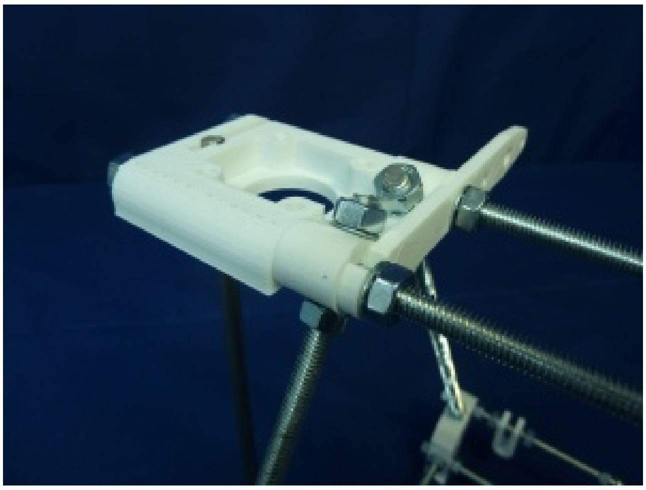
Then screw the second triangle to the other end of the cross bars:



Now we need to slide the two top bars through the top frame vertices. Slide each bar through one vertex, then fit one serrated washer, two M6 nuts and another serrated washer before sliding the bar through the opposite vertex.

Next, slide a Z motor mount onto each ends of the top bars. This may need a little force as the holes through the z motor mounts tend to be quite a tight fit on the M6 threaded bars (it's usually a good idea to make sure you can push a spare length of M6 threaded bar into each of the z motor mount holes before trying to fit them to your frame).

Add the filament drive bracket so it is inside the left Z motor mount and frame-vertex, and is held against it by the inner nuts and washers. The front slot next to the rounded end goes upwards, the middle slot goes at the back and downwards. Imagine hanging a weight on the projecting end - the slots need to go in the way that makes the weight tend to pull things into place, not to release them.



Before tightening the M6 nuts on the top bars, slide the bottom cross bar through the two bottom bar clamps. You do not need M6 nuts or washers either side of these bar clamps. At each end of this bottom cross bar, fit an M6 nut, a serrated washer, a bar clamp, a serrated washer, and another M6 nut.

At this stage, the frame should be quite loose, so just jiggle everything around until it all the angles look about right. Once you are happy with this step, you can tighten the nuts on the cross bars. The distance between the frame vertices along the cross bars should be 146mm. When tightening the M6 nuts on the top cross bars, please note that you do not need to tighten the nuts which clamp against the Z smooth rods too much, only enough to stop the smooth rod from sliding down. If you slip two washers into the groove on the Z-motor mount (with the threaded rod run through their holes) you will be able to clamp your frame solidly and grip the Z-rods without over-stressing the plastic. Your kit doesn't come with these washers. 1/4" washers work well for this.

Before tightening the bar clamps on the bottom cross bar, slide the Y axis smooth rods (270mm) into place. (These are easily confused with the X axis rods, which are 265mm - get the right ones.)

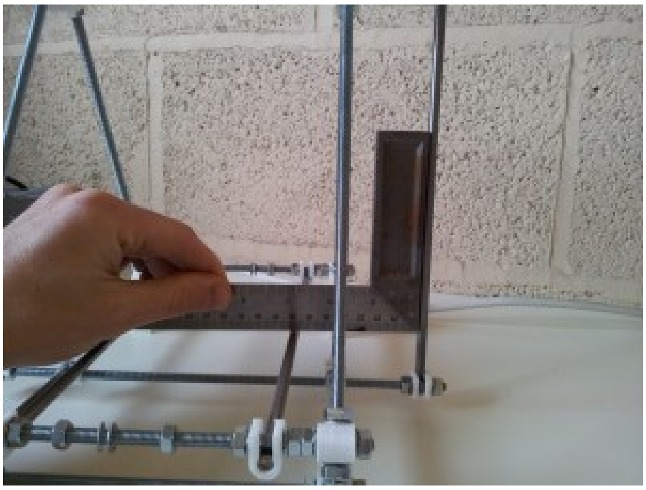
Aligning the Z Rods

Check all of the smooth rods. If the ends of the rods are sharp or burred from cutting, use a file to smooth off the ends to give a small taper/bevel/chamfer; 1mm is fine. Without it, there is a risk of unseating the balls inside linear bearings while inserting the rods.

Check that the linear bearings slide smoothly on each of the smooth rods. The linear bearings may need a little extra oil, and the smooth rod may need cleaning, for smooth running. The quick way to clean the smooth rod is to put it in an electric drill, then use wire wool or a kitchen scourer on it while the drill turns the rod. Be careful though!

You can now slide the two Z smooth rods (length 235mm) into place.

Use a set-square to get the angle of the Z smooth rods correct. Make sure you get the right smooth rod for the Y-axis; if you swap them you will have to go back and take things apart again.



You can now tighten the M6 nuts along the bottom cross bar.

Alternative alignment method

Some people swear by this method, others hate it...

For this you will need the spirit level, two pieces of cotton, and a small blob of Blu-tack.

Build the frame as above, as far as "Aligning the Z Rods".

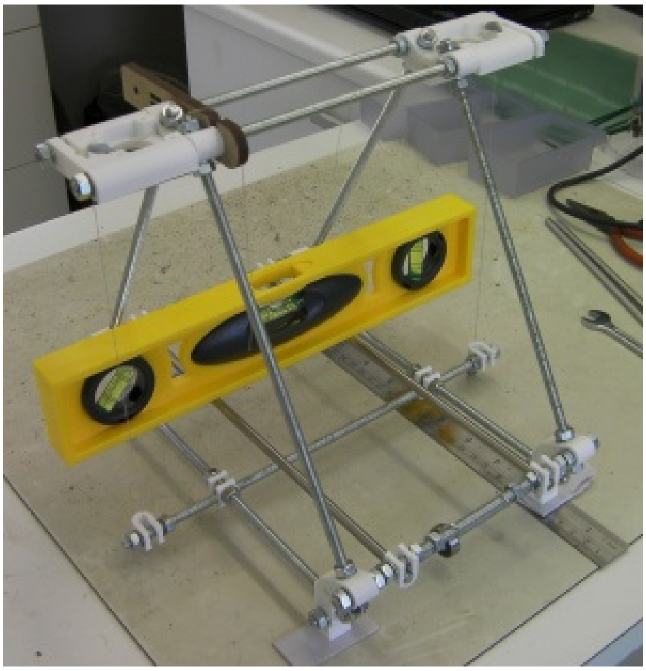
Place the frame on a **flat** surface (40mm-thick Formica-covered kitchen worktops are remarkably flat). You will almost certainly find that the feet aren't quite level and that the frame rocks a little about a diagonal. Tightening the frame has distorted it slightly.

Put an object about 10mm high under a foot on that diagonal, and **very gently** push the other two diagonal corners down. Try the feet on the flat surface again. Repeat this until the frame does not rock, but instead sits four-square on the surface. You can carry out this process at any future stage in the build to re-square the frame.

Put the spirit level across the Y smooth bars, and place folded paper shims under the left or right feet until the frame is level left-right. You will discover that a spirit level is an exquisitely sensitive instrument, and that it can easily detect a couple thicknesses of paper.

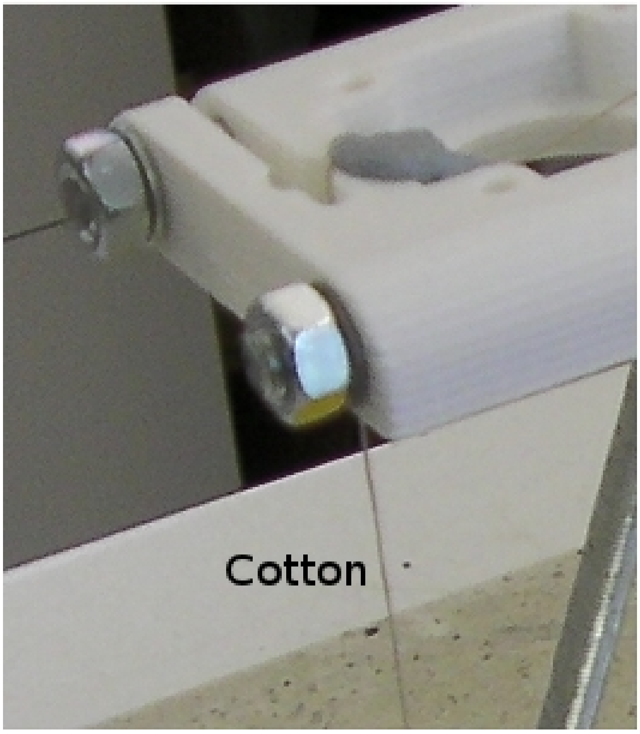
Rotate the spirit level through a right angle so it rests between the front and back cross bars, and get the frame level front-back too.

Check the frame is level in both directions.



Now thread two lengths of cotton down through the top bracket and the U clamp on the bottom where the Z axis smooth rods will be. Attach it to the Z-axis-smooth-rod holes at the top with Blu-tack such that it is half-way round the inside of the clamp arc.

Put a small blob of Blu-tack on the bottom of each piece of cotton to act as a plumb weight.



Now adjust the positions of the threaded rod at the bottom and the Z-axis-smooth-rod U clamps so that the cotton falls freely in the middle of the U-clamp holes.

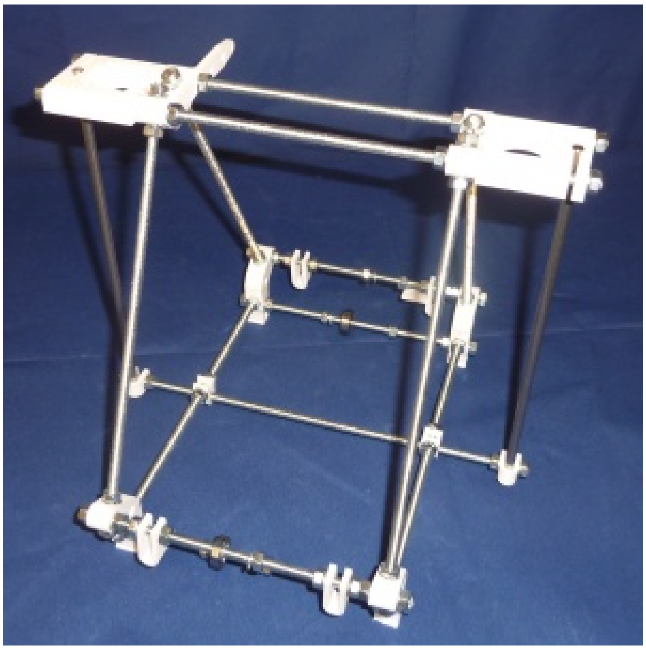
Tighten the nuts on the main frame holding the threaded rod, making sure that the cotton stays in the middle of the holes where it was.

Now tighten the inner nuts to move the U clamps outwards so that the cotton just kisses the edge of the U holes in exactly the same relative position as it is falling through the clamps at the top of the frame.

Slide the Z-axis rods in, tighten the clamps from the outside, and check with a square as in the section above. If you've done everything carefully there should be little or no discrepancy, but it is more important to have a right angle than to have the Z-rods plumb.

Frame finished

You will now have an assembled RepRapPro Huxley frame:

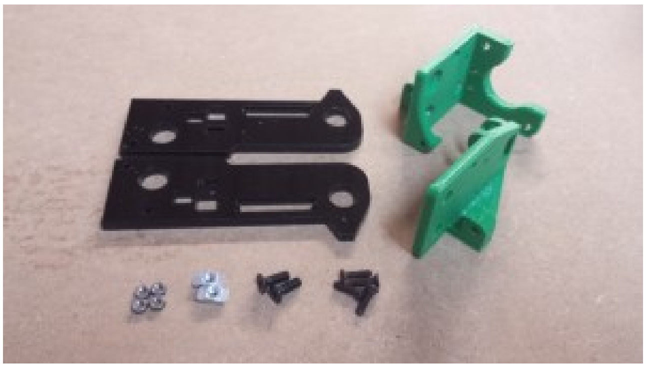


Y axis assembly

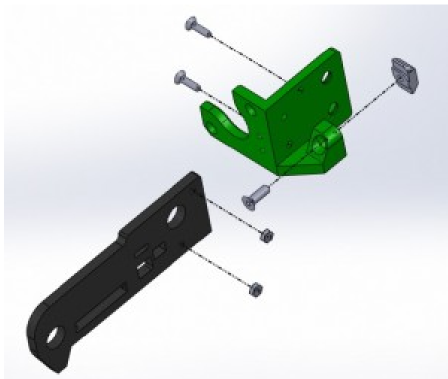
Y axis sub-assemblies

Y-motor-end and Y-idler-end

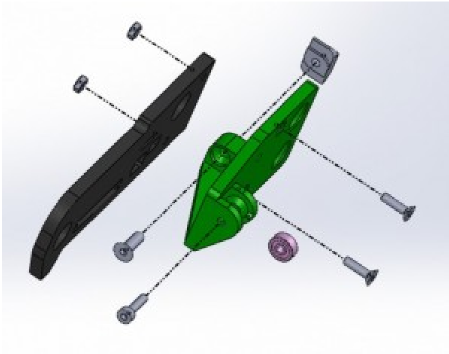
Component	Type	Quantity
y-idler-bracket	Printed	1
y-motor-bracket	Printed	1
y-axis-end-plate	Lasercut	2
M3 Nut	Fastener	4
M4 T-nut	Fastener	2
M4x12mm countersunk socket head screw	Fastener	2
M3x12mm countersunk socket head screw	Fastener	4



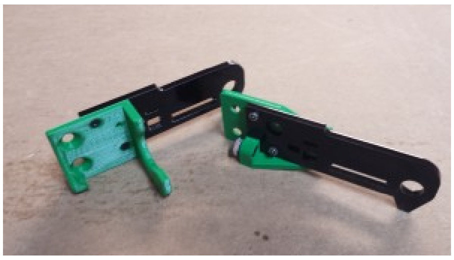
Begin by assembling the Y-motor-end, as shown. Use y-axis-end-plate 'A' with the y-motor-bracket. The 12mm holes will be slightly larger in diameter on one side of the y-axis-end-plate, the side with the letter 'A', which will make it easier to insert the 12mm ground steel bar later.



Repeat with the y-axis-idler-bracket, using y-axis-end-plate 'B', to build the y-idler-end.



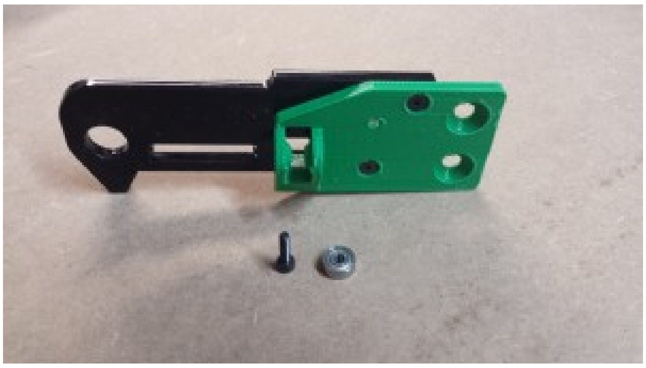
The Y axis ends assembled.



Y-idler-end bearing

Now fit the 623 idler bearing to the y-idler-end, for which the following are required:

Component	Type	Quantity
y-idler-end	Assembled	1
M3x12mm cap head screw	Fastener	1
623 bearing (10mm diameter)	Hardware	1



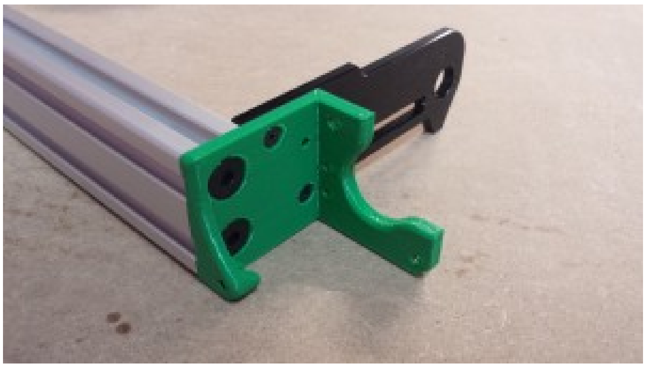
The retaining screw (M3x12mm) should self tap into the printed part, with no need for a nut on the free end. It may require a fair bit of force to push the bearing into position.

Y axis frame

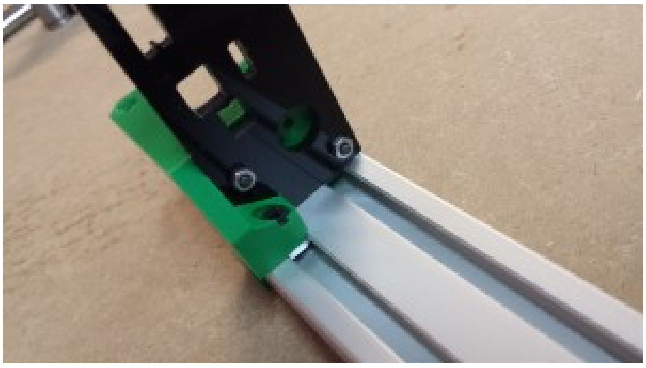
The next step is to assemble the Y axis frame. For this you will need the following:

Component	Type	Quantity
y-idler-end	Assembled	1
y-motor-end	Assembled	1
Alumninium extrusion	Hardware	1
LM12UU Linear bearing	Hardware	3
Smooth rod 12x350mm	Hardware	2
M6x16mm countersunk socket head screw	Fastener	4

Screw one of the Y axis ends onto the Aluminium extrusion, using two M6x16mm countersunk socket screws.



Ensure the M4 T-nut is located in the extrusion slot.



Next you will need to fit the ground rods into the y-axis-end-plate. The 12mm diameter holes are sized to be an interference fit with the rods, and the Acrylic laser cut plates are quite brittle so care must be taken when inserting the rods not to break the end plates.

Place the Y axis assembly on the edge of a flat surface to support the end plate, then press each rod in turn into the plate. Keep the rod perpendicular to the plate whilst pushing. You can use a small hammer on a piece of wood on the end of the rods if necessary.

Before fitting the idler end assembly, slide the linear bearings onto the rods. Press the idler end assembly onto the free ends of the rods, making sure you support the other end so as not to break the idler plates. With the ends pushed home, fix the idler end assembly using two M6x16mm countersunk socket screws, and tighten the M4 T-nut.

Y axis motor

Now you can fit the Y axis motor. For this step you will need the following:

Component	Type	Quantity
y-axis-frame	Assembled	1
NEMA17 stepper motor		1
M3x8mm countersunk	Fasteners	2

socket screw		
M3x40mm socket cap screw	Fasteners	1

One screw needs to be removed from the back of the motor as shown.

Fit the motor into the printed y-motor-bracket. Secure the motor in place with 2 x M3x8mm countersunk socket screws in the front face

Put one M3x40mm socket cap screw in the back, where you took out the motor screw.

X axis assembly

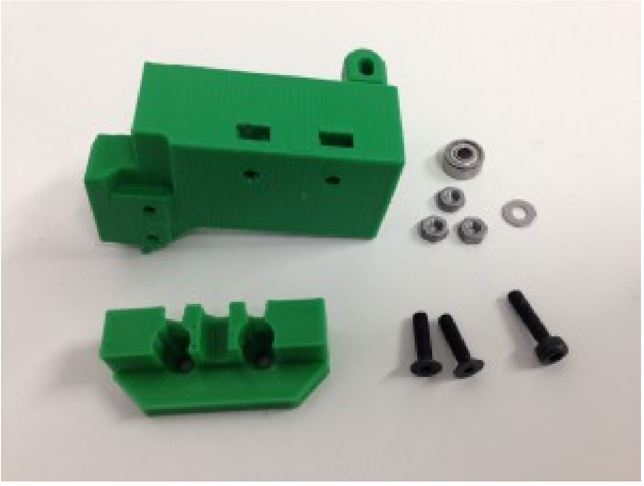
X axis sub-assemblies

The first step is to assemble a couple of sub assemblies.

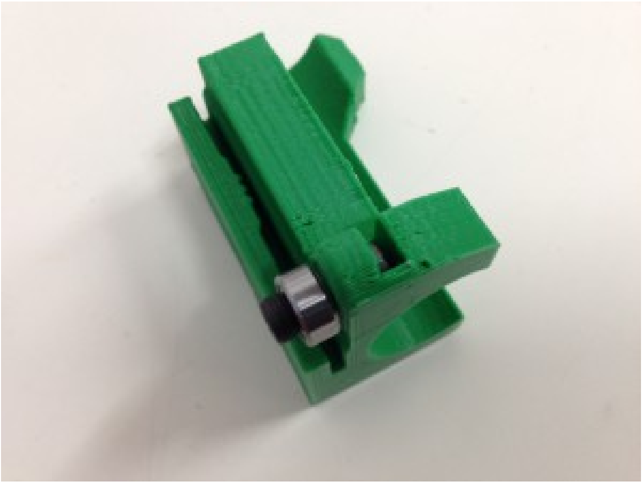
x-carriage

Starting with the x-carriage. You will need the following:

Component	Type	Quantity
x-carriage	Printed	1
nozzle-mount	Printed	1
MR93ZZ bearing (9mm diameter)	Hardware	1
M3x12mm cap head screw	Fastener	1
M3 washer	Fastener	1
M3 Nut	Fastener	3
M3x12mm countersunk socket screw	Fastener	2



Fit the runner bearing using the M3x12mm cap head screw. The washer should be positioned between the bearing and the x-carriage. Check that the screw can move in the slot; this allow you to adjust the angle of the hot end.

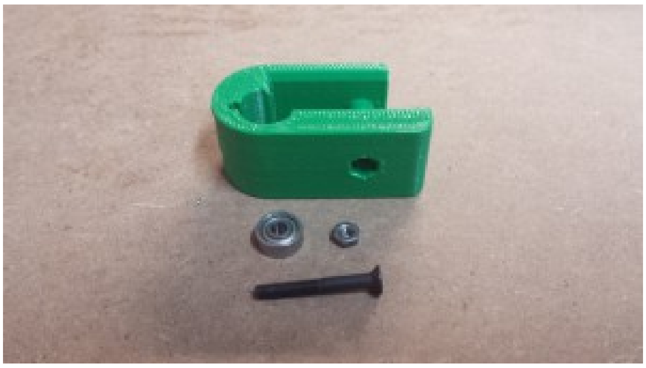


Put an M3 nut in each of the nut traps. Attach the nozzle mount as shown with two M3x12mm countersunk socket screws.

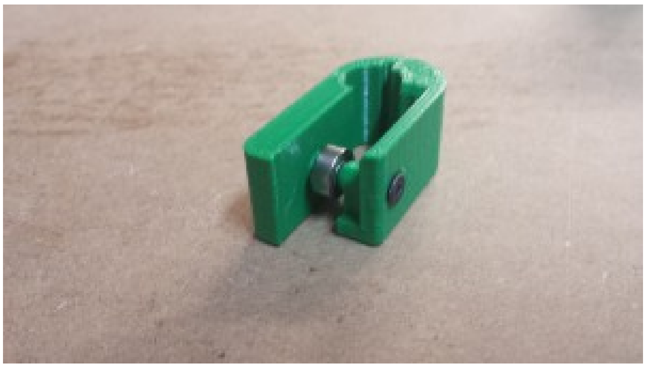
x-idler

Next you should assemble the X-idler sub-assembly. For this you will need the following:

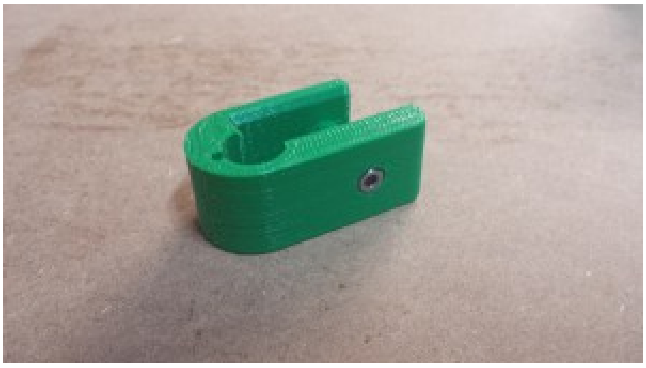
Component	Type	Quantity
x-idler-bracket	Printed	1
623 bearing (10mm diameter)	Hardware	1
M3x25mm countersunk socket screw	Fastener	1
M3 Nut	Fastener	1



Push the countersunk screw through the x-idler-bracket. The hole may be a little tight where it breaks through to the gap in the middle of the x-idler-bracket. Place the bearing inside the x-idler-bracket and fit the M3 nut to the protruding screw.



Pull the M3 nut into the nut trap, but do not tighten at this stage.

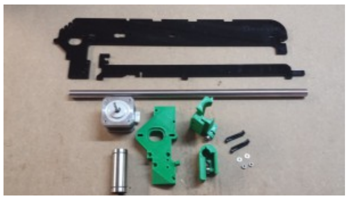


X axis assembly

Now you can start to assemble the X axis.

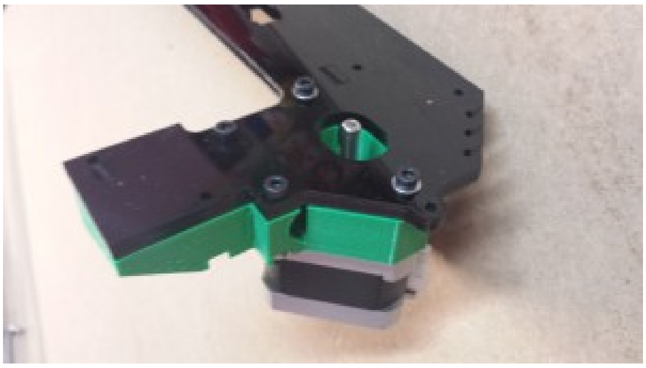
You will need the x-carriage and x-idler sub assemblies, as well as the following parts:

Component	Type	Quantity
x-carriage	Assembled	1
x-idler	Assembled	1
x-motor-bracket	Printed	1
x-axis-plate	Laser cut	1
x-rib	Laser cut	1
NEMA17 stepper motor	-	1
Smooth rod 12x350mm	-	1
LM12LUU linear bearing	Hardware	1
M3x25mm cap head screw	Fasteners	4
M3 Nut	Fastener	2
M3 washer	Fastener	2

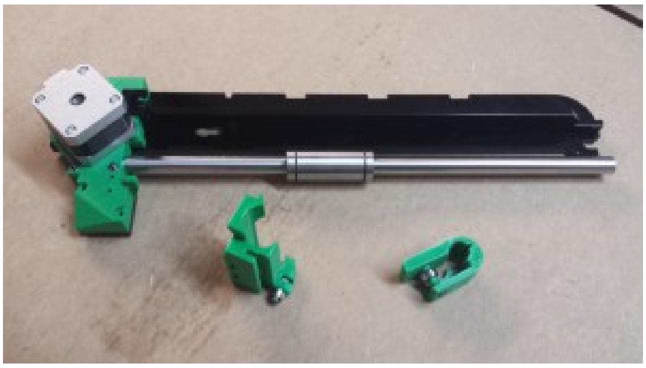


Push the x-rib into place in the slots in the x-axis-plate, which should slot together easily. **DO NOT FORCE!** Acrylic is quite brittle, and you may break the x-rib. Use a file to smooth any rough edges, and ease the tabs of the x-rib, so it goes into the x-axis-plate easily. Slide the x-motor-bracket into place (this may need trimming for a good fit around the x-rib), and put an M3 nut in each nut trap, as shown.

Insert the two of the M3x25mm cap head screws to engage with the M3 nuts in the nut traps. Insert the other two M3x25mm cap head screws, with washers on, to mount the motor, but do not fully tighten. Make sure all the M3 holes in the printed part line up with the laser cut part - trim as necessary.

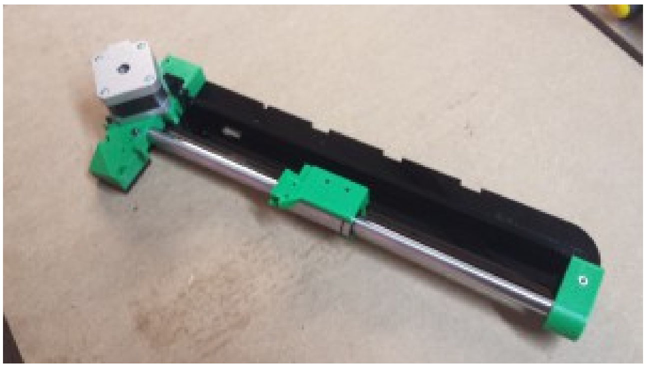


Slide the ground bar into the x-motor-bracket, then the linear bearing onto the bar.



Next slide the x-carriage into place.

Finally, push the x-idler sub-assembly onto the rest of the X axis assembly. Ensure you have the parts lined up before applying too much pressure as the Laser cut parts are not very forgiving. Tighten the countersunk screw in the x-idler-bracket, as well as the screws securing the ground bar at the X motor end.

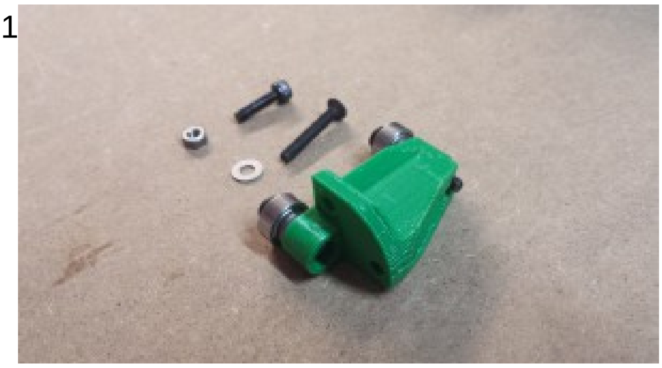


z-runner-mount

To finish the X axis assembly, you need to fit the z-runner-mount sub-assembly. For this you will need the following:

Component	Type	Quantity
[z-runner-mount]()	Printed	1
623 bearing (10mm diameter)	Hardware	2
M3x12mm cap head screw	Fastener	2
M3x20mm cap head screw	Fastener	1
M3x20mm countersunk socket screw	Fastener	1
M3 Nut	Fastener	4
M3 washer	Fastener	1

Pull the nuts into the nut traps with an M3 screw if they don't drop straight in, and make sure they are at the bottom of the nut trap. Using one M3x20mm cap head screw and one M3x12mm cap head screw, attach the bearings. Put one bearing on each screw, then 5 x M3 washers between each bearing and the z-runner-mount.



Mount the z-runner-mount assembly to the x-axis-plate using the remaining M3x12mm cap head screw and nut, which goes through the x-axis-plate and into the top hole of the z-runner-mount ...

... and the M3x20mm countersunk screw, which goes through the x-axis-plate and into the x-rib. The washer and M3 nut go into the cut-out in the x-rib to secure it. Check the bearing is free to rotate; add or remove a washer if it is touching the acrylic.

If you have the updated, adjustable z-runner-mount, it looks like this. Use an extra M3x20mm countersunk socket screw and M3 nut to secure it. **DO NOT OVER-TIGHTEN!** The z-runner-mount should only need to lightly hold the z axis aluminium extrusion.

Z axis assembly

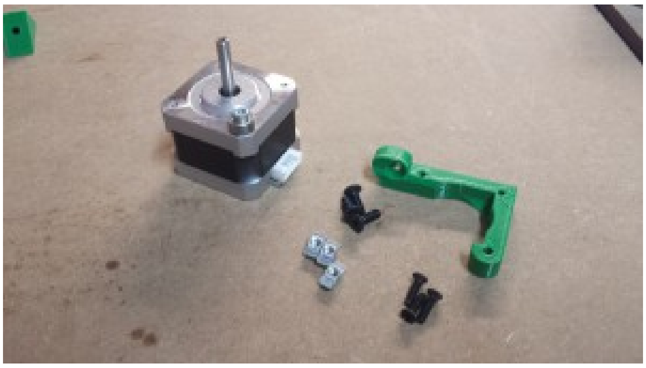
As with the Y axis, the Z axis is assembled in stages, starting with small sub-assemblies which are brought together towards the end.

Z axis sub-assemblies

z-motor-mount

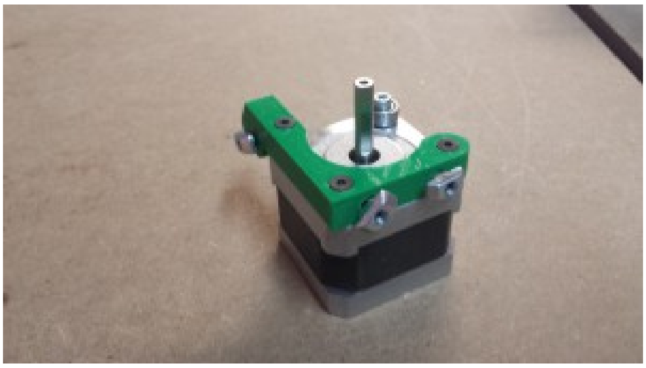
Begin with the z-motor-mount. You will need the following parts:

Component	Type	Quantity
z-motor-brace	Printed	1
NEMA17 stepper motor	-	1
M3x8mm countersunk socket screw	Fastener	1
M3 washer	Fastener	1
623 bearing (10mm diameter)	Hardware	1
M3x12mm countersunk socket screw	Fastener	3
M4x12mm countersunk socket screw	Fastener	3
M4 T-nut	Fastener	3



Begin by securing the 623 bearing on the corner of the Z motor, with an M3x8mm countersunk socket screw. The M3 washer goes between the bearing and the motor body; check the bearing can rotate freely.

Screw the z-motor-brace to the stepper motor using the M3x12mm countersunk screws, then loosely fit the M4 T-nuts with the M4x12mm countersunk screws, as shown.

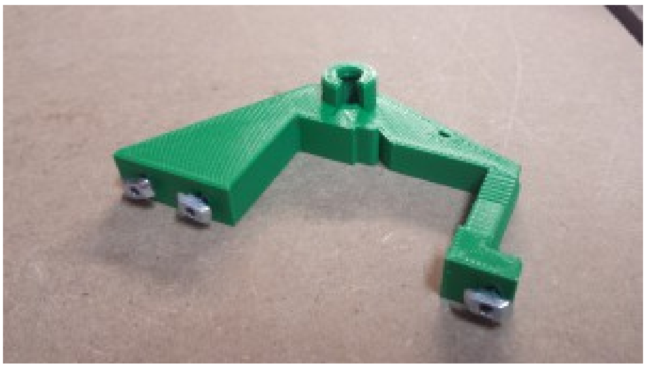


z-lower-mount

The z-lower-mount sub-assembly requires the following:

Component	Type	Quantity
z-lower-mount	Printed	1
M4x12mm countersunk socket screw	Fastener	3
M4 T-nut	Fastener	3

Loosely fit the M4 T-nuts as shown



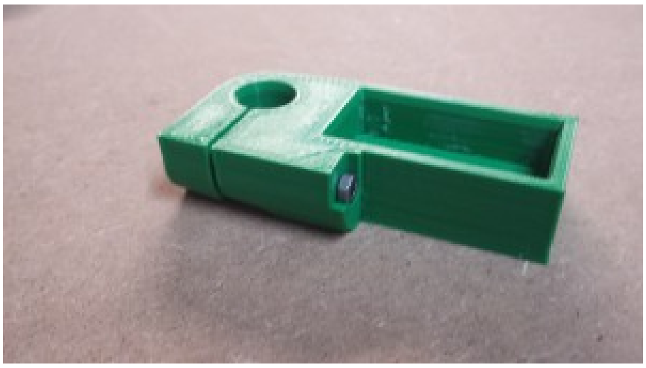
z-upper-mount

The z-upper-mount sub-assembly requires the following:

Component	Type	Quantity

z-upper-mount	Printed	1
M3x35mm cap head screw	Fastener	1
M3 nut	Fastener	1

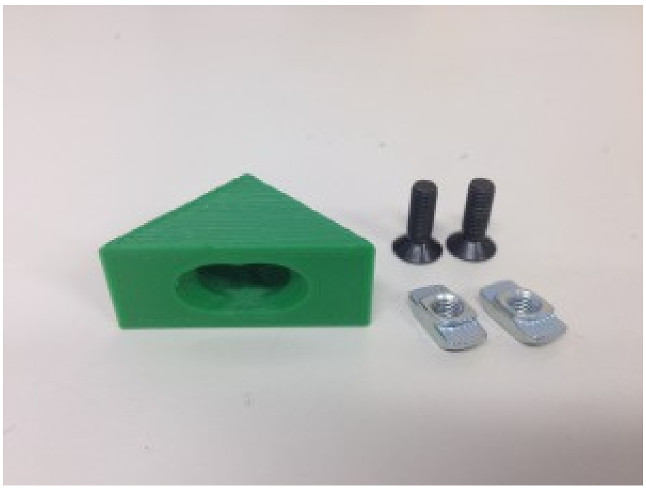
Fit the M3 screw and nut as shown.



