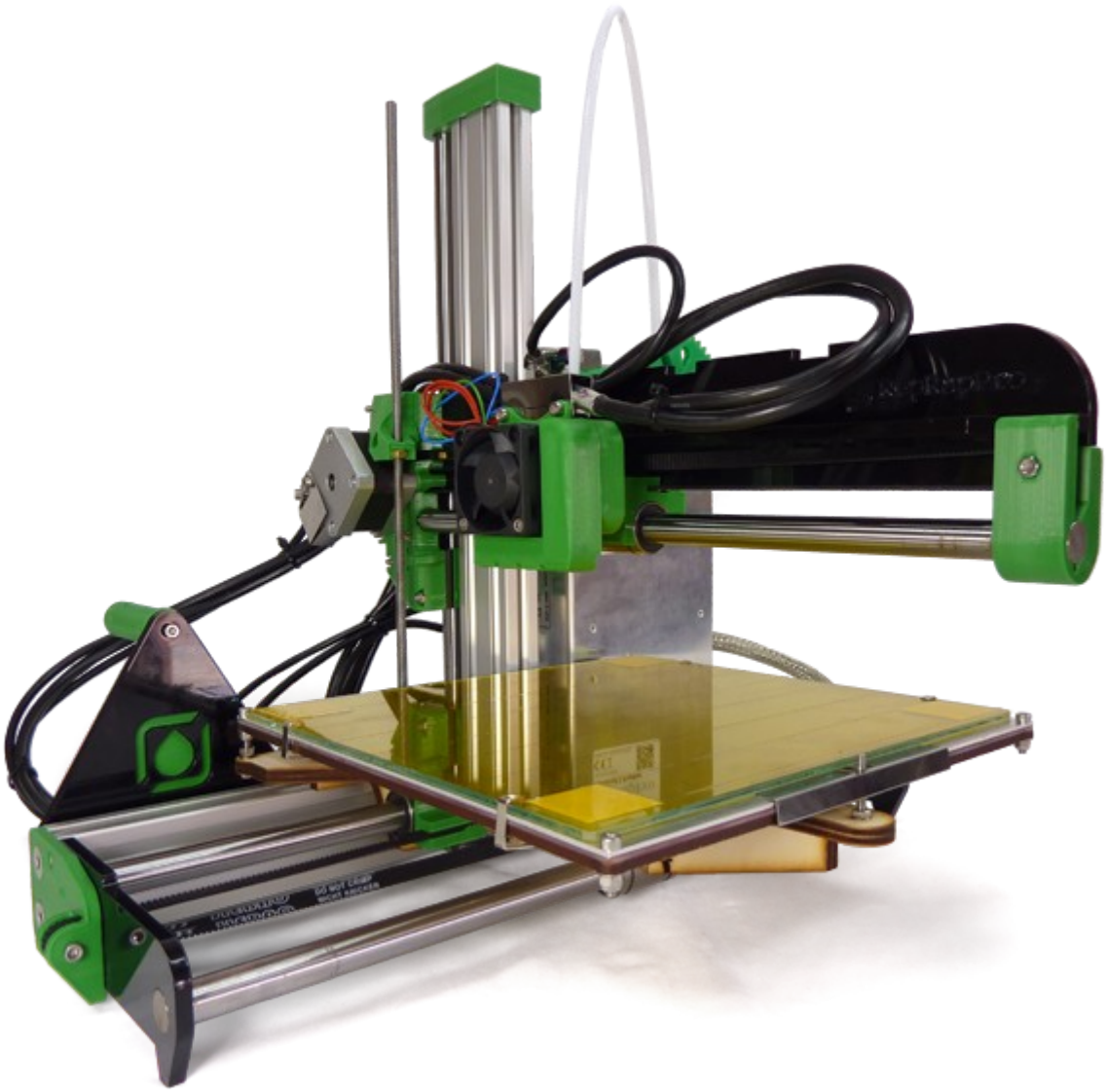
Ormerod 2 Build Manual



Forward

Credits & License

Original Machine Design:	Jean-Marc Giacalone Adrian Bowyer
Original Documentation:	Ian Stratford
Documentation Conversion to ODT/PDF:	Wesley Brooks
License:	GPL

Original Documentation Hosts:

Web Archive	https://web.archive.org/web/20160106171632/https://reprappro.com/documentation/ormerod-2/hot-end-assembly-quick-set/
cheeseandham (RepRap Forum)	http://reprappro.cheeseandham.me.uk/reprappro.com/documentation/index.html

This Documentation Iteration Host:

DocTrucker GitHub	https://github.com/DocTrucker/Ormerod/tree/master/Documentation

Table of Contents

Ormerod 2

Overview

The RepRap Pro Ormerod 2 is the latest RepRap self-replicating 3D printer from RepRap Pro. The machine is a faster to assemble, networked 3D printer with non-contact bed probe for full geometric compensation.

These pages are the complete instructions for building, commissioning and using the RepRapPro Ltd version of RepRap Ormerod 2. Like all RepRap machines, RepRapPro Ormerod 2 is fully open-source. It is licensed under the GPL. All the design files and software are available from the RepRapPro Ltd Github repository.

The RepRapPro Ormerod 2 is fitted with the open-source Duet electronics.

If you want to print the plastic parts for a RepRapPro Ormerod 2, see this web page.

General Notes

BEFORE YOU ATTEMPT TO ASSEMBLE ANY PART OF THE RepRapPro ORMEROD 2 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. You are building a complicated machine; many different skills are required to build, to commission and to operate a 3D printer. Try not to rush your build, or you may miss out something vital!

- 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 RepRapPro's own machines. 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 the RepRapPro Ormerod 2. 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 or damaged, please contact us through our contact page.
- We understand that people may want to change aspects of the machine's design, and in fact we encourage this as it is one of the benefits of open-source development. Before changing anything, please be aware that the RepRapPro Ormerod 2 has been designed to maximise its build volume relative to the the machine's footprint, and as such many of its components fit closely to others. So consider your changes carefully before you try to implement them. And when you find improvements, please tell us and the world so that we can include them in future kits, and so that existing owners can upgrade their own machines.
- The RepRapPro Ormerod 2 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 below.

Ormerod 2 Versions

Some sections of the instructions are arranged in tabs, with alternate parts and instructions, depending on the version of your kit. Below is the changelog, which shows the differences between kit versions. The tabs refer to the version number of the Ormerod kit. Your Ormerod kit version number is marked on the sticker on the power supply (on 528.2 and later kits), or on the x-rib (for earlier kits). Use the LATEST version number – some kits have the 528.2 PSU, but the 528.1 x-rib. Use the set of instructions that relate to your printer.

528.0	Sept 2014: Original shipping version of Ormerod 2.
528.1	Oct 2014: Changes to packing. Acrylic fan spacer replaces printed fan-duct and nozzle-duct.
528.2	Dec 2014: Change to supplied power supply, and added lasercut acrylic parts to mount Duet on new PSU.
528.3	Feb 2015: Changes to packing.
528.4	New heated bed design, new bed wiring loom.
528.5	Ships with new Quick-set nozzle. Separate hot end and fan looms. Cooling fan and duct supplied. Small updates to some printed parts (x-carriage, z-upper-mount, y-motor-mount). Changes to packing.

Printing Parts for Ormerod 2

If you have bought the hardware-only version of the Ormerod 2 kit, you will want to print the parts. You may also want to print spare parts for your printer. The list below shows the part number, part name, quantity and location of the parts. Parts are available as STL and SolidWorks files, and there should also be a STEP assembly of the whole printer.

For Ormerod 2, part number 528.0 to 528.4, the easiest place to get the parts is here: https://github.com/reprappro/Ormerod/releases

For 528.5 onwards, we use the part number, rather than the name of the part, for the file name. For the latest version of the parts, which should be backwards compatible with all the previous versions, see the Ormerod github repository. Some parts common to all our machines are in the Library github repository.

You can download the whole github repository, or download the parts individually; the ‘Location’ in the link below links to the stl page. This will also help you identify the parts. If you download the parts individually, make sure you download the ‘RAW’ version of the file; if you right-click on a link and download, you will end up with a file with the right name (with .stl on the end), but it will actually be an html document!

#	Description	Qty	Location
547	y-idler-bracket	1	Ormerod/STLs
548	y-motor-bracket	1	Ormerod/STLs
469	z-motor-brace	1	Ormerod/STLs
437	z-lower-mount	1	Ormerod/STLs
438	z-upper-mount	1	Ormerod/STLs
527	z-corner-bracket	1	Ormerod/STLs
503	z-foot	1	Ormerod/STLs
549	y-bearing-belt-clamp	1	Ormerod/STLs
550	y-bearing-clamp-tagged	1	Ormerod/STLs
462	x-idler-bracket	1	Ormerod/STLs
546	x-carriage	1	Ormerod/STLs
501	nozzle-mount (one-piece nozzle, 528.4 and before)	1	Ormerod/STLs
1079	nozzle-mount (Quick-set nozzle, 528.5 onwards)	1	Ormerod/STLs
473	x-motor-bracket	1	Ormerod/STLs
407	z-runner-mount	1	Ormerod/STLs
441	z-gear-driven	1	Ormerod/STLs
440	z-gear	1	Ormerod/STLs
492	z-bearing-clamp	2	Ormerod/STLs
425	z-nut-trap	1	Ormerod/STLs
554	Extruder drive block	1	Ormerod/STLs
446	Extruder small gear	1	Ormerod/STLs
447	Extruder large gear	1	Ormerod/STLs
152	Tongue	1	Library/STLs
820	PSU cover	1	Library/STLs
821	PSU brace	1	Ormerod/STLs
442	Spool spigot	1	Ormerod/STLs
525	Spool clip	1	Ormerod/STLs
1123	Cooling fan duct	1	Ormerod/STLs

Get Support

If you find you need help or advice with assembling, commissioning or using your RepRapPro Ormerod 2 3d printer, you can use the following channels:

- Check the instructions again; we are regularly updating them with feedback from our growing user-base.
- Contact the support department of the company that sold you your printer.
- Check the RepRap community forum, Ormerod section.
- Contact us on our irc (internet relay chat) channel RepRapPro on freenode irc

- Contact us via email; see our contact page.

Archived Documents for Older Versions

If you have an older RepRapPro Ormerod and want a past copy of this documentation see these links:

- RepRapPro Ormerod 1 Instructions

Tool List

Tools required for the build of the RepRapPro Ormerod 2 3D printer:

Required

Allen keys: 1.5mm, 2mm, 2.5mm, 4mm (the long reach type, with a ‘ball’ hex on the end, are very useful)

- Medium, cross-head screwdriver
- 8mm (M5) socket and/or spanner
- 15cm adjustable spanner
- Fine tweezers
- Ruler, at least 300mm
- Fine-nosed pliers
- Scissors
- Drill: 2mm
- Hand chuck, pin vice or small electric drill
- Small, flat-bladed, electrical screwdriver
- Pencil sharpener
- Digital Multimeter

- Hot air gun, or cigarette lighter (or other heat source such as a gas cooker ring for heating PTFE heatshrink; a hair dryer is not sufficient)

For Adjusting Plastic Parts, if Necessary

- Drills: 3mm, 4mm
- File
- Half round needle file
- Sharp craft knife

Nice to Have, But Not Necessary

- 5.5mm (M3) socket and/or spanner
- Vernier or digital callipers

Y Axis Assembly

Y axis sub-assemblies

Y-idler-end

TIP: There's a list of the Ormerod printed parts on THIS PAGE. Click on the 'Location', to see a preview of the printed part, if you're not sure what it is.

#	Component	Qty	Type
	y-idler-bracket	1	Printed
	y-axis-end-plate 'A'	1	Lasercut
	M4x12mm countersunk socket head screw	1	Fastener
	M4 T-nut	1	Fastener
	M3x12mm countersunk socket head screw	2	Fastener
	M3 Nut	2	Fastener
	M3x12mm cap head screw	1	Fastener
	623 bearing (10mm diameter)	1	Fastener

TIP: Click on pictures in the instructions to see a larger version. Right-click and select 'Open link in new Tab' to see the full size image.