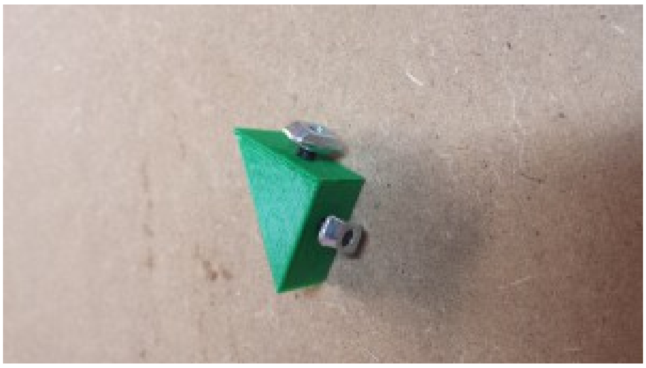
z-corner-bracket

The z-corner-bracket sub-assembly requires the following:

Component	Type	Quantity
z-corner-bracket	Printed	1
M4x12mm countersunk socket screw	Fastener	2
M4 T-nut	Fastener	2



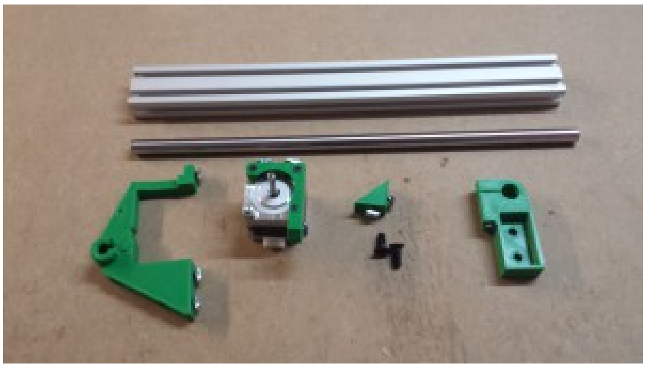
Now loosely fit two M4 T-nuts using M4x12mm countersunk socket screws into the z-corner-bracket.



Z axis assembly

You can now bring all of the Z axis sub-assemblies together, using the following parts:

Component	Type	Quantity
z-motor-mount	Assembled	1
z-lower-mount	Assembled	1
z-upper-mount	Assembled	1
z-corner-bracket	Assembled	1
LM12UU linear bearing (not shown)	Hardware	2
Smooth rod 12x350mm	Hardware	1
Aluminium extrusion	Hardware	1
M6x16mm countersunk socket screw	Fastener	2

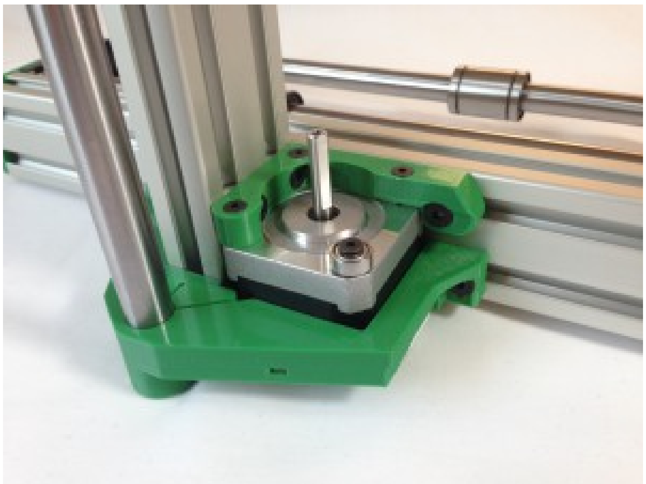


Start by putting the z-upper-mount on the aluminium extrusion - it's a tight fit. Secure it using two M6x16mm countersunk screws. Then fit the Z motor sub-assembly to the extrusion. The M4 T-nuts should not be done too tight at this stage; just enough to hold the Z motor to the extrusion.

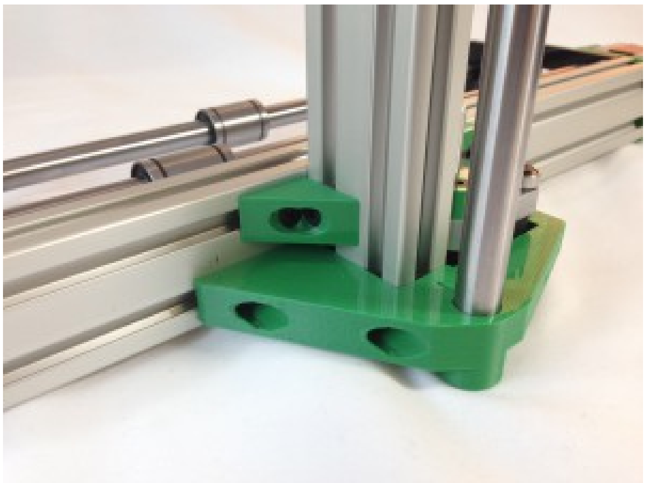
Now fit the rest of the Z axis parts as shown. Fit the 12mm smooth rod into the z-upper-mount, and slide the LM12UU bearings on. Then put on the z-lower-mount and z-corner-bracket. Use the other pictures below for reference.

Connecting the Z axis assembly to the Y axis assembly

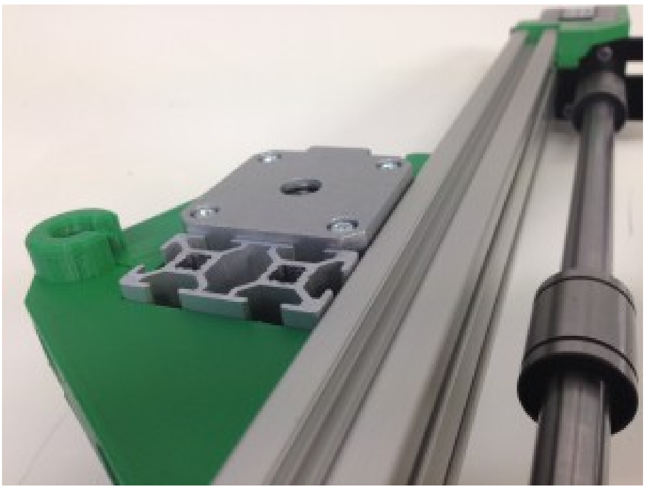
The Z axis assembly can now be attached to the Y axis assembly. Orientate the Z nuts so they drop into the extrusion, you don't need to slide it on from the end.



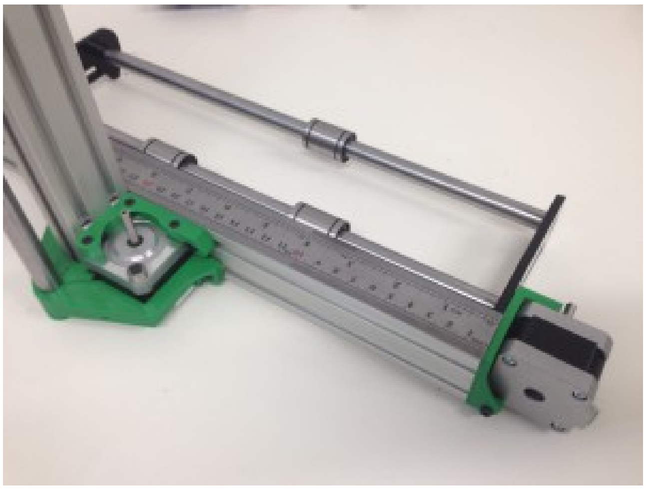
As you tighten the M4 countersunk screws, the T-nut should rotate 90 degrees and catch in the extrusion slot. They may need a wiggle to get them to turn. Assemble loosely to start with, so you can move the components to the correct places.



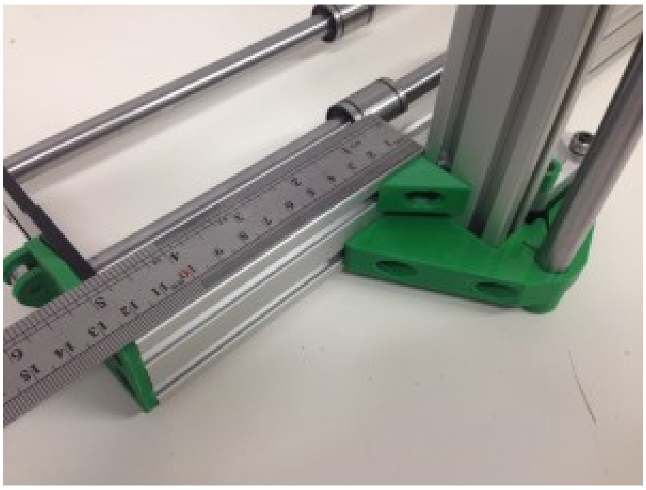
The base of the vertical Aluminium extrusion must be flush with the bottom of the Y axis extrusion. The bottom of the motor will be a little below the level of the extrusions.



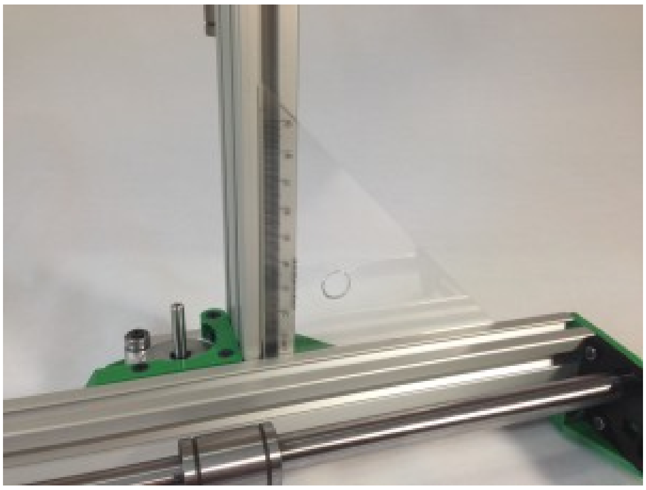
On the Y axis motor side, the face of the Z axis aluminium extrusion should be 210mm from the end of the Y axis aluminium extrusion.



On the Y axis idler side, the face of the Z axis aluminium extrusion should be 120mm from the end of the Y axis aluminium extrusion.

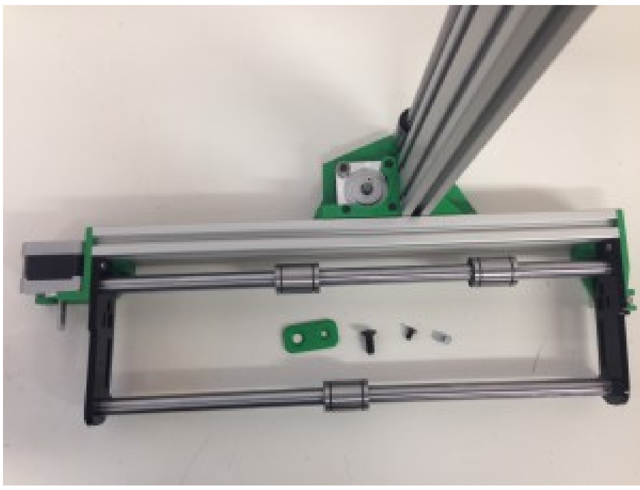


Use the supplied set square to check the Z axis and Y axis extrusions are at right angles to each other, before finally tightening of the screws. Repeat the above alignment steps to confirm they are all correct, before tightening all the fasteners.

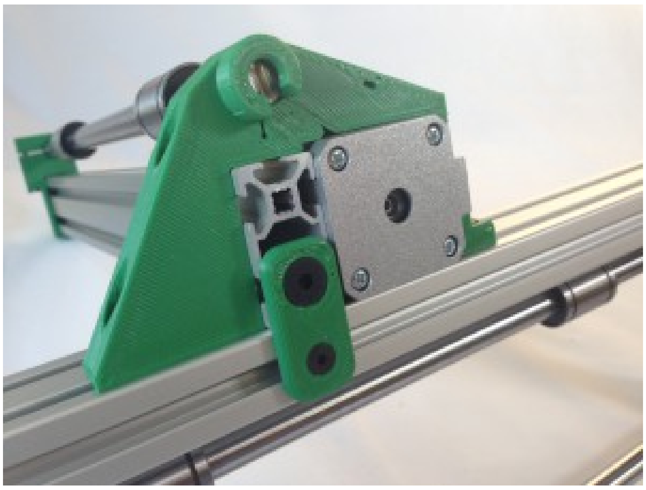


Attaching the Z-foot

Component	Type	Quantity
ZY assembly	Assembled	1
z-foot	Printed	1
M6x16mm countersunk socket screw	Fastener	1
M4x8mm countersunk socket screw	Fastener	1
M4 T-nut	Fastener	1



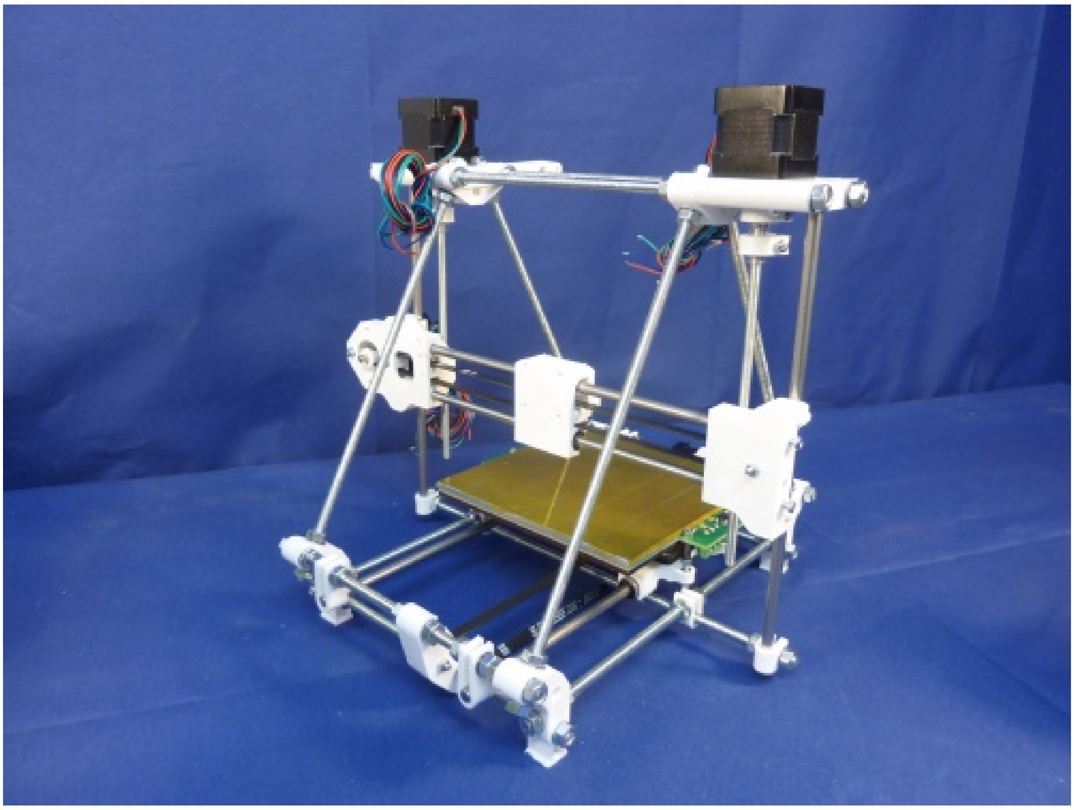
The base of the vertical Aluminium extrusion must be flush with the bottom of the Y axis extrusion. These two can then be secured using the z-foot, one M6x16mm countersunk socket screw, and an M4 T-nut and M4x8mm countersunk socket screw.



Heatbed Assembly

Goal

By the end of this stage, your machine will look like this:



See also [this wiki page].

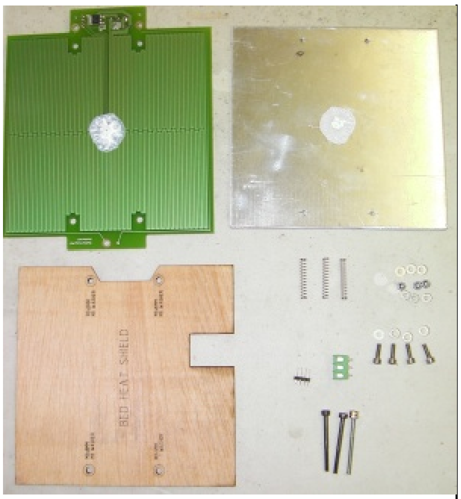
Tools

- Wire cutters
- Soldering iron
- Allen key

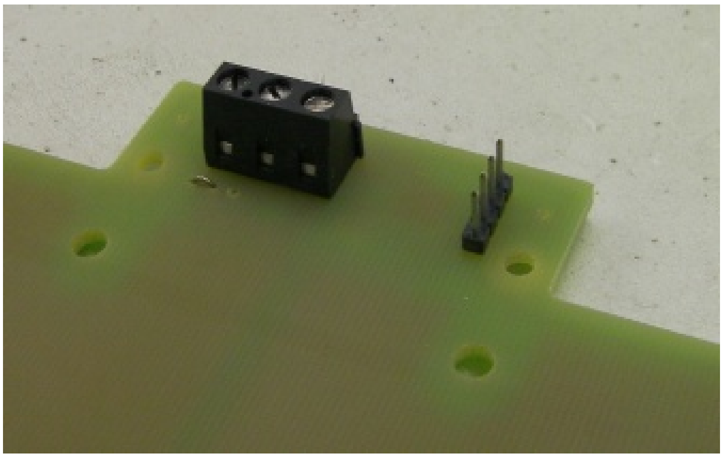
Heated bed assembly

Hardware	Quantity

Heated bed PCB	1
Aluminium plate	1
MDF insulator	1
Bed springs	3
3-way screw connector	1
4-way pin header	1
short wire (e.g. clipped resistor lead)	20mm
M3x30mm screw	3
M3x8mm screw	4
M3 nylock nut	3
M3 nut	6
M3 washer	10

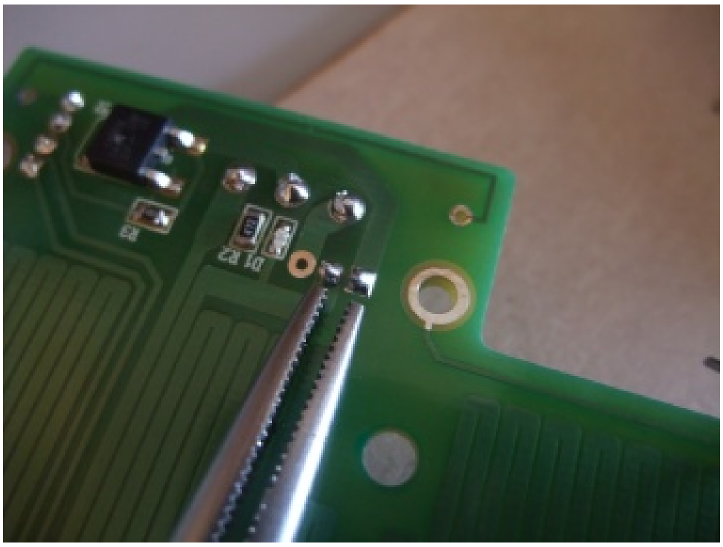


There should be 3 more M3 nuts and
3 more M3 washers in this picture

- 

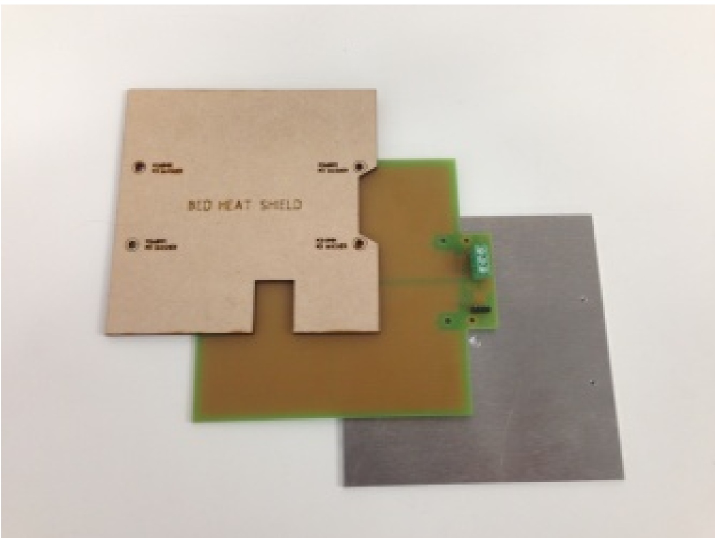
  Start by soldering the connectors in place. The wire holes on the screw connector face outwards.

-



Use a very short length of wire to make a jumper between the left two holes beside the 3-way screw connector. Be particularly careful when soldering the large connector. You need to ensure that there is no dry joint and that there is a reasonable, although no excessive, amount of solder. This connector has to take quite a high current.

-

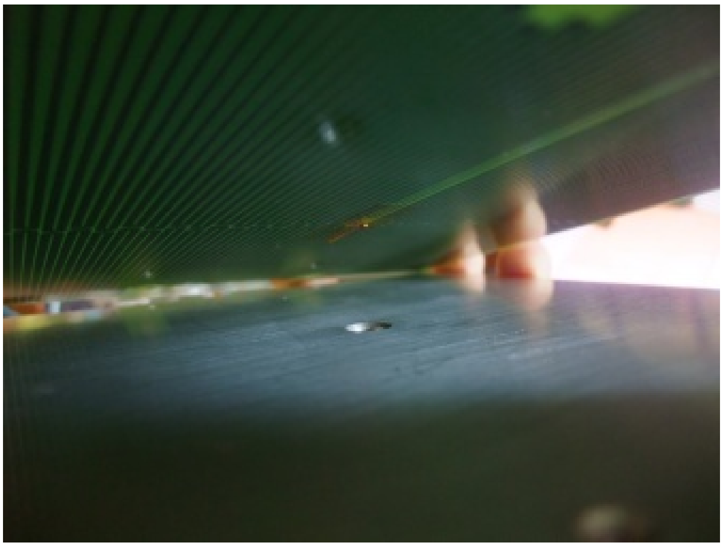


Assemble the heatbed components. From the top down in the picture they go: MDF insulator (lasercut lettering upwards, so you can see it), PCB (circuit side down, towards aluminum bed-plate), Aluminium plate. The notch in the MDF aligns with the Y axis motor mount, so that the bed can be as low as possible, but can still move the full distance in Y.

-

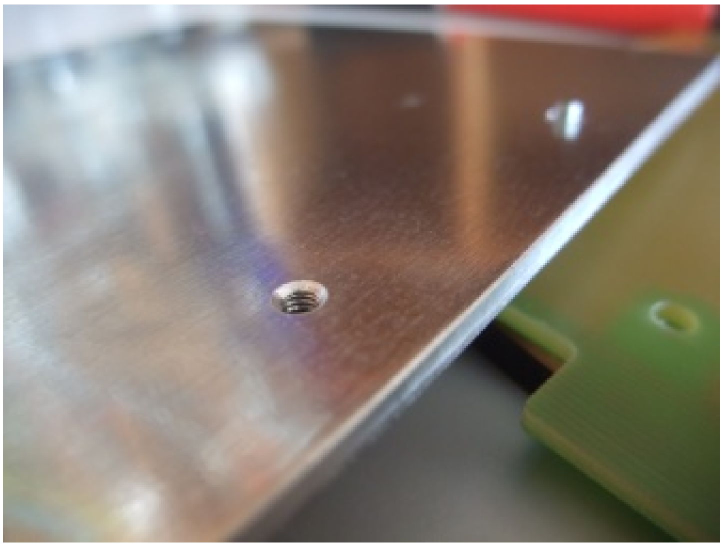
The aluminium plate has a recess in the centre to accommodate the tiny surface mount thermistor in the middle of the PCB.

-



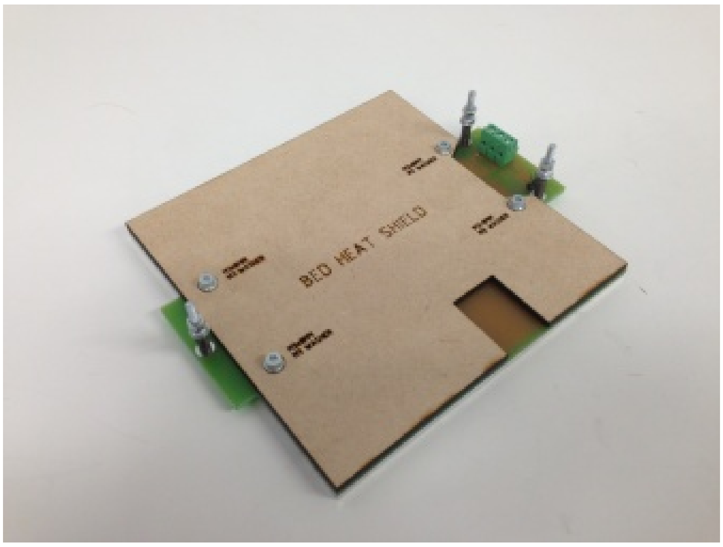
Take care when sandwiching the parts together that the edge of the recess does not hit the thermistor - you don't want to knock it off... **NOTE : The thermistor should be electrically insulated from the Aluminium plate**. This can be achieved using a small piece of Kapton tape over the thermistor.

-



Put washers under the heads of the four short M3 screws and screw them through the stack to hold it together. **Don't do the screws up so tight that they project through the aluminium plate.** The ends of the screws need to be just below the plane of the top of the plate. If they project, put extra washers under their heads.

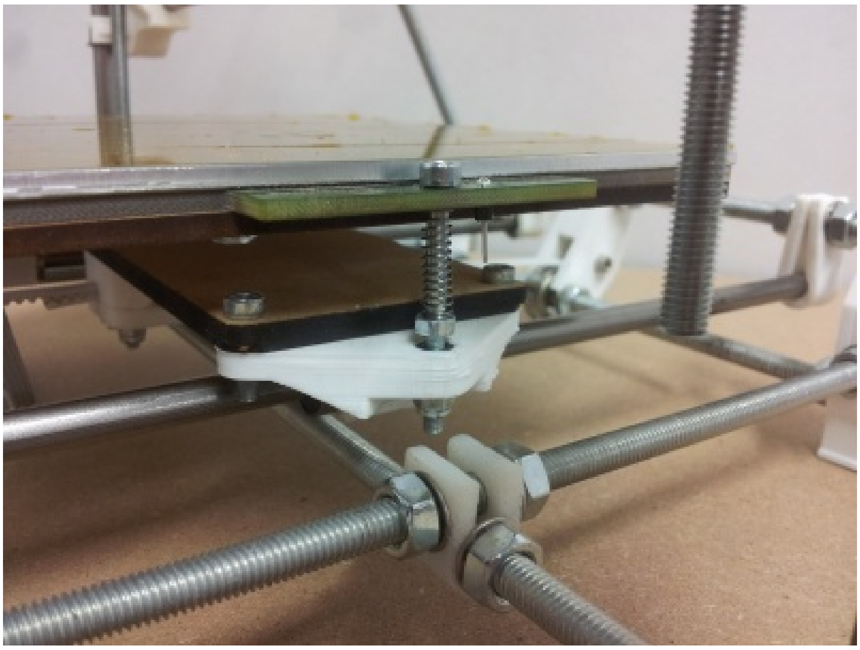
-



Sandwich the components together. This shows them upside down to the way they will be when fitted to the machine. For each of the 3 x bed height adjusters, put a 30mm screw through a hole in the PCB, put on a washer, drop a spring on, put on another washer, and put 2 x M3 nuts on by about 10mm. So the order is 30mm screw - PCB - M3 washer - spring - M3 washer - M3 nut - M3 nut.

Now may be a good time to consider applying Kapton tape to the surface of the printer bed.

Fitting the bed to the frame



On the bed adjusters, one M3 nut holds the spring under pressure, the other fits into the captive nut hole in Y sled. You can tighten the M3 nut that holds the spring up to the shank of the bolt (the unthreaded part); this will put the spring under load, and hold the bed firmly. Use the screws to attach the heated bed to the machine. The lower M3 nut sits in the hex hole in the Y sled. Screw the screws into the nylock nuts until the bed is secure and roughly level. Tighten them gently against the sled by unscrewing them without holding the nyloc; this pulls the M3 nut on top into the hex trap, and against the nyloc.

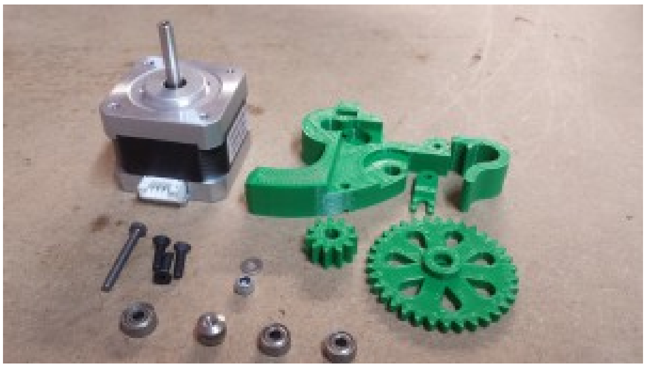
To level the bed accurately later, you will slacken those nuts, adjust the screws in the nylocks, then tighten the nuts again.

You should be able to push the bed down easily with a finger, and it should spring smartly back up again to rest under the screw heads.

Carefully run the Y-axis back and forth by turning the toothed pulley on the Y motor by hand. Make sure that nothing hits anything.

Extruder drive assembly

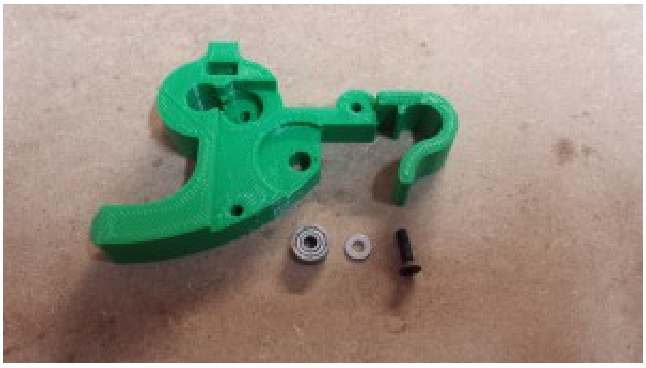
This section shows you how to assemble the extruder drive.



Extruder drive body

To assemble the extruder drive body, you will need the following:

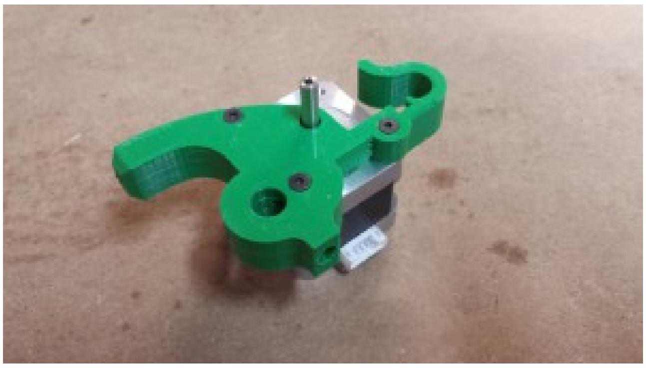
Component	Type	Quantity
NEMA17 motor (not shown)	-	1
Extruder drive block	Extruder drive	1
623 bearing (10mm diameter)	Extruder drive	1
M3 washer	Extruder drive	1
M3x12mm countersunk socket screw	Extruder drive	3
Extruder small gear (not shown)	Extruder drive	1



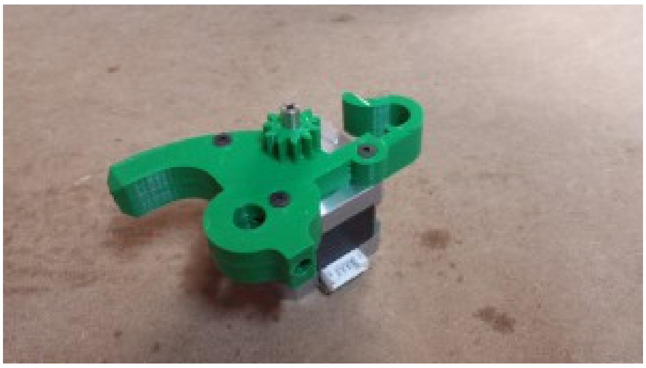
NOTE: The 'retaining tongue' that is included in the extruder drive set secures the Bowden cable from the hot end into the extruder drive. You'll need it later, so hang on to it.

Take the extruder body, and put the 623 bearing in the hole shown. One M3x12mm countersunk screw goes in from the back, and the washer goes on top of the bearing.

Fit the motor on top of this, then attach the other two M3x12mm countersunk screws, to mount the motor solidly.



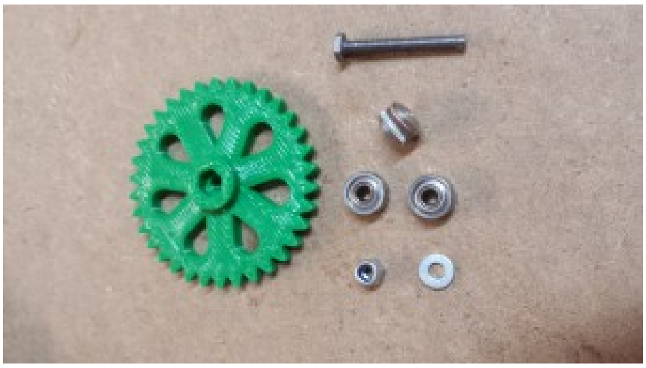
Push the small gear onto the motor shaft. This should be a tight fit. Ensure the flat part of the bore of the gear is aligned with the flat on the motor shaft before applying too much force. The gear has a small lip at the bottom of the teeth. This side must be against the drive block face.



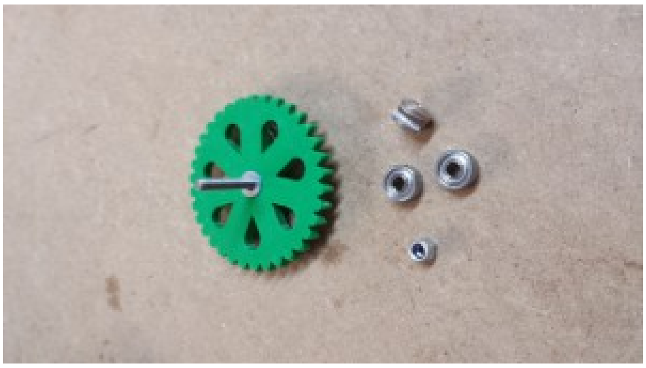
Extruder large gear

Now assemble the large gear drive assembly. For this you will need:

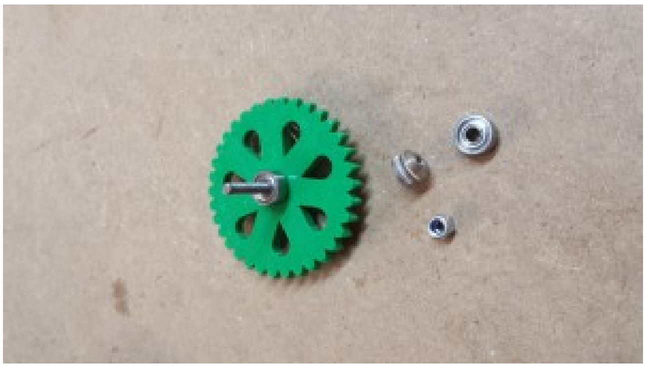
Component	Type	Quantity
Extruder large gear	Extruder drive	1
Hobbed insert	Extruder drive	1
M3 washer	Extruder drive	1
M3 nyloc nut	Extruder drive	1
M3x25mm hex head screw	Extruder drive	1
MR93ZZ bearing (9mm diameter)	Extruder drive	2



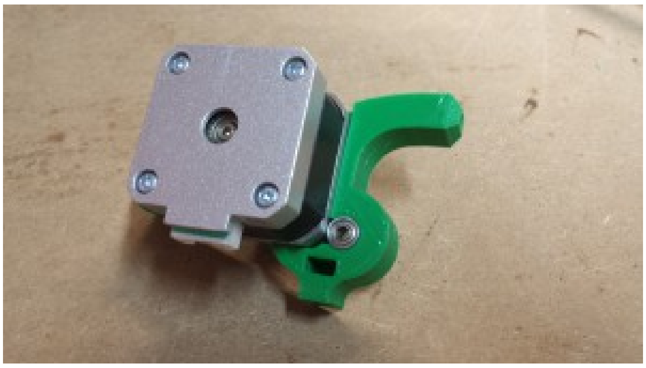
Push the screw through the gear. The hexagon head of the screw should be held tightly by the plastic part. Then slide an M3 washer on to the screw.



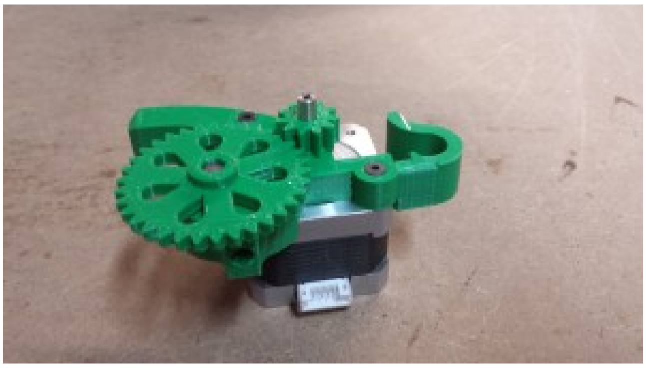
Next slide one of the MR93ZZ bearings on, followed by the hobbed insert. The insert is symmetrical so it doesn't matter which way round it is fitted, but it needs to be screwed tight.