Fit the 623 idler bearing to the y-idler-end. It may require a fair bit of force to push the bearing into position. It is held in place by a M3x12mm cap head screw. This should self-tap into the printed part, with no need for a nut on the free end.

Using the M3x12mm countersunk socket head screws, assemble the y-axis-end-plate ‘A’ with the y-motor-bracket, with an M3 nut on the back of each screw.

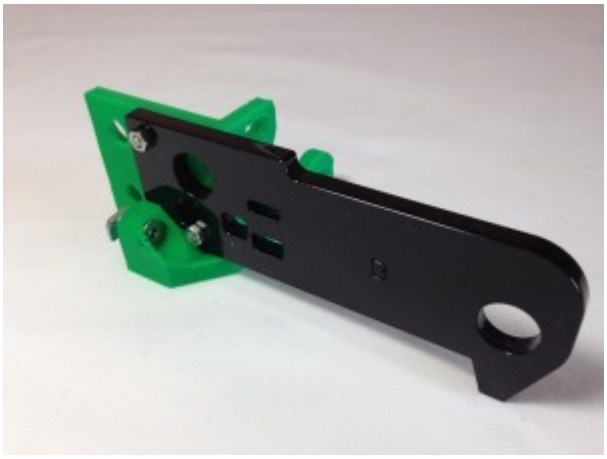
The M4x12mm countersunk socket-head screw goes through the y-idler-mount as shown, with the T-nut on the other side. Leave the T-nut loose – it connects with the aluminium extrusion.

Y-motor-end

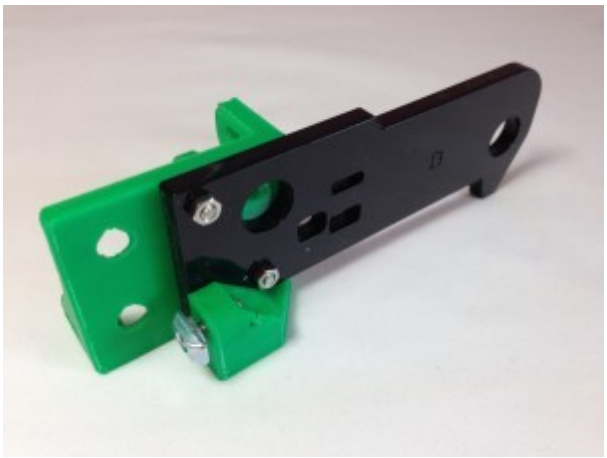
#	Component	Qty	Type
	y-motor-bracket	1	Printed
	y-axis-end-plate ‘B’	1	Lasercut
	M4x12mm countersunk socket head screw	1	Fastener
	M4 T-nut	1	Fastener
	M3x12mm countersunk socket head screw	2	Fastener
	M3 Nut	2	Fastener

Begin by assembling the Y-motor-end. Use y-axis-end-plate ‘B’ (there is a small ‘B’ engraved on one side of the plate) with the y-motor-bracket. As the y-axis-end-plate is laser-cut acrylic, the 12mm holes will be slightly larger in diameter on one side of the y-axis-end-plate (the side with the letter ‘B’) which will make it easier to insert the 12mm ground steel bar later.

Using the M3x12mm countersunk socket-head screws, connect the two parts together as shown, with an M3 nut on the back of each..



The M4x12mm countersunk socket-head screw goes through the y-motor-mount as shown, with the T-nut on the other side. Leave the T-nut loose – it connects with the aluminium extrusion.

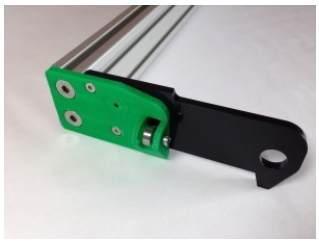


Y axis frame

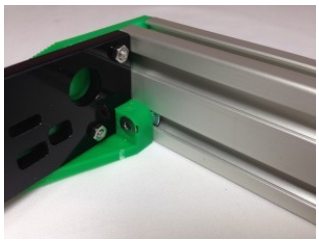
The next step is to assemble the Y axis frame. For this you will need the following:

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

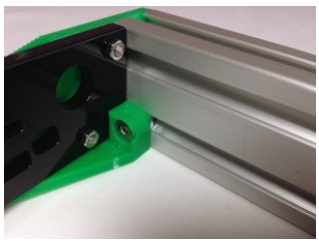
Screw the y-idler-end onto the aluminium extrusion, using two M6x16mm countersunk socket screws. These screws need to be tight – if they are loose, the Y-ends will move in relation to the aluminium extrusion, and the X axis will not be level to the bed.



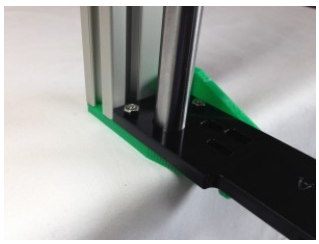
On the inside of the y-idler-end, check that the M4 T-nut is located in the extrusion slot.



As you tighten the screw, the T-nut should rotate 90 degrees in the extrusion, from horizontal to vertical. It may need a little help! If it can't rotate, it may have started too close to the printed part; loosen the screw off a couple of turns, then try tightening again. Once it has rotated so that it is vertical, fully tighten the screw.

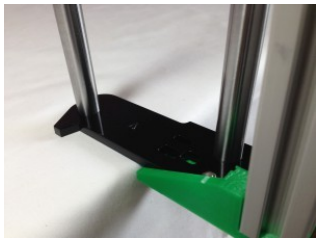


With the y-idler-end supported by the edge of a table, take one of the 12x350mm smooth rods and push it into the hole in the acrylic end piece that is closest to the aluminium extrusion. The 12mm diameter holes are sized to be an interference fit with the rods, and the Acrylic laser cut plates are quite brittle so care must be taken when inserting the rods not to break the end plates. You can use a piece of wood, or soft-faced hammer, to tap gently on the end of the rod, if necessary.



NOTE: Some 12x350mm smooth rods may be a little longer, due to variability in manufacture. The y-idler-end printed part can accommodate this, with a pocket. The other places that the rods are used can similarly accommodate these rods (Z axis), or it doesn't matter (X axis, Y axis front rod) – the longer rod will simply poke out the end a millimetre or so.

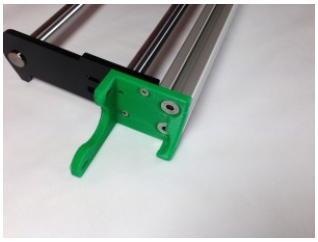
With the acrylic supported, push the second 12x350mm smooth rod into the hole in the end of the plate. Keep the rod perpendicular to the plate whilst pushing. Try to keep both rods upright, so they do not stress the holes in the Acrylic.



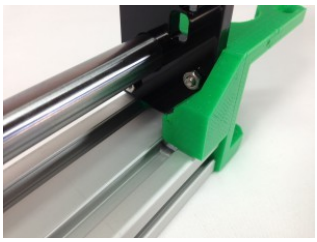
Slide the LM12UU Linear bearings onto the smooth rod. Put two onto the rod closest to the aluminium extrusion, and one on the front rod. Check they slide smoothly and freely.

Push the y-motor-end onto the smooth rods at the other end. This may be easiest with the Y axis vertical. Make sure the acrylic part is supported when pushing the rods in. Try and keep the smooth rods as straight as possible, to avoid damaging the acrylic parts. Push them home, so that the motor mount is flush with the aluminium extrusion. Again, only tap them in with a piece of wood, or soft-face hammer, to avoid damaging the parts.

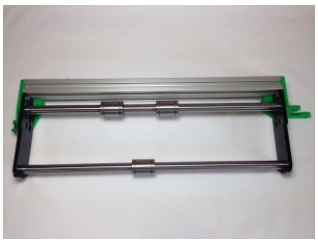
Screw the y-motor-end onto the aluminium extrusion, using two M6x16mm countersunk socket screws. These screws need to be tight – if they are loose, the X axis will not be level to the bed.



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



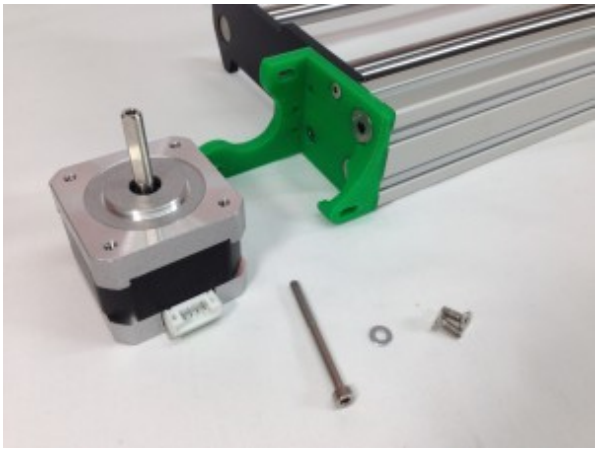
The completed assembly. Check all screws are tight.



Y Axis Motor

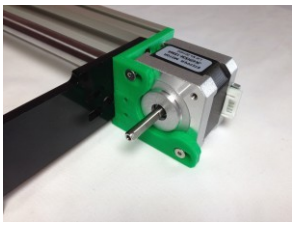
Now you can fit the Y axis motor. For this step you will need the following:

#	Component	Qty	Type
	y-axis-frame	1	Assembled
	NEMA17 stepper motor	1	Hardware
	M3x8mm countersunk socket screw	2	Fasteners
	M3x40mm cap head screw	1	Fasteners
	M3 washer	1	Fasteners

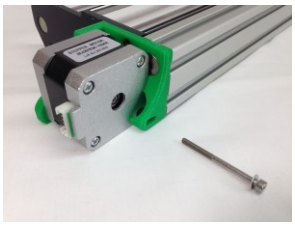


One screw needs to be removed from the back of the motor, as shown. Don’t lose this M3x26mm crosshead screw; we’ll be using it for the y-carriage.

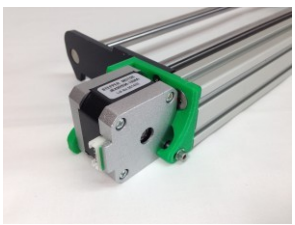
Fit the motor into the printed y-motor-bracket. Secure the motor in place with 2 x M3x8mm countersunk socket screws in the front face.



Put one M3x40mm cap head screw with an M3 washer, in the back of the motor, where you took out the motor screw.



The three screws of the motor are mounted in slots, so you can slide the motor a small distance. This allows you to adjust the belt tension, once the belt is fitted. Leave the screws hand tight with the motor at the right-hand end of the slots in the picture.



The completed y axis assembly.

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

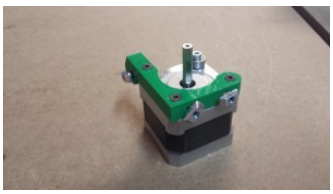
Z-motor-mount

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

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

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

Loosely fit the M4 T-nuts with the M4x12mm countersunk screws to the z-motor-brace. Then screw the stepper motor to the z-motor-brace using the M3x12mm countersunk screws, as shown.

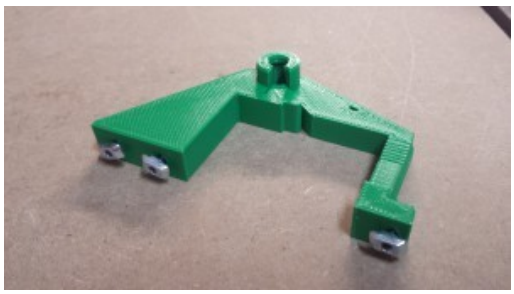


Z-lower-mount

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

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

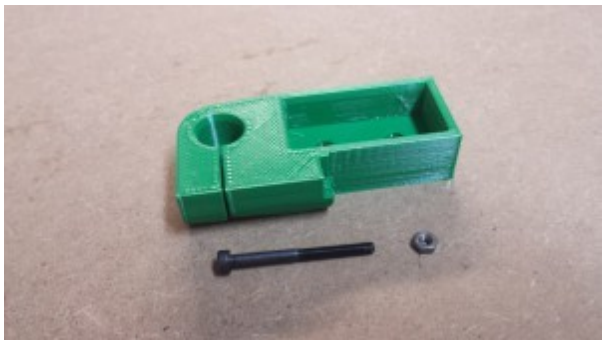
Loosely fit the M4 T-nuts as shown



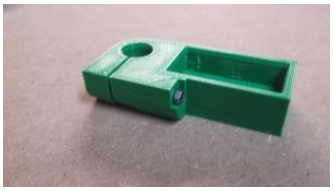
Z-upper-mount

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

#	Component	Qty	Type
	z-upper-mount	1	Printed
	M3x35mm cap head screw	1	Fastener
	M3 nut	1	Fastener



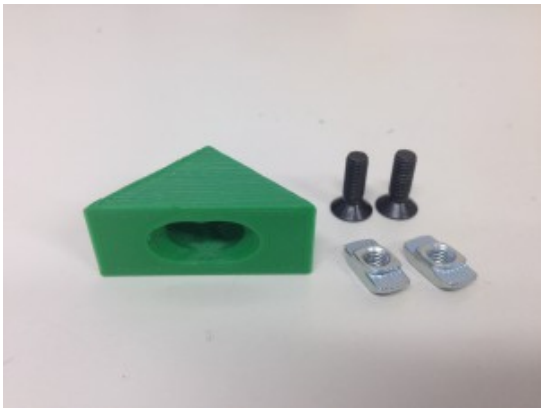
Fit the M3 screw and nut as shown.



Z-corner-bracket (528.5 onwards)

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

#	Component	Qty	Type
	z-corner-bracket	1	Printed
	M4x10mm countersunk socket screw	2	Fastener
	M4 T-nut	2	Fastener

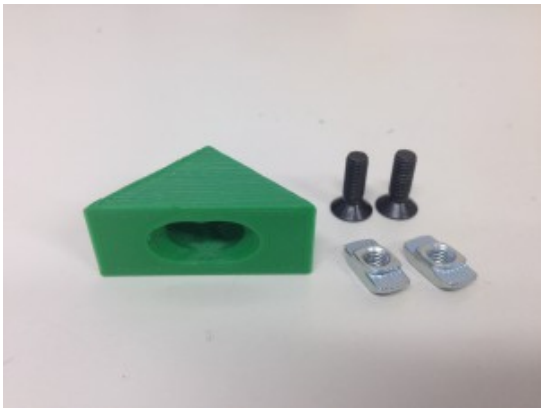


Now loosely fit two M4 T-nuts using M4x10mm countersunk socket screws into the z-corner-bracket.

Z-corner-bracket (528.0 to 528.4)

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

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

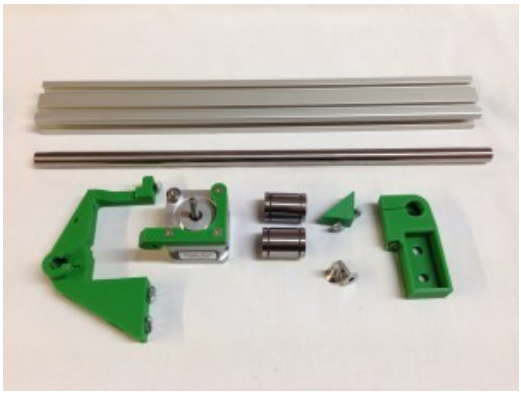


Now loosely fit two M4 T-nuts using M4x10mm countersunk socket screws into the z-corner-bracket.

Z axis assembly

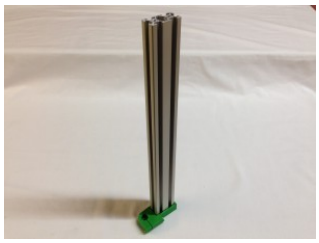
You can now bring all of the Z axis sub-assemblies together, using the following parts:

#	Component	Qty	Type
	z-motor-mount	1	Assembled
	z-lower-mount	1	Assembled
	z-upper-mount	1	Assembled
	z-corner-bracket	1	Assembled
	LM12UU linear bearing	2	Hardware
	Smooth rod 12x350mm	1	Hardware
	Aluminium extrusion	1	Hardware
	M6x16mm countersunk socket screw	2	Fastener

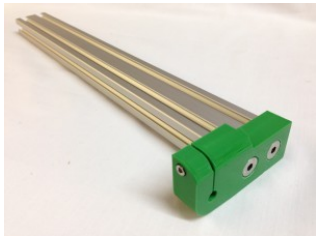


NOTE: THERE IS NO NEED TO SLIDE THE T-NUT IN FROM THE END OF THE ALUMINIUM EXTRUSION!
The M4 T-nuts are designed to drop into the extrusion slot. As the retaining screw is tightened, the T-nut rotates 90 degrees in the slot and locks into place.

Start by putting the z-upper-mount on the aluminium extrusion – it's a tight fit. Try to put it on as squarely as possible, to avoid damaging the printed part. If you need to, use a wooden block or soft-faced hammer if you're going to tap the aluminium extrusion, to avoid damage to the aluminium!

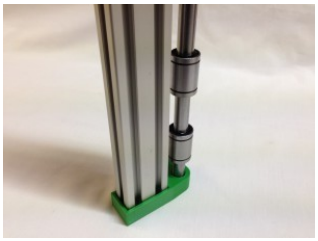


Check the aluminium extrusion is all the way in to the z-upper-mount. Secure the z-upper-mount with two M6x16mm countersunk screws.

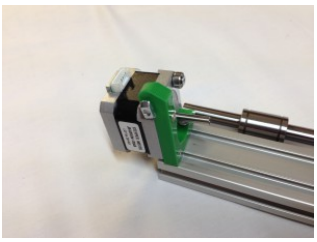


Fit the 12x350mm smooth rod into the z-upper-mount. You may need to slacken off the clamp screw to get it in. Make sure it is pushed in as far as it will go; it should be level with the end of the aluminium extrusion. Tighten the clamp screw.

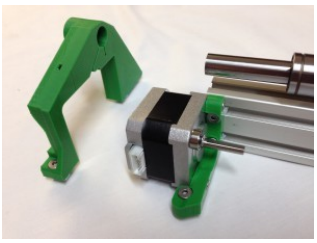
Slide the LM12UU Linear bearings onto the smooth rod. Check they slide smoothly and freely.



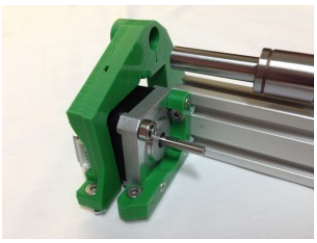
Slide the z-motor-mount sub-assembly onto the end of the extrusion. Keep all of the M4 T-nuts loose to allow for moving the motor around.



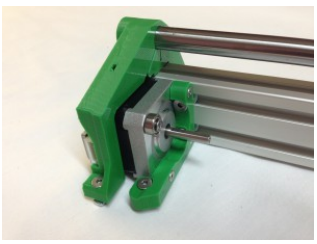
The z-lower-mount goes around the motor, and it’s easiest to put them on together.



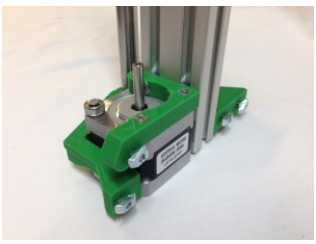
Hook the z-lower-mount over the motor, and move them together up the aluminium extrusion. The smooth rod should engage in the hole of the z-lower-mount; make sure it is pushed on as far as possible.



Lightly tighten the two M4 T-nuts on the z-motor-mount that are engaged in the aluminium profile slot. The M4 T-nuts should not be done too tight at this stage; just enough to hold the Z motor to the extrusion.



The assembly from another angle. Try to orientate the T-nuts horizontally, so they can drop into the Y axis aluminium extrusion easily.

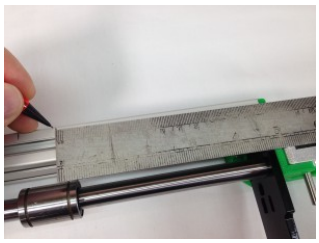


The complete Z axis assembly.

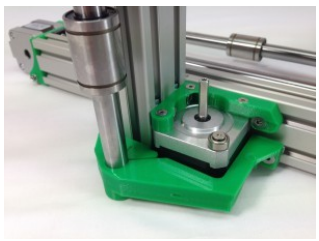
Connecting the z axis assembly to the y axis assembly

On the Y axis idler side, measure 210mm from the end of the Y axis aluminium extrusion without the Y axis motor, and mark with a pencil. This is to mark where the Z axis will be connected.

On the Y axis motor side, measure 120mm from the end of the Y axis aluminium extrusion, and mark with a pencil. The Z extrusion will sit between these two marks.

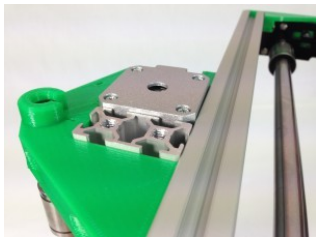


The Z axis assembly can now be attached to the Y axis assembly. Orientate the Z nuts so they drop into the extrusion; you don't need to slide them on from the end.

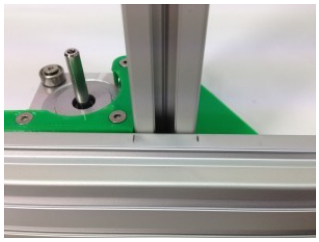


Tighten the three M4 countersunk screws on the z-lower-mount first. As you tighten them, the T-nuts should rotate 90 degrees and catch in the extrusion slot. They may need a wiggle to get them to turn. Do the middle one shown in the picture first; it's the most difficult, as you can't see if it catches, but the axis will hold when it does. Assemble loosely to start with, so you can move the components to the correct places.

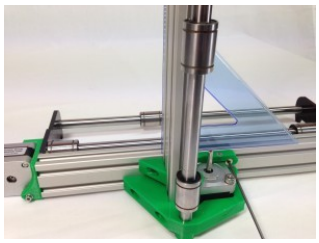
The base of the vertical aluminium extrusion must be flush with the bottom of the Y axis extrusion. The bottom of the motor will be a couple of millimetres below the level of the extrusions.



Try to get the extrusion between the two marks on the Y axis aluminium extrusion, so it's in the right place.

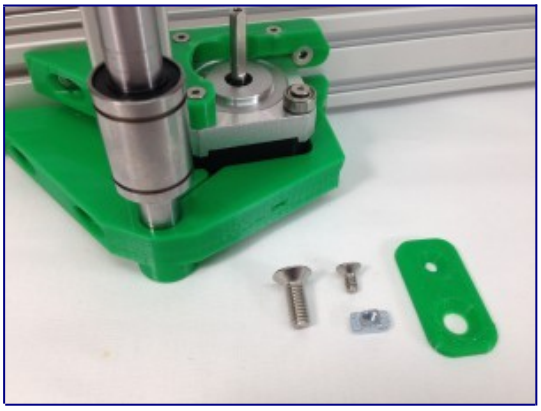


Use the supplied set square to check the Z axis and Y axis extrusions are at right angles to each other. Tighten the z-motor-mount to the two extrusions, then attach and tighten the z-corner-bracket, which gives additional support (shown on the left side of the Z extrusion). Repeat the above alignment steps to confirm they are all correct, before fully tightening all the fasteners.

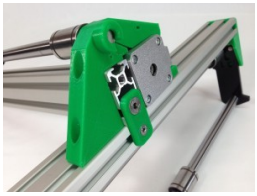


Attaching the z-foot

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



The base of the vertical aluminium extrusion should 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.