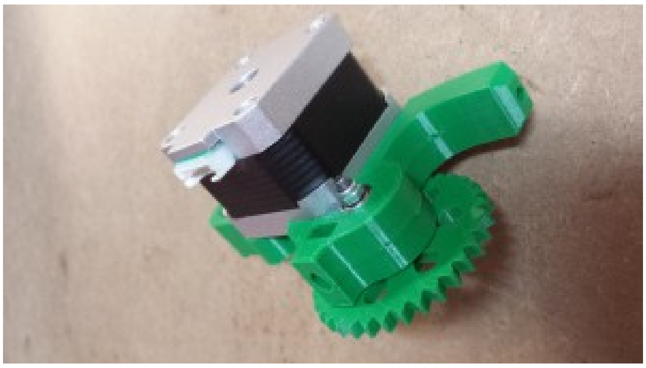
Push the second MR93ZZ bearing into the extruder-drive-block, next to the motor.



Now push the large gear sub-assembly into place ...

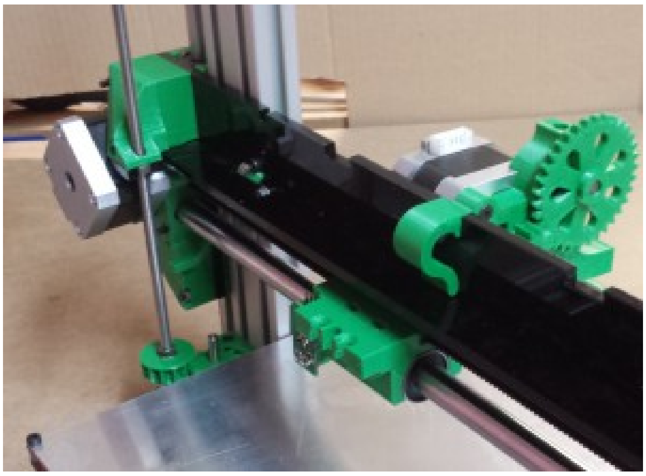


... and secure it there with the M3 nyloc nut.



Mounting the extruder drive

The extruder drive assembly can now be mounted on to the machine.

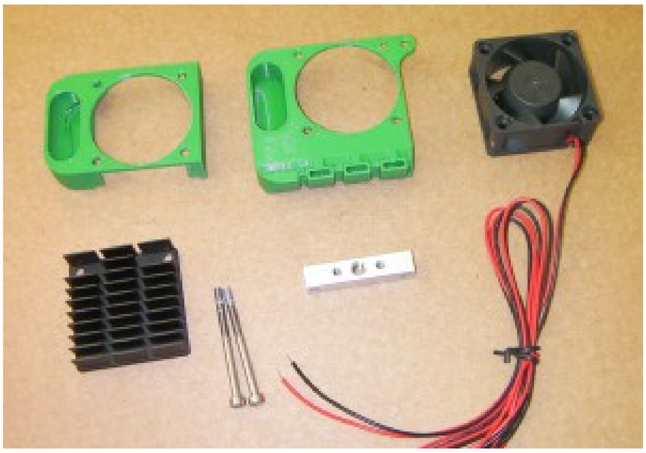


The x-axis-plate is profiled to receive the extruder-drive-block from one side, so push it down with a rotating motion and it will lock into place, using the mass of the motor to keep it there.

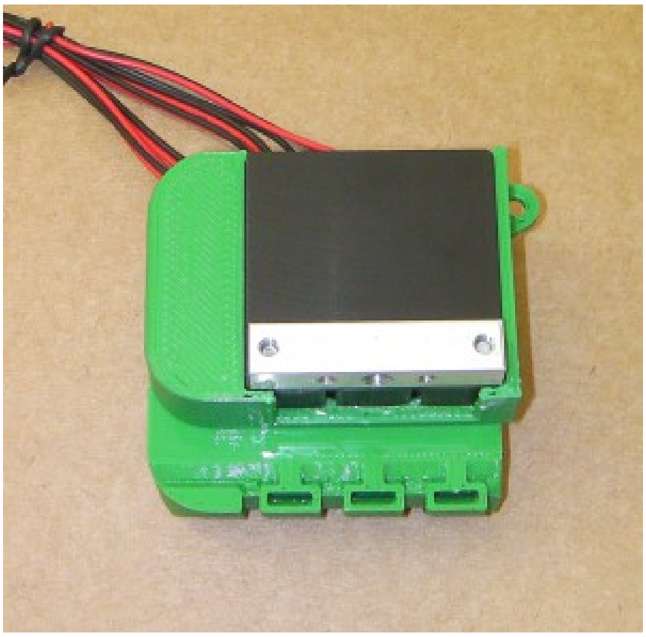
Hot end assembly

The airflow system

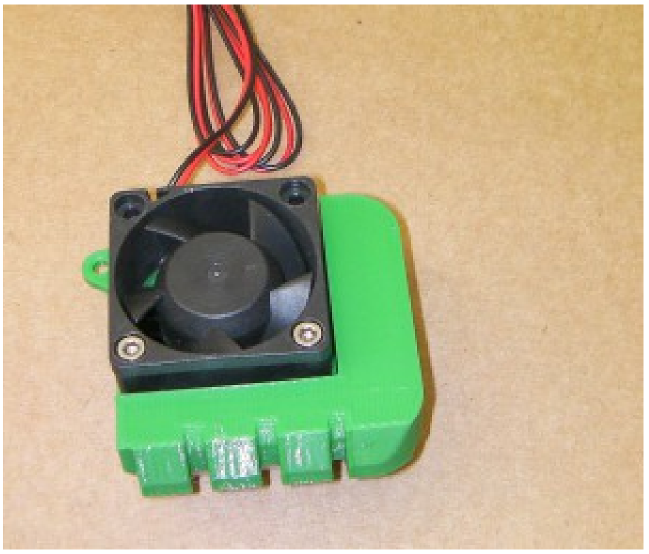
Component	Type	Quantity
heatsink duct	Printed	1
fan duct	Printed	1
Fan	Hot end	1
Heatsink	Hot end	1
M3 x 40mm cap screws	Fastener	2
Aluminium cooling block	Hot end	1



The wires on the fan in this picture are too long. They will be shorter, and each terminated with a crimp pin.Place the heatsink with its fins inwards and its flat face outwards in the cavity in the heatsink duct. The screw holes are at the bottom in the picture above.

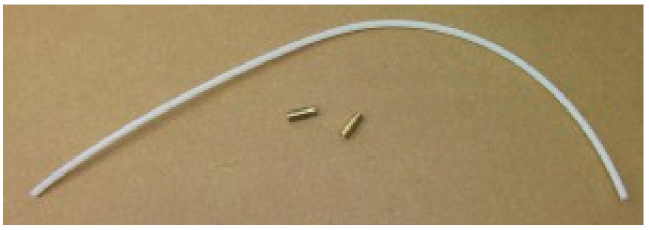


Turn the device over, and add the fan duct then the fan, with its wires coming out the top, and its face with the fan-axis support inwards. Use the two screws into the cooling block to hold all five major pieces together. If you have it you can put a little heatsink compound between the cooling block and the heatsink.



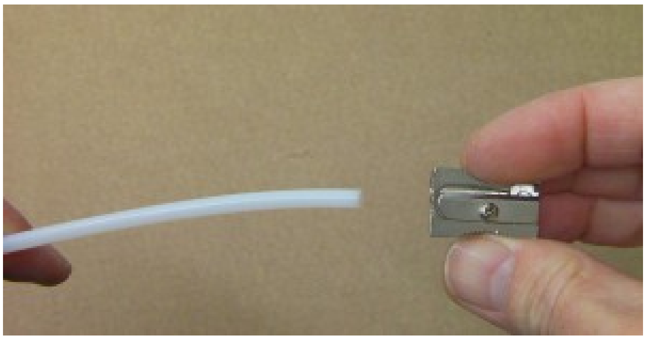
The plastic filament Bowden tube

Component	Type	Quantity
PTFE tube	Hot end	1
Threaded brass union	Hot end	1
Notched brass union	Hot end	1

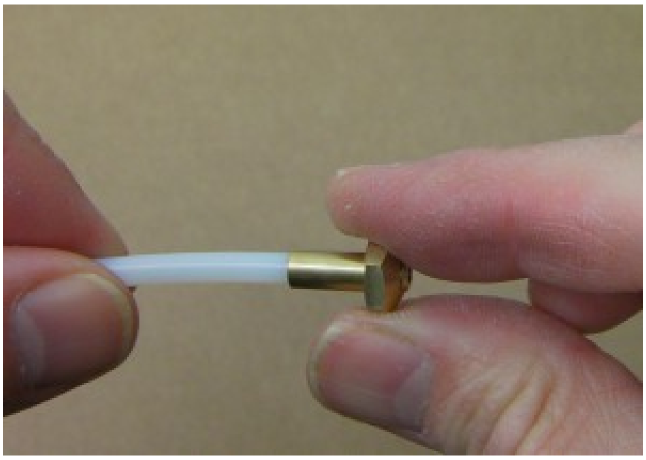


Start by trimming a couple of millimetres off each end of the PTFE tube with a very sharp blade to get the ends clean and square.

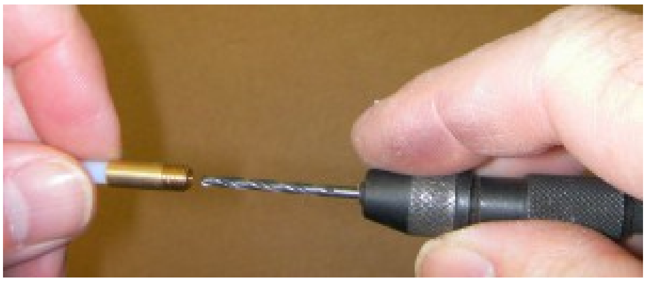
Next use a pencil sharpener to cut the ends of the PTFE tube to a cone. Be very gentle. PTFE is a soft material and it is easy to remove too much. You just want a frustum of a cone at each end that doesn't quite reach the inner hole in the tube.



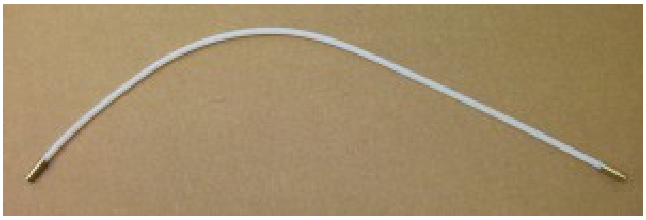
Put the conical brass nut that you will use below on the threaded brass union. This is not its final resting place, but it will make it easier to screw the internal thread on the union over the PTFE tube, by giving you something to grip. Screw the union over one end of the tube. It will cut its own thread. Take care to keep the two parts axially in line. You don't want the brass screwed on at an angle.



Do the brass up until you can see the cone you cut by looking down the free end of the brass. Then, unscrew the brass union, and repeat the thread cutting process at the other end of the tube. The threaded part of the PTFE tube should be about 10mm long, and it will be easier to screw each brass union on, once threaded.
Screw the slotted brass union onto the free end of the PTFE tube. Remove the nut from the other union by gently gripping the brass union (not the PTFE) with a pair of pliers and use a small spanner to remove the nut. Take care not to crush the brass with the pliers - it is quite thin.
Screwing the brass onto the PTFE will have compressed its inner hole. You need to open it out again so that the plastic filament that your Ormerod will print with will run freely in the tube. Use a 2mm drill bit in a small hand chuck. Gently, and twisting clockwise all the time - never anti-clockwise, whether going in or coming out - use the drill bit to enlarge the inner

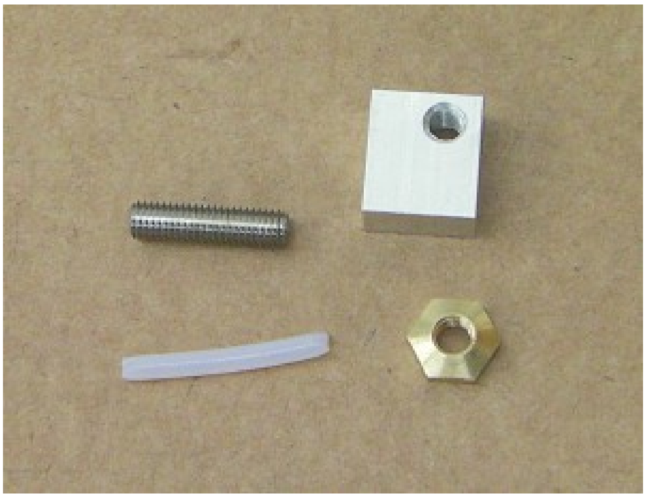


hole in the PTFE where it passes through the brass. Take several goes at it, going a couple of millimeters deeper each time and drawing the PTFE swarf out by keeping twisting clockwise and pulling. Stop when the tip of the drill is about 5mm into the clear transparent PTFE.
The finished Bowden tube



The nozzle and heater block

Component	Type	Quantity
Stainless steel nozzle	Hot end	1
Aluminium heater block	Hot end	1
Small-diameter PTFE tube	Hot end	1
Conical brass M5 nut	Hot end	1

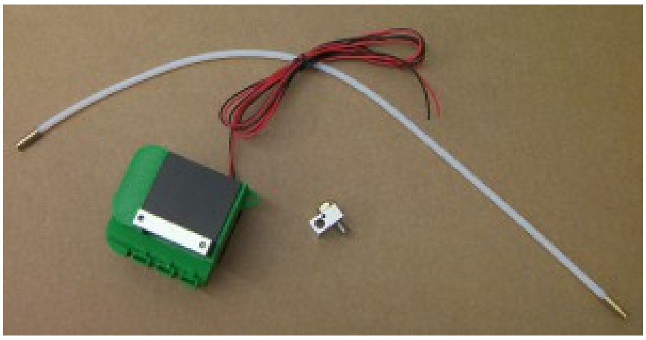


Screw the stainless steel nozzle into the aluminium block. The small nozzle hole should protrude from the face of the block nearest the small (2mm) diameter hole through the block. Screw the nut onto the nozzle. The cone on the nut points away from the block, and the nut is at the small-hole end of the nozzle.
Adjust the three so that the cone of the nozzle

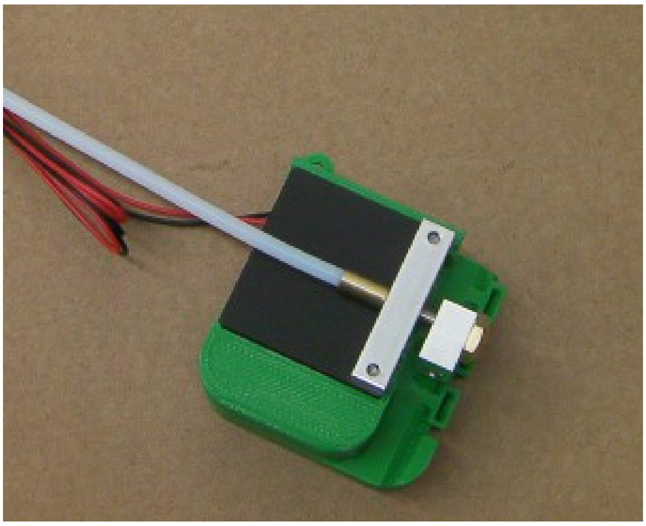
continues the cone of the nut. There shouldn't be a shoulder between the two, nor should the nozzle be down inside the nut.
Hold the aluminium block between folded pieces of paper in the jaws af a vice. (The paper is to stop the jaws damaging the aluminium.)
Tighten the nut against the block with a spanner. It needs to be reasonably tight, but don't force it so hard that you damage anything.
Cut a few millimetres off the end of the small tube with a very sharp blade to get it square and to clean it up, just as you did with both ends of the larger tube above.
Push the end you have cut all the way into the large hole in the longer end of the nozzle sticking out from the block. It may be quite stiff. You may have to put the free end of the tube on the bench and push against that. Be careful - you don't want to buckle the tube.
Use the sharp blade to trim the end of the PTFE tube flush with the nozzle.

Assembling the cooling system, the heater block and the Bowden tube

Take the cooling system, heater block and Bowden tube



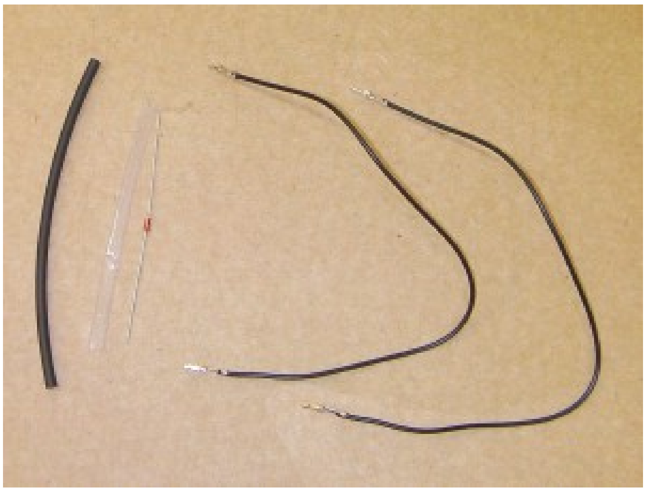
Screw the threaded brass union on the Bowden tube into the cooling block on the cooling system. Screw it in all the way, then back it off half a turn
Screw the nozzle and heater block assembly into the other side of the cooling block. If the small PTFE lining tube in the nozzle is loose, take care not to drop it - make sure it is in there or the hot end won't work.
Get the heater block square with the rest of the assembly, with its longer protruding side pointing away from you in the picture above.
Using pliers, tighten the threaded brass union against the top of the stainless steel nozzle. Again, take care not to grip the brass too tight and damage it, but do the two up as tight as you can.



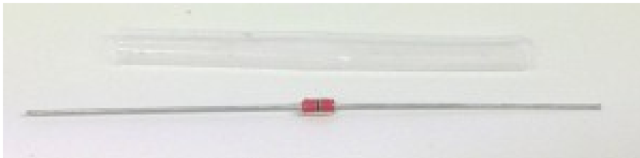
Adding the temperature-measuring thermistor

Component	Type	Quantity
Transparent PTFE heatshrink	Hot end	about 50mm

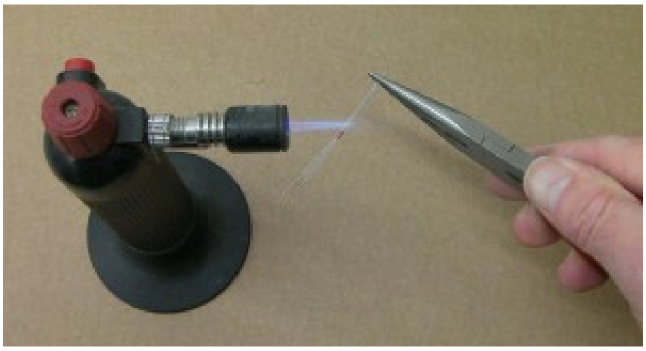
100K thermistor	Hot end	1
Thermistor wiring - 160mm	Hot end	2
Cartridge heater (not shown)	Hot end	1



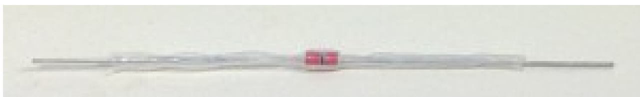
Cut the transparent PTFE heatshrink about 10mm shorter than the thermistor with its axial connecting wires. Put the thermistor in it so that 5mm of wire protrudes from each end.



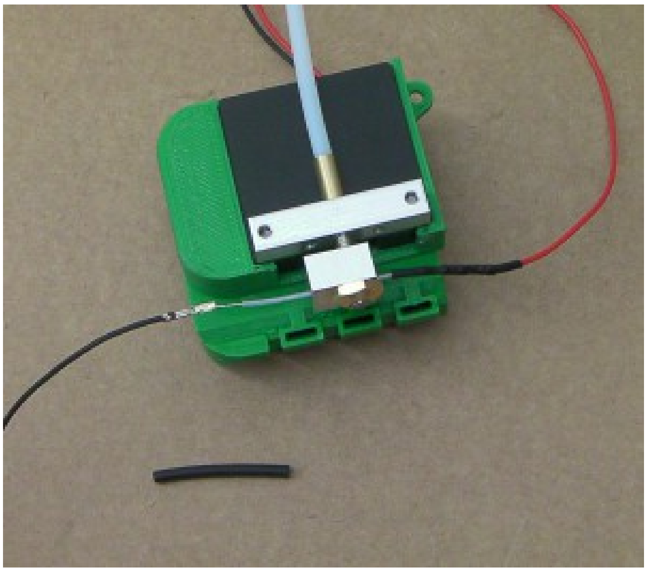
Using a flame (a cigarette lighter, blowtorch, gas hob, or hot air gun work well; a hair dryer does not), shrink the heatshrink over the thermistor. Just waft the thermistor and heatshrink through the flame. You don't want the heatshrink to overheat and burn.



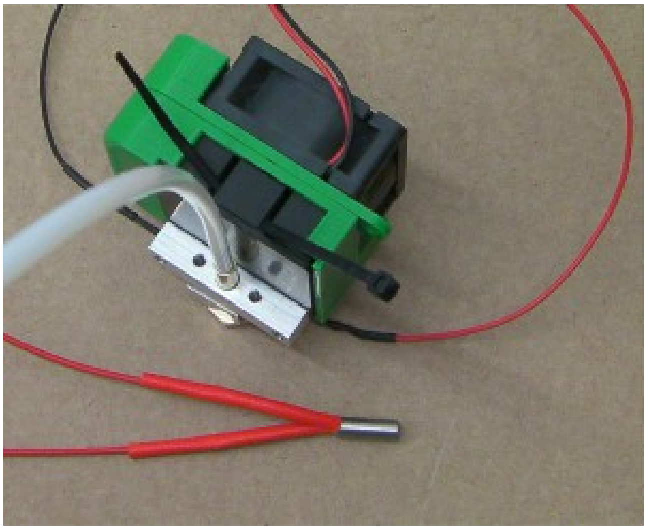
This is how the thermistor should look with the PTFE shrunk onto it. It may even look neater than this!



Pull the thermistor through the small hole in the heater block so that it is about half way through. If you pull it with pliers, be gentle, and grip on the PTFE heatshrink, not the bare wire. Attach the thermistor wiring to each side of the thermistor - it is pre-crimped, and should just push onto the bare ends of the thermistor wire.

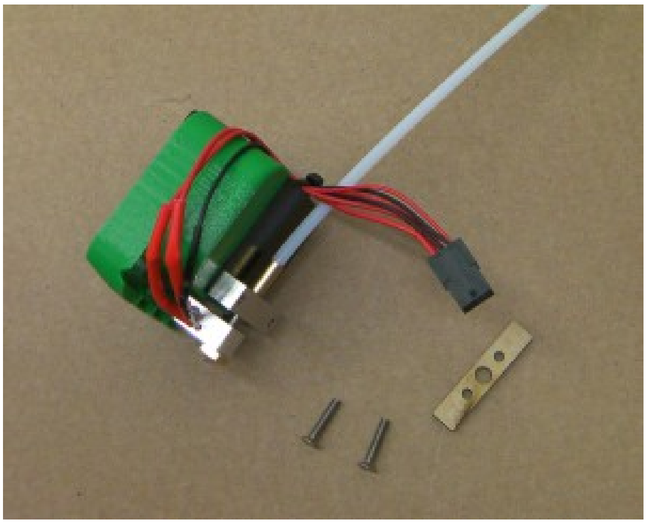


Slacken the two screws that hold the air duct assembly together by a few millimeters, and loop a cable tie through the top two gaps in the heatsink, as shown. Re-tighten the screws. Push the heater cartridge (with the red leads) into the heater block.

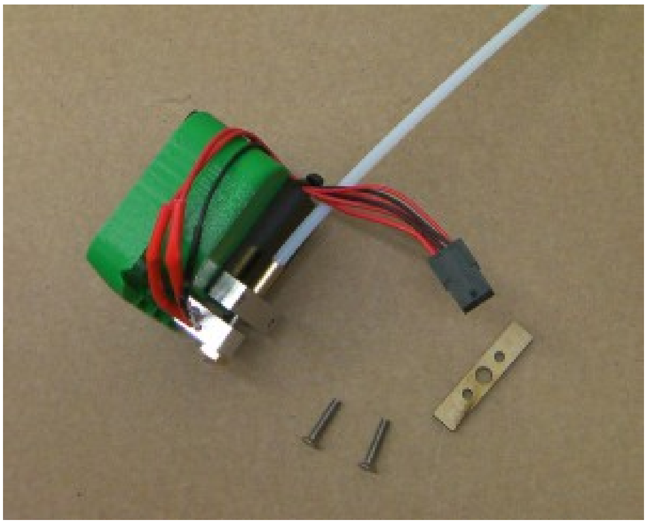


Final assembly

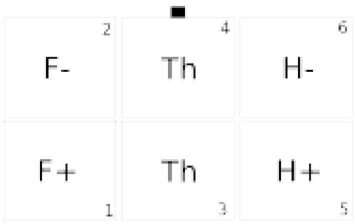
Component	Type	Quantity
2x3 female black crimp socket	Hot end	1
M3x16mm cap head screws	Fastener	2
MDF heat insulator	Hot end	1

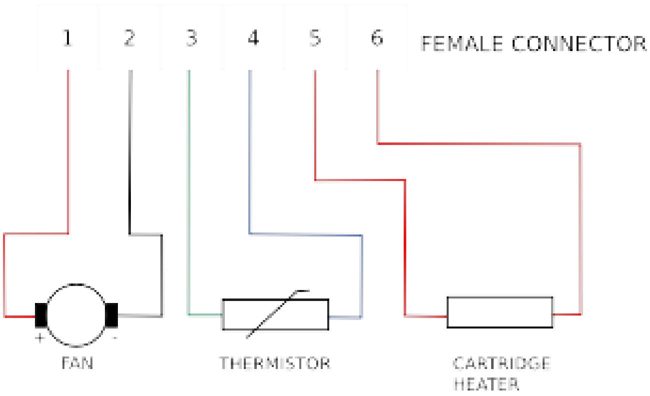


Run all six leads (fan, heater cartridge, and thermistor) up and through the cable tie. Pull the cable tie closed, but not too tight. It doesn't need to squash anything.



CAUTION! The next step describes wiring up the hot end connector. However, GREAT CARE should be taken doing this. The heater cartridge and the fan wires have 12V running through them ALL THE TIME. The thermistor wires are 3.3V, and connect directly to the Arduino chip on the Duet. If you incorrectly wire the plug, a short circuit between the thermistor wires and any of the other wires MAY DESTROY YOUR DUET!


2
4
6
F-
Th
H-
F+
Th
H+
1
3
5

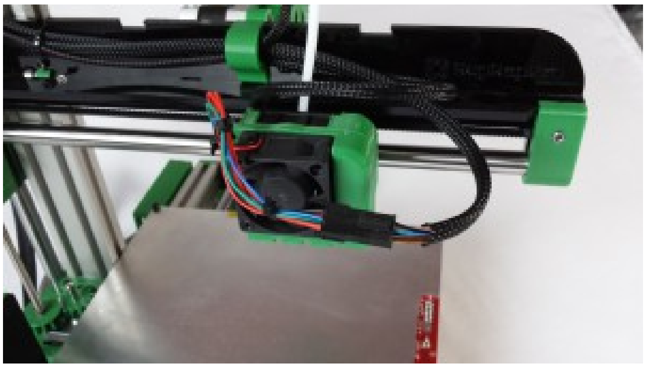

1
2
3
4
5
6
FEMALE CONNECTOR
+
-
FAN
THERMISTOR
CARTRIDGE
HEATER

Wiring

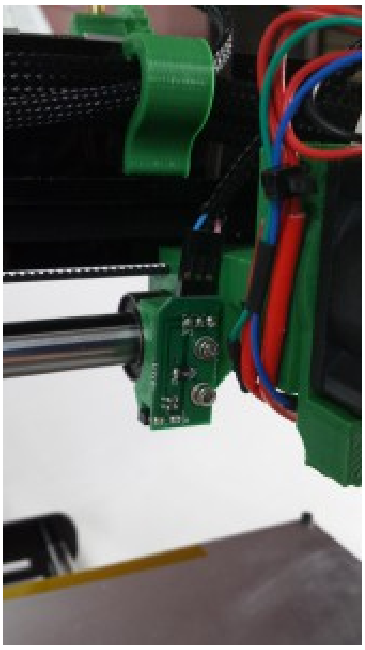
RepRapPro Ormerod 3D printer kits are supplied with pre-assembled wiring looms. The wiring sequence should be to connect all looms to the motors, hot end and sensor board, route them back to the electronics, then make the connections on the board.

Wiring the printer

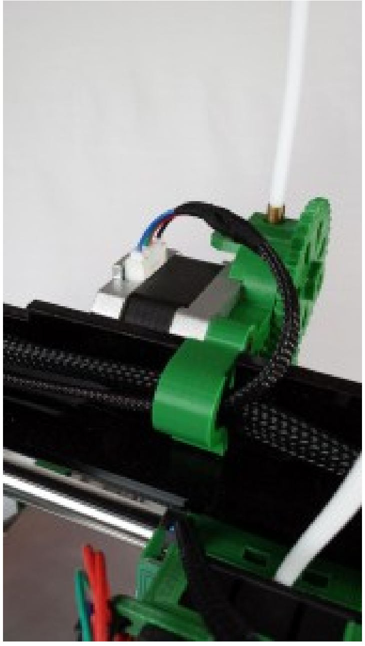
Hot end loom.
Length: 930mm



Proximity sensor: Attach the proximity sensor to the X carriage to the left of the hot end with 2 x M2.5x5mm cap head screws. Connect loom. **NOTE:** the sensor has a polarity; the order of the wires is very important. It should be as the picture; blue, black, red (or pink on some looms).
Loom length: 960mm

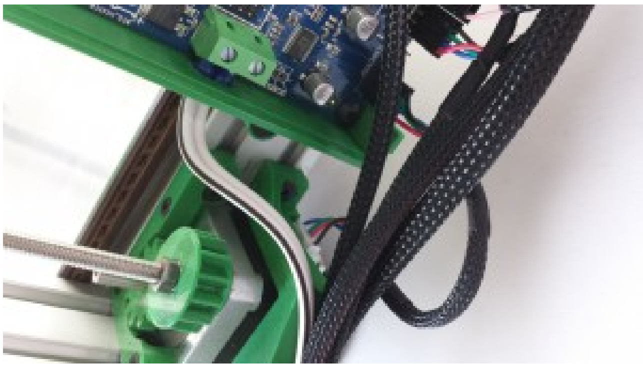


Extruder drive motor loom.
Length: 720mm

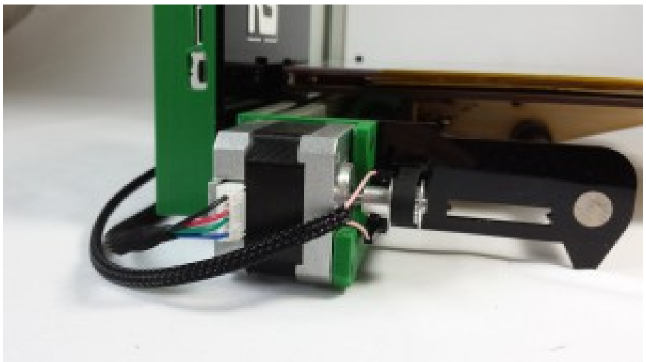


X axis motor loom.
Length: 440mm

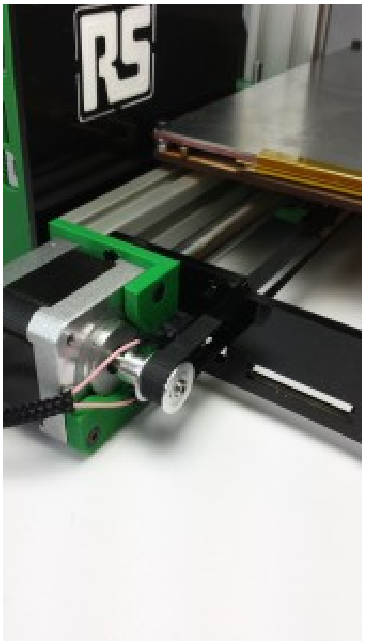
Z axis motor loom.
Length: 90mm



Y axis motor loom.
Length: 160mm

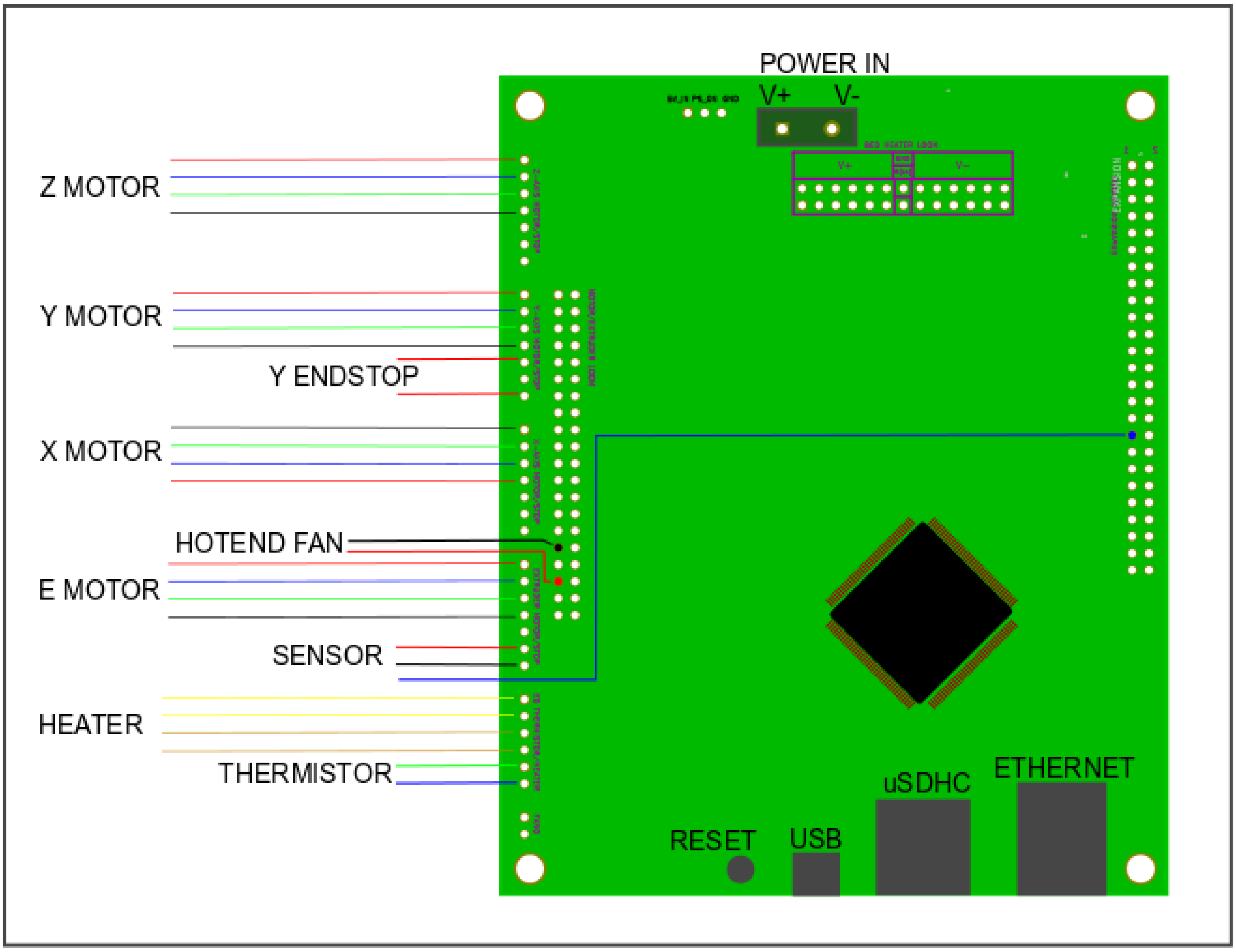


Y axis endstop: The loom connects to the outer two pins of the microswitch. You will need to bend the top pin upwards to 45 degrees, so the wire doesn't foul the Y axis belt pulley.
Length: 260mm

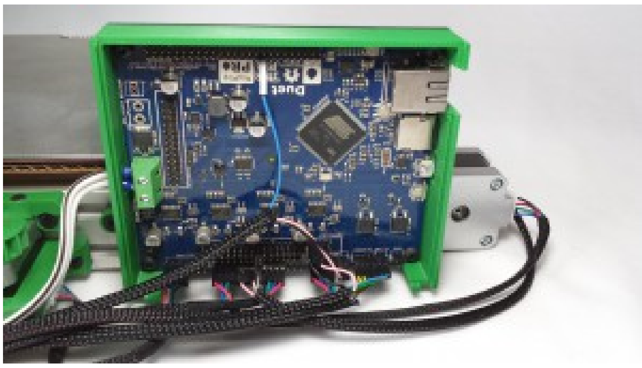


Wiring the Duet

Connect each loom as per the diagram shown:



The wiring should now look like the image below; there is a difference between the hot end fan connections between the picture and wiring diagram, but either works:



Power Supply

Goal

By the end of this step your power supply should look like this:

Safety

RepRapPro Mendel works entirely at low voltage, and there is no danger in putting a finger on any part of the circuitry on the machine itself (though remember some parts are hot).