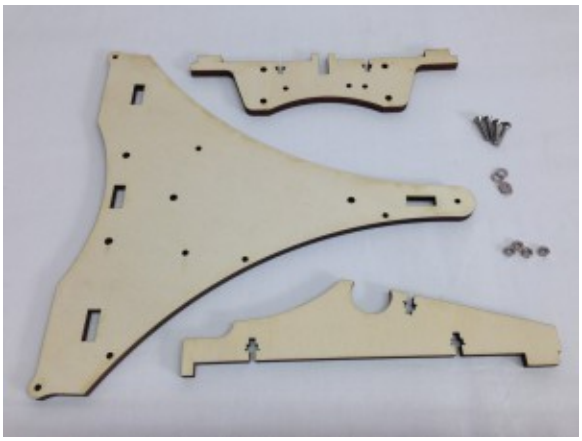


Y Carriage

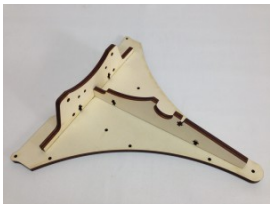
Y carriage assembly

The Y carriage can now be assembled and fitted. You will need the following parts:

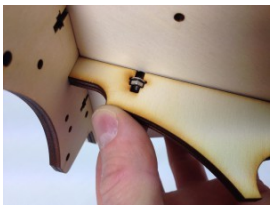
#	Component	Qty	Type
	bed-support (6mm ply)	1	Laser cut
	y-axis-rib (6mm ply)	1	Laser cut
	y-axis-cross-rib (6mm ply)	1	Laser cut
	M3x16mm countersunk socket screw	4	Fastener
	M3 nut	4	Fastener
	M3 washer	4	Fastener



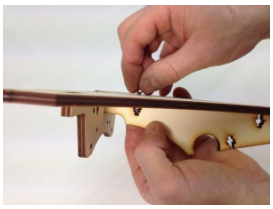
The y-axis-rib and y-axis-cross rib slot into the bed-support. Make sure the holes in the edge of the bed-support are on the left; these are used to attach the bed wiring later.



Secure the bed-support to the Y axis ribs using the four M3x16mm countersunk socket screws. An M3 washer and M3 nut go in the captive holes of the Y axis ribs. The easiest way to do this is to hold the bed vertically, and put your finger under the hole. Drop the washer in, then the nut.



Then thread the M3x16mm countersunk socket screw through from the top of the bed-support, so it engages with the nut. Repeat for the other three nut traps between the ribs and bed-support. Tighten all of them.

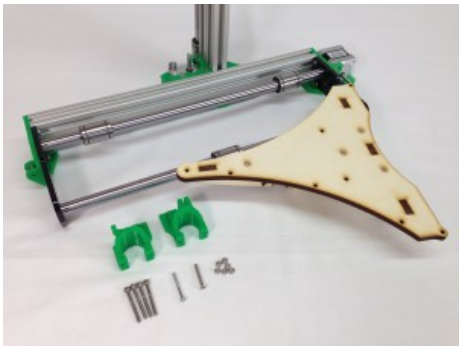


Make sure the bed-insulator is orientated correctly, as shown in the picture. The holes for the wiring are on the right-hand side when the y-carriage is the correct way up as in this picture.

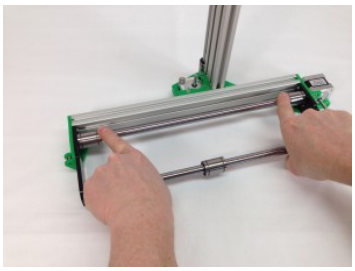
Y carriage mounting

Fit the y-carriage to the assembled y-z-axis assembly. The following parts are required:

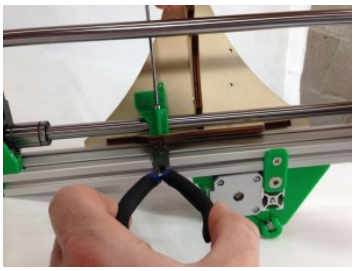
#	Component	Qty	Type
	y-z-axis assembly	1	Assembled
	y-carriage assembly	1	Assembled
	y-bearing-belt-clamp	1	Printed
	y-bearing-clamp-tagged	1	Printed
	M3x30mm cap head screw	4	Fastener
	M3x25mm countersunk socket screw	1	Fastener
	M3x26mm crosshead screw (removed from NEMA17 motor)	1	Fastener
	M3 nut	6	Fastener



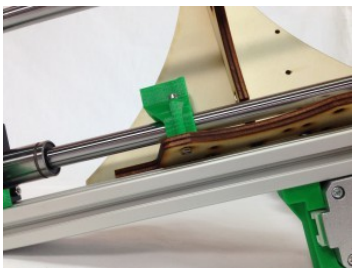
Push the two bearings on the back Y rod to the extreme ends of the carriage. This gives you the space you need to mount the y-carriage.



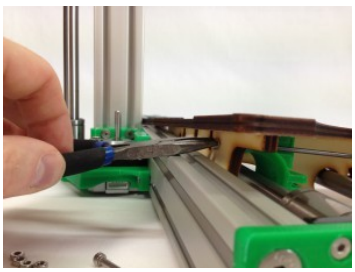
Take an M3x30mm cap head screw, and thread it through the lower hole of the y-bearing-clamp. Note the orientation of the y-bearing-clamp in the picture. Using a pair of pliers (or fingers if they are small enough!) with an M3 nut, mount the clamp on the y-carriage, around the back smooth rod, as shown.



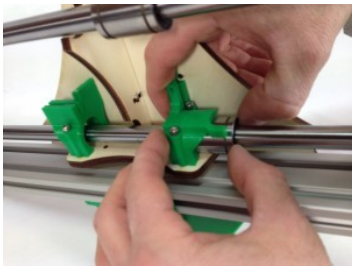
This can be quite fiddly! But it’s much easier without the bearings in the y-bearing-clamps. Lightly tighten the screw, as it will be easier to push the bearing in.



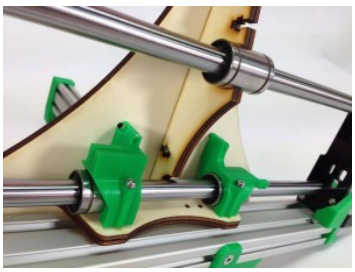
Lift the y-carriage up to allow you to hold an M3 nut in position, with pliers, to fix another M3x30mm cap head screw through the top hole in the y-bearing-mount.



Repeat the process for the y-bearing-mount on the other side, noting the orientation. Slide the back bearings into the y-bearing-clamps.

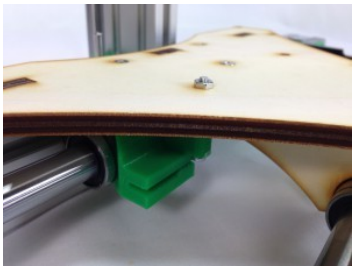


Note the position of the mount on the bearing. This is important to allow maximum movement of the Y axis in its frame. Slide the front bearing sideways into the notch in the Y carriage.

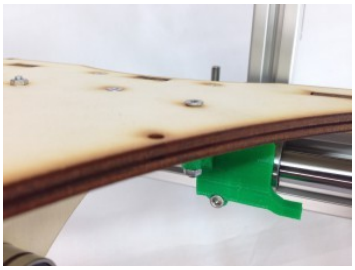


Using the M3x26mm crosshead screw your removed from the y-axis NEMA17 motor, push this up through the y-bearing-clamp-. If you put it in from the top, it will get in the way of the belt.

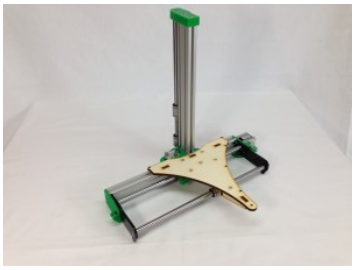
Secure with an M3 nut on top of the bed-support.



On the other side, thread a M3x25mm countersunk screw down through the bed-support, through the y-bearing-clamp, and secure with an M3 nut.

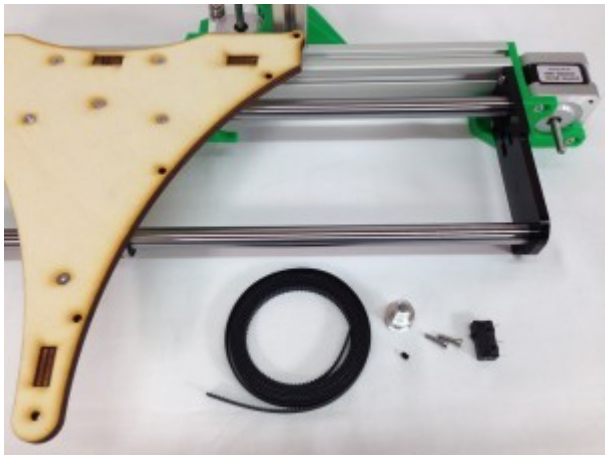


Tighten all six clamp screws. While doing this, slide the y-carriage up and down the smooth rods; this help centre the bearings, and lets the carriage slide smoothly. The picture shows the finished assembly.



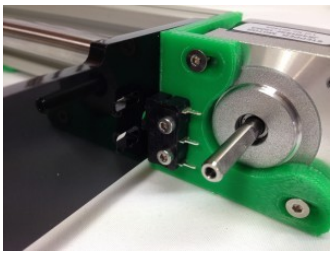
Y axis drive belt

#	Component	Qty	Type
	1/4″ MXL Belt	1	Hardware
	MXL pulley	1	Hardware
	M3 grub screw	1	Hardware
	Microswitch	1	Electronics
	M2.5x10mm cap head screw	2	Electronics

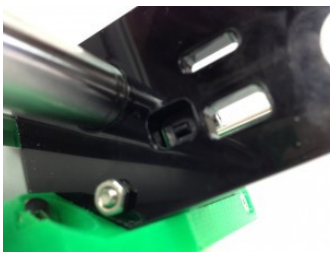


The 1/4″ MXL belt is supplied as one piece. Measure it with a tape measure, and cut the MXL belt to at least 710mm for the X axis, making sure you have at least 830mm left for the Y axis. There should be more belt than you need, but DO NOT just cut it in half – it may leave with you with too little for the Y axis!

Mount the microswitch with the two M2.5x10mm cap head screws. These should self-tap into the plastic of the y-motor-mount. Do not widen these holes with a drill, or the screws won't hold.



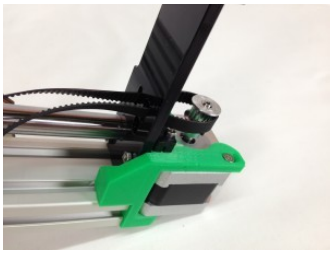
The switch should align with the hole in the laser cut y-axis-end-plate. Check the tab on the y-bearing-clamp hits the switch at the end of its travel.



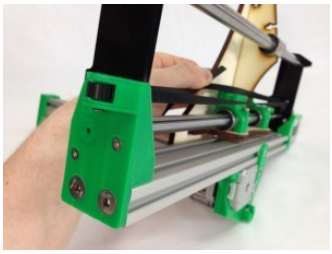
Screw the grub screw partially into the pulley. The motor shaft has a flat on it; align the grub screw with this.

Put the pulley on the motor shaft, and tighten the grub screw using a 1.5mm Allen key.

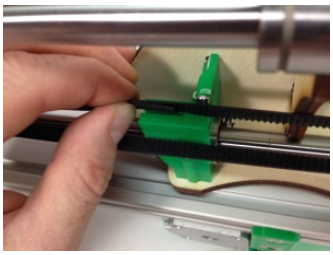
Thread the belt through the top hole in the y-axis-end-plate, around the drive pulley, and back through the lower slot in the y-axis-end-plate. The teeth of the belt should mesh with the teeth of the pulley.



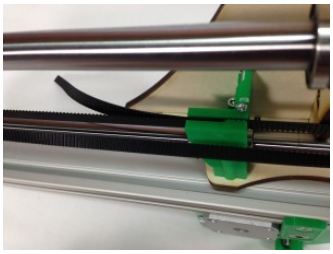
Thread the belt along the length of the Y axis. Twist the belt 180 degrees before feeding it through the through the lower slot in the idler end y-axis-end-plate, around the bearing, and back through the top slot. The twist in the belt means it will run on the bearing on the back of the belt.



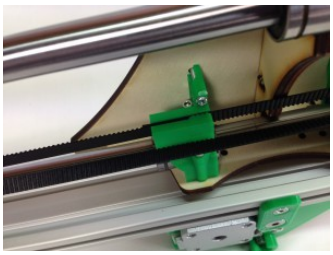
The twist in the belt also means the teeth of the belt can interlock. This is used to join the belt, and fix it to the y-carriage. Pull the belt tight, interlock the teeth, then push the two belt ends into the y-bearing-clamp, as shown.



One end of the belt should finish in the clamp, while any extra belt is free to come out the end of the clamp. Adjust the belt until it is as tight as possible. It will probably still be a little loose; don't worry, you will be able to adjust the tension.

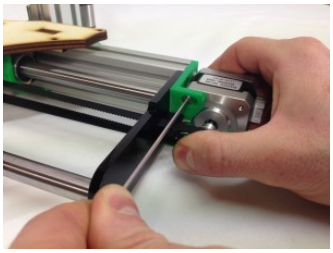


Cut off the excess belt. Leave about 10mm projecting; you may need to remove and re-fit it one day.

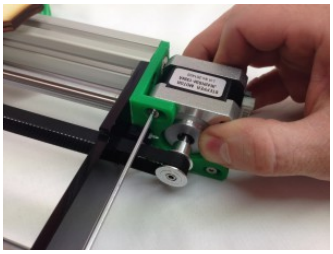


Y belt tensioning

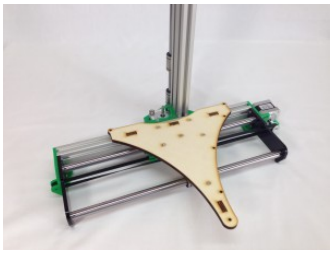
The belt tension needs to be quite tight, or the axis will suffer from backlash, and you will not get smooth vertical walls in your prints. But the belt should not be too tight, or the motor will struggle to move the axis! To adjust the belt tension, the y-axis motor is mounted in slots. Loosen the three screws, and pull the motor away from the mount to increase the belt tension. Re-tighten the screws, keeping the motor square to the axis. It is sometimes easier to get someone to help you with this, as more than two hands are useful.



When you twang the bottom belt, which has the longest uninterrupted span, a just-audible note should be heard. For reference, the note of the lowest string of a bass guitar is suitable. This is the bottom ‘E’ string; search online for another audio example for reference, if you need it. Adjust the belt as required.



The completed assembly.



X Axis Assembly

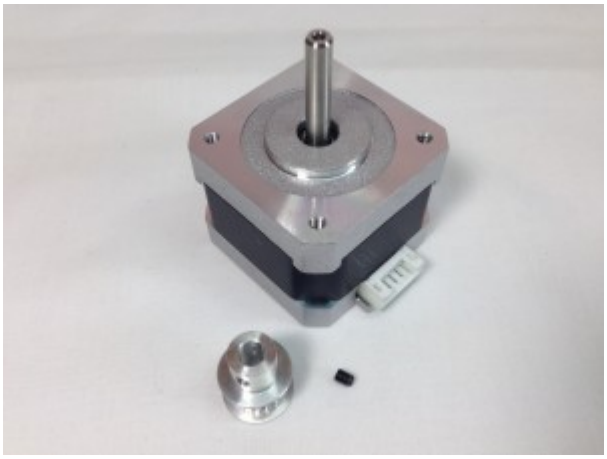
X axis sub-assemblies

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

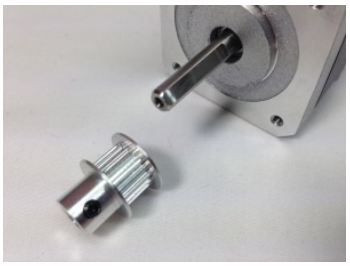
X-axis-motor

The x-axis-motor moves the x-axis belt.

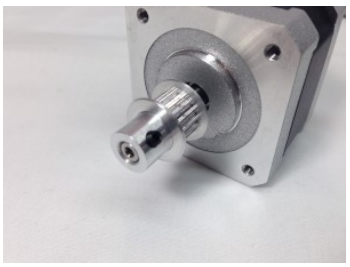
#	Component	Qty	Type
	NEMA17 motor	1	Hardware
	MXL pulley	1	Hardware
	M3 grub screw	1	Hardware



Screw the grub screw partially into the pulley. The motor shaft has a flat on it; align the grub screw with this. For the X axis, the pulley goes on the shaft with the pulley teeth closest to the motor body.



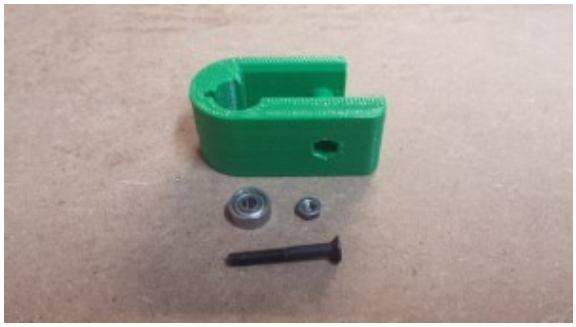
Put the pulley on the motor shaft, and tighten the grub screw using a 1.5mm Allen key. The pulley needs to sit right on the very end of the motor shaft, as shown in the picture.



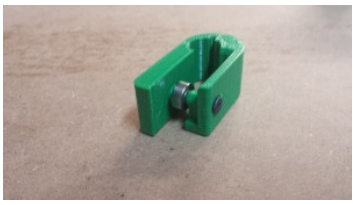
X-idler

The x-idler is at the other end of the x-axis from the x-motor, and carries the bearing for the x-axis belt.

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



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.

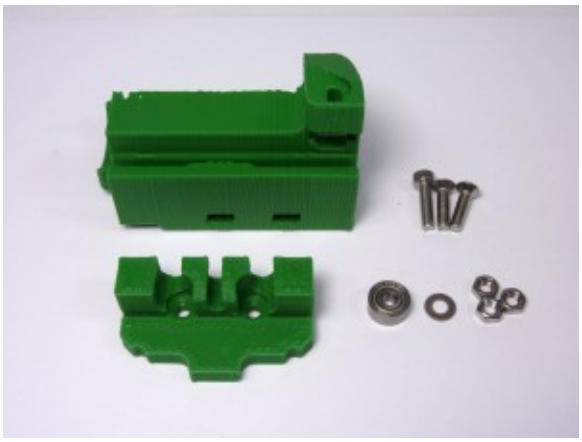


Pull the M3 nut into the ‘nut trap’, but leave the assembly loose at this stage. A ‘nut trap’ is a hole in a printed part that is designed to hold a nut ‘captive’.

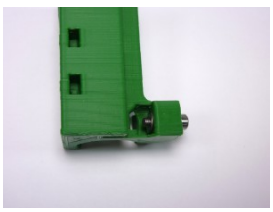
X-carriage (528.5 Onwards)

The x-carriage is connected to the x-axis belt, and travels along the X axis, carrying the hot end.

#	Component	Qty	Type
546.1	x-carriage	1	Printed
1079	Quick-set nozzle-mount	1	Printed
423	MR93ZZ bearing (9mm diameter)	1	Hardware
257	M3x12mm cap head screw	1	Fastener
212	M3 washer	1	Fastener
258	M3 Nut	3	Fastener
466	M3x12mm countersunk socket screw	2	Fastener



Fit the bearing using the M3x12mm cap head screw. IMPORTANT: use a 3mm drill to clean the slot that the screw goes through; this allows you to adjust the angle of the hot end. When it is loosened off the screw needs to be able to slide in the slot.

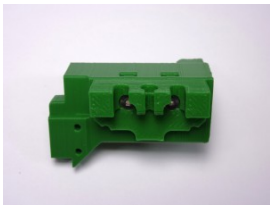


The M3 washer should be positioned between the bearing and the x-carriage.

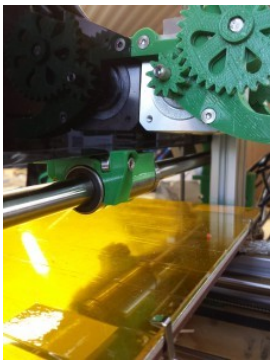
The M3 nut is quite fiddly to fit. It should be possible to tighten it without using a tool on it, as the flat of the nut rests against the shoulder in the printed part.

Put an M3 nut in each of the nut traps.

Attach the nozzle mount as shown with two M3x12mm countersunk socket screws.



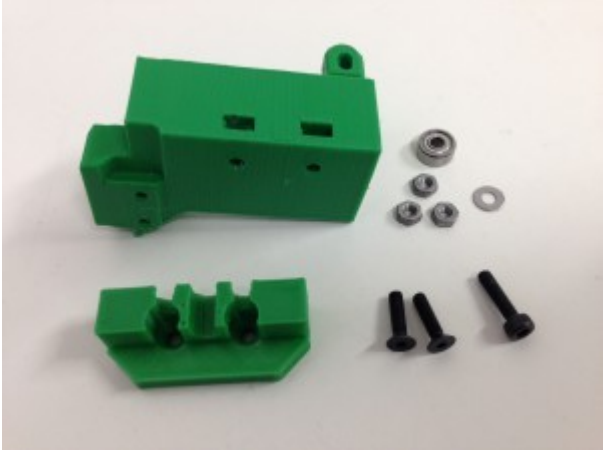
With this version of the x-carriage, the bearing runs on the underside of the x-axis plate, rather than on the back of it. This reduces the amount of flex of the x-axis-plate.



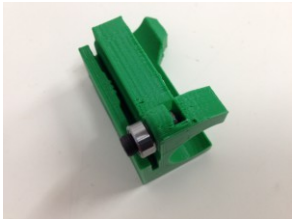
X-carriage (528.0 to 528.4)

The x-carriage is connected to the x-axis belt, and travels along the X axis, carrying the hot end.

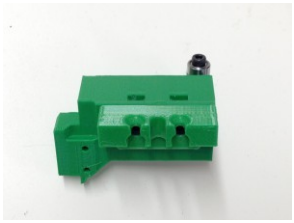
#	Component	Qty	Type
546	x-carriage	1	Printed
501	nozzle-mount	1	Printed
423	MR93ZZ bearing (9mm diameter)	1	Hardware
257	M3x12mm cap head screw	1	Fastener
212	M3 washer	1	Fastener
258	M3 Nut	3	Fastener
466	M3x12mm countersunk socket screw	2	Fastener



Fit the bearing using the M3x12mm cap head screw. The M3 washer should be positioned between the bearing and the x-carriage. IMPORTANT: use a 3mm drill to clean the slot that the screw goes through; this allows you to adjust the angle of the hot end. When it is loosened off the screw needs to be able to slide in the slot.



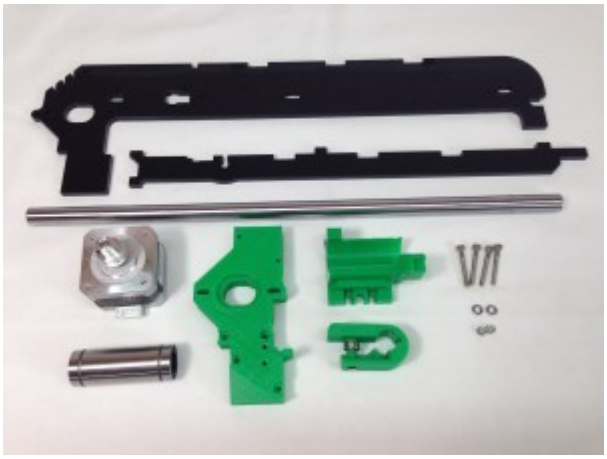
Put an M3 nut in each of the nut traps. Attach the nozzle mount as shown with two M3x12mm countersunk socket screws.



X axis assembly

Now you can start to assemble the X axis.

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

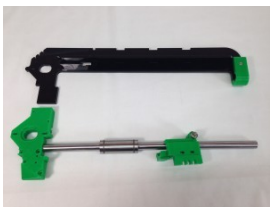


Push the x-rib into place in the slots in the x-axis-plate, which should slot together easily. **DO NOT FORCE!** Acrylic is quite brittle, and you may break the x-rib. Use a file to smooth any rough edges, and ease the tabs of the x-rib, so it goes into the x-axis-plate easily. The x-axis-plate should be perfectly flat; if it is bowed or twisted, the x-carriage will not run straight and true.

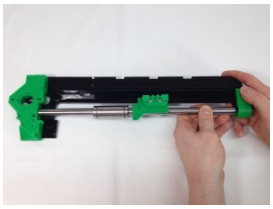
Make sure the screw through the x-idler sub-assembly is loose. Push the x-idler onto the end of the x-axis-plat and x-rib as shown, making sure it goes on straight.