But the power supply necessarily involves a few mains wires. Mains will kill you if you touch it. So don't.

There are six soldered mains connections in the power supply. If you are not sure about mains wiring, or your soldering is blobby, prone to dry joints, or in any way un-neat, then **get someone who knows what they are doing to help you with the work on this page**.

When doing all wiring make sure that connections have no stray wire filaments that may short on neighbouring parts.

Bare the ends of wires, twist them, check for a neat twist with no strays, and then finally tin them.

This is important on the next page (wiring up the machine), but it is really important for wiring the power supply here. The power supply works with both large voltages and large currents, and so careful, tidy work is essential.

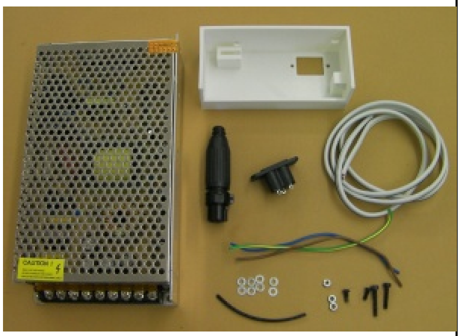
Tools

You will need the following tools:

1. M3 Allen key
2. Cross-head screwdriver
3. Tweezers
4. Multimeter
5. Soldering iron and solder

Parts

Hardware	**Quantity**
12v Power supply	1
20A wire	As required
Mains cable (not shown)	1
XLR socket	1
Printed cover	1
Mains panel plug	1
LNE mains wires	100mm
M3 washers	8
M3 nuts	3
heatshrink	50mm
M3 x 8mm screws	2
M3 x 20mm screw	1
M3 x 16mm screw	1



Note that sometimes the three mains wires are supplied as a cut length of mains flex. Simply pull the three wires from the outer coating.

The 20A wire is the piece you have left over from the kit so far. Take a look at the wiring page and run it along the route it will take from the XLR connector to the controller board. Cut off a piece that is a little too long for that job (you don't want to find it's too short...), and use the remainder for the power supply.

Mains voltage

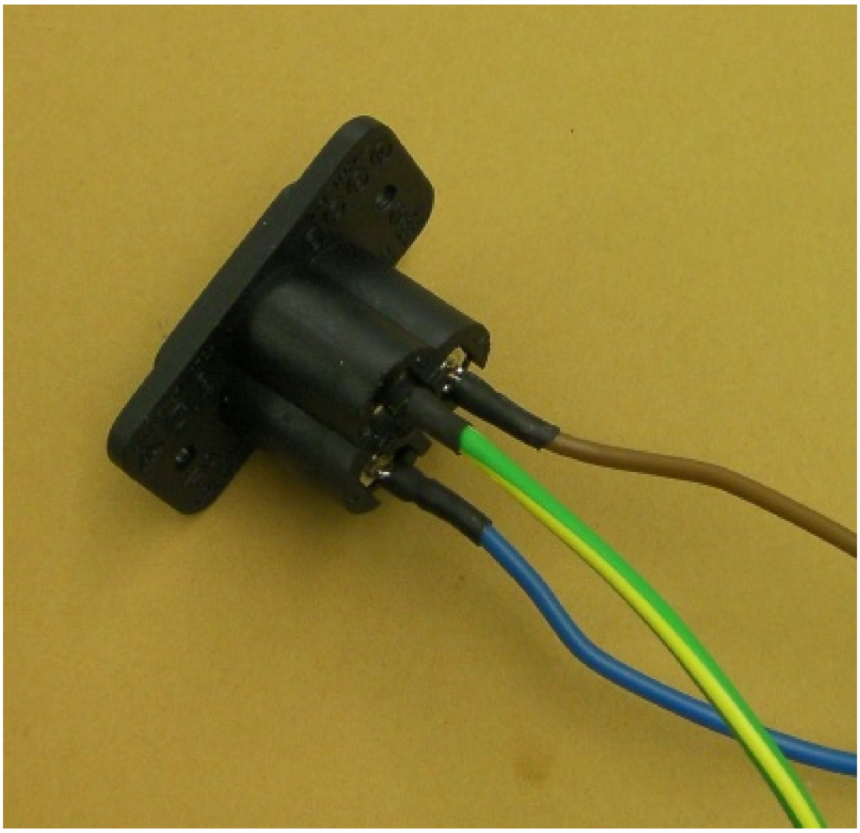
Set the mains voltage for your country. The switch, shown above, is set to 220 volts when the power supply is shipped. This is the fail-safe setting: if you plug the supply into a lower mains voltage it won't work properly, but it will do no harm.

If your country has mains at 110 volts, flip the switch.

Some power supplies are universal - they are designed to work with any mains voltage found in the world. Read the label. For universal supplies there is no switch to set.

Construction

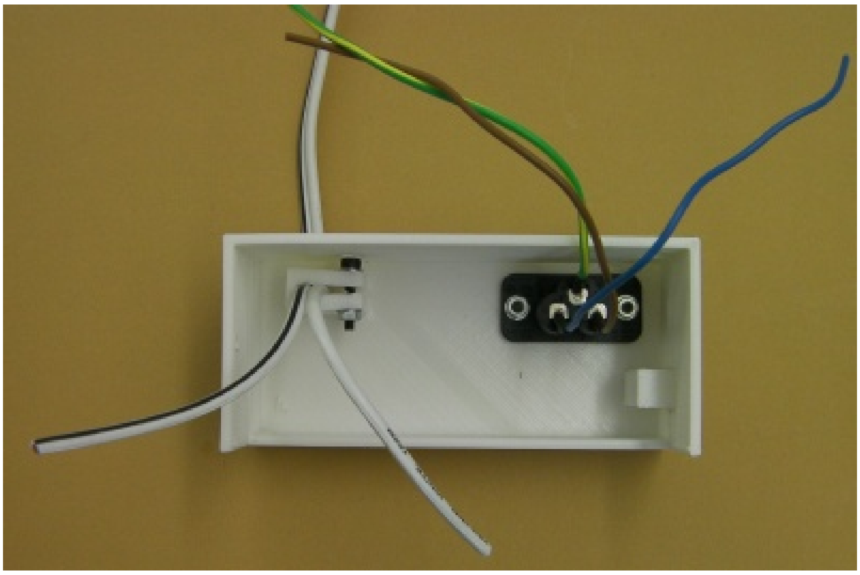
Initial wiring



Start by soldering the mains wires onto the panel-mounting plug. The picture above shows European-convention wiring colours: Brown=Live, Blue=Neutral, and Green-yellow=Ground-Earth. The back of the plug has L, N and the symbol for Ground embossed next to the appropriate connection.

Different countries have different conventions on this, of course. The best way to get things right is to connect your mains wire into this plug **but not to the mains**. Then use your meter to check which terminals on the plug the live and neutral pins on the end of the lead that will plug into the wall socket go to.

When you have soldered the short wires, insulate your joints with short lengths of heatshrink.



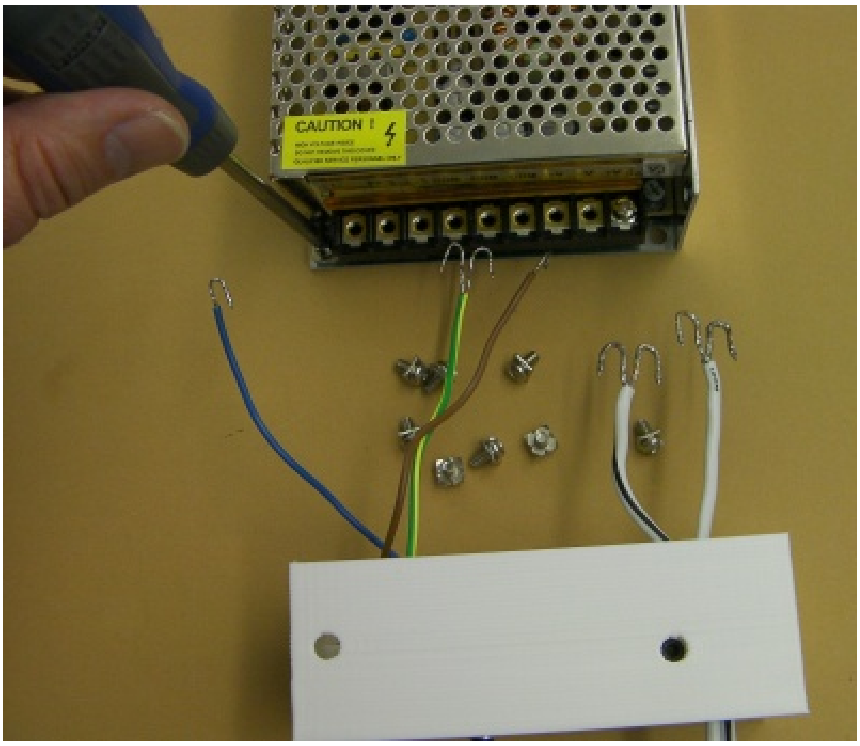
Attach the mains plug to the printed panel with the two short screws, two nuts and four washers. You may find that the holes in the plug are slightly undersized (though the specification says 3mm). This does not matter: screw the screws in and use them to cut threads in the plastic - this will give a more secure construction. Then put the washers and nuts on the back.

Put the thick low-voltage wire through its cable grip so it projects by about 100mm. Secure the grip with the 16mm screw, two washers and a nut. Getting the washer under the screw head in is a bit fiddly - you will probably have to use tweezers.

Don't tighten the grip excessively. Just do the screw up enough to secure the cable so it can't slip.

Split the low-voltage wire into two leads.

Connect the power supply



Remove all the contact screws from the power supply except the one on the extreme right in the picture.

Then remove the screw that holds the case together (where the screwdriver in the picture is). Set that aside for use later.

Next, strip, twist and bend the wires. Check lengths and fit before you tin.

For the live and neutral: form the ends into a U that will fit in the connector and be secured by one of the screws.

For the Ground wire and the two fat low-voltage wires, split the filaments of each end into two equal bundles, twist those separately, then form each of them into a U that will fit in the connector and be secured by one of the screws.

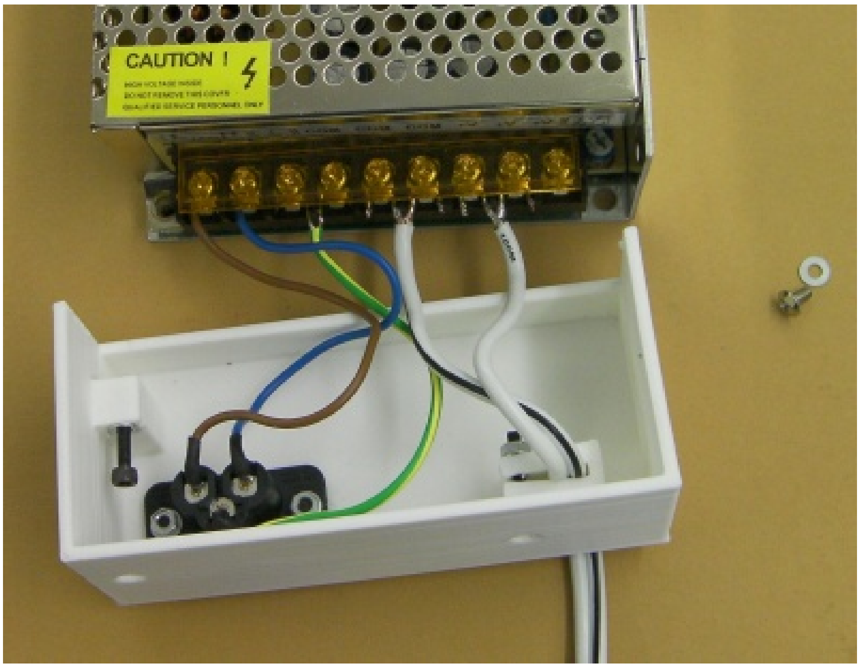
When you are happy that everything fits neatly, tin all the ends.

Screw the Live, Neutral, and one leg of the Ground wire to the labelled connectors.

Screw the other leg of the Ground wire to the COM or -V terminal next to Ground. This is important: it is the connection that earths all the wiring in your machine.

Screw the two Us of the low-voltage wire with the stripe into the two other COM or -V connections.

Screw the two Us of the low-voltage wire with no stripe into the two +V connections.



If the tail ends of the Us stick out, trim them with side-cutters. Take care where the cut pieces go - you don't want them shorting out parts of the power supply.

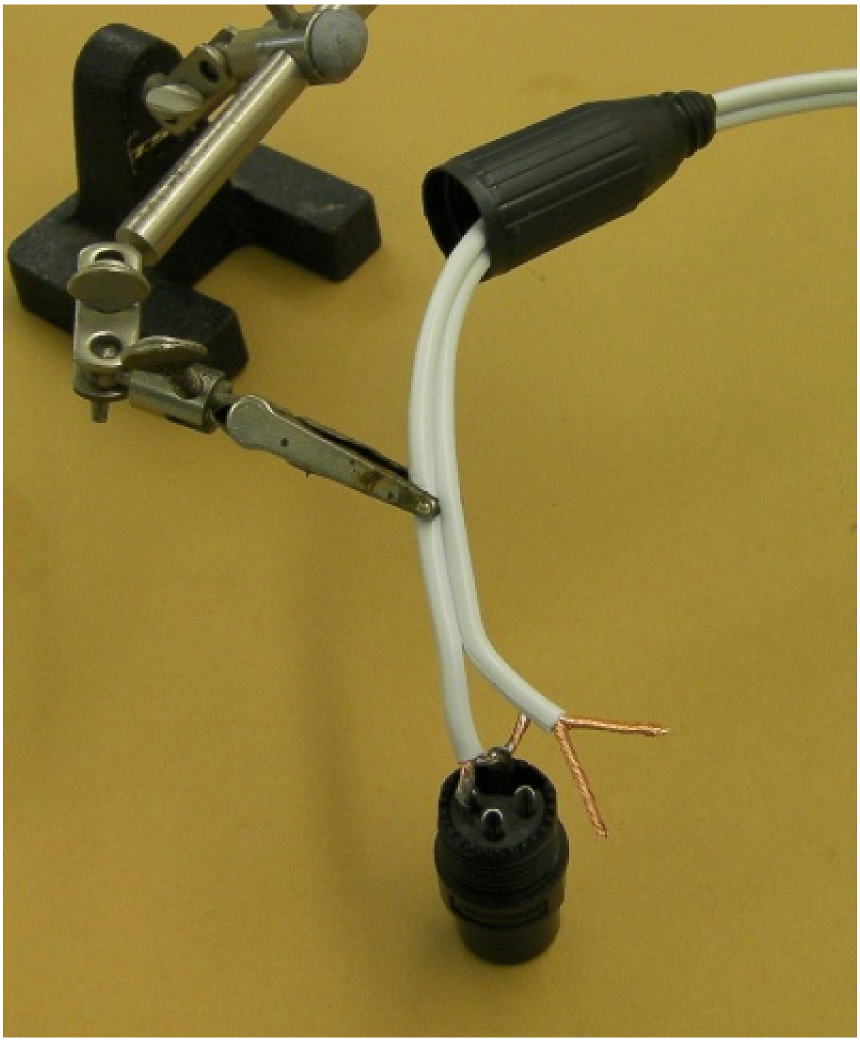
Finally put the 20mm screw with a washer under its head into the hole in the block on the left as shown and attach the cover to the power supply.

Take care to tuck the wires neatly inside. You may have to flatten the mains wires so that they lie in the plane of the back face of the plug.

Use the 20mm screw to secure the cover where you removed the short cover screw before. Use that short cover screw with a washer to secure the other end of the cover to the threded hole in the power supply case.

The XLR socket

In what follows take great care that there are NO filaments of wire that are sticking out from twisted bundles. These can cause shorts, and may damage the power supply or electronics.



Put the shell of the XLR connector onto the low-voltage wire.

The picture above shows the ground wire connected, and the +12V wires ready to connect.

Separate and strip the ends. Once more divide the ends into two equal bundles, then twist each bundle.

The pin numbers are embossed on the plastic part of the plug, next to each pin.

The Ground wire (with the black stripe) goes to Pin 1 of the socket and the tab on the outer case.

The +12V wire (plain white - no stripe) goes to pins 2 and 3.

Push the twisted bundle down the connector (the hole goes quite deep). Give each one a good generous amount of solder.

For the Ground/Tab connection, simply push the wire through and solder it as shown in the picture. Then cut off the excess wire with side cutters.

Screw the shell onto the socket. Hold the wire still so that the turning action doesn't twist it up inside.

Step 4: Testing

If any of these tests don't work, stop, unplug everything, and find the fault before going on.

Switch your meter to measure resistance. Remember, you cannot measure resistance if the circuit power is on!

Plug the mains wire into the power supply **but not into the mains yet**.

Important: Check the resistance between the Ground pin on the mains plug and the metal case of the supply. This should be 0 ohms.

Check the resistance between the Ground pin on the mains plug and Pin 1 of the XLR socket. This should be 0 ohms.

Check the resistances between the case and the Live and Neutral pins of the plug. These should be infinite.

Switch your meter to measure **DC** voltage.

Put the Ground or Common meter probe in Pin 1 of the XLR socket and the Volts-Ohms-Amps probe into Pin 3.

Plug the mains lead into a socket and switch on the power.

The meter should read +12V plus or minus about 0.3 volts.

Switch off power, unplug the power supply from the mains.

Final testing

Now the most important check: plug the power supply into your RepRap and put the mains wire on the power supply, but DON'T connect it to a mains socket. Measure the resistance between the earth pin on the mains plug and the cover of the SD card socket. The meter should read 0 ohms, or at most a small fraction of an ohm. If it doesn't, you have made a mistake. Find it and fix it before you do anything else.

If you are in any way unsure that you have wired the XLR socket incorrectly, do this test:

Remove one of the 12V supply wires from the Melzi, making sure it does not touch anything. Plug in and turn on the power supply, and test you get 12V on the Melzi supply wires, and check the polarity of the wires is correct. Switch off power, unplug the power supply from the mains, unplug the XLR socket. Replace the 12V supply wires into the Melzi screw terminals, positive wire to positive terminal, negative wire to negative terminal.

Commissioning

There are six pieces of software required to use the RepRapPro Ormerod:

1. Arduino IDE (Integrated Development Environment) - used for device drivers, basic communication, problem solving
2. The RepRap firmware - this controls the hardware functions of the Duet board
3. Pronterface - used for communication and control over the USB connection
4. Google Chrome - used for controlling the Duet via the web interface
5. Slic3r - used for translating 3D files into the g-code, which controls the movements of the printer
6. The Ormerod files - profiles for Slic3r, and all the files you need to print another Ormerod

IMPORTANT: note about USB 5V power

Establishing communication with the Duet

This first section should be done with the ATX PSU disconnected.

The Duet electronics board is based on the Open Source Arduino Due board, with the addition of ethernet, stepper drivers (to control the stepper motors), SD Card slot, temperature sensing and other inputs and outputs needed by a 3D printer.

First connection

Download Arduino IDE v1.5.5 BETA (with Arduino Due support) for your operating system from: http://arduino.cc/.

Install Arduino IDE

Connect USB cable to Duet, making sure it is pushed all the way in. An LED should light up, near the USB connector. See the important note above about 5V USB power if it does not. If your Y-axis endstop is fitted, a second LED will light up near this connection on the board. It will be lit if the Y carriage is away from the endstop, and will go out if you move the Y carriage until it touches the microswitch.

The device drivers should be found and installed automatically.

Open the Arduino IDE and go to Tools->Board menu and select 'Arduino Due (Native USB)'. If this is greyed out, check the device drivers have been installed.

Then go to Tools->Port menu and select the USB port for your Ormerod.

Then go to Tools->Serial Monitor. Make sure the speed is set to 115200 (bottom right) and that Newline is selected (next to the speed).

Wait for 1 minute (this is normal when no ethernet is connected and the firmware is searching for the network), and following should show:

```
RepRapFirmware is up and running.
```

If no message is received, send the following command:

```
M105
```

And you should get a response from the machine, similar to this:

```
T:5.3 B:18.4
```

or this:

```
serial: M105  ok T:5.3 B:18.4
```

If you get no response, close the Serial Monitor window, unplug the USB, check the Arduino settings and try connecting again. Wait for 1 minute after plugging in the USB.

If you get temperatures of -273.1 on either the hot end or heated bed thermistor, it usually means the thermistor is disconnected, or shorting out. Check your thermistor wiring.

What to do if it isn't working?

See the note at the top of the page 'IMPORTANT: note about USB 5V power'. If the power is low, it can cause strange problems, such as odd temperature readings, failure of SD card, and failure of Ethernet. If you don't have any other USB power source available, turn off the Duet, remove the motor and heater wires from the board, put a jumper on JP9 and connect the ATX power supply. See the later section 'Now connect the ATX power supply unit' for full details, but return to this point, and try connecting again.

It's also possible that the USB socket on the Duet is loose, and the USB lines have broken. Check the USB socket; it has 4 legs that go through the board. All four of these should be soldered, to hold the socket firmly on the board. If they are not, you can solder them yourself; this is easier from the back of the board. If you still get no response, contact support.

Check SD card Settings

Your Ormerod was supplied with an SD card, and a USB adapter. Put the SD card in the USB adapter, and into your computer - it should appear on your desktop. The SD Card is used for storing settings, serving the web pages of the web interface, and has some test gcode files for printing.

Download the RepRap firmware from our Github repository. Do this by going to the page, and clicking the 'Download ZIP' button on the right hand side. Extract the ZIP file once downloaded.

In the extracted directory is a directory called 'SD-Image'. Open this, and copy the contents (three directories - gcodes, sys and www) to the root of the SD card, so that they are the first thing you see when you open the SD card.

Eject the SD card, remove it from the adapter, and put it into the SD card holder on the Duet. It should click in.

Is the SD card being read?

Connect the USB cable to the Duet, and connect to it using the Arduino Serial Monitor, as above. Wait for 1 minute, and you should then see (again):

```
RepRapFirmware is up and running.
```

In the top part of the Serial Monitor window, type, without quotes 'M503' and press 'Send'.

The response should be similar to:

```
; RepRapPro Ormerod  ; Standard configuration G Codes  M111 S1; Debug
on  M550 POrmerod; Set the machine's name  M551 Preprap; Set the passw
```

```
ord  M552 P192.168.1.14; Set the IP address  M553 P255.255.255.0; Set
netmask  M554 P192.168.1.1; Set the gateway  M555 P2; Emulate Marlin U
SB output  M92 E420; Set extruder steps/mm  G21 ; Work in mm  G90 ; Ab
solute positioning  M83 ; Extrusions relative  M558 P1 ; Turn Z Probe
on  G31 Z0.5 P500 ; Set Z probe height and threshold  M906 X800 Y800 Z
800 E800 ; Motor currents (mA)  T0 ; Select extruder 0
```

If the SD card is not inserted, or not being correctly read (the error code may be different), you get:

```
Can't open 0:/sys/config.g to read from. Error code: 12  Configuration
 file not found
```

Check that you have inserted the SD card properly. Some customers have reported problems with the supplied SD cards and/or the USB adapter. If you can, try a different SD card, and writing files to it with a different adapter. SD cards come in a variety of sizes; we have tested cards up to 8GB. They should be a FAT32 formatted disk.

Is the SD card being read AT STARTUP?

The easiest way to test if the card is being read at startup is to open the Arduino Serial Monitor, connect, and then send a command, like M105. The correct response should be:

```
serial: M105  ok T:-273.1 B:-273.1
```

The important thing is the 'ok', which means the M555 P2 (Emulate Marlin USB output) command has run. If you send M105 and get:

```
T:-273.1 B:-273.1
```

(without the command echoed, and no 'ok') the config.g has NOT been read at start up.

What to do if it isn't working?

Update your firmware (see next section); there are some fixes in it to improve the chances of the SD card being read.

Replace the SD Card with a better or known-working card.

For some people, it helps to apply power to the board, then after a couple of seconds press the reset button on the Duet, then the SD card gets read.

Update your firmware!

Your Ormerod will have been supplied with firmware flashed in its microcontroller. Now you have established communication with the Duet, it's a good idea check you have the latest version, and update the firmware on the Duet if not. See here for how to do that. We will be adding features and squashing bugs regularly, to improve the usability of your printer, so check often.

No, really, update your firmware!

Recent updates have improved network connectivity, improved USB communication, improved accuracy of thermistors, improved the SD card reading, fixed homing problems, fixed printer stopping problems, and many others. So please, to save yourself potential frustration, update your firmware.

To check your firmware version, connect to your Duet board via the Arduino IDE Serial Monitor and send the 'M115' gcode. The response should be something like:

```
FIRMWARE_NAME:RepRapFirmware FIRMWARE_VERSION:0.57a ELECTRONICS:Duet D
ATE:2014-01-16
```

If the response is:

```
Error: invalid M Code: M115
```

You have an very old version of the firmware, and should definitely update!

Compare the firmware version information from your response to M115, with the file name of the file in this link, which is on our github page. But DO NOT DOWNLOAD THIS FILE DIRECTLY! See here for the full firmware update instructions.

Following updating the firmware, don't forget to update the SD Card with the latest files from the 'SD-Image' folder.

Connect via Pronterface

Pronterface is used to control the printer's basic functions, via USB. Any version of Pronterface should work with the Duet, though we supply a customised version for our customers.

Two installation methods are available:

- **Easy** - download the pre-compiled version here, Windows or Mac, and extract the zip file.
- **Advanced** - For Windows/Mac/Linux - download the zip file from our Github repository here, installation instructions HERE. This is slightly modified version of Pronterface, enhanced for the Duet.

Once installed, close the Arduino Serial Monitor if it is still open, connect the USB cable to the Duet, then run Pronterface.

Select the USB port that your computer has allocated the Duet in Pronterface's 'Port' box, select a communication speed of 115200, and click the **Connect** button.

As before, wait for about a minute, and the software will confirm when the printer is online.

Press the GET POS button, and if the machine returns a position of X0.00 Y0.00 Z0.00 your serial communication is functioning correctly.

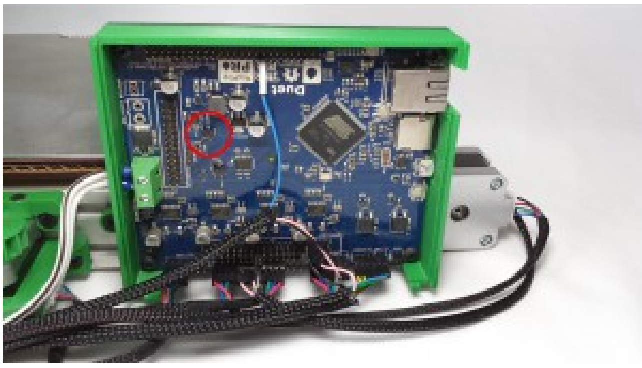
If a temperature is too high then there is probably a short circuit in the corresponding thermistor circuit. If it is too low, then there may be an open circuit. In either case, find the fault and fix it before you go on.

Check the settings by sending 'M503' by typing it into the command line in the bottom right hand side of the Pronterface window. The settings will scroll above the command line, in what we call the log window. This establishes that Pronterface is talking correctly to the Duet, and it is responding correctly.

Now close Pronterface, and disconnect the USB lead, to turn off the Duet.

Now connect the ATX power supply unit

The PSU will supply the motors and heaters with 12V, while the logic is supplied with 5V. Make sure that there is a jumper on the JP9 (5V_EN) pins (see picture below for location of jumper). With no USB lead connected, a light should turn on on the board, near the reset button.



NOTE: The first 220 Ormerod (red plastics) printers supplied by RS Components need the USB lead to be connected **at all times**, to supply the logic side of the board with 5V. If they wish, buyers of the initial 220 machines with this restriction can return their Duet electronics to RepRapPro Ltd for an updated Duet without this restriction. Email support to arrange this.

Testing machine control

Checking the heaters

Plug in the USB and run the Pronterface program. Click "Connect" and wait for your RepRap to appear online.

The heated bed and the hot end are the two parts of the printer that may cause damage as they are high-current devices; we check them first, in case there are any problems that have caused a fault.

Tick the 'Watch' check box (or 'monitor', depending on Pronterface version) to report the temperatures of your heatbed and nozzle. Ensure that the readings are similar to the ambient temperature of the room. If they are not, check connections. Usually, if they are very low (-273), this indicates the thermistors are not connected.

Hot end

Command the nozzle to 100C, by typing '100' in the box next to 'Heater', and watch the temperature rise, overshoot and eventually settle around 100C. Keep an eye on the nozzle during this test. If you see lots of smoke come out of the hot end, turn off the heater and check your wiring. You may have a short on the heater wires, or to the heater block, or there may be some contamination around the heater block.

Repeat the test with a target temperature of 200C. The nozzle should reach the target temperature in about 1 minute or less and settle within a couple of degrees of 200C. Some smell of oil burning off is not unusual - it's the oil from machining the parts - but should dissipate after a minute.

Press 'Off' next to 'Heater' to turn off the hot end.

Heated bed

Command the heatbed to 45C (warm), by typing '45' in the box next to 'Bed', and click 'Set'. Verify that the heatbed temperature reading rises and stabilises around 45C, and that the heatbed is actually warm.

The heated bed will heat up more slowly than the hot end.

Press 'Off' next to 'Bed' to turn off the heated bed.

Test axis movement

Now type in the following command in the command line:

G1 X5 F500

in the field below the log window and click Send. The X-carriage should move to 5mm in the positive direction (X5) at 500mm/min (F500).

Now type:

G1 X0 F500

and send. The X-motor should move back to its starting location (X0).

Repeat the above test for the Y axis, replacing the 'X' in the above command with 'Y'.

For Z, make the feedrate 200 mm/minute:

G1 Z5 F200

You can use the 'jog dial' on the left hand side of the Pronterface window.

NOTE: When you turn on the printer, where each axis is, is where the printer thinks X=0, Y=0 and Z=0 are.

Homing

'Homing' sends an axis to the end of its travel, and hits an endstop, which gives the printer a reference point. Then it will know where the bed is.

Send a homing command for the Y axis first. Either press 'Y' homing button in Pronterface (above the 'dial' on the left of the Pronterface window), or use the homing command: for example

G28 Y0

The Y carriage should move towards the Y motor, hit the microswitch, then reverse to the other end of the Y axis. The Y endstop is a 'MAX' endstop; it records the point where the Y axis is at its maximum point, ie 200mm, then moves to 0, at the other end of the axis.

If the wiring for the microswitch is not connected properly, it will start by moving towards the idler end, eventually clattering off this end! This will stop after a few moments. Don't worry, no damage will be done. Check the wiring for the microswitch, it is possibly disconnected. There is an LED on the Duet above the Y motor connection. It will normally be on, and will go out when the Y endstop switch is hit.

The X axis endstop is not a microswitch; the Ormerod uses the proximity sensor for X homing. This is triggered by the bar that sticks out from the x-motor-bracket. It is important that the X carriage can pass by the electronics housing; this should have been checked earlier in the build. Check that the polarity of the wires connected to the sensor are correct - see the 'Wiring' instructions. Also, depending on lighting conditions where the printer is, you may need to add a piece of silver foil (like that used on the bed) to the top of the bar for the sensor to work consistently.

Press 'X' homing button in Pronterface, or use the homing command:

G28 X0

The X carriage should move up 5mm, and towards the Z axis. It should stop before it hits the end.

Finally, home the Z axis. Again, this uses the proximity sensor. Press the 'Z' homing button in Pronterface, or use the homing command:

G28 Z0

The X carriage should move out, to be over the corner with the aluminium foil underneath, then move down and stop. Initially, the nozzle will be some way from the bed; you will correct this by following the 'Axis compensation' instructions.

Pronterface - RepRapPro Duet features

Use of the RepRapPro version of Pronterface, with extended features for the Duet, is documented here**.**

Connect via web interface

To use the web interface, you need to connect an ethernet cable from the Duet to your ethernet hub, switch or router. The Duet will need to be powered, either by USB or the ATX PSU - it cannot be powered by the Ethernet cable.

It is also possible to connect the Duet directly to your PC via Ethernet, but you will need to set up the ethernet port of your PC to match the Duet (or the Duet to the ethernet port of your PC). You PC will still need to have access to the internet (via another ethernet port or wifi) for the RepRapPro web interface to work.

You need three pieces of information to set up the Duet for your network; ip address, netmask, and gateway ip address. Often, small networks are setup using DHCP, which assigns ip addresses automatically to the devices that connect to the network. The Duet, at the moment, can't use this; you need to set the ip address manually.

By default, the settings in sys/config.g on the SD card are:

```
IP address: 192.168.1.14  netmask: 255.255.255.0  gateway: 192.168.1.1
```

If you're on a Windows PC, check that the settings you use on your network by opening a Command Prompt and sending 'ipconfig'. This should respond with something that includes:

```
Wireless LAN adapter Wireless Network Connection:  Connection-specific
 DNS Suffix . : lan    Link-local IPv6 Address . . . . . : fe80::45dc:
fdd3:67dd:db47%11  IPv4 Address. . . . . . . . . . . : 192.168.1.66  S
ubnet Mask . . . . . . . . . . . : 255.255.255.0  Default Gateway . .
. . . . . . . : 192.168.1.254
```

On a Mac OS X, look at the 'Network' preferences panel to get the information. On Linux, look in the Network Manager, or in a terminal window type 'ifconfig'.

This will show the settings you need to put in config.g for these two settings:

```
M553 P255.255.255.0; Set netmask (Subnet Mask)  M554 P192.168.1.254; S
et the gateway (Default Gateway)
```

For the last setting, the ip address, choose a number that is 10 higher or lower than the address listed by ipconfig. In the example above, it lists 192.168.1.66, so set:

```
M552 P192.168.1.76; Set the IP address
```

If you need to edit these settings, edit the config.g file in RepRapFirmware/SD-Image/sys/ that you downloaded earlier. Then copy the new config.g onto the SD card.

Connect the ethernet cable to the Duet, and the hub/router/switch at the other end. The GREEN LED on the ethernet connector should light up, and flicker. The Orange LED is a indicator light for 10base-T connections - most ethernet hubs/routers/switches are 100base-T or gigabit, so it will stay switched off.

At the moment, only Google Chrome **is supported. Other browsers will be added with later firmware releases. Download and install** Google Chrome**.**

Run Google Chrome, and enter the ip address you set in config.g into the address bar; for example, 192.168.1.76 (from the example above)

If the web interface is correctly set up, you should be presented with a login screen. The default password is 'reprap'; you can change this in the config.g file, too.

More in-depth use of the web interface is documented here**.**

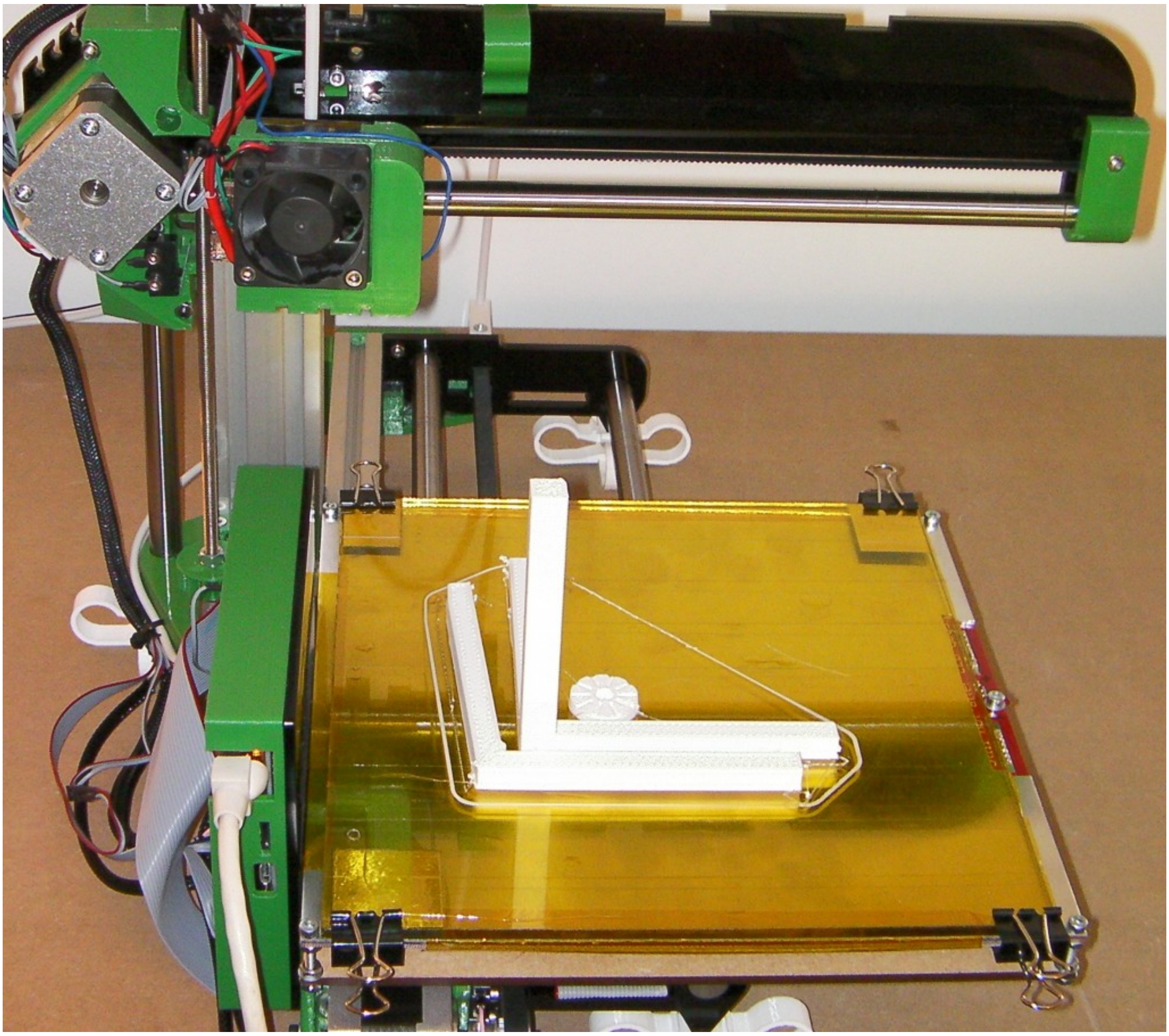
Problems?