Slide the smooth rod into the x-motor-bracket.

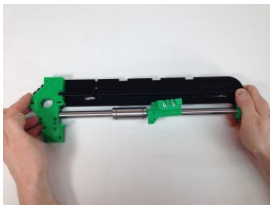
Then slide the linear bearing onto the bar, then the x-carriage. You need to fit the x-carriage now, as it won't fit on once the smooth rod is connected to the x-idler (next step). Don't push the x-carriage onto the bearing yet, as it needs to be off the bearing to attach the x-axis-drive-belt.



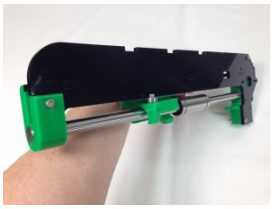
Push the smooth rod into the x-idler. Be careful not to bend or twist the acrylic parts.



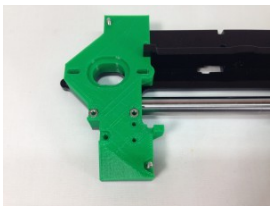
Push the x-motor-bracket until it buts up to the x-rib. Ensure you have the parts lined up before applying too much pressure as the acrylic parts are not very forgiving. You may find this easier if you do it vertically, with the x motor bracket supported by the edge of a bench just under the smooth rod, but don't let the assembly drop to the floor…



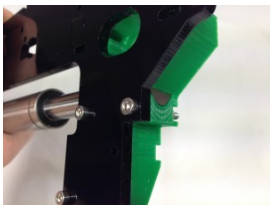
The x-carriage runner bearing should be behind the x-axis plate for the old version of the x-carriage (528.4 and earlier). If you're using the newer version of the x-carriage (528.5 onwards), the bearing runs on the underside of the x-axis-plate. See last picture in the preceding section.



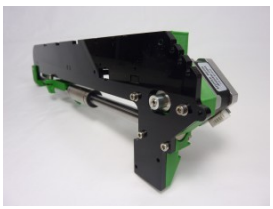
Insert two of the M3x25 screws in the top and bottom holes in the x-motor-bracket, to act as guide screws, and to hold the x-motor-bracket in place. Check that the x-motor-bracket fits in place; it may need trimming for a good fit around the x-rib. Make sure all the M3 holes in the printed part line up with the laser cut part – trim as necessary. Put an M3 nut in each nut trap, as shown.



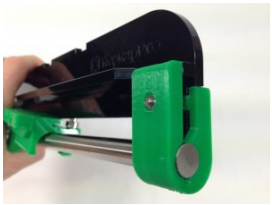
The smooth rod should butt up to the end of the x-motor-bracket, as shown. Insert two M3x25mm cap head screws to engage with the M3 nuts in the nut traps. Tighten the screws.



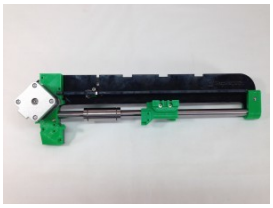
Remove the two M3x25mm screws that you put in as guide screws. Insert them, with washers on, to mount the motor. Orientate the motor as shown, with the wiring connector pointing out and down from the axis. Do not fully tighten the screws; the motor is mounted in slots to allow for tensioning the x-axis-drive-belt. Slide the motor to the end of the slots nearest the x idler bracket.



Tighten the countersunk screw in the x-idler-bracket.



The completed assembly.



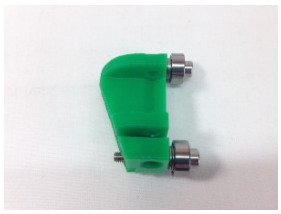
Z-runner-mount

The z-runner-mount sub-assembly stops the x-axis rotating around the z-axis.

#	Component	Qty	Type
	z-runner-mount	1	Printed
	623 bearing (10mm diameter)	2	Hardware
	M3x20mm cap head screw	1	Fastener
	M3x12mm cap head screw	2	Fastener
	M3x20mm countersunk socket screw	1	Fastener
	M3x16mm countersunk socket screw	1	Fastener
	M3 Nut	5	Fastener
	M3 washer	9	Fastener

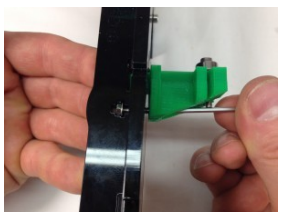
Put an M3 nut in each nut trap. Make sure they are at the bottom of the nut traps. If they don't drop straight in, pull them into the nut traps with an M3 screw. Using one M3x20mm cap head screw and one M3x12mm cap head screw, attach the bearings. Put one bearing on each screw, then 4 x M3 washers between each bearing and the z-runner-mount.

Assemble as shown in the picture.

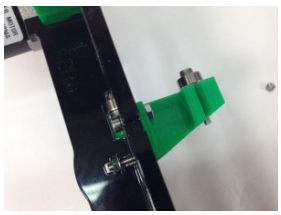


Put the M3x20mm countersunk screw through the recessed hole in the z-runner-mount.

Put your finger under the captive hole in the x-rib, and drop an M3 washer and M3 nut into it. Mount the z-runner-mount assembly to the x-axis-plate, putting the M3x20mm countersunk screw through the x-axis-plate and into the x-rib, where it is secured by the captive M3 nut and washer.



Use the M3x12mm cap head screw, which goes through the x-axis-plate and into the top hole of the z-runner-mount, and is secured with an M3 nut. Check both bearings are free to rotate; add or remove a washer if the bearing in the x-axis-plate is touching the acrylic.



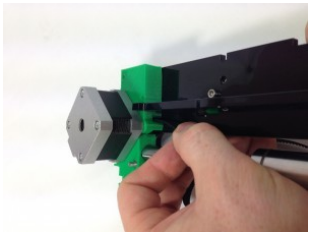
Use an M3x16mm countersunk socket screw and M3 nut to secure it. **DO NOT OVER-TIGHTEN!** The z-runner-mount should only need to lightly hold the z axis aluminium extrusion, or the axis will be difficult to move.

X axis drive belt

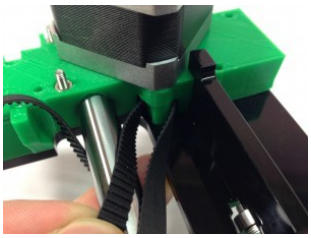
To finish the X axis, attach the drive belt.

#	Component	Qty	Type
	x-axis assembly	1	Assembled
	MXL belt	710mm	Hardware

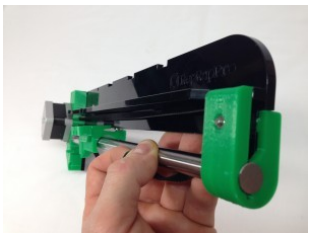
The X axis drive belt can now be fitted. The 1/4″ MXL belt should be accurately cut to 710mm in length. Insert the belt through the slot in the x-motor-bracket, around the drive pulley and back out through the second slot.



This is quite fiddly; moving the motor back and forth will help feed the belt through, as will rotating the motor pulley. You can also push the belt around the back of the pulley, with a small Allen key or screwdriver.

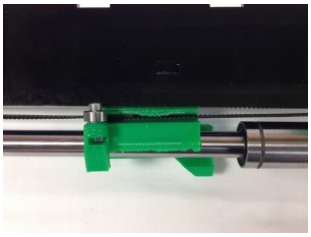


Twist the top section of belt 180 degrees, and pass it over and around the idler bearing. The smooth side of the belt will be in contact with the bearing.

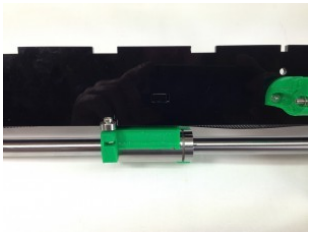


Slide the end of the lower section of belt, from the motor end, into the x-carriage. The end of the belt should be flush with the end of the x-carriage if your belt has been cut to 710mm. Mesh the teeth of the two ends of the belt, and push it into the slot in the x-carriage.

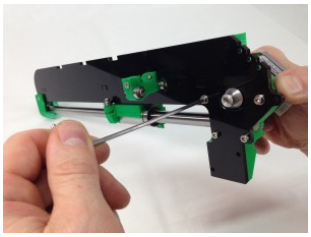
Make sure the belt is pushed fully back in the slot, and that there is as much engagement of the teeth as shown.



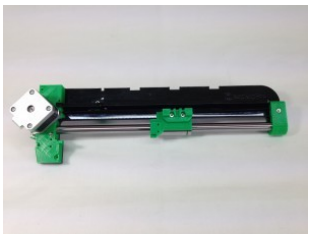
The linear bearing can now be slid into the x-carriage.



Tighten the belt by sliding the X axis motor back. Tighten the motor mounting screws.



The completed assembly. Check the x-carriage runs smoothly by moving the x-carriage up and down the smooth rod. If it sticks, the bearing may need lubricating. It's actually the rubber seals on the bearing ends that need lubrication; use a drop of light oil (like 3-in-1 oil or similar) on each side of the bearing and run it up and down. A remaining film of oil on the rod is good. But make sure there are no drips. Also check the belt doesn't rub at either end; this is usually signified by a little black 'dust', which is where the edge of the belt is rubbing. Check the alignment of the motor pulley. If you do the x-idler up very tight, you may need to put an M3 washer on one side of the bearing, to give the belt a little more space.



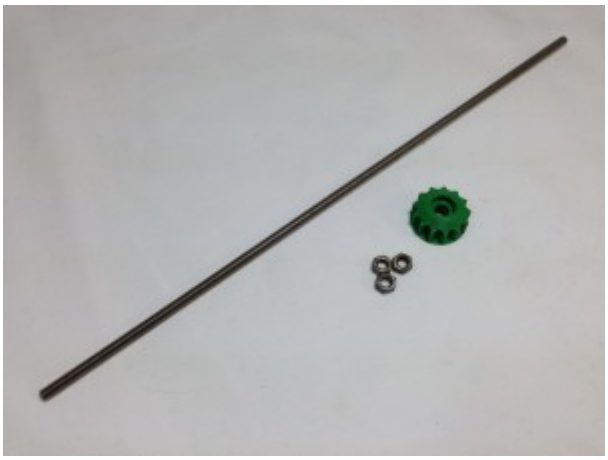
X Axis Mounting

The X axis assembly can now be mounted to the previously assembled ZY assembly.

Z axis leadscrew

The Z axis leadscrew moves the X axis up and down.

#	Component	Qty	Type
	z-gear-driven	1	Printed
	M5 threaded z-rod	1	Hardware
	BZP M5 nut	3	Fastener



Make sure the M5 threaded z-rod is clean, with no swarf or other debris in its threads. Screw two M5 nuts onto one end of the M5 threaded z-rod. Tighten one nut against the other, so that they are locked in place, right at the end of the rod.

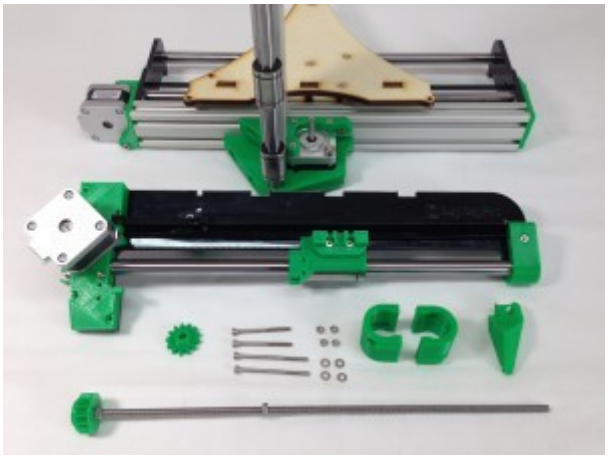
Push the z-gear-driven onto the locked M5 nuts. The bottom nut of the two should fit into the nut trap in the gear.

Screw the last M5 nut onto the z-rod. It should look like this, when assembled. You can lightly oil the threaded rod; see the Maintenance section later in the instructions for guidance.