If you have problems with any of the steps on this page, particularly connecting to the Duet, see the 'troubleshooting' section of the instructions.

If you spot any mistakes in these instructions, please email your feedback to the support email address.

Printing

Printing the Orthogonal Axis Compensation Test Pieces



The first thing to print is the orthogonal axis compensation test pieces, as in the picture above. The G Codes for this are in a file called ORMAXIS.G on the SD card.

(The 3D models for the test pieces are in the **Data** folder of the RepRap Firmware download, incidentally: **gauge.stl**, **thumbwheel.stl**, **testpiece.stl**, and **calibration.scad**.)

For help on the Ormerod user interface, see here.

Plug in the USB and power, power on your Ormerod, wait a short time for it to connect to the network, open the browser, and type the IP address of the Ormerod in the address bar.

Log in, and go to the **Control** page.

If the nozzle is low, lift it with the up-Z buttons to about 10mm above the bed.

Now home the X and Y axes.

Normally, we would use the Z probe to home the Z axis as well, but as this is the first print we will home Z by hand. Move to the first point you used for setting the Z probe (in the Axis Compensation Instructions).

Lower the nozzle using the small-increment Z move buttons until it is just clear of the bed. You want it as near touching as possible, but so you can just see light in the gap.

Send a G92 Z0 command to set this as Z=0.

Now run your bed plane compensation. If you recorded it in a **setbed.g** file, simply go to the **Print** page and run that.

Go back to the Control page and check all the numbers for position and temperature look as you would expect.

Now run the ORMAXIS.G file. It should print the objects above. Before you take them off the bed, use a felt-tipped pen to label the axes of the three-legged piece. In the picture above, X runs left-right, Y runs front-back, and Z runs down-up.

You can now go back to the Axis compensation instructions and set the orthogonal axis compensation.

The G Code files for printing a snowman Christmas tree decoration and the traditional RepRap coathook are also on the SD card. You can print those in just the same way as above.

Converting CAD files for printing

File formats

Most CAD software can output files that can be used for 3D printing. There's a useful list of free CAD systems here on the RepRap website. Professional software like SolidWorks and Autocad, as well as free options such as RS DesignSpark Mechanical, Sketchup, Blender,Sketchup and OpenSCAD (as well as many others) can export stereolithographic (STL) files. They use the file extension '.stl'.

An STL file is a list of triangles completely covering every surface of a 3D object. This is not a very robust way of representing a solid, but it has become a universal standard.

Slicing software

Like all 3D printers, Ormerod is actually controlled by G Codes - low-level instructions that say things like *go-to-this-point*, or *print-filament-in-a-line-from-this-point-to-that*. We need a program to convert STL files into G Codes. A very good program to do that is called Slic3r. It is open-source and free, and it is available here. There is also documentation on Slic3r available here, so that is not reproduced here.

Slic3r profiles

Slic3r needs to be set up for each type of 3D printer for which it translates STL files into G Codes. We have performed that set-up for you for Ormerod. To get it you need to download the main Ormerod repository (if you haven't already), which is stored here on Github. As with downloading the RepRap Firmware, click on the **Download ZIP** button with the little cloud and arrow. In the download is a folder called **Slic3r-settings** that contains the files Slic3r needs to convert STLS to G Codes for Ormerod.

To use our profiles with Slic3r, the contents of the 'Slic3r-settings' folder that is in our github repository here [github.com] needs to replace the contents of the default Slic3r profiles folder. The location of this folder depends on which operating system you are using. You need to run Slic3r once, so it creates the 'Slic3r' folder that holds the profiles.

On **Windows 7/8,** the profiles are stored in folders under
c:\Users{username}\AppData\Roaming\Slic3r

AppData is a hidden folder; you will need to change the View settings to see System folders, so you can find it.

On **Windows XP,** the profiles may be stored in the same folder as above, or in C:\Documents and Settings{username}\Application Data\Slic3r

On **Ubuntu**, the profiles are stored in an invisible .Slic3r folder, in /home/{User}/.Slic3r

On **Mac OS X**, the profiles are stored in /Users/{username}/Library/Application Support/Slic3r

This is a hidden folder, but you can get to it by going to the main menu option 'Go' then 'Go to Folder...' and typing '~/Library/Application Support/'

After replacing these files, when you open Slic3r the next time, there should be three 'Ormerod-0.5' (for Print settings, Filament and Printer) options at the bottom of the Slic3r application window.

Printing from the SD card

You may have noticed that, so far, all printing is done from the SD card. This is the preferred way of printing. It is possible to print directly from Pronterface (ie load gcode files into Pronterface and press print), but the serial communication is slow. The printer will pause a lot during printing, and the printed part will not be of good quality.

Always copy gcode to the 'gcodes' folder of your SD card to print. This is where the firmware looks for files. There are currently two ways to transfer files to the printer:

1. Turn off the printer, remove the SD card from the Duet, insert it into the USB adapter, then into your computer. Copy the gcode file from your PC to the SD card, then eject the USB adapter. Wait for it to finish writing, then remove the SD card. Reinsert it into the Duet. Restart the printer. Your gcode file should be accessible from the Pronterface 'SD' menu.
2. In Pronterface, click the 'SD' button, and click 'SD upload'. You can then upload the gcode file to the SD card while it is still in the Duet. This is quite slow, and is suitable for small files only (1MB will take a couple of minutes).

Future firmware updates will improve the speed of serial communications, and give more options for uploading files to the SD card.

Print an Ormerod

Ormerod is a RepRap - a *Replicating Rapid Prototyper*. So, to experiment, why not print out some of Ormerod's own parts? These are available in the folder **stl/individual parts** in the Ormerod download. When Slic3r has generated a G Code file for you from an STL file, you can put it in the **gcodes** folder of Ormerod's SD card and then print it. Either put the SD card in your computer to copy the file (remember not to take it out of Ormerod unless all power including the USB is off), or you can upload G Code files using Pronterface. The Duet controller in Ormerod expects file names to be in 8.3 format at the moment. This restriction will be removed on a future release.

And, now you have started, why not print out a full set of Ormerod parts for a friend? Hardware-only kits for Ormerod will soon be available, giving all the things you will need other than the printed parts to build another complete Ormerod.

Happy 3D printing!

Multimaterials

Introduction

This page describes the steps to build the multi-material and multi-colour version of RepRapPro Ltd's version of RepRap Mendel.

For the most part, the construction is the same as for the single-colour machine, and you should follow the instructions for that through to the end and get your machine working as a Mono before starting the work on this page. The experience you will gain doing this will speed the process, and help you troubleshoot any problems.

If you are upgrading an existing Mono or Legacy Mendel to colour, still read through the single-colour instructions - at various points there are extra tasks that you need to do for the colour upgrade. These sections are highlighted in green on the relevant pages, but are also linked below. Also, you will need to update the firmware of you Mono/Legacy Mendel to the multimaterials firmware; see HERE for instructions on firmware updating.

When you have followed the single-colour machine instructions through to the end, then start...

Extra hardware build

...here.

Extruder drives

You will need three drives in total. Build two more as described HERE and fit them evenly spaced along the top bars of the machine. The first one should have been fitted on the left, and attached to the first (master) Melzi. The other two can be mounted middle and right, and will connect to the slave Melzi.

Hot ends

Build two more hot ends, as described HERE

Our standard layout is to fit the first hot end in the front-left mounting point on the X carriage, the second front-right, and the third back-right. But you can always change the order; you just need to change the offsets for the two extra extruders, set using the G10 gcode (instructions below).

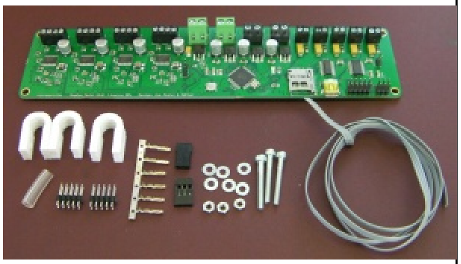
Adjust the cap screws on the nozzle mounts to raise each hot end, so that the first extruder is lowest and the other two are about 1mm higher.

Power wiring

If you are upgrading an existing Mono or Legacy Mendel with a colour enhancement kit, you will need to wire up your XLR socket to provide power to the slave electronics. Follow the green instructions [HERE]

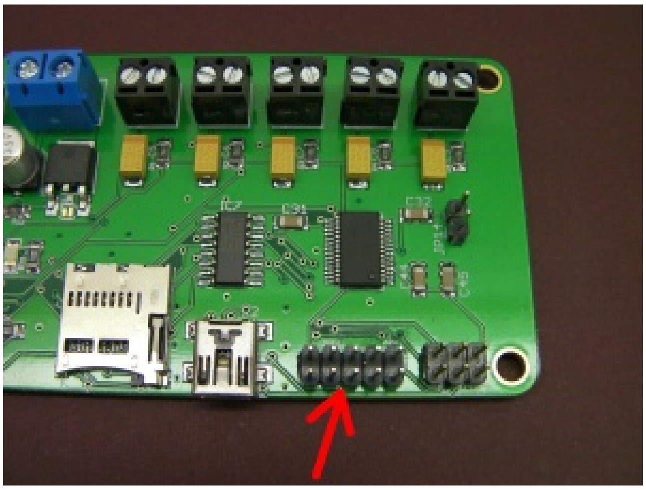
Installing the slave electronics

Hardware	Quantity
Slave controller board	1
10-way pin header	2
Printed PCB clips	3
M3 nuts	3
M3 washers	6
25mm M3 screws	3
3mm I.D. poly tube	15mm
Crimp shell connectors	8 (picture is wrong - it shows 6)
3-way shells	2
4-way ribbon cable	700mm
Heat-shrink	30mm



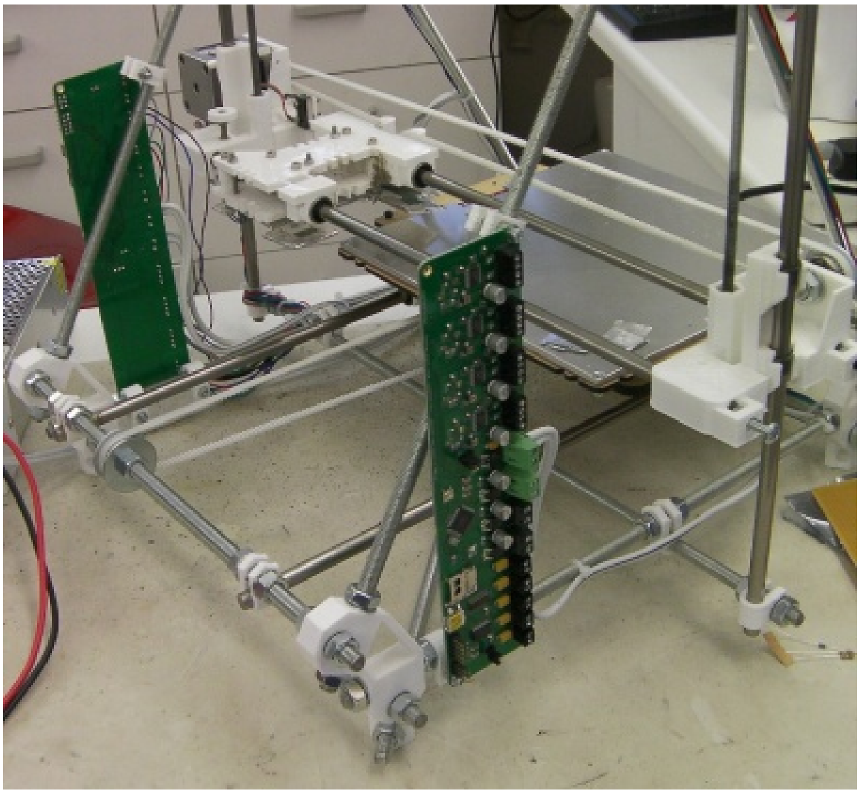
Remember to disconnect both the power and the USB before making any electrical changes to your RepRap.

If the 10-way header pins are not already soldered into their locations in your Melzi master and slave controllers:

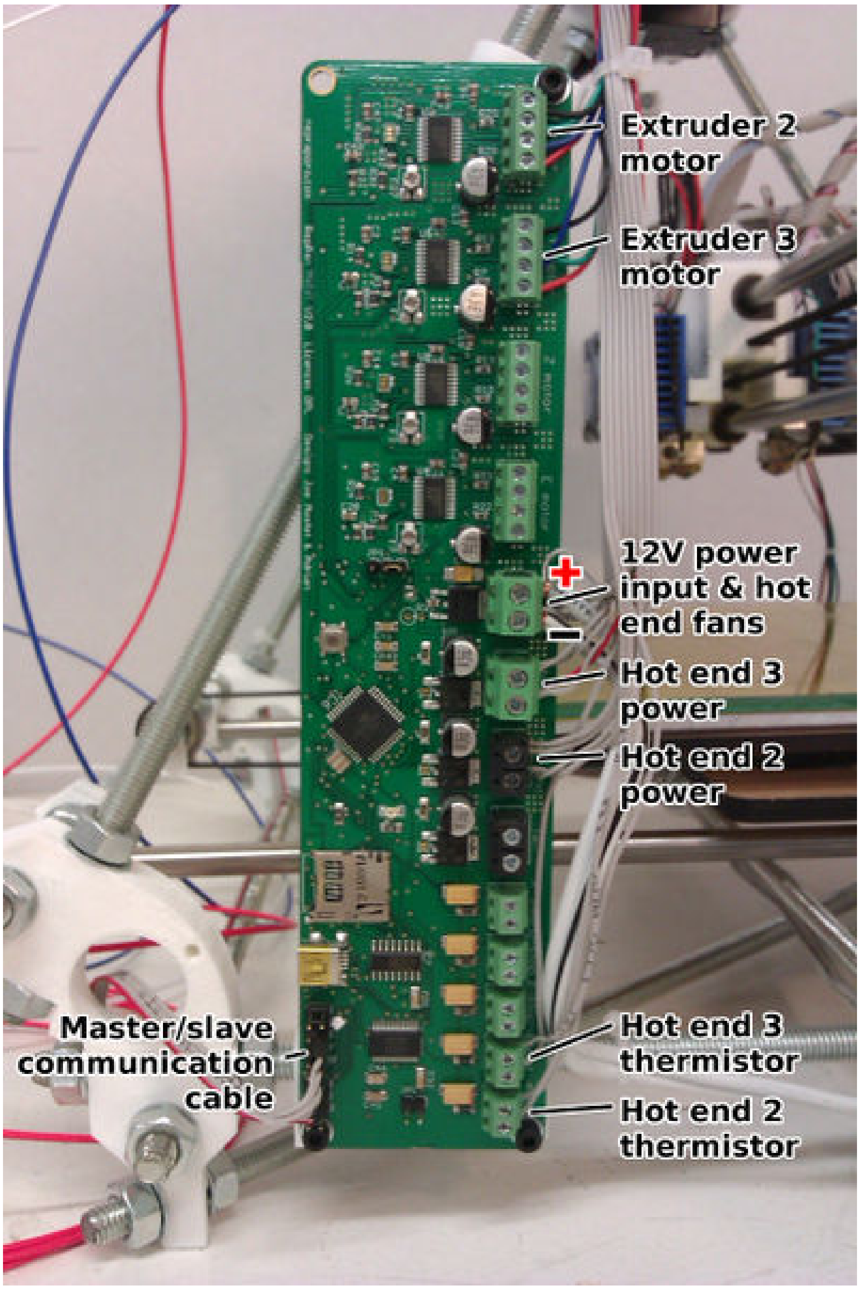


Solder them in now. You will find this easier if the circuit boards are not mounted on the machine.

The slave controller is mounted in exactly the same way as the master controller, but on the opposite side of the machine. Mount it with the screw connectors at the back, and the USB connector at the front and the bottom. Wiring connections are the same, but go top-to-bottom rather than bottom-to-top when compared to the master board on the other side.



Wiring diagram



Extruders

Extruder 1 should already be wired into the master controller from when you got the machine working in single-colour mode.

Wire the other two extruders to the slave controller.

Extruder 2

- Motor wires go to the 'X motor' screw terminals of the slave. The order of the wire colours is the same as the order of the extruder drive wires on the master controller, but

top to bottom - black, green, blue, red.
- Hot end heater wires go to the 'hot end' screw terminals of the slave.
- Hot end thermistor wires go to 'etemp' screw terminals of the slave.
- Hot end fan wires go to 12V power input. Do this at the same time as the power wire below. Check polarity, the fan only works one way.

Extruder 3

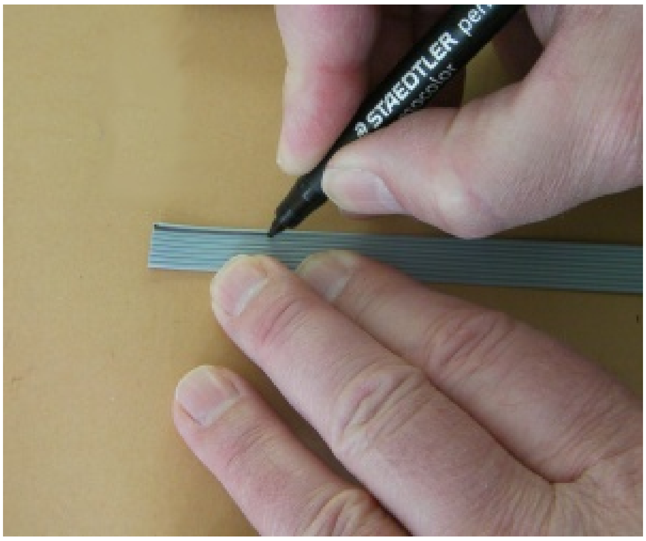
- Motor wires go to the 'Y motor' screw terminals of the slave. The order of the wire colours is the same as the order of the extruder drive wires on the master controller, but top to bottom - black, green, blue, red.
- Hot end heater wires go to the 'bed' screw terminals of the slave.
- Hot end thermistor wires go to 'btemp' screw terminals of the slave.
- Hot end fan wires go to 12V power input. Do this at the same time as the power wire below. Check polarity, the fan only works one way.

Power

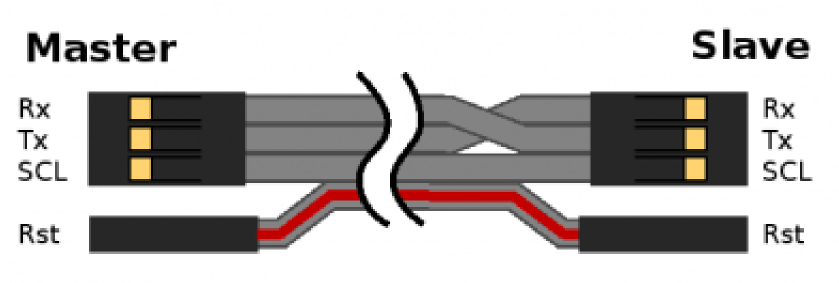
Take the insulating tape off the power wires and connect them to the slave controller, along with the hot end fan wires for the extruders. Make sure to get the polarity right - the +12V is the top terminal on the slave, the ground is the bottom terminal. The polarity is marked on the PCB in front of the terminals with a + and -, if you are not sure.

Master/slave communication cable

Run the tip of a felt pen along between two of the wires in the ribbon cable so you can tell which is which from either end. (This is a generic picture; the actual ribbon you want is 4 way.)

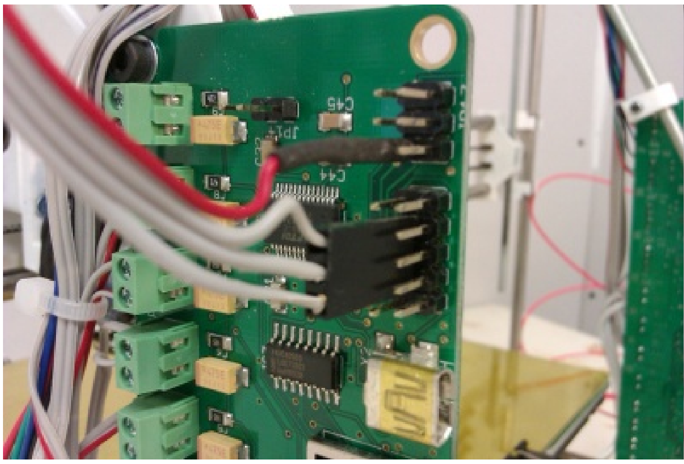


Take a 660mm length of 4-way ribbon cable. Separate out three of the four wires at each end and put a three-way crimp housing on each one. **NOTE:** the Rx and Tx wires cross over; see below. Put two single crimp connectors on each end of the fourth wire.



Use the resulting cable to connect the master controller to the slave:

- Rx on the master goes to Tx on the slave,
- Tx on the master goes to Rx on the slave, and
- SCL on the master goes to SCL on the slave.
- Rst on the master goes to Rst on the slave.



Master with communication cable fitted

Slave with communication cable fitted
Note Rx/Tx crossed over

Run the four wires across one of the bars at the front of the machine, where no other wires run, to minimise interference.

Important: In the future, if you upgrade the firmware in either the master or the slave controller ([details of how here](#)), you must first disconnect one end of this 4-way wire. Reconnect it when you have finished reloading the firmware.

Really Important: Jumper settings

The autoreset jumper on the Melzi, at the end of the board nearest the thermistor connectors, needs to be removed.
Move the central power selector jumper to short the two pins nearest the screw connectors. This will power the logic from the main power supply, not from the USB. Set the jumpers on both the master and the slave the same. If you don't do this, when you connect to the Master in Pronterface, the slave will fail to initialise with the message:

Slave init. Please wait ...
....................Slave init FAIL head 1

Check wiring

Use your multimeter to check that the resistance between the case of the SD card holder on the slave controller and the outer metal shell of the XLR power input plug at the back of the machine is 0 ohms.

Check that the resistance between the + power input screw connection on the slave controller (the wire with no stripe) and the + power input screw connection on the master controller is 0 ohms.

Measure the resistance between the two screws on the power connector of the slave. This may start low and then rise. (This is the capacitors in the circuit charging up with the tiny current from the meter.) It should level out at a few hundred ohms.

Measure the resistance between the two screws on the bed power connector of the slave. This should be about 3 ohms.

Measure the resistance between the two screws on the hot-end heater resistor connector of the slave. This should be about 3 ohms.

Check the heated bed temperature sensor connector of the slave. The resistance should be about 10 kilohms. This is not just the resistance of the sensor. Other parts of the circuit on the controller board are in parallel with it.

Check the hot-end temperature sensor connector of the slave. The resistance should be about 10 kilohms. This is not just the resistance of the sensor. Other parts of the circuit on the controller board are in parallel with it.

Checking thermistors via Pronterface

Leave the mains power off switched off, and put the central power jumper to USB power, on the two pins furthest from the screw terminals. Now connect to the slave directly with Pronterface, by USB cable plugged into the slave. It will appear to hang with "Connecting...". Press reset on the slave, and you should get the message:

```
RepRapPro slave controller Version 1.1, 2013-05-15 restarted.   Temps:
22.37 23.46
```

If you get something like:

```
RepRapPro slave controller Version 1.1, 2013-05-15 restarted.   Temps:
-273.15 23.46  ERROR: temp bounds exceeded
```

after this, your thermistors are not reading correctly. Check your wiring, particularly the thermistor wires. The temperature reported will indicate which thermistor is not reporting correctly; the first temperature is T1, the second T2. If the board doesn't report temperatures, you need to update the firmware on your Slave. See guide HERE.

Test that everything is working

If you are upgrading an existing RepRapPro Mendel then you will need to upgrade its firmware in its master controller. There are instructions here. If you have got a new Mendel together with the colour upgrade your new master controller should have the correct firmware already. Similarly a new slave controller will have its correct firmware.

Plug in the power and USB, and turn your RepRap on.

Run Pronterface and connect it to your RepRap.

Move the axes by a few millimeters in the + direction to make sure that they are still all working, and turn on the bed and check that it starts to warm up. Turn the bed off again.

Now home the X, Y, and Z axes, then raise Z by 10mm.

In Pronterface's "Send" window (bottom right) that allows you to transmit G Codes directly to your RepRap type in and send the following three commands:

```
G10 P0 X0 Y0 Z0 S100 R80  G10 P1 X-34 Y4 Z0 S100 R80  G10 P2 X-11 Y51
Z0 S100 R80
```

Nothing should happen.

The P numbers are the numbers of each extruder. The G10 command sets distance offsets in X, Y and Z for the numbered extruder and the working (S) and standby (R) temperatures it will use.

None of these settings have any effect until the given extruder is selected.

Move X and Y to (100, 100).

Select the third extruder (numbering starts at 0):

```
T2
```

(The "T" stands for "tool" - a G Code standard.) You should see its temperature start to rise. When it reaches its target temperature the X and Y axes will move to place it roughly where Extruder 0 was (that was the X-11 Y51 in the G10 command).

Select T1 and the same should happen.

Select T0 and the same should happen.

Send an M0 (switch motors and heaters off until they get another request) command.

Repeat the input of the G10 codes above with higher temperatures:

```
G10 P0 X0 Y0 Z0 S200 R150  G10 P1 X-34 Y4 Z0 S200 R150  G10 P2 X-11 Y5
1 Z0 S200 R150
```

These parameters need to be stored using an M500 command before your first print. Equally whenever you wish to update your offsets, this process may be repeated and stored again using an M500. The procedure for measuring offsets is outlined later, however the values above are approximately right for a Three colour first generation Mendel. For the latest Tricolour Mendel approximate values are below:

```
G10 P0 X0 Y0 Z0 S200 R150  G10 P1 X-42 Y0 Z0 S200 R150  G10 P2 X-42 Y-
32 Z0 S200 R150
```

Select "Motors Off" (top left in Pronterface).

Insert three different coloured filaments into the three extruder drives and feed them forward by hand turning the big gears until they are just visible in the PTFE tubes that lead to the hot ends.

Select each extruder in turn using the T commands described above, wait till it gets to temperature, and then drive the filament forward down the PTFE tube until it enters the nozzle (you can do this quite fast - say at 800 mm/min - but make sure you don't hit the hot end at that speed). Select a slower speed (200 mm/min for an 0.5mm nozzle; 80 mm/min for an 0.3mm nozzle) and drive the filament forward to extrude it and check that extrusion is working.

At the end of each test of each extruder, reverse a 5mm length of filament to reduce the pressure in its hot end (it's a good idea to get into a habit of doing this whenever you test an extruder by hand).

Find a pair of tweezers or a fine pair of needle-nosed pliers.

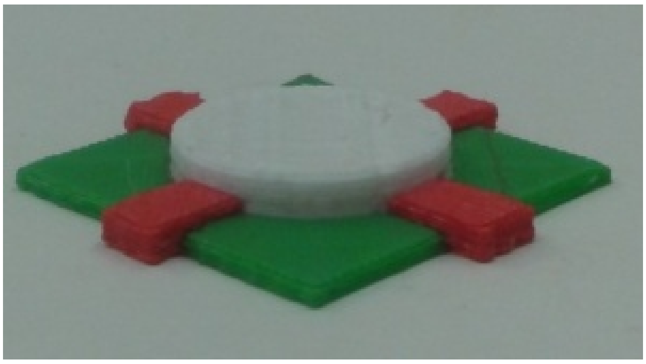
Send an M0 command and watch the temperatures drop. When they get to around 120 ^{o}C any plastic still on the ends of the nozzles will be sticky enough to pull it all away in one piece with the tweezers.

Carefully clean the nozzles of any plastic on their outsides.

Send the carriage and bed to X=100mm, Y=100mm. Then zero Z.

You should have left the second and third nozzles very slightly higher than the first on the X carriage when you put the hot ends on it. Now adjust the heights of the second and third nozzles so that they are at the same level above the glass as the first.

Your first multi-colour print!



Download the colour test object simple-test.rfo (download the individual white, red and green stls for Slic3r) from our [Github repository here](). Don't worry if your test colour filaments are not white, red and green as in the picture above. You will still be able to print it in whatever three colours you have.

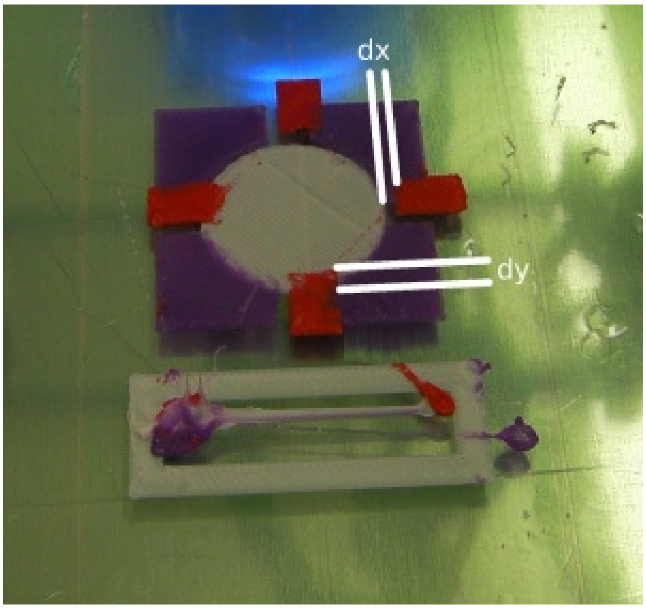
You have a choice of slicing software to use. You have already installed Slic3r, but it needs to be set up for 3 colour printing; see Slic3r_Multicolour. You can also use our home-grown RepRapPro Slicer. This gives a huge amount of control over your prints; see RepRapPro Slicer.

But before you do, read the next section on colour registration.

Head Levelling and Registration

To get all three heads level, do this:

1. First make sure that all three heads are clean. If you have solidified PLA on them it will be difficult to judge the position of the nozzle.
2. Call the nozzles A, B and C (the order doesn't matter). Tighten the screws to raise B and C by about 1mm, and then raise A by about 0.5mm.
3. Move the head so it is roughly in the middle of the glass plate and lower it to Z=0. If A is still clear of the glass, adjust the Z-height screw and lower again. You want A just touching the glass. Make sure that it is just touching, not pushing against it (remember that the glass is sprung and it will move down under a push).
4. Then gently lower B and C by loosening their screws until they just touch the glass too. Then all the heads should be level.



Stop your print after it has finished the first layer (press the reset buttons on the master and slave controllers, then move the X carriage to one side by hand to stop the nozzle sticking to the print).

The result will probably look something like the above picture. The rectangle at the front is the shield structure the software builds to keep the nozzles clean (which is why it is so dirty).

But as you can see, also the heads are not quite in registration. Use digital callipers to measure the X and Y errors (dx and dy) for each colour (purple and red here) relative to the plastic from Extruder 0 in the machine (white here).

To find the current offset values values, use the **Send** box in Pronterface to send an M503 command to list them (you will get a lot of other data as well; the offsets are at the end).

You can set the correct offsets using the G10 G Code (see here for a complete list):

```
G10 P2 X-33.7 Y3.2 Z0
```

This says set the X, Y and Z offsets for extruder 2 (that's from the P2) to (-33.7, 3.2, 0). The precise meaning of the X, Y (and Z) values is: **"move this extruder by this much to place it where Extruder 0 is"**. As you can see, in the picture the red extruder (Extruder 2) is too far in +X and too far in +Y.

This means that the dx and dy values you measured have to be subtracted from the X and Y values on the **G10 P2** line.

Use the **Send** box in Pronterface to send the right G10 commands to your RepRap. You should leave the values for P0 to be all zero (that is the default, so you don't need to set that) and just correct the values for P1 and P2.

To save the values you set, send an M500 command. This will write the values into EEPROM in the controller, and then they will be picked up again automatically when you next turn it on.

You should never have to change the Z values from 0, incidentally. If you do the heads will collide with your print. (They are just there for completeness.) You should always adjust the Z offsets by using the nuts on the screws on the X carriage.

Hints and tips for multimaterial printing

1. Make sure that you have the **Watch** or **Monitor Printer** checkbox in Pronterface **unchecked** when using the multicolour machine. Continually bombarding it with requests for its temperature (especially during a print) can occasionally cause trouble with the communications between the Master and the Slave controllers. (The problem occurs when the Master has requested the slave for its temperature as part of its internal operation, and Pronterface then coincidentally asks for that temperature again before the Slave has had a chance to reply to the first request.) You can click the Pronterface **Check temp** button occasionally if you want - the probability of the problem occurring with just one click is vanishingly small.
2. If you are running Pronterface and you press the reset button on the Master or Slave controllers, give things about 10 seconds after the controllers have rebooted themselves before you ask them to do anything.
3. Accurately setting the number of stepper steps per millimetre of filament fed for a single-material machine is described here. Unfortunately Marlin can't handle different numbers of steps per millimetre for multiple extruders. The way to get round this is to set the value right for Extruder 0, and then to make small adjustments to the value of Extruder1_ExtrudeRatio (and Extruder 2 as well) in the RepRapPro Slicer software. For example, for Extruder 1 if you ask the machine to extrude 100mm of filament and you get 98 mm of filament, set the value of Extruder1_ExtrudeRatio to 1.0204 (= 100/98).

Slic3r Multicolour

Introduction

Two pieces of software may be used to create the tool paths, or GCode, for multicolour printing; RepRapPro Host and Slic3r. RepRapPro host is tremendously versatile, and allows for different areas of the part to be assigned different properties such as temperature or infill percentage. Slic3r on the other hand is not as versatile, but is recommended in all cases for mono prints and generally it produces better quality prints.

If you are new user it is recommended that you start with Slic3r, and progress to the extra versatility of host if required.

Installing Slic3r

You should have Slic3r already installed from commissioning your printer as a Mono printer. Make sure you have our Profiles installed too. Instructions are HERE.

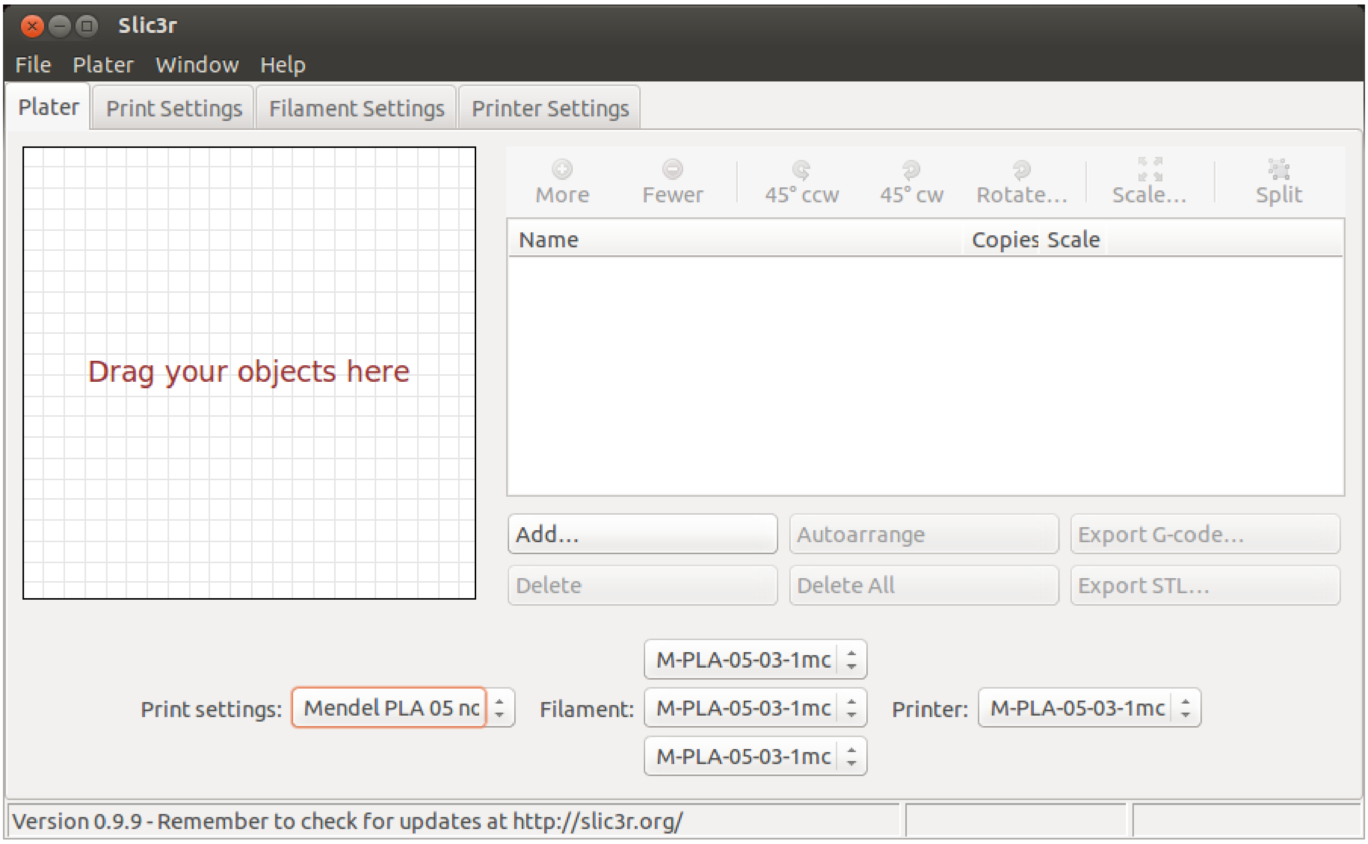
To run Slic3r, simply open the application from your applications folder.

Selecting your profile

Before Slicing, you first need to select the appropriate profiles. These are chosen from the drop down boxed on the main window of Slic3r.

First select the printer profile from the right hand side of the window. For a Tricolour Mendel select "M-PLA-05-03-1mc". This corresponds to a Mendel printing PLA, with a 0.5mm nozzle and a layer height 0f 0.3mm

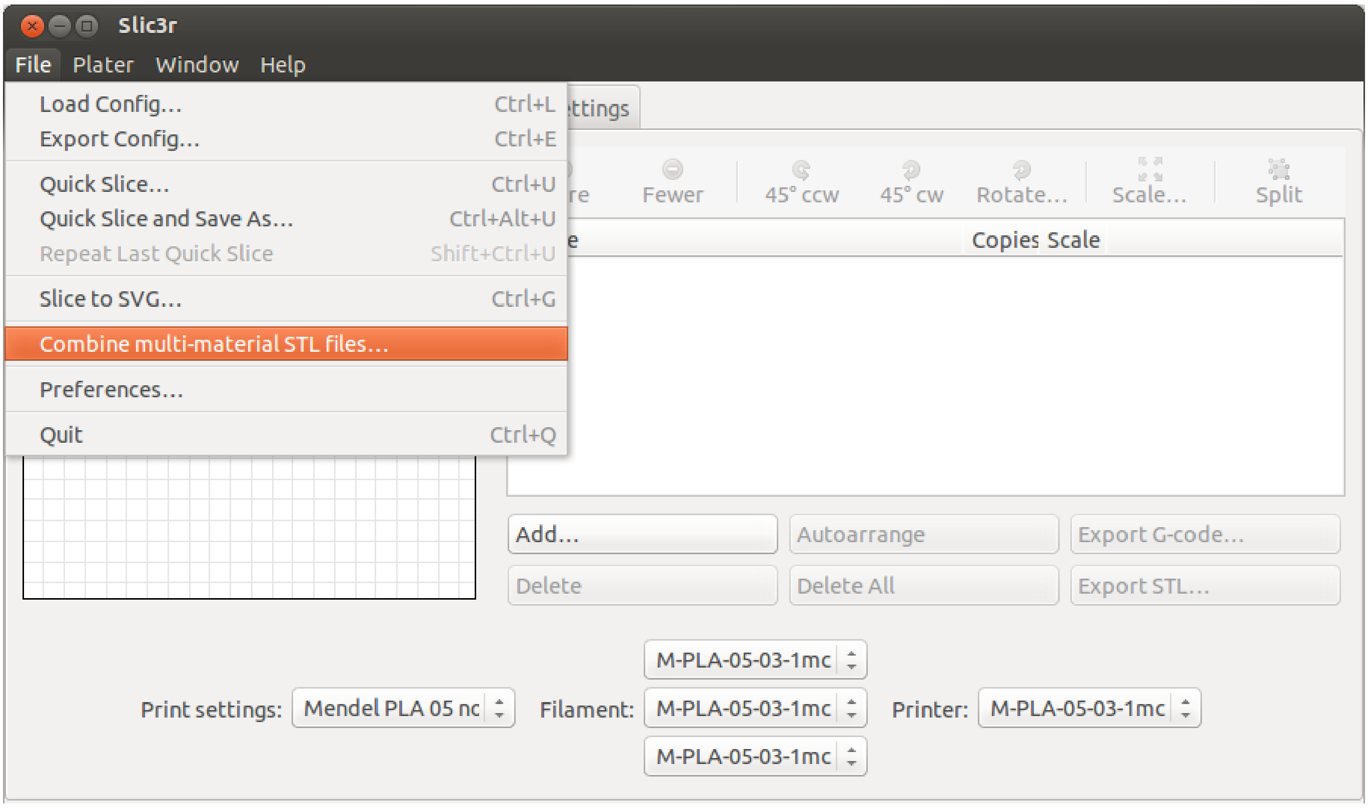
This will then produce more drop down boxes for the filament settings, one corresponding to each extruder. Again choose the "M-PLA-05-03-1mc" filament setting for each extruder. Finally choose "Mendel PLA 05 nozzle - mc" from the print settings drop down menu.



Creating an AMF File

Where as single material prints require STL files for printing, multimaterial files require AMF files. However, AMF files have not yet been adopted by most CAD packages and so STLs need to be converted. If you are designing parts that need to be printing in multiple colours, you need to ensure that the STL files produced share the same coordinates and origin, such that Slic3r knows their relative positions.

To create an AMF select the "Combine multi-material STL files" from the file menu:

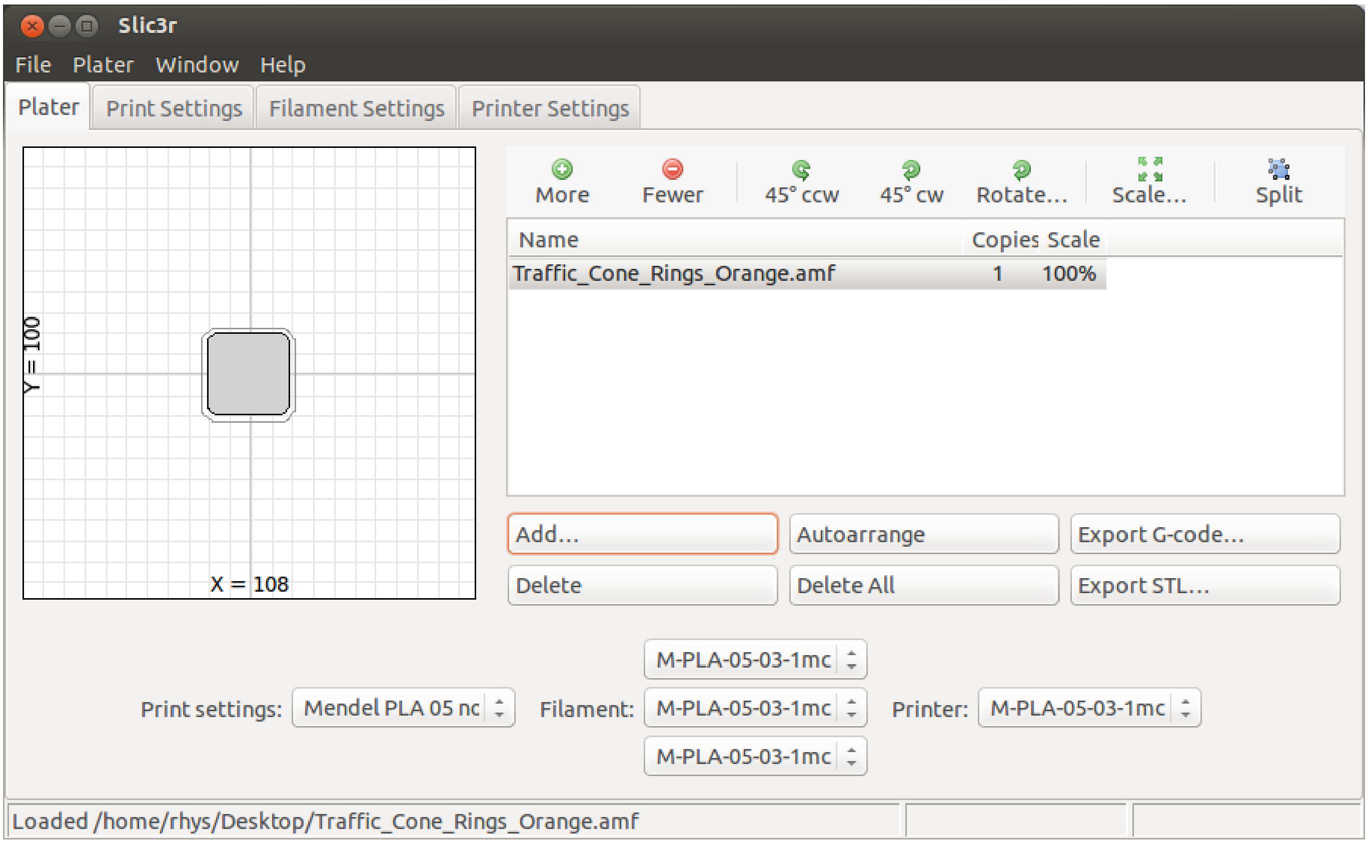


You will be presented with a file window to choose an individual STL. You need to navigate to your STLs in the order the corresponds to their extruder number. Select your first STL, then click 'Open'. The file window will open again; select your second STL, then click 'Open'. The file window will open again; select your third STL, then click 'Open'. The file window will open again; once you have selected all the STLs you require, hit the cancel button. A new window will open allowing you to save your AMF file; give it a sensible name, as it usually gives it the name of the first STL you chose. Then click 'Save'.

The order you choose the STLs relates to the extruder each part will print from; the first STL you pick will be assigned to extruder one, the second STL to extruder 2 and so on.

Plating

You may now add your print to the build area. Choose 'Add' from the build area, or from the main window, and navigate to your AMF file if your are producing a multicolour print, or your STL files for a single colour print. If you have multiple files, you can keep adding AMFs/STLs to the tray and position them using the window to the left.



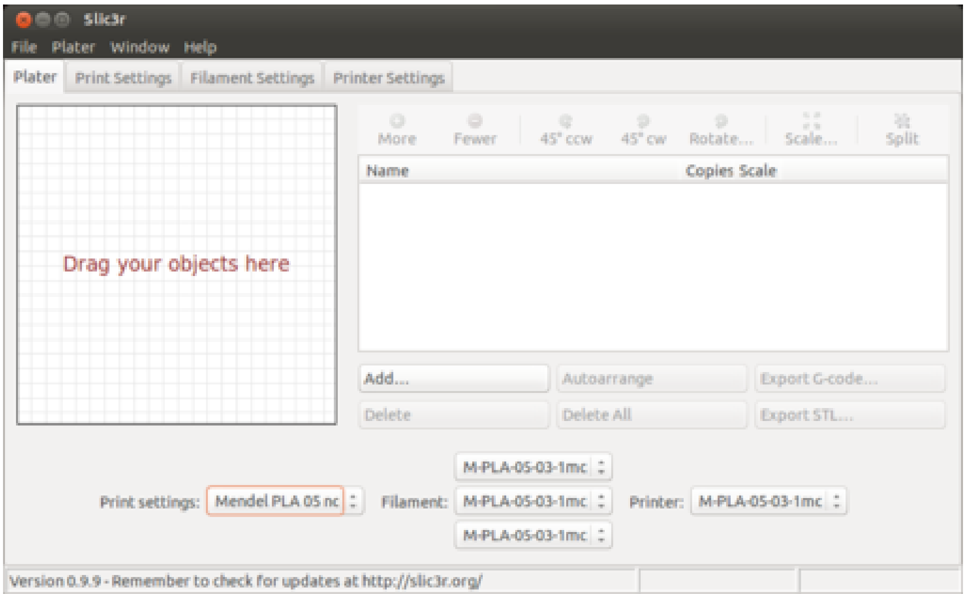
Slicing

To slice your files, simply choose export GCode, and save the file to a convenient location. It is highly recommended that this is copied to an SD card for printing rather than over USB. This file may then be printed from pronterface in the usual fashion.

Switching back to mono printing

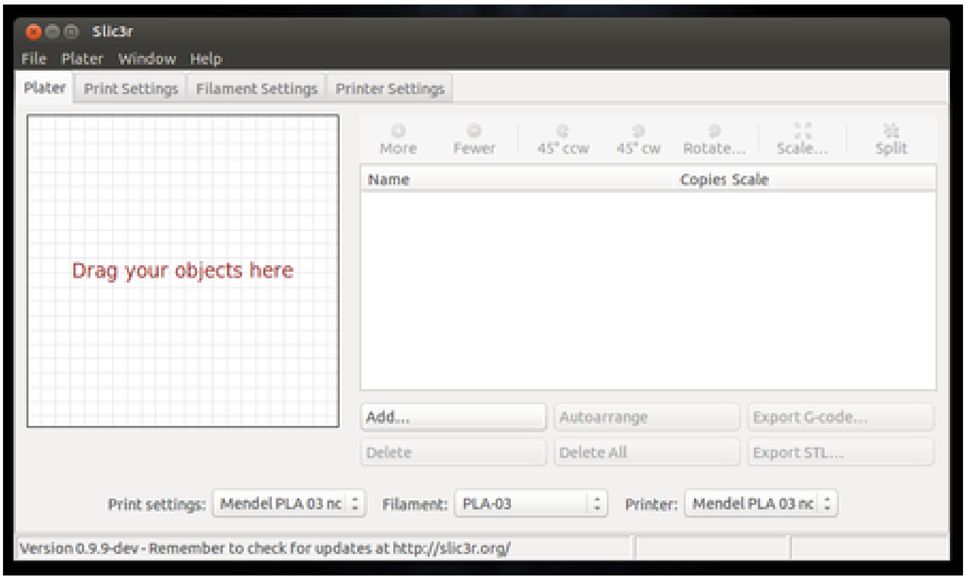
If you want to print single colour parts again, you just need to change all three Slic3r profiles back to the mono print profiles; Printer, Filament and Print settings.

-



Tricolour: Notice the 'Filament' setting has 3 filament options

-



Mono: If you have selected the correct 'Printer', it will show just one.

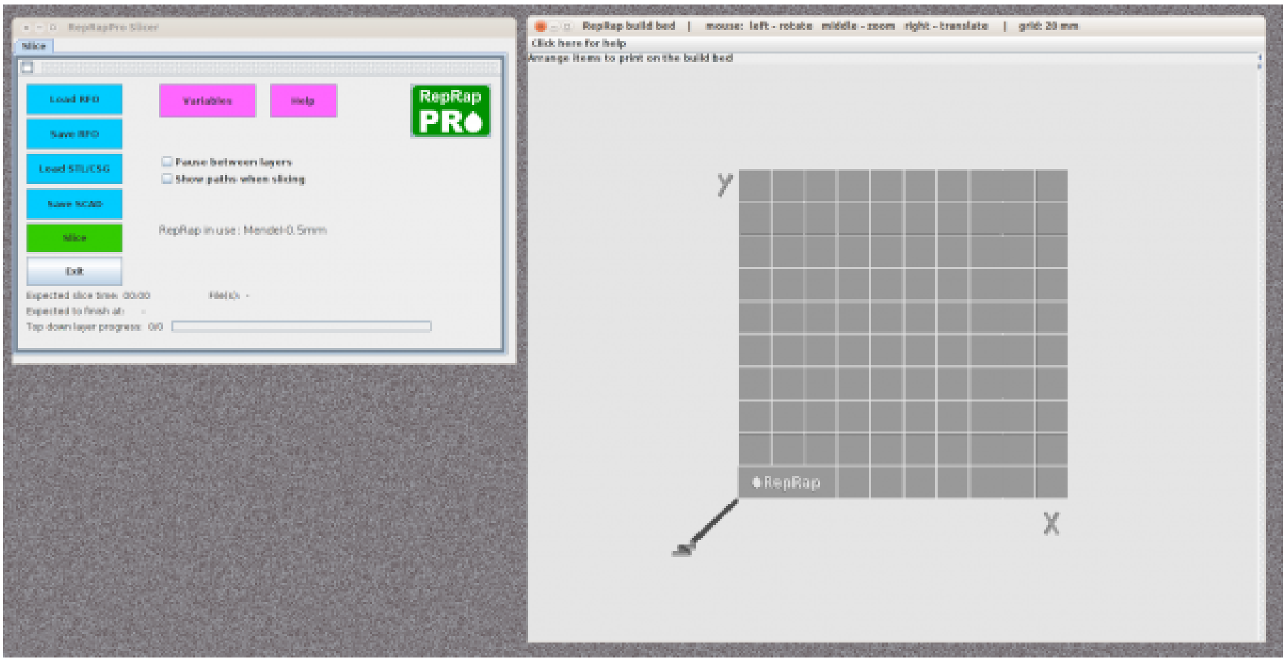
When it comes to printing, you may need to reset the printer if you have issued any tool change commands (T0, T1, T2). If you have, printing mono gcode should print using the currently active extruder; the other extruders will sit at their standby temperature for the whole print. If you get a message 'cold extrusion prevented!', you may have a mix of profiles selected in Slic3r.

RepRapPro Slicer

This software is currently in Beta Release

It is functional, but may contain bugs. Check here on Github for the latest release.

Introduction



This page describes RepRapPro Ltd's slicer software for taking STL files and slicing them to create G Codes to drive a RepRapPro Ltd RepRap printer (such as RepRapPro Tricolour or RepRapPro Huxley). It is heavily based on the original RepRap Java Host Software.

The reason we have created this software is that other software for slicing that we have looked at does not handle multiple colours and multiple materials well. This software is slightly slower than some others (we will work to improve this), but it does allow you to set-up and to slice multi-colour and multi-material prints in an easy, intuitive and graphical way. Specifically, it allows you:

1. To see a 3D colour representation of the entire build on the build bed from any angle or position,
2. To specify the order in which parts will be printed,
3. To specify that some parts will be built with support material and others not,
4. To reposition, to remove, and to add parts to the build pattern, to save the result, and to reload it and edit it further later,
5. To build parts with any combination of colours/extruders in any order, and to not use some colours/extruders at all for some parts, and

6. To have complete control over the shield that is built to purge and to clean multiple colours/extruders between colour changes.

These might seem like a simple set of requirements for slicer software, and indeed they are. But not all software allows all these.

When you run the RepRapPro slicer software it opens these two windows. The one on the left is a console that allows you to set up objects to be printed and to slice them. The one on the right is a 3D view of the base of the RepRap machine onto which you can load STL files of the parts that you want to make, and then position them where you want the machine to make them.

The software is on Github here. There are installation instructions on that page.

NOTE: If, when you run the RRP Slicer, you get a blank window, you have probably installed the Slicer in a folder with spaces in any of the folder names in the path where you put the download. Replace them with the underscore. Unfortunately, this is a Java-related problem, and effects Windows and Ubuntu. For example, if you want to install into:

C:\Some Folder\MySubFolder\My Other Folder

change the names to:

C:\Some_Folder\MySubFolder\My_Other_Folder

You will also need to delete the invisible configuration folder '.reprap', which is in your user 'home' folder (the one that contains 'My Documents' and 'My Pictures' etc).

Loading things to print, then saving them as G-Codes

The Load RFO Button

Typically you start by clicking on the blue "Load RFO" button. This will put up a file-selector window, which you can use to find and select the RFO file that represents the things that you want to build.

The things will be loaded onto the bed wherever they were saved.

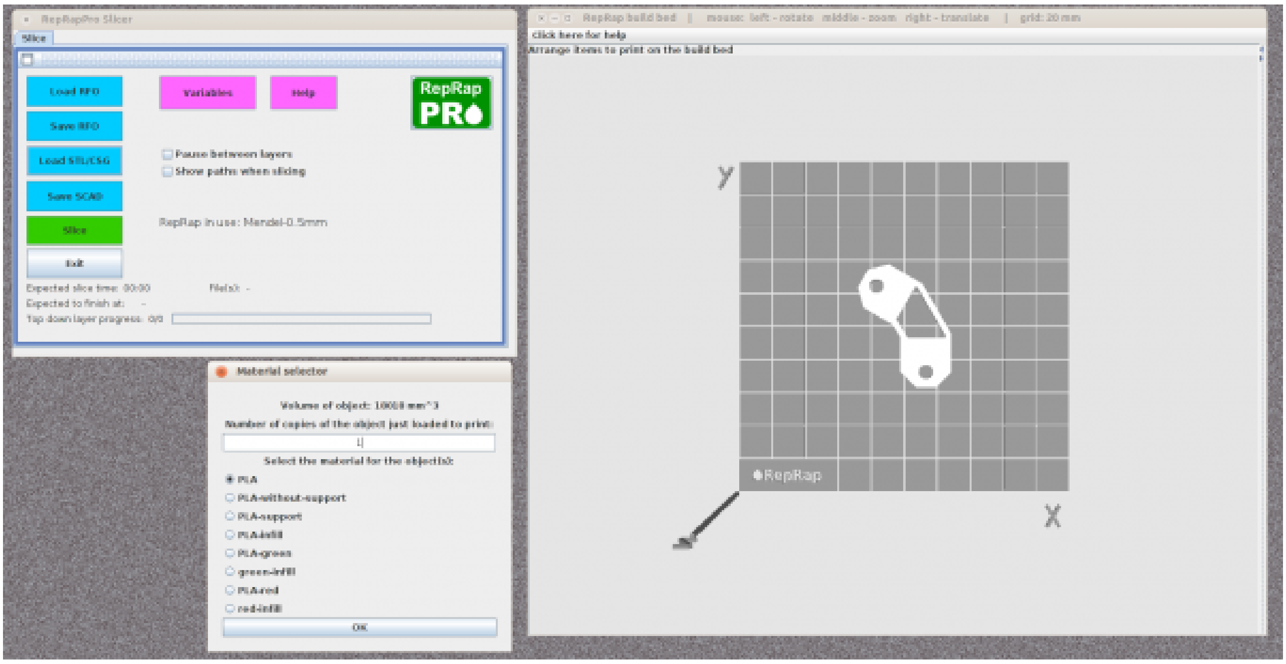
You can rotate the view of the RepRap machine's base in the right-hand window with the left mouse button. The middle button zooms the view, and the right button slides it sideways or up and down.

See here for details of RFO files.

The Save RFO Button

This allows you to save the entire arrangement that you have created on the build bed for use later.

The Load STL/CSG Button



To load up just one STL-file object of one colour, use the "Load STL/CSG" button. This will put up a file-selector window, which you can use to find and select the STL file that represents the thing that you want to build (CSG will be discussed in a moment).

The thing will be loaded at the centre of the bed. A pop-up window (shown) will appear for you to select how many copies of the thing to make, and what extruder to use to make them. Select the extruder you want for the surface of the object. (Relating infill and support extruders to surface extruders is described below.)

As supplied, the software has eight materials selectable. But some of these are actually just different rules for how to treat the same material. Usually you will want to select one of:

1. PLA - this is for an object that you want to make with PLA in the first extruder in the machine.
2. PLA-without-support - as above, but no support material will be laid down for overhangs in this object.
3. PLA-green - the second extruder's material.
4. PLA-red - the third extruder's material.

We will probably change these names to better ones later (this is in Beta...).

The pop-up window allows you to set the number of copies of the object that you want to build. It also tells you the volume of the object (which will generally be more than the volume of the material that you will use to print it, unless you use 100% infill, which is possible but not recommended).

Using CSG

In addition, the RepRapPro slicing software allows you to bypass the STL format for generating prints, and use more robust CSG files from OpenSCAD directly instead. This is handled completely automatically once you have generated the appropriate CSG file.

To do that, design (or download someone else's published design for) a model to be printed in OpenSCAD. Export the model from OpenSCAD as an STL file in the usual way (Design->Export as STL...). Call it, say, **my_model.stl**. In addition, export the CSG representation of the model (Design->Export as CSG) to a file called **my_model.csg** *in the same folder as the STL file you saved*. (In older versions of OpenSCAD you have to select Design->Display-CSG-tree..., then copy and paste all the text in the window that pops up into the file **my_model.csg**.)

When you then load the STL file into the RepRapPro Slicer software as described immediately above, the CSG file will also automatically be found and loaded too. The software will then use the STL file just to render its picture of the object on the build tray. However, all the slicing, outlining, and infilling code that actually prints the model will work directly with the CSG representation and won't use the STL data at all. This is both faster and much more reliable than using STL files to print with.

You don't have to use CSG. The software will work just with STL files alone. But CSG is an extra option.

So far the supported OpenSCAD primitives are cubes, cylinders (including frustums and cones), and spheres. We will soon add extruded polygons, extruded imported DXFs, polyhedra, and imported STL files (in that order, which is also the order of difficulty of doing it...). Note that the final one of those will implicitly (there's a mathematical joke there somewhere) allow any STL file to be converted to CSG.

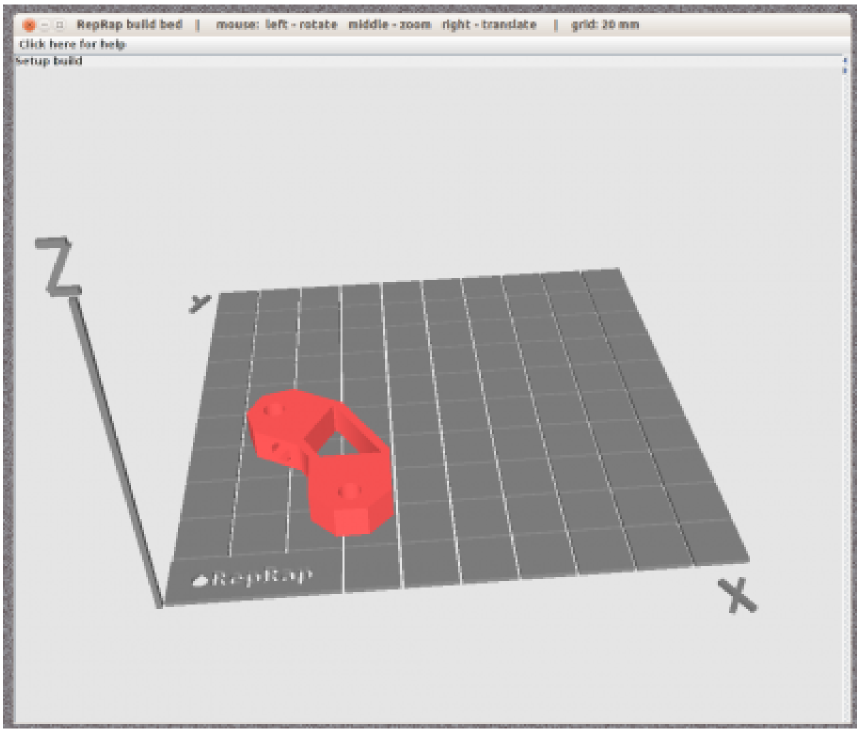
Variables

This button opens another window that allows you to edit all the many variables that control the production of 3D prints. See this page for a complete list of them and a description of what they all do.

Help

This button opens a web browser and displays this documentation.

Putting things where you want

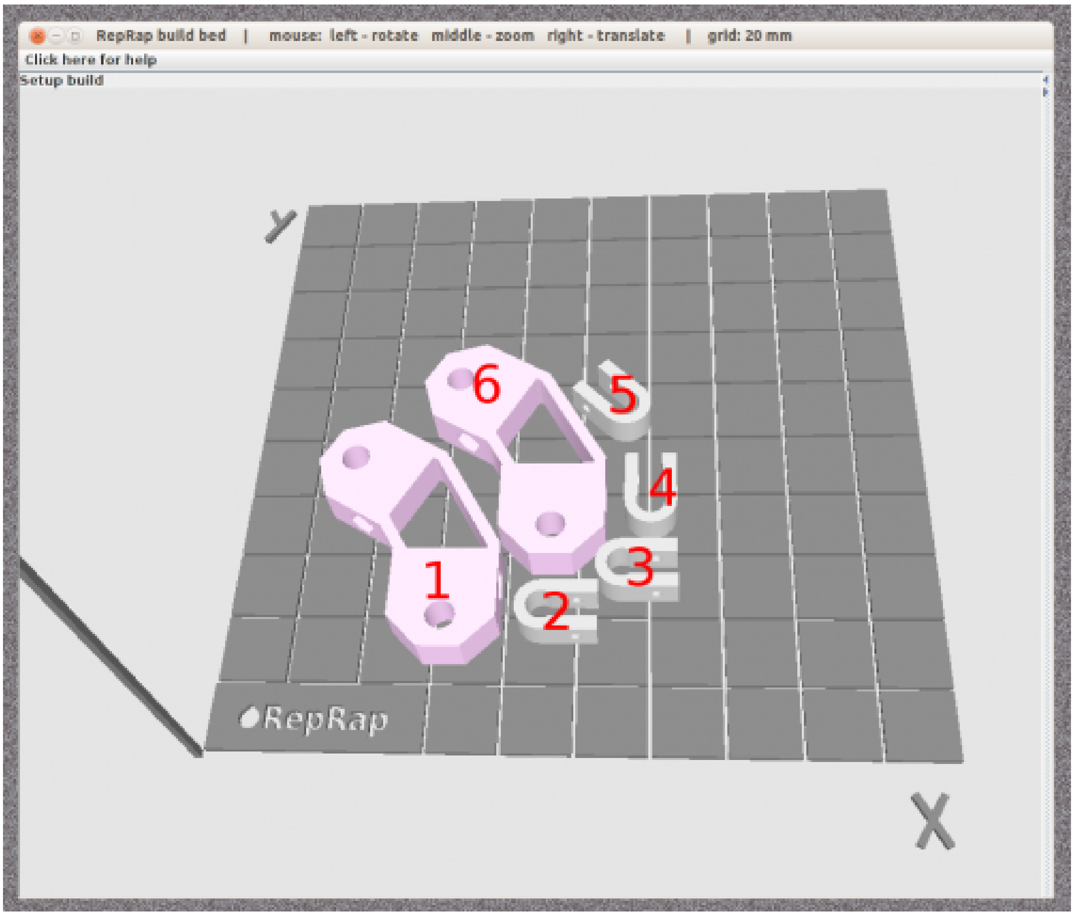


You may not want to build the parts where they are loaded. If you point at a part with the mouse and left-click, it will change colour, indicating that it has been selected. You can then slide it about the base with the right mouse button to the position you want to build it in. The grid squares on the green base have 20 mm sides. You can rotate the selected object in 90^o clicks about the X and Y coordinate axes by X and Y. Z rotation is done by Z, which rotates in 45^o increments around Z. If your STL file was in inches you can scale the selected object to millimeters by multiplying by 25.4 with I. To delete the selected object use the key.

To see more options, including much finer Z rotation, click on the "Click here for help" tab.

To release the selected object, left-mouse-click on any other part of the grey base. You will then be able to use the mouse to zoom, rotate and slide everything as one again.

Printing more than one thing at once



You can load several STL files to build at once, either of different objects, or multiple copies of the same object. Just click on the blue "Load STL" button again, then position them in different places. Leave a gap of about two or three millimetres between different objects to be built. Make sure that previously-loaded objects are not selected when you load a new one (loading new objects attached to previous ones is a special feature for printing in multiple materials that is described below). If you are building a small object and a large object with a hole, and the smaller fits inside the larger, then doing that to save space is a good idea. Make sure they don't touch (look straight down from above).

By default parts are printed in the order in which you load them. But when you have multiple parts loaded it is sometimes hard to remember what that order is. If you select one of the parts, typing N (next) will show you the next in the printing order. The sequence cycles: when you get to the last one, it moves on to the first. If no part is selected, N selects the first to be built.

If you want to reorder the build sequence, type R (reorder). Then select the parts in turn with the mouse in the order that you want them built. The system will highlight them as you go along so you can remember what you've done. When you select the penultimate part it, then the ultimate part, are automatically added to the new order and the highlighting is reset. You can use N to check your new order.

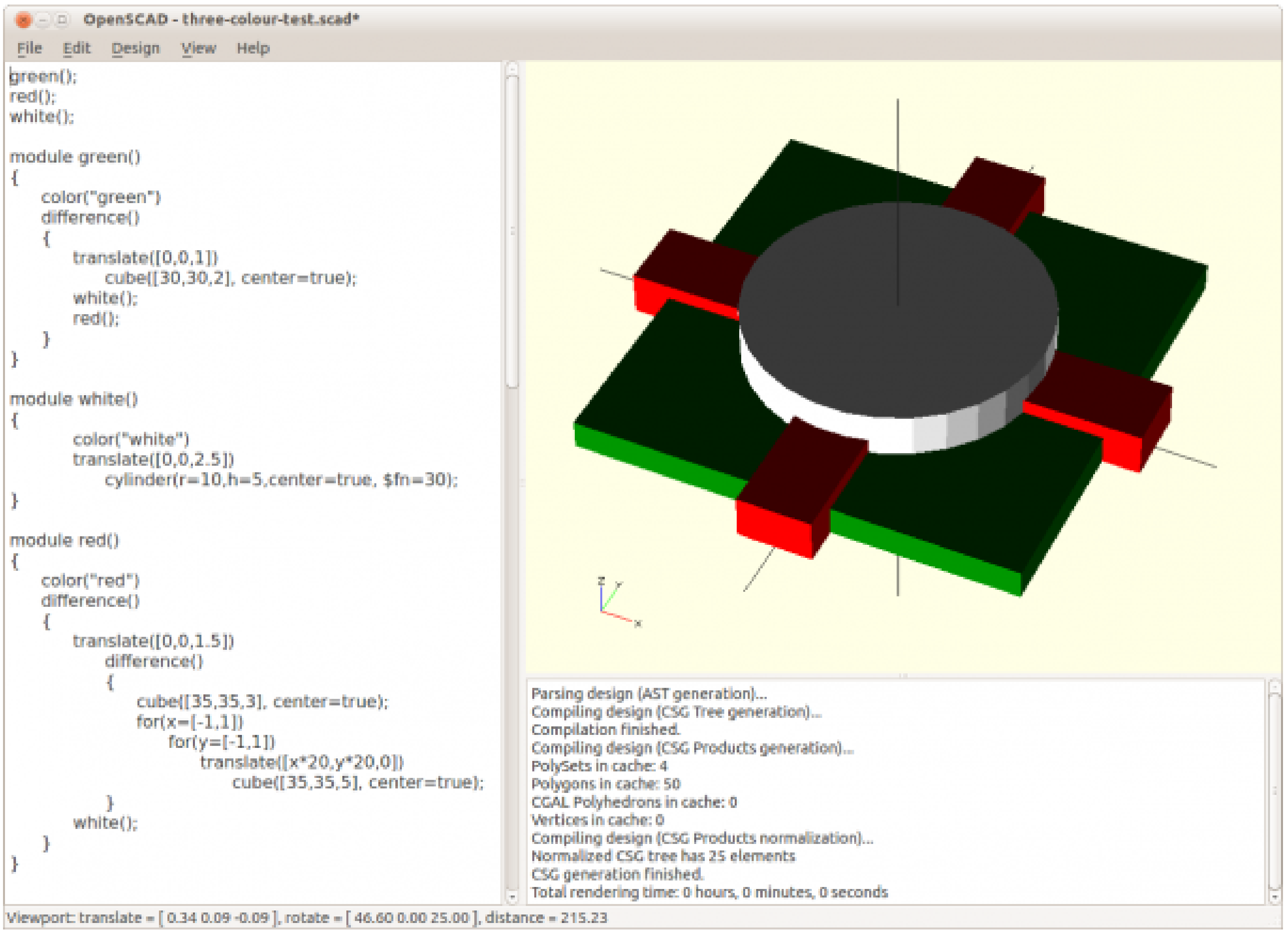
The picture on the right shows a reasonable ordering, though it would probably be better if all the parts were nearer the middle of the bed. Put parts close to other parts of roughly the same height. Generate an order so that there are no long moves between parts. If you do all the low parts together (order numbers 2 through 5 here) when they are finished the machine will simply move straight from Part 1 to Part 6. Try to end the ordering with the last part near to the first part.

You can also load one or more RFO files with the "Load RFO" button, select individual parts in them, move them about, or delete them, and add extra STL files. You can then save the whole arrangement as a new (or the same) RFO file.

Finally, you can change the material that a part is made from by selecting it then typing M (material). A material selector will come up to allow you to specify a different material. (The selector is the same as the one that you used to specify material when the part was loaded, but with the number-of-copies option disabled.)

If you have several STL files loaded in a pattern that you may want to use again, you can save the whole lot by selecting the "Save RFO" button. Any CSG files that you are using will be saved in the RFO file as well, and will be re-acquired automatically when you re-load it.

Printing things made from more than one material



This example of how to print multiple colours uses OpenSCAD, but any CAD system that saves its STL files in the correct location in the 3D space in which they were designed will do just as well.

This picture shows three interlocking but separate shapes designed as a test piece.