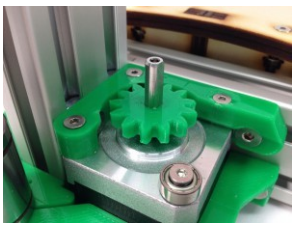
X axis assembly

Now, the x-axis-assembly can be mounted on the z axis. For this, the following parts are required:

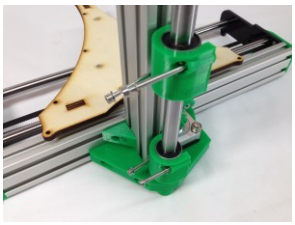
#	Component	Qty	Type
	x-axis-assembly	1	Assembled
	y carriage and z axis	1	Assembled
	z-axis-leadscrew	1	Assembled
	z-bearing-clamp	2	Printed
	z-nut-trap	1	Printed
	z-gear	1	Printed
	M3x50mm cap head screw	2	Fastener
	M3x40mm cap head screw	2	Fastener
	M3 Nut	4	Fastener
	M3 washer	4	Fastener



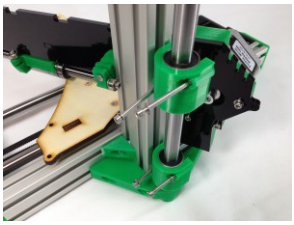
Press the z-gear onto the z-motor shaft, conical side down. The z-gear has a flat in the hole, that should align with the flat on the motor shaft, which stops the gear rotating on the shaft. The gear should be a tight fit, so make sure you line it up before pushing the gear on the motor shaft.



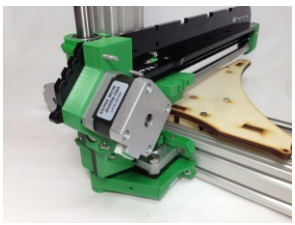
Slide a z-bearing-clamp onto each z axis linear bearing. Place the two M3x50mm cap head screws in the top mount, and the two M3x40mm cap head screws in the bottom mount, with a washer under each head.



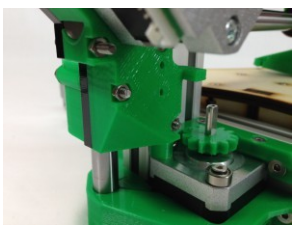
Take the x-axis-assembly. Hook the z-runner-mount bearing around the z axis aluminium extrusion.



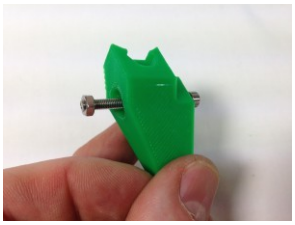
Offer up the x-axis-assembly and push the four z-bearing-mount screws through the X axis. The X axis can now sit at the bottom of the Z axis.



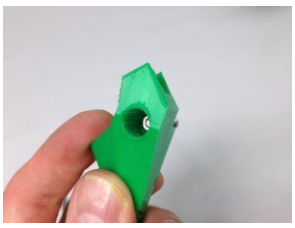
Use two M3 nuts to secure the bottom z-bearing-mount. Don’t do them up too tight yet.



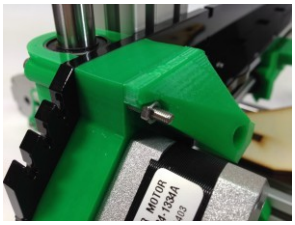
Use a screw to pull an M3 nut into the recessed nut trap, in the z-nut-trap printed part.



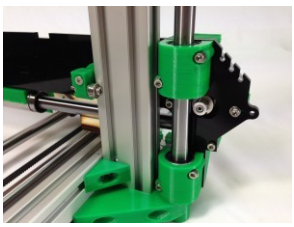
You may need to push the M3 nut into the nut trap with a screwdriver, but the screw will help to align it correctly. Remove the screw once it is held in place.



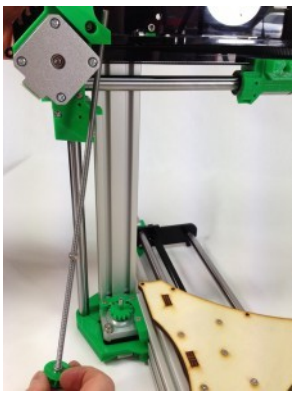
Push the z-nut-trap onto the end of the 50mm cap head screws, add the remaining M3 nut, and do up the screws, but not tight.



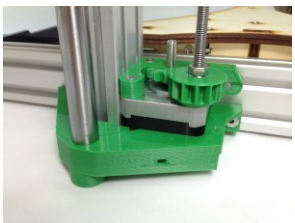
Now tighten the bearing mount screws. The holes in the bearing clamps are clearance for the M3 screws, so keep moving the axis up and down between turns of each screw. This will let the bearings settle in the right place, and ensure that the axis runs smoothly.



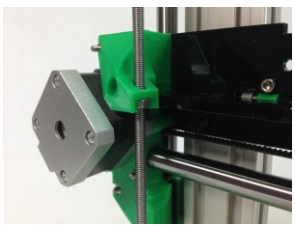
Lift the X axis to the top of the Z axis, and carefully feed the z-axis-leadscrew assembly up through the z-nut-trap.



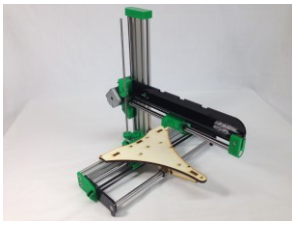
The z-axis-leadscrew sits on the 623 bearing on the corner of the Z axis motor, engaging with the z-gear on the motor.



The x-axis-assembly can now be supported by the loose M5 nut on the z-axis-leadscrew. Gently lower the X axis onto it, being careful to orientate the M5 nut correctly – see picture.



The completed assembly. Put a little light oil on the Z-axis M5 screw using a cloth. An thin even spread without drips is best.



Checking for play in the x axis

Adjusting the z-runner-mount.

Rotation of the x-axis around the z-axis is prevented by the z-runner-mount. It is important that the z-axis aluminium extrusion is held securely by the bearings in the z-runner-mount. The outer bearing on the z-runner-mount is mounted on a hinged clamp, which allows the tension to be adjusted. However, don’t over-tighten this, or movement of the Z axis may be compromised.

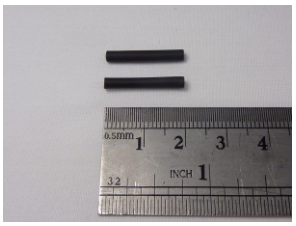
Heated Bed Assembly

Bed thermistor assembly

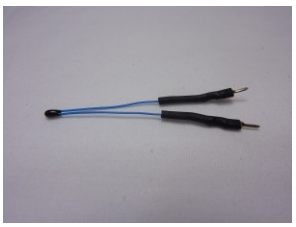
The bed thermistor measures the temperature of the heated bed.

#	Component	Qty	Type
	10k (bed) Thermistor	1	Electronics
	Black heatshrink	As required	Electronics

Cut two pieces of heatshrink, about 20mm in length.



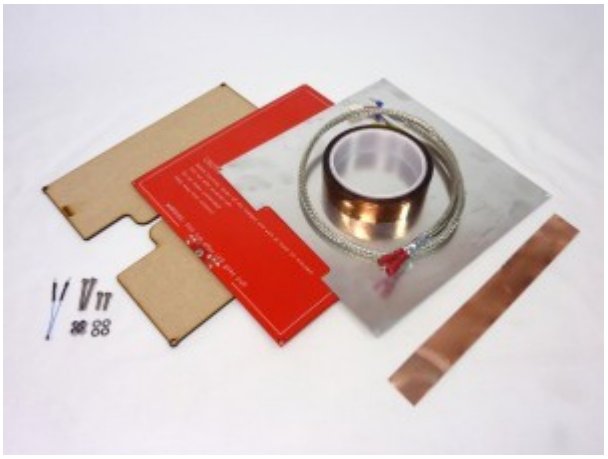
Fold the sharp parts of the crimp, on the sides, in with a pair of pliers; this ensures that they do not cut through the heatshrink, and cause a short circuit later. Cover each crimp with a short piece of heatshrink, and use a hot air source or cigarette lighter to shrink it into place, leaving the pins exposed. If you use a flame, waft the shrink above the flame. Don't play the flame directly on the shrink, or you will burn it. Check that the crimp, except for the pins, is insulated.



Heated bed assembly (528.4 Onwards)

The heated bed helps the extruded plastic stick to the build surface, and improves the print quality.

#	Component	Qty	Type
	Heated bed wiring loom	1	Heated bed
	MDF bed insulator	1	Heated bed
	PCB heated bed	1	Heated bed
	Aluminium heat spreader	1	Heated bed
	Kapton tape	As required	Hardware
	Metal tape	1	Heated bed
	Thermistor assembly	1	Assembled
	M3x25mm cap head screw	2	Fastener
	M3x12mm cap head screw	2	Fastener
	M3 washer	4	Fastener
	M3 nyloc nut	4	Fastener



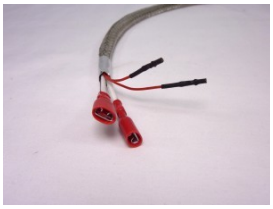
Bend the thermistor bead at 90 degrees to the wire.

The thermistor bead fits into the central hole in the heated bed PCB. Secure it in place with some Kapton tape, with the legs of the thermistor pointing towards the PCB contacts.

Make sure the thermistor protrudes through the hole in the PCB a little. It will then have good contact with the aluminium heat spreader, and temperature readings will be more accurate.

It’s a good idea to put a piece of Kapton tape over the bed contacts, so you cannot inadvertently short circuit the bed.

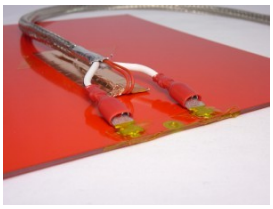
Put heatshrink on the female crimps of the two smaller wires of the wiring loom, if there is none. Covering any exposed metal, but leave the hole in the end of the crimp clear. These wires connect to the thermistor and have to be insulated from each other, and any other part of the heated bed, or you will get incorrect temperature readings, or possibly short circuit the thermistor.



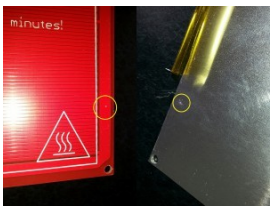
Connect the wiring loom to the thermistor. The thermistor has no polarity, so it doesn't matter which way around you connect them. The thermistor wires need to sit in the slot of the MDF bed insulator. Hold It in place with a piece of Kapton tape. Put this over the connection between the thermistor and the loom; it's extra insulation in case there is metal poking through, that could come in contact with the metal tape, which is fitted in the next step.

Tape the wires in place with the metal tape, checking the wires sit between the MDF bed insulator. This shields the thermistor wire from Electro Magnetic Interference (EMI).

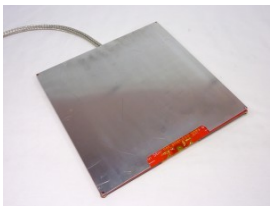
Push the bed wiring loom crimps onto the tabs on the heated bed. Make sure they are pushed fully on. The bed has no polarity, so they can go on either way around. The wires will be closer to the bed if you put the flat side of the crimp towards the bed, as shown.



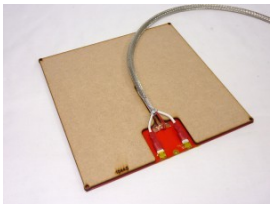
CAUTION!
Wipe the aluminium heat spreader with a paper towel, to remove any metal swarf, and carefully check it for damage, burrs or projections before final assembly. Any scrapes or sharp protrusions from the aluminium heat spreader may scratch the PCB, and short circuit through the aluminium heat spreader, which may result in damage to the electronics.



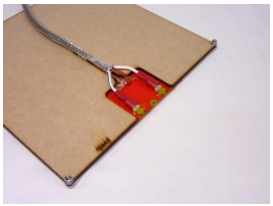
Line up the aluminium heat spreader with the PCB, making sure that it doesn't touch the contacts.



Turn the bed over, and put the MDF bed insulator in place.



Now assemble the heated bed by putting two M3x12mm cap head screws through the two corners of the bed at the connector end, each side of the PCB contacts. The order should be aluminium heat spreader, PCB, MDF, M3 washer, M3 nyloc nut.