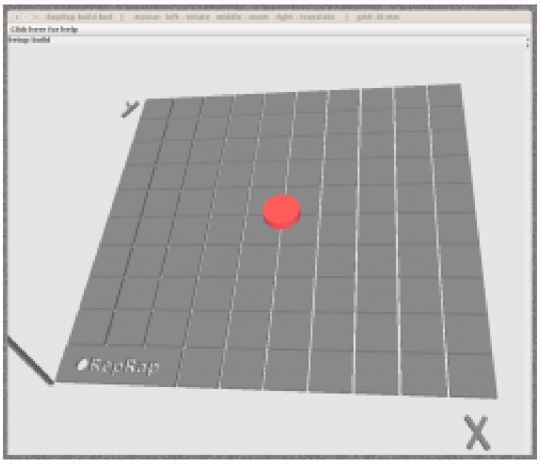
Here is the OpenSCAD program:

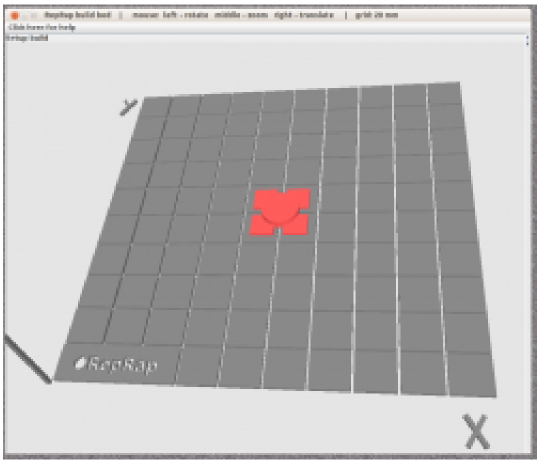
```
green();  red();  white();    module green()  {   color("green")   difference()   {    translate([0,0,1])     cube([30,30,2], center=true);
   white();    red();    }  }    module white()  {    color("white")
 translate([0,0,2.5])     cylinder(r=10,h=5,center=true, $fn=30);  }
  module red()  {   color("red")   difference()   {    translate([0,0,1.5])     difference()     {      cube([35,35,3], center=true);      for(x=[-1,1])       for(y=[-1,1])        translate([x*20,y*20,0])
   cube([35,35,5], center=true);     }    white();    }  }
```

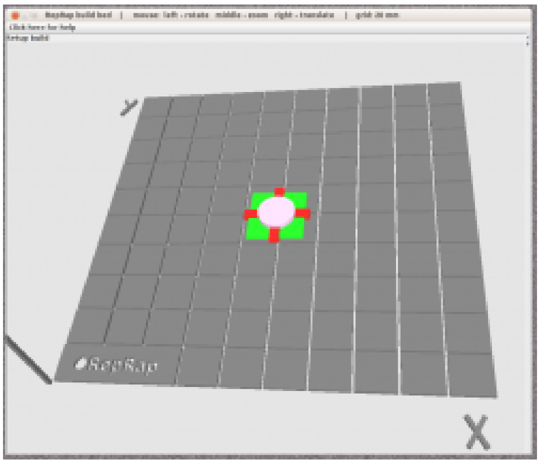
Save the three separate coloured components as three STL (and CSG as well if you want) files by commenting out the two unwanted colours:

```
//green();  //red();  white();
```

then evaluating and saving just the one object (white(); in this instance) as, say, **white.stl**.







Then load the STL of the shape that is the base or reference object into the RepRapPro slicing program - here we have made that reference object the central white cylinder. Make sure to use a part of the multi-material object that you are building that will be on the build-base as a reference object. Don't use one that will be in mid air. Choose the material to make the reference object from, then select it (so it changes colour to selected, as in the left-hand picture) and leave it at the centre where it was loaded (though you can move it if you want).

Then load the second STL for the second shape (green.stl, say) and choose its material. It will be positioned in the correct (*i.e.* designed) position relative to the first, and they will both be locked together in this relative positioning. Leave both objects selected (and therefore coloured as in the middle picture).

Finally load the red STL, then click on the grey base to deselect the resulting composite object (right picture).

If you select the base shape (white in this instance), you can then move the composite object about the build base as one thing to the position where you want to build it. Remember that all the print heads have to reach the coloured parts of your print, so put it near the middle.

If you save one or more of these combined objects as an RFO file, they will be re-loaded in the correct orientation and position when you subsequently read that file in.

Infill and support

Obviously, to print in multiple colours, the RepRapPro slicing software is capable of dealing with multiple physical extruders depositing multiple materials. In addition, one physical material may have several logical extruders associated with it. These logical extruders can have different parameters associated with them, so that, for example, one might be used to extrude material-A finely for the surfaces of a part to be printed, another might be used to extrude material-A coarsely for quick solid infill of the part, and a third might extrude material-A in a deliberately weak pattern to form a support for overhangs that can easily be broken away. Alternatively, you can outline in material-A, infill in material-B and support with material-C.

You can change all the many parameters of each extruder by clicking on "Variables".

In the variables for each extruder are fields containing the names of two other extruders: InFillMaterialType(name) and SupportMaterialType(name). These are the extruders to use to build infill pattens and support patterns respectively for the material for the extruder that names them. See the description of variables for full details. To turn infill or support off for a particular material, change the appropriate material field to be called "null" (without the quotes).

Microlayering

The RepRapPro Slicer software allows you to set different layer heights for different extruders (which may correspond to different materials, or different settings for the same material). This allows you, for example, to outline an object with a very fine layer height (thus reducing the staircase effect on surfaces and producing much smoother vertical faces) whilst infilling with a much coarser height, thus working faster.

To use this start by getting the machine working well with all extruders set to have the same height. Choose a height that is easy to subdivide (such as 0.24 mm or 0.36mm) rather than one that isn't (such as 0.25 mm). 24 and 36 have many more prime factors than 25.

Then, to plot outlines as fine layers, select the default outline materials (PLA or PLA-no-support) from the Variables Menu, and set their layer heights to the value you want - say 0.12 mm.

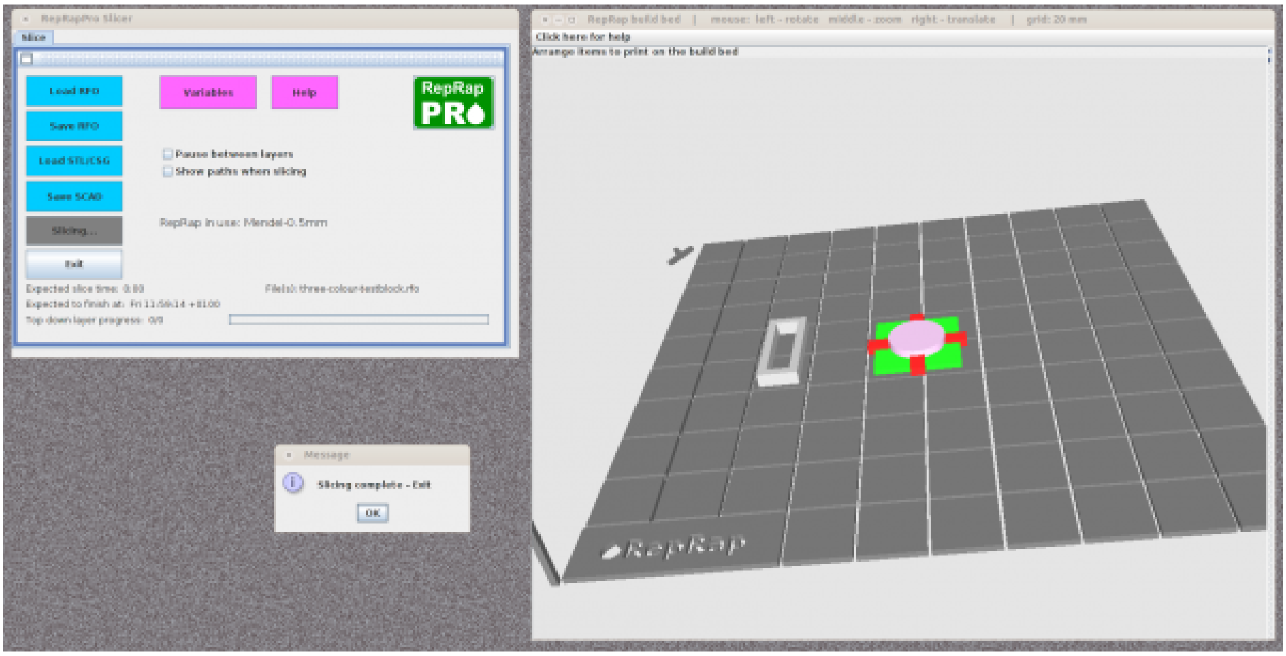
That is one-half the height you used to get the machine working (0.24mm). This will also extrude one half the material for a given distance than it did before.

Finally, you may want to increase the value of Extruder0_SurfaceLayers(0..N). This will ensure that upward and downward facing surfaces get finely infilled to a sufficient depth to give a good result.

You must always set extruder heights to simple integer multiples of each other. Thus if the thickest material is 0.24mm thick, others can be 0.01, 0.02, 0.03, 0.04, 0.06, 0.08, 0.12 and (of course) 0.24mm thick.

In practice, you will find that some objects won't print well with a layer height much less than 0.1mm because so little material is coming out of the nozzle for that that the bridging of overhangs and gaps between the print on the layer below.

Sending the G-Codes to a file



Before you generate a GCode file to send to your RepRap, you must first save the layout of parts on the bed with the "Save RFO" button if you want to keep it. The software will prompt you to do this.

When you are happy with the layout select "Slice". This will put up another file-selector window to allow you to specify the G-Code file that you want to save the results in.

If you wish, before selecting "Slice" you can select "Show paths when slicing". This will open a graphics window that will show the paths that the machine will follow to make each Z-slice of the objects being printed.

You can also select "Pause between layers". This pauses the generation of output at the end of each layer to allow you to inspect the slice pattern. Then Continue/Cancel buttons will be displayed as each layer is about to be written to allow you to continue or to cancel the whole process.

If you have debugging turned on (See Variables) then comments will be written into the GCode file saying what each line does. That will more-or-less double the size of the file. If you turn debugging off you will get almost no comments: a couple of header comments will be written into the file saying when it was computed and how big the object being printed is, and a comment line will be written at the start of each new layer to track that.

When the GCode file has been written, the program will exit. The picture on the right shows this about to happen (when the OK button is clicked).

But, you ask, what is that mysterious extra white rectangle that is on the left? This is the shield that can be automatically added to multi-material prints to give the machine somewhere to purge and clean the nozzles between material changes. It is built along with the print (so it is always the same height), and the well in the middle is used to purge the nozzles to prevent ooze from the wrong nozzle getting on your print. Details are here.

To print your GCode file that you just generated on your RepRap machine, see this page.

Saving as an OpenSCAD file

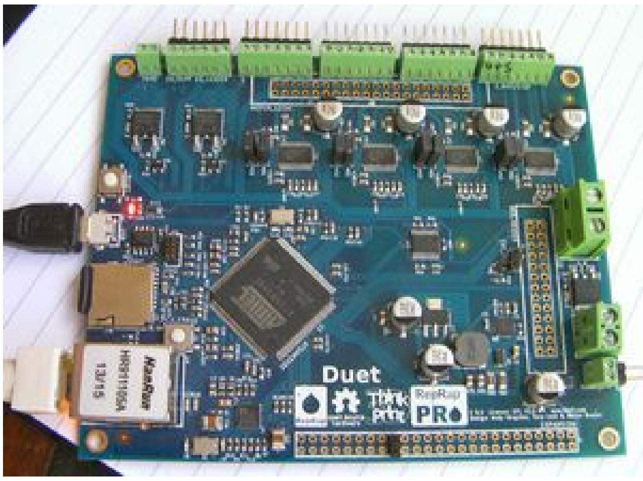
The "Save SCAD" button allows you to save the set of parts you've laid out on the tray as an OpenSCAD model.

It prompts you to specify a directory. All the STL files you have on the tray are copied into that, then the software creates an OpenSCAD program in that directory that moves the STLs to the right place and takes their set union. That is to say, the entire tray is then a single OpenSCAD object, which you can, for example, then write out as a single STL file.

Note that this will not preserve colour/material information.

Maintenance

RepRapPro Firmware



RepRap Firmware was written to allow RepRap machines (and other 3D printers) to be driven by more powerful controllers, such as the Arduino Due-compatible RepRap Duet (illustrated above). It permits the RepRap machine to be controlled either using a traditional USB connection with software such as Pronterface, or over a network. To control the RepRap machine over a network all that is needed is a web browser. These instructions describe how to use the RepRap Firmware on the Duet.

RepRap Firmware is available on Github here. Select the master branch, then use the Download Zip button (with the little cloud and arrow) on that page to download it. The master branch is the stable branch for the duet. The duet branch is also for the duet, but is the development branch for that board. You can use the duet branch if you wish - it will be more up-to-date and have more features; but it may also contain unfixed bugs.

Installation - Flashing the Firmware

Your Duet will have been supplied with a copy of the RepRap Firmware installed. But upgrades and enhancements will be made available regularly, and you will want to upload or *flash* these to your Duet.

Check your firmware version

Connect to your Duet board via the Arduino IDE Serial Monitor, or Pronterface, and send the

'M115' gcode. The response should be something like:

FIRMWARE_NAME:RepRapFirmware FIRMWARE_VERSION:0.39 ELECTRONICS:Duet DATE:2013-12-14

If the response is:

Error: invalid M Code: M115

You have an old version of the firmware, and should definitely update!

Compare the firmware version information from the M115 command above, with the file name of the file in this link, which is on our github page. But DO NOT DOWNLOAD THIS FILE DIRECTLY! This file is the latest binary image of the RepRap Firmware for the Duet. The name of the firmware reflects the version number, eg **RepRapFirmware-XXX-DD-MM-YYYY.bin**, where XXX is the version, and DD-MM-YYYY is the date of the firmware.

If your firmware version is the same as the github version, there is no need to update. If not, read on...

Download the latest firmware

In the RepRap Firmware folder that you downloaded in the Commissioning instructions, there is a folder called **Release**.

If the version on our github page is newer, download the WHOLE firmware folder from Github; click **Download ZIP**, on the right hand side of THIS PAGE. Extract it to a sensible place on your computer.

Required Software

You will need a copy of the Arduino IDE for the Arduino Due microcontroller. You should have already downloaded this, earlier in the commissioning instructions. It is available for download here: http://arduino.cc/en/Main/Software. Download and install from the link appropriate to your computer and operating system.

Once installed, in the Arduino application folders there is an application called **bossac**. This is the program that flashes firmware to the Duet (or Arduino Due).

On a Windows system, the Ardiuno IDE is installed in **C:\Program Files (x86)\Arduino-1.5.5** (or something similar). The **bossac.exe** program will be in **C:\Program Files (x86)\Arduino-1.5.5\hardware\tools**

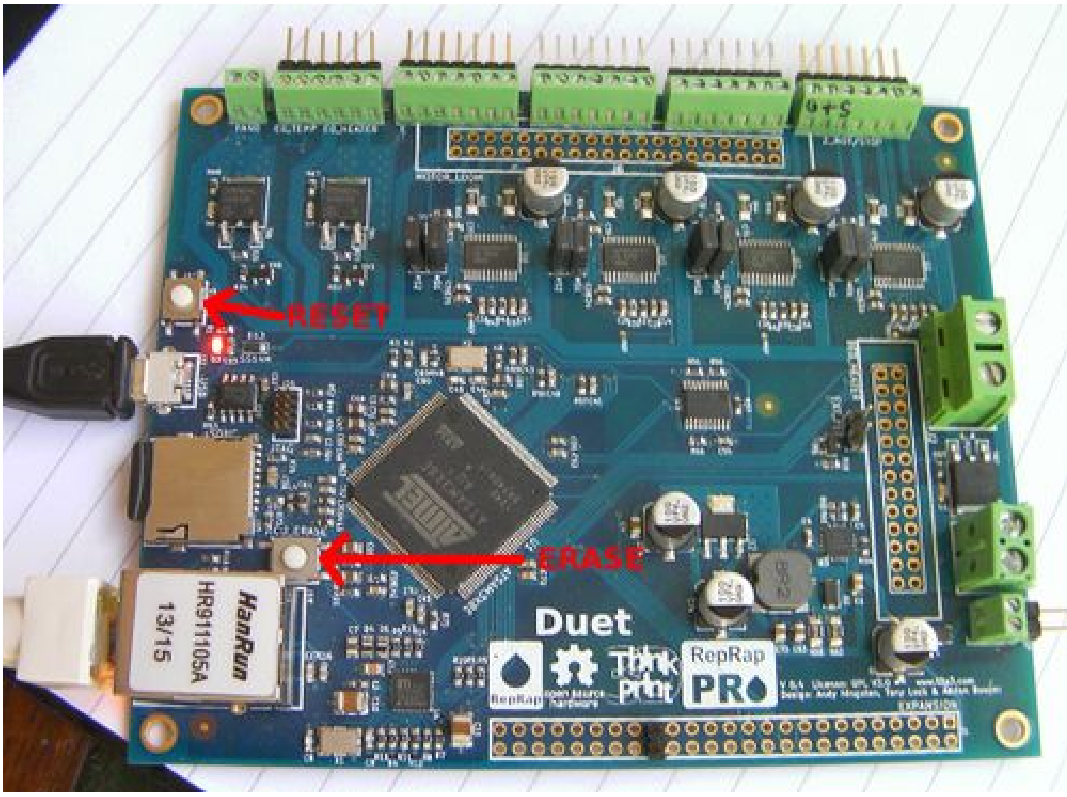
On a Linux system, you might install the Arduino IDE in **/usr/local/arduino-1.5.5/**. The **bossac** program will then be in **/usr/local/arduino-1.5.5/hardware/tools/**

On a Mac, bossac is part of the Arduino application package; install the Arduino application in your Applications folder.

Updating the firmware

Leave the main power to your RepRap off, and connect the Duet to your computer with a USB cable. Make sure that the Arduino IDE Serial Monitor or Pronterface are NOT connected to the Duet board.

Press the ERASE button on the Duet. Then press the RESET button.



Wait at least 10 seconds for the Duet board to start up.

Windows

Find out which USB port on your computer the Duet has been allocated. On Windows it will be something like **COM4:** - you can check this by looking in the Device Manager (how to). The Duet may be listed as an 'Arduino Due', or 'bossac programming device', in the list of USB devices.

It will be easier if you copy 'bossac.exe' (from the Arduino\hardware\tools\ folder) and the **RepRapFirmware-XXX-DD-MM-YYYY.bin** file to a simple C:\Temp\ folder.

Open a Command prompt (How to), then type (without quotes) 'cd C:\Temp\' and press return to change directory (or change directory to wherever you put bossac and the firmware). Assuming the port for the Duet is COM4 (change this to what is reported by the Device Manager), the command entered into the Command Prompt window will look like:

```
  bossac --port=COM4 -U true -e -w -v -b RepRapFirmware-XXX-DD-MM-YYYY.bin -R
```

Send the command. You should see bossac report the upload/flash progress then tell you that it has verified the process.

If it doesn't work, press 'erase' and 'reset' again, and wait a little longer. The system does take a while to stabilise after the ERASE button has been pressed. If you get a 'no device found' error, check the COM port number in the Device Manager again, in case it has been reassigned.

Mac

Find out which port on your computer the USB has been allocated. Get the port address from system profiler, or send 'ls /dev/cu.*' in a Terminal window for a list of ports; it will be something like **cu.usbmodemfa131**.

Open a Terminal window (how to), cd (change directory) to the folder where you have put **RepRapFirmware-XXX-DD-MM-YYYY.bin**. Assuming the Arduino application is in the Applications folder, the command will be similar to:

```
/Applications/Arduino.app/Contents/Resources/Java/hardware/tools/bossac --port=cu.usbmodemfa131 -U true -e -w -v -b RepRapFirmware-XXX-DD-MM-YYYY.bin -R
```

Send the command. You should see bossac report the upload/flash progress then tell you that it has verified the process.

If it doesn't work, press 'erase' and 'reset' again, and wait a little longer. The system does take a while to stabilise after the ERASE button has been pressed.

Linux

Find out which port on your computer the USB has been allocated. This will be something like **/dev/ttyACM0**. Open a terminal windows (xterm, gnome-terminal etc.) and cd (change directory) to the folder where you put **RepRapFirmware-XXX-DD-MM-YYYY.bin**. Assuming arduino is installed in /usr/local/ :

```
/usr/local/arduino-1.5.5/hardware/tools/bossac --port=ttyACM0 -U true
-e -w -v -b RepRapFirmware-XXX-DD-MM-YYYY.bin -R
```

Send the command. You should see bossac report the upload/flash progress then tell you that it has verified the process.

If it doesn't work, press 'erase' and 'reset' again, and wait a little longer. The system does take a while to stabilise after the ERASE button has been pressed. Check the port number again, in case it has been reassigned.

Update the SD Card files

IMPORTANT: Finally, you need to keep the files on the SD card ON THE SAME VERSION as the firmware you just updated to. Copy the contents of the **SD-Image** folder from firmware folder (the .zip file you downloaded) to the root of your SD Card, as you did in the Commissioning instructions. If you have created a custom config.g or setbed.g file on your SD Card, copy them off the card first, then replace them after you have updated the contents of the SD Card.

SD Files

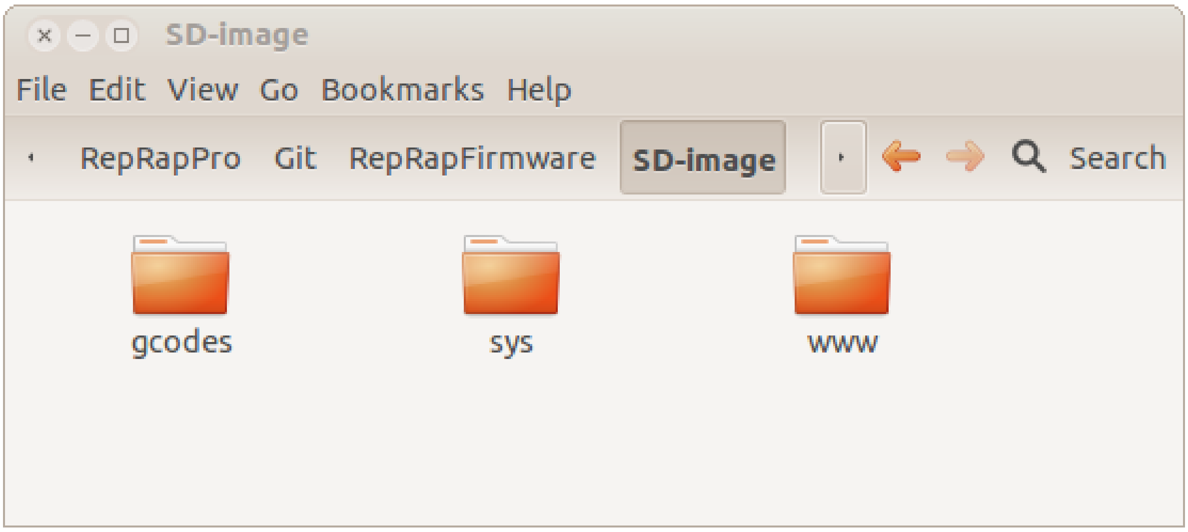
The Duet needs to store RepRap Firmware configuration files on an micro SD card. It needs those files to be present all the time that the firmware is running, so **don't unplug the SD card while power is applied**, either from the RepRap's main power supply, or just from the USB.

Your Duet should have been supplied with a micro SD card. You will need to copy the configuration files to this. You will also need to set your network addresses in the configuration files, if you plan to access the printer via the ethernet port.

Take the SD card, put it in a computer adapter, and plug it into your computer.

Download the RepRap Firmware files from the Git repository here. Use the Download Zip button (with the little cloud and arrow) on that page to download all the files.

There is a folder in the Github repository you downloaded called **SD-Image**. It has three sub-folders:



You can put any GCode files you want to print in the **gcodes** folder. For the moment file names are restricted to [8.3 format](). This restriction will be removed in a future upgrade.

Remove any old versions of these folders from the SD card, then copy the **gcodes**, **sys**, and **www** folders onto it.

In the **sys** folder on the SD card there is a file called **config.g**. This special G Code file is run whenever the RepRap Firmware is restarted. It is described in detail below. For the moment you just need to set appropriate values in it for your network. Open a text editor (such as gedit or Notepad) and read in the file **config.g**. Near the top are three lines like this:

```
M552 P192.168.1.14; Set the IP address  M553 P255.255.255.0; Set netma
sk  M554 P192.168.1.1; Set the gateway
```

Change the numbers after the capital letter "P" to the values for your network. If you don't know these, your network administrator will be able to tell you. Save the edited file.

Unmount or eject the SD card and its adapter from your computer. If it asks you if you want to erase any deleted files, say yes.

Put the SD card in your Duet's SD card slot. It has a bistable click action - push it in and it will click in. To get it out, push it again and it will spring out. A short length of RepRap 1.75mm diameter filament makes a good tool to push with.

The configuration file

As has already been mentioned, RepRap Firmware can run a configuration file when it starts to set it and your RepRap up in the way you want. This is the file **config.g** in the **sys** folder on the SD card. This is an ordinary file of G Codes, but it is saved in a separate folder so that it can't be deleted by accident.

The contents of **config.g** will look something like this:

```
; RepRapPro Ormerod  ; Standard configuration G Codes  M111 S1; Debug
on  M550 POrmerod; Set the machine's name  M551 Preprap; Set the passw
ord  M552 P192.168.1.14; Set the IP address  M553 P255.255.255.0; Set
netmask  M554 P192.168.1.1; Set the gateway  M555 P2; Emulate Marlin U
SB output  M92 E420; Set extruder steps/mm  G21 ; Work in mm  G90 ; Ab
solute positioning  M83 ; Extrusions relative  G31 Z0.5 P500 ; Set Z p
robe height and threshold  M906 X800 Y800 Z800 E800 ; Motor currents (
mA)  T0 ; Select extruder 0
```

Anything including and after a ";" is a comment and will be ignored. As you can see you can give your machine any name you like, and any password. If you have several machines you can be talking to them with multiple tabs in a web browser, so giving them unique names obviosly helps to keep track. There is a complete list of all the RepRap G, M and T codes on the RepRap website here. RepRap Firmware does not (nor does it need to) implement them all, but if you send it one that is not implemented it will output a short error message on its USB connection, which you can see in the Pronterface monitor window.

You can edit **config.g** with an ordinary text editor (gedit, Notepad etc.), then upload it using Pronterface as described above.

Generally speaking, it is a bad idea to put anything in **config.g** that will cause the RepRap machine to move, or its heaters to heat up. This is because it will do this every time it is switched on or rebooted.. Moving and heating G Codes are much better put at the head of individual G Code files for printing things, as described here.

Other sys files

RepRapFirmware allows subprograms or *macros* to be programmed and placed in the **sys** folder. There are standard ones in there for doing things like homing the axes, but you can write your own too. Simply place a GCode file in the **sys** folder called, say, **mymacro.g**. You can then run it from Pronterface or the web interface or from within a GCode file by giving the command:

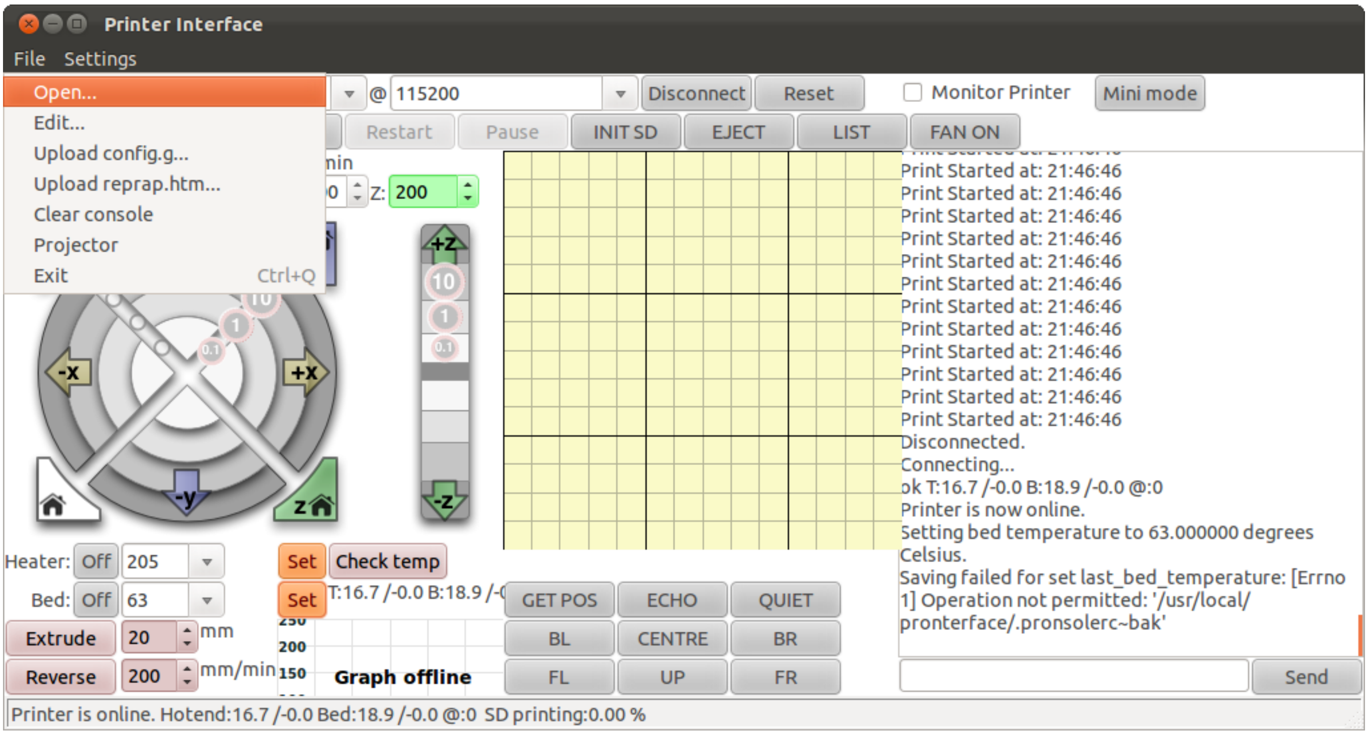
```
M98 Pmymacro.g
```

Macros can run macros from within them up to a depth of about 5 before you run out of stack. Recursion will give you an infinite loop, of course, and so is probably best avoided...

Here is the macro that homes the X axis as an example, with comments:

```
G91 ; set movements relative  G1 Z5 F200 ; move upwards 5mm at 200 mm/
min to make sure we don't hit anything  G90 ; set movements absolute
G1 X-240 F2000 S1 ; Move X a long way negative while checking the ends
top  G92 X0 ; The endstop will have been hit.  Set the X coordinate to
 0  G1 X3 F200 ; Move a little away from the endstop more slowly  G1 X
-30 S1 ; Approach the endstop more slowly to get a more accurate 0  G9
2 X0 ; Set the X coordiante to 0  G91 ; set movements relative  G1 Z-5
 F200 ; Go down 5mm to reset the upward movement at the beginning
```

Using Pronterface to Control your RepRap Firmware



One of the strengths of RepRap Firmware is that it has the ability to emulate other existing RepRap Firmware in the way that it outputs information to its USB interface. This makes it possible to use it with a variety of software intended for that other firmware. We often use Pronterface to talk to a Duet running RepRap Firmware.

Download our version of Pronterface and its associated software from github here. See the README.md file on that page for installation notes.

To use Pronterface you first need to set the Firmware output to emulate RepRap Marlin firmware - the firmware that Pronterface expects to talk to. This can be achieved by including the line

```
M555 P2
```

in the file **config.g** in the **sys** folder on the Duet's SD card. See the section on **config.g** below. This line may already be in the file; lots of distributions include it.

Connect the Duet to your computer with its USB cable, and also - if you can - connect the Duet's ethernet cable. When the RepRap Firmware reboots it tries several times to establish a network connection. If it can't find one, this can delay the boot process (sometimes by up to a minute). So if you plug in an ethernet cable (even if you don't intend to use it) this will speed things up.

Run Pronterface.

Select the USB port that your computer has allocated the Duet in Pronterface's Port box, select a communication speed of 115200, and click the **Connect** button.

You should now be able to control your RepRap/Duet from Pronterface in the usual way. This includes uploading files to the SD card for printing. If you do this, these files will also be available when you use the web interface described below.

Finally, there are two special additions to our distribution of Pronterface just for RepRap Firmware. You can see them in the File dropdown menu in the picture above. **Upload config.g...** allows you to upload a new version of the config.g file (see below) to your Duet without unplugging then plugging in the SD card. **Upload reprap.htm...** allows you to upload a new version of the web page that the RepRap firmware serves to the web interface described below. So - if you want to personalize the appearance of the web interface, go ahead. If you make a mess, you can always recover the original from the Github repository download.

Changes to these files will not come into operation until you next reboot your Duet.

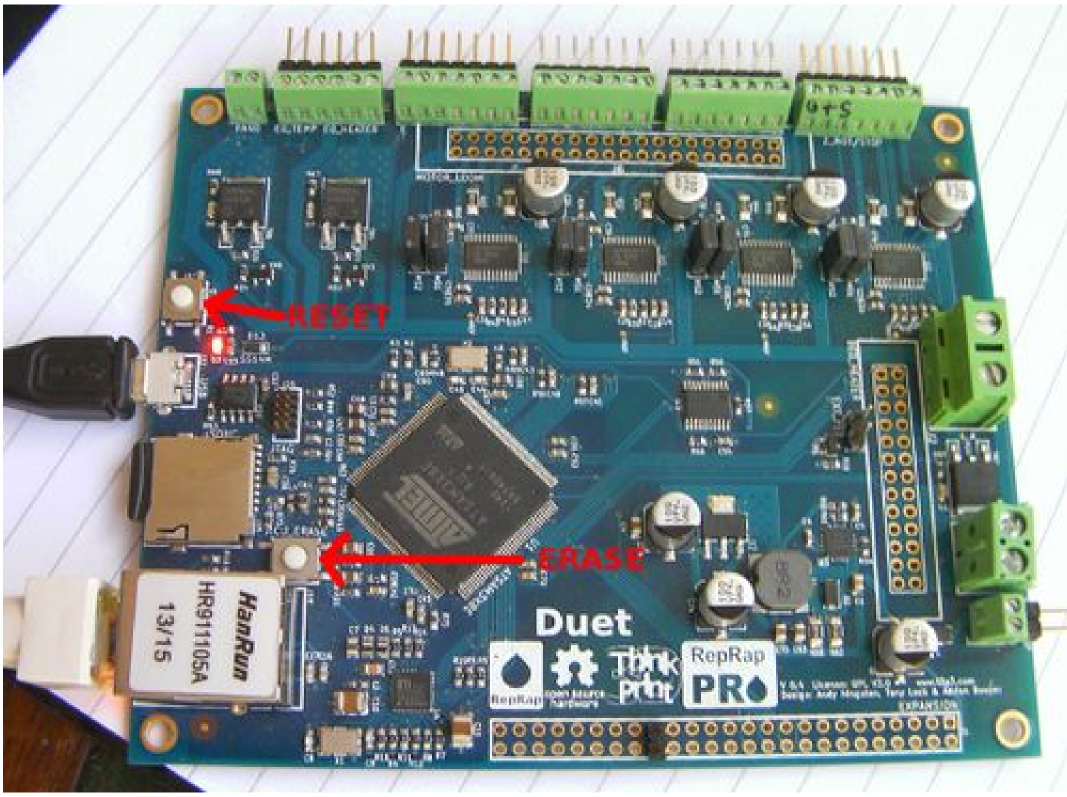
Using a Web Browser to Control your RepRap Firmware

At the moment the RepRap Firmware is configured to use the Google Chrome browser, which is available to download from that link. Other browsers will be supported soon.

Make sure that your network addresses in your Duet are set correctly - see the SD Files Section below.

Plug an RJ45 network cable into the socket on your Duet and plug the other end into your network hub or router.

Turn on the power to your RepRap. The green LED on the Duet's network socket should come on, go out briefly, and then come on again, and may flicker. The orange LED may come on, or not, depending on the router it is attached to. Don't worry about it if it doesn't come on.



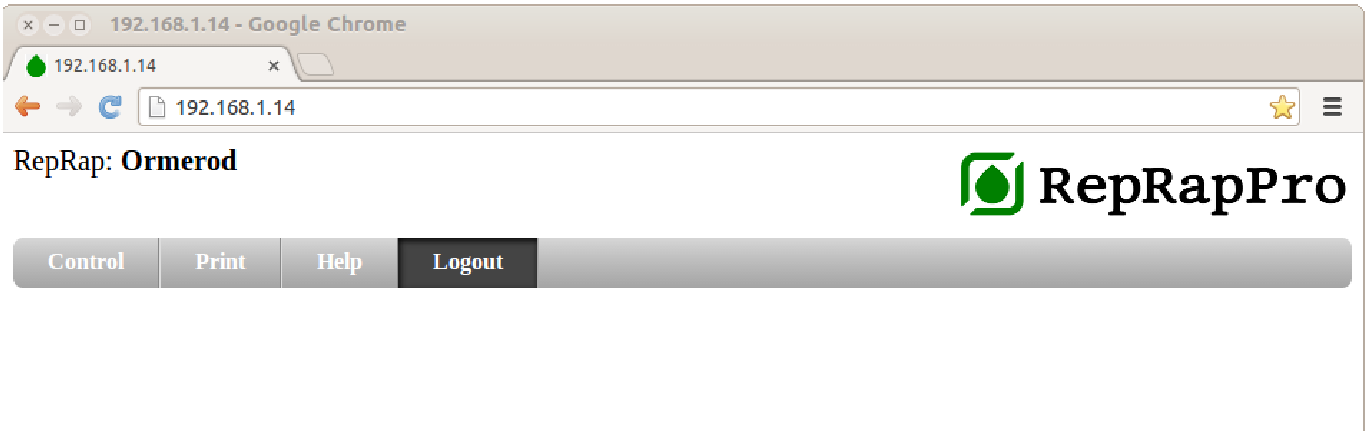
To double check, press the Duet's RESET button. The LEDs should go through the sequence above. Don't press the ERASE button by mistake. If you do, you will then have to re-flash the firmware (see below).

Give it a few moments to settle down.

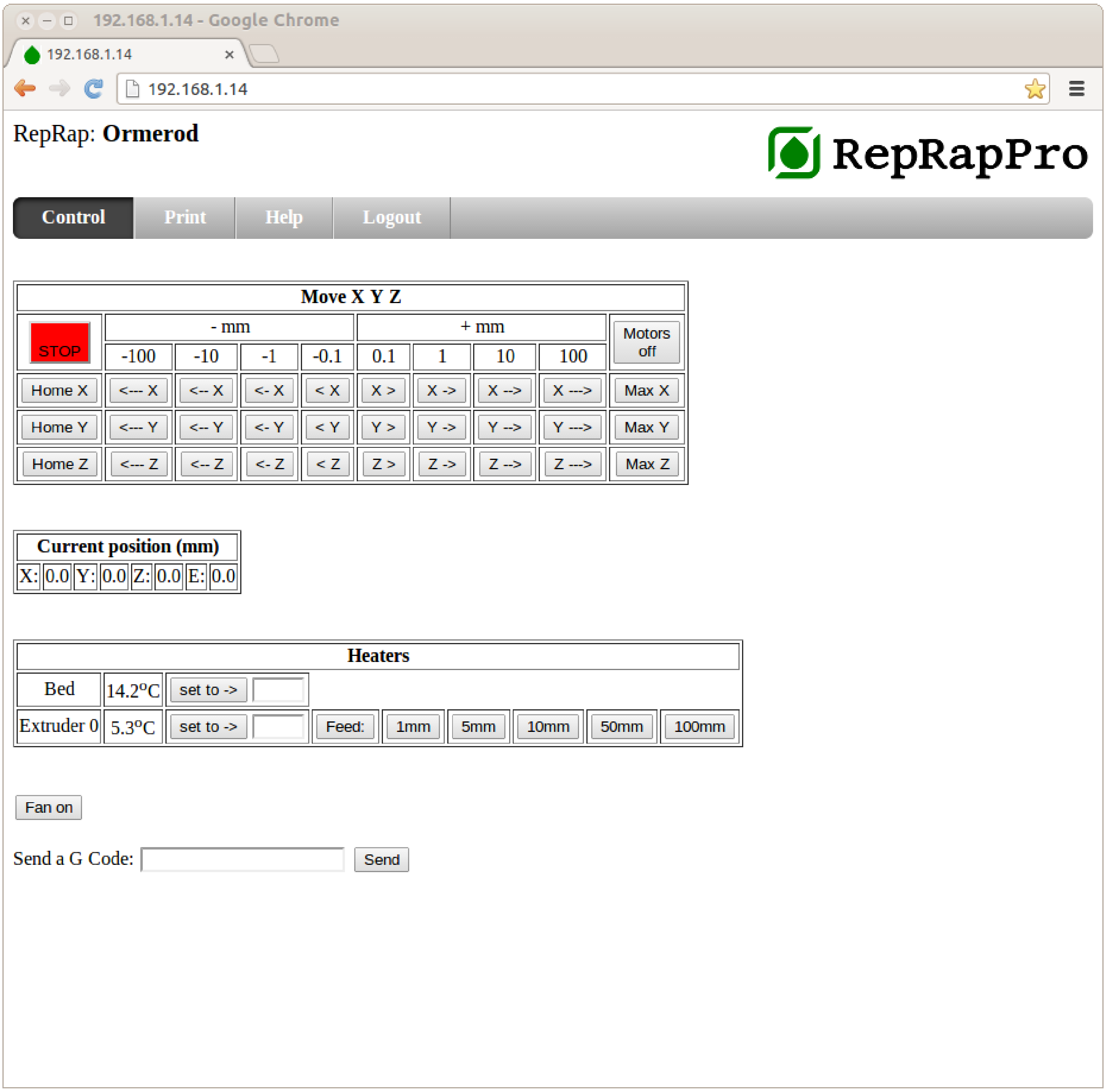
Open the browser on your computer, and type the IP address (see SD Files below) of the Duet into its address bar. The following page will be displayed:

If the machine's name is not displayed top left, then close the browser, press the RESET button, and try again.

The default password is "reprap" in lower case and without the quotes. Type that and click **Submit**. The page displayed will change to:



Click the **Control** link. You will now get:



The controls should be reasonably self-explanatory.

The **STOP** button is an emergency stop. It immediately stops all motors and turns off all heaters. After stopping the RepRap the only way to restart it is to press the Duet's reset button. It will continue to talk to the USB and ethernet interfaces after stopping, but you won't be able to move the machine automatically or turn on any heaters.

The **Move** box allows you to move the axes of the machine is small or large increments, and to home them to their zero positions.

The **Motors Off** button turns the motor currents off so you can move the RepRap by hand (especially useful for loading and unloading the extruder). There is no **Motors On** button - using a motor turns it on automatically.

The **Current Position** box displays where the RepRap is. These boxes are updated about once every two seconds. And the RepRap Firmware only updayes these values internally at the end of every move - they don't track the progress of each individual move.

The **Heaters** box displays the RepRap's temperatures (updated at the same time as the positions) and allows you to set them.

PLA printing temperatures: Extruder 200^{o}C, Heatbed 60^{o}C

ABS printing temperatures: Extruder 240^{o}C, Heatbed 110^{o}C (Don't touch!)

To turn a heater off set its temperature to 0.

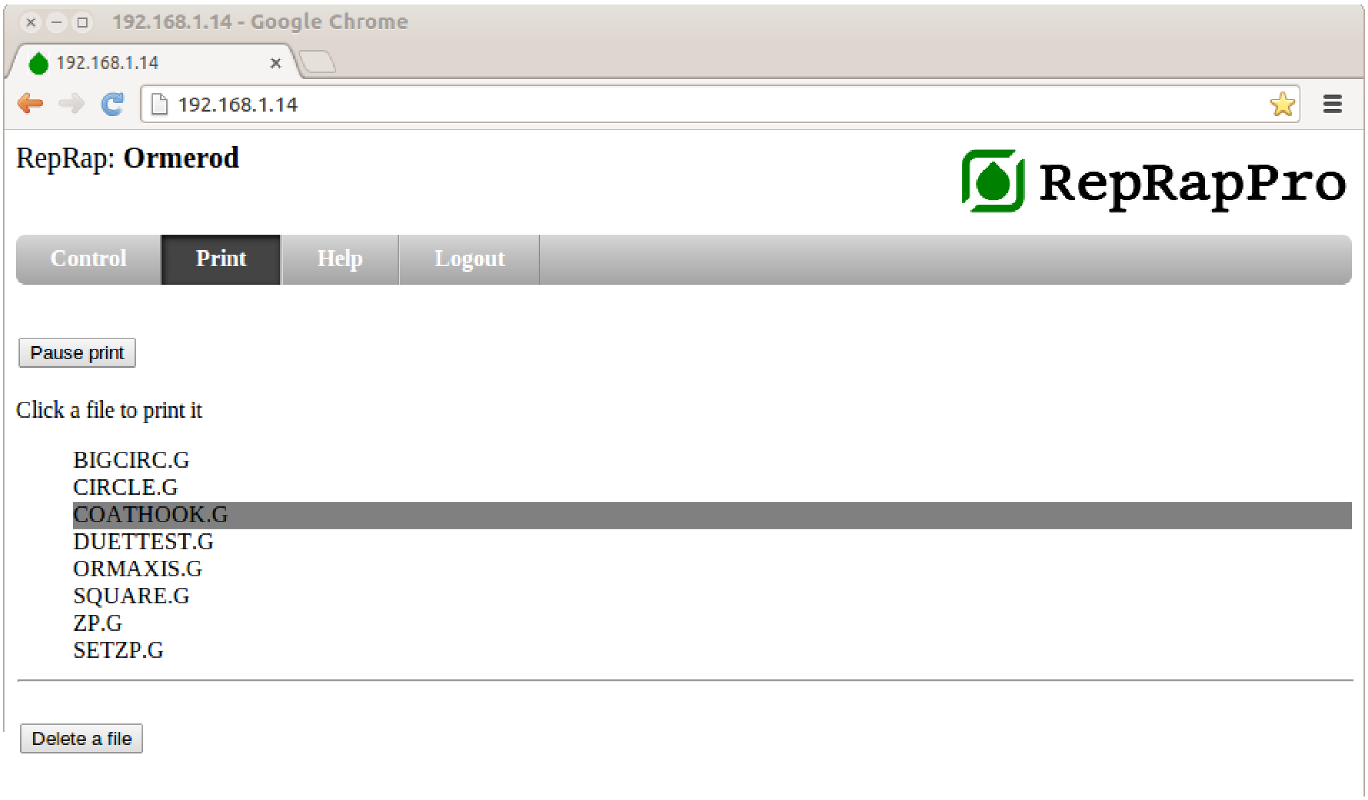
The **1mm**, **5mm** etc buttons after the **Feed** label extrude that input length of filament. **If the extruder isn't hot, don't move the filament -** it will be frozen in the nozzle and unable to move.

If you click on the Feed label it will cycle through **Feed**, **Fast**, and **Reverse**. **Fast** and **Reverse** are to allow you to load and unload filament quickly. Take care not to drive filament right into the RepRap's nozzle at **Fast** speed. Rotate back to **Feed** when it has 30 or 40 mm to go.

In RepRaps with a controlled fan the **Fan on** button turns it on and off.

Finally, there is a panel that allows you to type any G, M or T code then send it to the RepRap. For a list of RepRap G Codes (not all of which are, or need to be, implemented in RepRap Firmware), see here.

Next click on the **Print** link in the menu bar. You will get this page:



Though the list of G Code files may be different.

To print a file on your RepRap, simply click on it. The print will start immediately. If you press **Pause print** the print will continue for a few moves (RepRap Firmware has an internal print buffer that has to be exhausted) then pause.

You cannot use the other controls to the machine while a print is running, as this would spoil the print. But if you pause the print, then move to the control page you will be able to use the controls after the second or so that it takes the temperatures and positions to update (whether the machine is paused or not is also sent with that update signal). Note that a side effect of this is that the web page does not know that a print is finished until you move back to the control page. This will be fixed in a future release.

To delete a file, select the **Delete a file** button then click on the file you wish to delete. The display will not update immediately; to force it to do so, go to the **Control** page then come back again.

Troubleshooting

Duet problems

Duet hardware problems

There have been a couple of issues with the construction of the Duet board.

- The Duet boards that were supplied with the first 220 red RS kits have a mistake in manufacture, which means that a USB cable needs to be attached to the board to supply 5V to the board logic all the time. The mistake is the resistors that allow 12V power to be fed to the 5V power regulator are incorrectly mounted. These are R60 (3k92) and R61 (750R), near the JP9 (5V_EN) pins, which have been soldered to the board at 90 degrees to where they should be. These resistors are next to capacitor C5; if they are the same orientation as C5, they are the wrong way around. The Duet schematics are HERE. If you feel confident in your abilities to remove and replace SMT components, please feel free to try. Otherwise, contact support for a warranty board exchange.
- The first 800 boards did not have their USB sockets soldered correctly. Looking at the USB socket, it has 4 pins that go through the board. All four of these should be soldered, to support the USB socket. Boards had only two soldered, or none, so inserting the USB cable can cause the fine connections to the board to break. Please solder up all four contacts, if you feel it is within your ability. Please contact support if you have intermittent or no USB connection for a warranty board exchange.

Power problems

When power is applied to the board, you should see at least one LED light. With USB, it should be the one next to the USB socket. With ATX PSU power, it should be the on below this; this is the LED for the MOSFET that controls the FAN0 output. It is on by default. You may also get the Y endstop LED. When powered by ATX PSU and with the USB connected, you should get all three LEDs switched on.

Problem

- No light turns on next to the USB socket on the Duet, when Duet plugged into USB
- No light when jumper JP9 (5V_EN) is enabled, and ATX PSU is turned on
- No USB or COM port appears on PC
- Duet is listed as a USB or COM port, but can't connect

Test voltage

Test the voltage of the 12V, 5V and 3.3V. Test 12V at the large green screw terminals; using a multimeter, put the probes on the two screw terminals. If connected by USB, you will get 0V here, otherwise 12V. Test the 5V by using the probes between ground (the top of the SD Card holder is useful for this) and pin 1 of the expansion header, then 3.3V on pin 3 – these are the pins closest to the heated bed connection, just under the ‘SION’ of ‘EXPANSION’.

Solutions

1. If no light appears on the Duet next to the USB socket when plugged in via USB, check the cable, then check the USB socket. Some boards have loose sockets due to insufficient soldering of the socket, which may cause the board to get no power. See 'Duet hardware problems', above.
2. If the voltage is not as expected on 12V, 5V and 3.3V, contact support with your readings; your Duet board may have a fault with the 5V or 3.3V rectifier, or some other fault
3. If the voltage checks are correct, but no USB or COM port appears on your PC, check the USB socket soldering. It may be disconnected.

If a USB or COM port does appear on your PC, but you can't connect, this may be a hardware, firmware or software fault:

1. Hardware fault - the USB socket may be disconnected
2. Firmware fault - if you've tried flashing the firmware and the port still says 'bossac programming port', see below 'Firmware update problems'
3. Software fault - Particularly Windows 7 and 8, check the drivers have installed correctly , see below 'Check software installation'

Firmware update problems

Problem

- Can not update firmware
- After firmware update, Duet no longer visible
- Printer stops at the beginning of the print, even with the gcode supplied on the SD card

Solution

1. Check the instructions, and follow them carefully
2. If the 'bossac' command fails, make a note of the error, and contact support
3. If the error is to do with the port not being found, try sending the command without this part: '--port=COMxx -U true'
4. If the board is inaccessible following a firmware update, but then does reappear after the 'erase' and 'reset' buttons are pressed - we are testing a fix for this. When you send the

bossac command, leave the '-R' off the end. Once the flash has completed, wait for 10 seconds, then press 'reset' button on the board, and see if the board shows up correctly
5. 'Printer stops at the beginning of the print' - this problem has been solved with a firmware update.

Duet software connection problems

If you are having trouble communicating with your Duet board, follow this troubleshooting guide to narrow down where the problem is.

USB connection

Check software installation

1. Download Arduino IDE v1.5.5 BETA (with Arduino Due support) for your operating system from: http://arduino.cc/en/Main/Software
2. NOTE: if you are using a Windows PC, use the .zip file, NOT the 'Windows Installer'. The 'Windows Installer' may not have the up to date 'bossac' command in it (to be confirmed)
3. Install Arduino IDE
4. Connect Duet via USB
5. On Windows computer, open the Device Manager. It should show up as 'Arduino Due'. If it shows as 'bossac programming port', the firmware has been erased, and you will need to flash the firmware. Follow the instructions here: http://www.reprappro.com/documentation/RepRapPro_Firmware#Installation
6. NOTE: Windows 7 and 8 users - the Arduino device driver has to be installed manually. See the note under 'First connection' in the 'Commissioning' intructions
7. Open the Arduino IDE and go to Tools->Board menu and select ‘Arduino Due (Native USB)’ at the bottom of the list. If this is greyed out, check the device drivers have been installed.
8. Then go to Tools->Port menu and select the USB port for your Duet board; it's usually named ‘Arduino Due (Native USB)’
9. Then go to Tools->Serial Monitor. Make sure the speed is set to 115200 (bottom right) and that Newline is selected (next to the speed).
10. Wait for 1 minute (this is normal when no ethernet is connected and the firmware is searching for the network), and following should show:

```
RepRapFirmware is up and running.
```

The above steps should diagnose that the Arduino driver is installed, the USB is functioning correctly.

Check Micro SD card is functioning correctly

Some customers have reported problems with the supplied SD cards and/or the SD card to USB adapter. If you can, try a different SD card, and writing files to it with a different adapter. SD cards come in a variety of sizes; we have tested cards up to 8GB. They should be a FAT32 formatted disk. It's also possible you have a faulty Duet board, but please do the tests on this page before returning your Duet board for a warranty replacement; it will be quicker for you than a miss-diagnosed problem with the Duet board when the real problem is, for example, with the SD card.

- Test the SD Card as described in the Commissioning instructions HERE
- If it's working at startup, it's generally safe to assume it will work the rest of the time.
- If it isn't working, update your firmware if it is an old version (we have improved the firmware to help with the problem of slow cards)
- If it STILL isn't working, replace the supplied Micro SD Card with a better quality card

You should now be able to connect using Pronterface, as described in the main instructions.

Ethernet connection

Physical connection problems
If you get no green light on the ethernet connector, either there is no power to the Duet board (via USB or from the ATX PSU - it can't be powered from the ethernet connection), or the ethernet cable is not making contact/isn't working, or there is a problem with the Duet board. Check power and the ethernet cable.

Testing the connection
For testing, you can connect an ethernet lead directly from your computer to the Duet, so long as your computer's ethernet port is setup with an ip address (eg 192.168.1.12) and netmask (eg 255.255.255.0) in the same range as the Duet.

Duet Firmware ip defaults - line 170-172, Platform.h, here: github.com

```
#define IP_ADDRESS {192, 168, 1, 10} #define NET_MASK {255, 255, 255, 0} #define GATE_WAY {192, 168, 1, 1}
```

Even without an SD card, you should be able to ping 192.168.1.10 and get a response from the Duet. However, you won't be able to access the printer web interface.

The following instructions assume you have a working SD card (see HERE). The standard SD card ip defaults - from sys/config, SD-Image here github.com are:

```
M552 P192.168.1.14; Set the IP address M553 P255.255.255.0; Set netmask M554 P192.168.1.1; Set the gateway
```

Edit the config.g on the SD card to suit your network, as described in the commissioning instructions HERE.

Establishing connection

1. Connect ethernet cable to router, then to the Duet.
2. Connect USB lead to Duet (this is needed for power, and can help with diagnosis), or turn on the ATX PSU, and check that JP9 has a jumper on it
3. The GREEN LED on the ethernet connection should light up on the Duet. The ORANGE LED is a indicator light for 10base-T connections – most ethernet hubs/routers/switches are 100base-T or gigabit, so it will stay switched off.
4. If you don't get a green light, check the Duet board is getting power (by USB or ATX PSU), check your ethernet cable is okay by testing it in a known working ethernet port. We have had a couple of reports of the ethernet not working at all on the Duet; contact support for a warranty replacement.
5. You should be able to ping the Duet, on the ip address you set.
6. If you ping 192.168.1.10 and get a response, this is the firmware default; the network settings are not being loading at startup, and the web interface will not respond correctly. Check the Duet is loading config.g at start up; see HERE
7. You should then be able to connect to the web interface, using Google Chrome, by typing the ip address you set in the address bar.

If you are having problems during connection, you could try the version of the web interface that has been developed by Ormerod owner Matt Burnett; see http://forums.reprap.org/read.php?340,290811,301393#msg-301393 and https://github.com/iamburny/OrmerodWebControl

This doesn't use password control, so is perhaps more reliable at connecting, if more insecure.

Random disconnections during printing

If the printer is resetting, and stopping mid-print, the cause is likely to be related to power to the printer. Double-check that the 12V power input wires and the heated bed power wires are well-seated in the screw terminals; they should be really solid. They have to carry a lot of current, and a loose connection here will generate heat, and possibly cause a disconnection/reset if the contact is poor. Once you are satisfied with this, check that you are getting 12V from the power supply when under load. Test at the 12V power input screw terminals, turn on the bed, and see if the voltage drops. A small voltage drop of 0.5 to 1V is to be expected, but more than that can cause a problem.

If the printer is loosing the USB connection, check the soldering on the USB connector. See 'Duet hardware problems' above.

If the printer is loosing the USB connection and the soldering is okay, there can be a variety of causes. USB is quite prone to Electro Magnetic Interference (EMI), via the power line. Large motors (in air conditioning, fridges, fans, drills and other hand tools etc) starting and stopping on the same ring main can cause power spikes, while other high current devices, unstable mains supply, or poor USB power connectivity on the host PC can knock out the USB connection. If the printer seems to continue working without resetting (for example, if you are printing from SD card, it continues to print), this is the most likely source of the problem. Check that the USB cable is connected properly, and for any damage - a poor connection will be more susceptible. Customers have found that adding a surge suppressors, power conditioners and/or UPSs to smooth the mains supply, and/or using a USB cable with a ferrite core, can help.

Proximity sensor problems

Problem

- Homing of X and Z axis does not work properly
- Response from G31 is inaccurate, or varies, or doesn't change

Solution

1. Check your wiring of the proximity sensor, at the sensor end and the Duet end. See: http://www.reprappro.com/documentation/ormerod/wiring/
2. Updated your firmware, and update the files on your SD card, with the files from 'SD-Image' in the firmware folder. These should be kept on the same version. This should update any firmware behaviour that may be causing homing problems. See: http://www.reprappro.com/documentation/RepRapPro_Firmware#Installation
3. Check that your SD card is working AT STARTUP. This is crucial, because it effects the behaviour of the proximity sensor: http://www.reprappro.com/documentation/ormerod/commissioning/#Is_the_SD_card_being_read_AT_STARTUP
4. Check that there is no big Infra Red source near the printer, this will upset the proximity sensor. See the noted below the picture here: http://www.reprappro.com/documentation/ormerod/axis-compensation/#Setting_the_Z_Probe
5. Check the values you get from the probe. With axis a long way from the bed, send G31. The result should be a low number, like 10. Put a piece of white paper under the sensor, very close, and send G31. The result should be a very high number, like 950. This is the normal range for the sensor.
6. If you get a constant value from G31, the board may be damaged. If you get 1023 from G31, check your wiring.

If the homing seems inaccurate after all of the above, check that the Z axis is moving correctly; there could be backlash that is causing problems. Check:

- look for binding or stalling in the z-gears
- stiff movement of the Z axis up and down

- If you have an adjustable z-runner-mount, it should only be lightly gripping the extrusion, or that will cause problems for the Z axis movement

Printing problems

Poor or no extrusion

Problem

This could be due to a number of reasons:

- Initial construction problems (if the nozzle has never successfully extruded)
- The nozzle is partially or fully blocked
- Extruder motor does not move much but makes a squeaking noise.
- Extruder motor rotates, but the gears do not.
- Extruder drive motor and gears rotate, but the filament does not feed.
- The extruder gears squeak, rub and/or get stuck as the big gear turns.
- The Bowden tube comes out of the brass unions

Solutions

Construction problems

- Hot end cooling: Check that the hot end fan is on ALL THE TIME. If the hot end fan turns off, heat can travel higher up the nozzle, and the force of extrusion increases, eventually stopping extrusion. The hot end fan MUST run all the time (it should be wired to the +12V directly), and there should be good contact of the heatsink to the heatsink block.
- Hot end cooling: Make sure the heatsink is installed so that the fan can blow air through it!
- Hot end construction: Check that the brass tapered nut is tight against the heater block on the nozzle. Tighten with spanners - more than finger tight! This will ensure the threads make good contact with the nozzle, and heat transfers well.
- Hot end construction: If the ptfe nozzle liner is not cut square, or cut too short, and there is sufficient gap that fills with molten filament, again the force of extrusion increases. Cut a new piece of ptfe tube, 8mm long, with square ends.
- Bowden tube: If the Bowden tube is tight into the brass unions, and the filament has difficulty moving through the tube, this increases the force needed for extrusion. The tube should be 10mm into the brass unions, then run a 2mm drill into the ends to clear them. Push a piece of filament through to check it is smooth, and to clear out any debris.
- Extruder: If the teeth of the hobbed insert has slipped on the filament, there may be pieces of plastic in the teeth, which the filament will slip on. Remove the filament, take out the big gear with the hobbed insert, then check and clean the teeth of the hobbed

insert - a small wire brush is good for this.

- Extruder: Check the idler bearing has a washer on it between the bearing and the motor, or the bearing will have difficulty turning

Nozzle blockage (also for changing filament)

To ensure the nozzle and melt zone are free from contamination, follow these steps:

1. Heat nozzle to operating temperature (200C for PLA)
2. Extrude a little filament, like 10mm (if possible) by hand or via Pronterface, then set temperature to 100C
3. Wait for the temperature to drop to 100C, then reverse filament until it comes out of the extruder drive (about 380mm). You can do this at 600mm/min, or by hand if you wish.
4. This should pull out the filament from the melt chamber, hopefully down to the nozzle, along with any contamination.
5. Cut the contaminated end from the filament, and drive or feed the filament to just before the hot end.
6. Set temperature to operating temperature
7. Command the filament to extrude short lengths, 5mm at 200mm/min, until it squirts out of the nozzle.
8. Only in the worst case will you need to disassemble and clean the hot end.

Extruder problems

If the extruder motor does not move as expected, but makes a squeaking noise or just vibrates, it may mean it does not have enough torque to drive the extruder feed mechanism, because it is stuck or jammed.

1. Check that the nozzle is not blocked (see solution above)
2. Check that the idler bearing can rotate freely (there should be an M3 washer between the bearing and the motor)
3. Check the diameter of your filament is not too wide (over 2mm in diameter will not feed through the extruder)
4. If the motor vibrates rather than turning, even with no load on it, the stepper driver chip may be damaged

Extruder gear rotates, gears do not

1. It is unlikely the small gear will rotate on the motor shaft. If it does, contact RepRapPro support for a replacement.
2. On the big gear, check that the hex head bolt is not rotating in the hex hole. If it is, again, you will need a replacement. As a temporary fix, you may be able to use epoxy glue or superglue to get the hex head to hold again.

Extruder drive motor and gears rotate, but the filament does not feed. There are a number of potential reasons for this:

1. The teeth of the hobbed insert have plastic in them. This will cause the teeth to slip on the filament. Clean the teeth with a pointy tool.
2. The nyloc nut on the back of the large gear has come loose, and the hobbed insert is unwinding
3. The filament may be to thin, or it is trying to grip on a section where filament has been worn away. Remove filament and check diameter.

The extruder gears squeak, rub and/or get stuck as the big gear turns:

1. There may be printing artefacts on the large and small gear, or they have been printed too 'full', so that they mesh very tightly. You can use sandpaper to improve the fit, or contact support to send you new gears.
2. There is no other adjustment available

The Bowden tube comes out of the brass unions

1. If the ptfe tube pushes out of the brass union, it is probably not screwed in far enough into the union. It should have about 10mm of thread. Remember to drill, with a 2mm drill, into the brass union with the ptfe in place, or there may be a tight spot that the filament can't push past.

Filament doesn't stick or parts warp

Problem

- If the first layer does not adhere well enough to the heatbed, there is a chance the component(s) will warp during printing.

Solutions

Bed surface: Some people are lucky, and seem to be able to print directly onto the glass bed, and the PLA sticks. Most, it seems are not so lucky; for them we provide a roll of Kapton tape. Kapton can be applied to the glass surface in strips - try to keep the air bubbles out, and put the strips as close together as possible. Kapton is durable: we use it in the production of kits, and will last at least a couple of months of 24/7 printing. Usually it peels up before the PLA won't stick to it. Blue painter's tape can also be used. PLA doesn't stick as strongly to it, and the surface isn't as flat or durable as Kapton, but it is more widely available, and often in wider widths.

Cleanliness of build surface: The bed surface needs to be completely free of all oil and grease (including finger marks), otherwise your prints won't stick to it. Set the heatbed to a temperature of 45C and wait for it to settle there. Clean the surface with nail polish remover (containing acetone, glycerine, and as few other ingredients as possible, and definitely '''not''' lanolin or any other oil or grease) using a lint free cloth. Set your heatbed to your print temperature ready for printing. Other products that also work include pure Acetone, Isopropyl Alcohol, White Methylated Spirits, White Vinegar. All of these are acidic, and dissolve oil and grease before evaporating. Don't use Windex/Windowlene or polish; they often have a non-stick component!

Setting Z zero: At the Z 'home' position, where Z=0, the nozzle should be just touching the bed. Follow the instructions laid out in the Commissioning and Axis Compensation instructions

Bed temperature: For PLA, try a setting of 50-60C. If you go too hot, the PLA will stay liquid and can be pulled away from the bed by the cooling of subsequent layers. Too cold, and it won't stick. For ABS, the bed temperature needs to be much higher, at around 100C. See the ABS printing guide later.

Hot end parts hit print and bed fold-back clips

Problem

- Fan/nozzle duct is closer to the bed than nozzle
- Proximity sensor is closer to the bed than nozzle
- Parts that are being printed are knocked off the bed

Solution

This can have a number of causes, in construction, and set up/adjustment. The bottom of the cooling nozzles and the proximity sensor should be about 1mm ABOVE the tip of the nozzle. To achieve this, a number of things need to be set correctly.

1. When constructing the hot end, the brass Bowden tube union that screws into the aluminium cooling block needs to screw ALL THE WAY IN. If it is not, the nozzle will be lifted slightly, in relation to the sensor and the fan duct.
2. The hot end need to sit on the x-carriage so it is vertical. If it leans forward, the fan duct will be lower. Change this angle by adjusting the bearing on the back of the x-carriage. If there is not enough adjustment, you can elongate the adjustment slot that the bearing sits in, or replace the bearing with a larger one (the standard is a 9mm bearing, replace with a 10mm 623 bearing if available), or put a 'runner' on the back of the x-axis plate for the bearing to run on - some people have used a hacksaw blade.
3. If the hot end changes angle as it moves along the X axis, the x-axis-plate may be twisted, so the whole x axis arm has a twist along it's length. Look along the arm, and rotate it until it is straight. Tighten the 8 screws in the x-motor-mount, and the screw in the x-idler to hold it in position.
4. If the proximity sensor is too low, check that the mdf spacer is inserted between the nozzle-mount and aluminium cooling block. You can add an extra couple of washers if

you need more clearance.
5. It's also possible that the y carriage bed is a long way out of level with the x-axis. You may need to adjust the corner screws of the heated bed to get it more level with the x-axis.

Axis sticking problems

Problem

- Axis doesn't move smoothly
- Motor stalls when moving (sometimes okay at low speed, doesn't move far enough at high speed)

Solution

1. Make sure rods are clean and linear bearings run smoothly. A little light oil (like 3-in-1 oil) will help lubricate the bearing seals. Smooth rods can be cleaned with wire wool or kitchen scourer to remove stubborn lumps
2. Check stepper motor voltage is not set too low in config.g. As standard this is set to 800 milliamps by this line:

   ```
   M906 X800 Y800 Z800 E800 ; Motor currents (mA)
   ```

3. Check that belt alignment is correct, and the belt is not rubbing unduly on belt guides or anything else.
4. Check there is no mechanical obstruction to the movement of the belt, or bearings on the smooth rods.

Wobbly Z walls and non-circular circles

Problem

- Vertical walls are not accurately printed on top of each other
- Variability in layer height causes vertical walls not to be smooth
- Circular objects print out square

Solution

Generally we lump these problems together under the term 'backlash'. This can happen on any of the axes, or a combination of them.

1. Check belts are tight enough. On the longest free length, ie the side not attached to the carriage, pluck the belt. It should make a just audible, low pitch, twang. Tighten or loosen as needed.
2. Check pulleys are not loose on stepper motor shafts (X and Y axis) - hold the motor shaft with pliers, then try moving the carriage, while looking at the pulley
3. Check that the axes are moving freely: see 'Axis sticking problems' above
4. Check extrusion is consistent: see 'Poor or no extrusion' above

Stepped layers

Problem

Partway through a print, the next layer appears to have slipped by a millimetre or two (or much more) causing a step which should not be there. This can be caused by:

- Axis belt slipping where it is attached to the carriage.
- Print head snags on part of the print, usually the print curling up or lifting off the bed. This can cause the belt to skip on the pulley, or the motor to stall.
- Axis snags on something. For example, the wiring catching/getting in the way of movement. This can cause the belt to skip on the pulley, or the motor to stall.
- Stepper driver overheats and temporarily shuts down.

Solution

Belt slipping in carriage

1. This usually happens on the y-carriage. To test, hold the motor pulley tight and try and move the carriage. If it slips, secure it in place more positively. The quickest fix is to put a cable tie around the two ends of the belt, on the left side of the y-rib, push it up against the y-rib, and tighten it.

Nozzle hitting printed part

1. The printer should generally have the power to overcome hitting a part while printing, and the hot end can flip up a little. However, if printed parts are curling up, particularly on overhangs or bridging, reducing the extrusion temperature 5°C at a time will usually help.
2. If the parts are curling up from the first layer, see 'Filament doesn't stick or parts warp' section above

Belt skipping on pulley

1. Check belts are tight enough. The actual tension required comes with experience, but

should be at least tight enough to produce a low frequency, just audible 'twang' on the longest section of belt. Over-tensioning the belts can also be detrimental, as the motors will have to work harder.
2. Check that the belt is running smoothly and in line, and the edge of the belt is not snagging on the motor and idler ends. With the motors off, check the axis moves smoothly - if not, see the 'Axis sticking problems' section above.
3. Check all wires, pulleys and belts whilst printing and reposition/realign anything impeding the smooth movement on all axes.

Stepper motor stalling

This is a result of the motor not having enough torque to move the axis (temporarily, since the print continues at the new position).

1. Check that the motors are being supplied with sufficient current to meet the demand; check the setting in config.g
2. Use secondary cooling fan to cool the electronics if they are getting too hot.

Printing ABS

Problem

- Concerns about printing ABS
- Heated bed takes a long time to get up to 100C, or never reaches it
- ABS doesn't stick

Advice

Important: all the supplied printer parts are made from PLA. Long term exposure to the heat of ABS printing will cause some of them to fail. If you plan to print a lot of ABS, you should first remake some of the parts from ABS, specifically (and in this order) the x-carriage, z-runner-mount, extruder-body and the rest of the extruder parts, nozzle-duct, fan-duct.

When printing ABS without upgraded parts, at the start of the print leave the x-axis high above the bed (at least 100mm) so that it is not getting hot while the bed heats up.

Heated bed

Check the voltage of the power supply, particularly under load. Ormerod PSUs should supply around 12V, but may be supplying a voltage below this. Some customers have replaced the supplied PSU with ones that can supply 13V, which allows the heated bed to heat up quicker and get to a higher temperature. However, don't go beyond 13.5V, or the heated bed will draw too much current.

The heated bed can max out at around 100C, due to the thermal mass of the aluminium and glass. This is a designed limit, and is generally okay for the ABS we have tested. You can increase this to around 110C by covering the bed with an insulator while it heats up. In the past, we've used a foil-fronted piece of MDF, which reflected heat back onto the bed, but was held off the surface by the clips, so didn't heat up. Remove it to start printing; the first layer will then be a bit hotter, so should stick better if it's being difficult, and the temperature will drop during printing to hold at around 100C. Another improvement suggested by a customer is to put aluminium/kitchen foil between the heatbed PCB and MDF insulator. This also decreased warm up time. Be VERY careful not to short the main power connections through the silver foil! ABS shouldn't need heating to more than 110C anyway, as this is beyond it's glass transition temperature; it's like printing PLA onto a bed at 80 degrees - the PLA stays so soft it gets pulled off the bed. ABS generally does this above 110C.

Other considerations

Also, keep draughts to a minimum, and try to keep the area around the printer at a reasonable temperature - above 25C minimum. This should help to prevent the part warping as it prints. You can build a small 'greenhouse' to cover the printer, but be careful it doesn't get so hot (over 45C) that the PLA parts of the printer melt!

It should be noted there are plenty of other problems getting ABS to stick at any temperature, and there are quite a few workarounds; the favourite around here are super strength hold hairspray (it can contain both PVA and acrylic) or making a slurry of some ABS dissolved in Acetone, applied to the bed at 50C, and wait for it to dry before printing. Joseph Prusa shows how he does it HERE (follow the pictures in the 'Older' direction). And then some people have no problem with ABS at all! It's a bit of a dark art, but probably depends on the quality of your ABS filament.

Improvements

Improvements to RepRapPro Huxley

Huxley X-carriage mounted ducted fan

We have designed an x-carriage mounted fan that is pretty effective, in two parts - a fan mount for 40mm fan and a ducted x carriage.

https://github.com/reprappro/Huxley/blob/master/Print-Huxley/Individual-STLs/optional-fan-mount-1off.stl

https://github.com/reprappro/Huxley/blob/master/Print-Huxley/Individual-STLs/optional-x-carriage-1off.stl

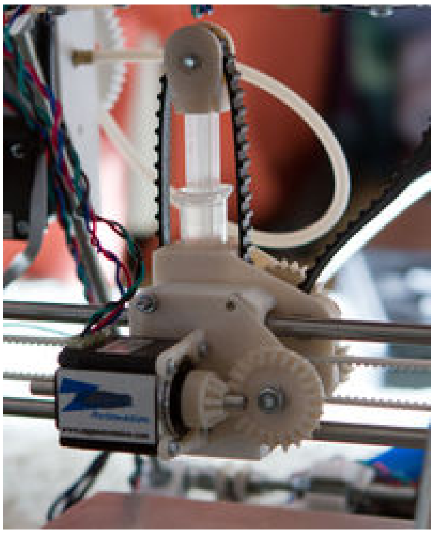
Click 'Raw', then download the file, or you get an html page instead of an stl file. A variation has appeared on thingiverse: http://www.thingiverse.com/thing:160549

Huxley Mini-Spool

A horizontal mini-spool to store a small amount of filament right under your Huxley.

Mattroberts'_Huxley_Paste_Extruder

Replace the hotend with a 5ml syringe.



Mattroberts'_Huxley_Carriage

Adds nuttraps to the carriage, so you replace the self tapping screws with metal screws.