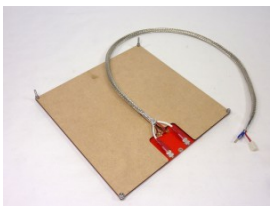
Put two M3x25mm cap head screws through the back corners of the bed. The order should be: aluminium heat spreader, PCB, MDF, M3 washer, M3 nyloc nut.

Test the thermistor wiring at the end of the wiring loom; the resistance should be around 10k ohms. It was a warm day when we took this picture, around 28C, so the reading is lower, at 8.48k ohms. Remember that you have a resistance, which will become apparent with a wrong value if you hold both wires in your fingers…

Test the heated bed power wires are making a good connection by testing the resistance. This measures the resistance of the heated bed, and it should be around 1.3 ohms. You may need to wait for a few seconds for the figure to stabilise. Make sure you have a good battery in your multimeter and check that when you short its leads it reads 0 ohms, or your reading may be inaccurate.

Finally, test there is NO continuity (i.e. infinite resistance) between the aluminium heat spreader and the contacts of the heated bed. If there is continuity, there is a connection between them somewhere, and possibly the heated bed PCB has been damaged. See the earlier warning in red in this section.

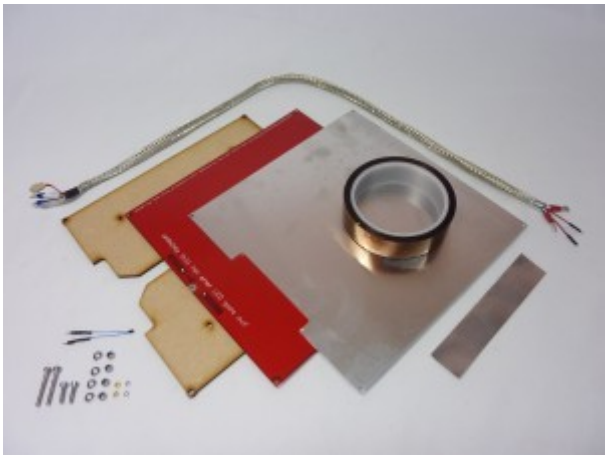
The completed heated bed assembly.



Heated bed assembly (528.0 to 528.3)

The heated bed helps the extruded plastic stick to the build surface, and improves the print quality.

#	Component	Qty	Type
	Heated bed wiring loom	1	Heated bed
	MDF bed insulator	1	Heated bed
	PCB heated bed	1	Heated bed
	Aluminium heat spreader	1	Heated bed
	Kapton tape	As required	Hardware
	Aluminium tape	1	Heated bed
	Thermistor assembly	1	Assembled
	M2 spring washer	2	Fastener
	M2 nut	2	Fastener
	M3x25mm cap head screw	2	Fastener
	M3x12mm cap head screw	2	Fastener
	M3 washer	4	Fastener
	M3 nyloc nut	4	Fastener

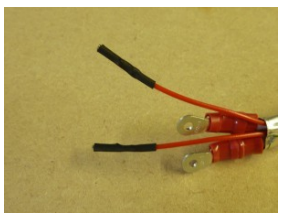


The thermistor bead fits into the central hole in the heated bed PCB. Secure it in place with some Kapton tape, with the legs of the thermistor pointing towards the PCB contacts.

Make sure the thermistor protrudes through the hole in the PCB a little. It will then have good contact with the aluminium heat spreader, and temperature readings will be more accurate.

It’s a good idea to put a piece of Kapton tape over the bed contacts, so you cannot inadvertently short circuit the bed. (The rest of the pictures in this sequence do not show this, but fit it now.)

Put heatshrink on the female crimps of the two smaller wires of the wiring loom, if there is none. Covering any exposed metal, but leave the hole in the end of the crimp clear. These wires connect to the thermistor and have to be insulated from each other, and any other part of the heated bed, or you will get incorrect temperature readings, or possibly short circuit the thermistor.



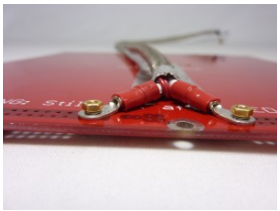
Connect the wiring loom to the thermistor. The thermistor has no polarity, so it doesn't matter which way around you connect them. The thermistor wires need to sit in the slot of the MDF bed insulator.

IMPORTANT: Hold the thermistor wires in place with a piece of Kapton tape. Put this over the connection between the thermistor and the loom; it's extra insulation in case there is metal poking through, that could come in contact with the metal tape, which is fitted in the next step.

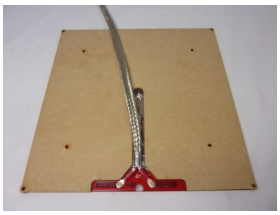
PICTURE TO COME

Tape the wires in place with the metal tape, checking the wires sit between the MDF bed insulator. This shields the thermistor wire from ElectroMagnetic Interference (EMI).

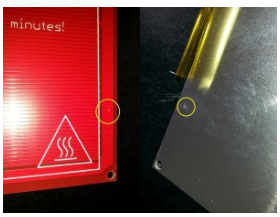
Connect the crimped eyelets to the M2 brass screws. The sequence should be eyelet – spring washer – M2 nut. Make sure the crimped eyelets are flat against the bed; they won't fit on the brass screws if they are the other way up.



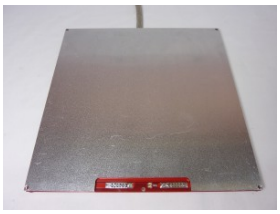
The power terminals should fit into the MDF bed insulator as shown. Get them in the correct place before fully tightening.



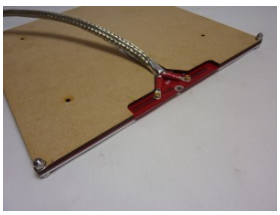
CAUTION!
Wipe the aluminium heat spreader with a paper towel, to remove any metal swarf, and carefully check it for damage, burrs or projections before final assembly. Any scrapes or sharp protrusions from the aluminium heat spreader may scratch the PCB, and short circuit through the aluminium heat spreader, which may result in damage to the electronics.



Line up the aluminium heat spreader with the PCB, making sure that it doesn't touch the contacts.



Now assemble the heated bed by putting two M3x12mm cap head screws through the two corners of the bed at the connector end, each side of the PCB contacts. The order should be aluminium heat spreader, PCB, MDF, M3 washer, M3 nyloc nut.



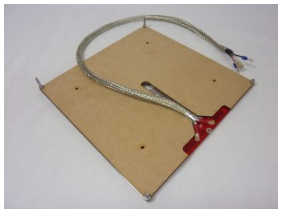
Put two M3x25mm cap head screws through the back corners of the bed. The order should be: aluminium heat spreader, PCB, MDF, M3 washer, M3 nyloc nut.

Test the thermistor wiring at the end of the wiring loom; the resistance should be around 10k ohms. It was a warm day when we took this picture, around 28C, so the reading is lower, at 8.48k ohms. Remember that you have a resistance, which will become apparent with a wrong value if you hold both wires in your fingers…

Test the heated bed power wires are making a good connection by testing the resistance. This measures the resistance of the heated bed, and it should be around 1.3 ohms. You may need to wait for a few seconds for the figure to stabilise. Make sure you have a good battery in your multimeter and check that when you short its leads it reads 0 ohms, or your reading may be inaccurate.

Finally, test there is NO continuity (i.e. infinite resistance) between the aluminium heat spreader and the contacts of the heated bed. If there is continuity, there is a connection between them somewhere, and possibly the heated bed PCB has been damaged. See the earlier warning in red in this section. You can cover any exposed copper on the heated bed with a small piece of Kapton tape, then re-assemble the bed and test again.

The completed heated bed assembly.

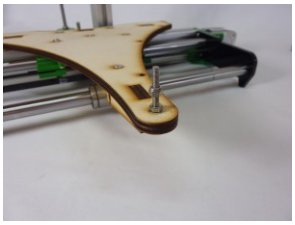


Mounting the heated bed

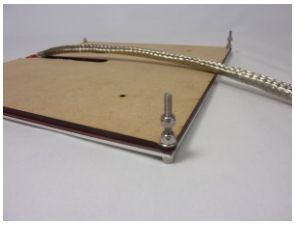
The heated bed can now be mounted on the x-carriage.

#	Component	Qty	Type
	Printer assembly	1	Assembled
	M3x25mm cap head screw	1	Fastener
	M3 washer	3	Fastener
	M3 nut	4	Fastener
	M3 nyloc nut	3	Fastener

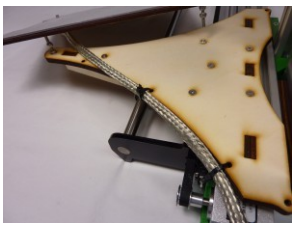
Put the M3x25mm cap head screws up through the end of the y-carriage, as shown. Put an M3 washer on, then an M3 nut, and tighten. The M3 nyloc nut goes on part-way. The heated bed will sit on this, and it will provide adjustment for levelling the heated bed manually.



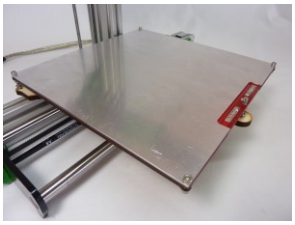
Put the other two M3 nyloc nuts on the M3x25mm cap head screws on the heated bed. These will provide levelling adjustment for the back of the bed.



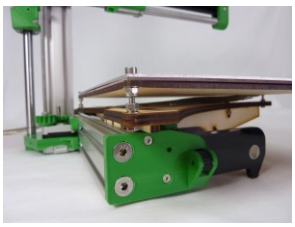
Use two cable ties to loosely attach the heated bed wiring to the edge of the y-carriage. This is important; it stops the hot end cable moving at the connections. The cable will bend along it’s length as the y-carriage moves, not at one point.



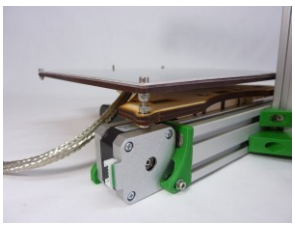
Place the heated bed assembly on the y-carriage. It is mounted on three points, and the nyloc nuts provide manual height adjustment. Put the two M3 washers on top of the y-carriage, so that the two M3 nyloc nuts at the back of the bed rest on them.



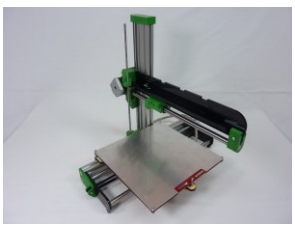
Use two M3 nuts as lock nuts under the y-carriage. You can move the y-carriage to the far end to make it easier to put them on.



Slide the y-carriage to the other end of the axis to put the other M3 nut on.



The final M3 nut fits on top of the heated bed PCB, on the M3x25mm screw that points upwards through the end of the y-carriage. It holds the front of the heated bed down. The M3 nut is not shown in this picture, but put it in it’s place!

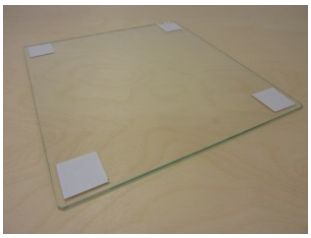


Print surface

The glass print surface must be prepared before fitting onto the machine.

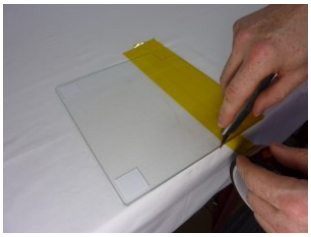
#	Component	Qty	Type
	Glass plate standard float glass, 200mm x 214mm x 3mm	1	Heated bed
	Plain white paper or adhesive labels	1	not supplied
	Kapton tape	1	Consumable
	Picture frame clips	4	Hardware

Cut the plain white paper into four 25mm x 25mm squares. Alternatively, you can use white adhesive labels, which makes it easier to stick them on the glass before covering them with Kapton. Stick the paper squares to the four corners of the glass plate, roughly 5mm from the edge. These will act as targets for the proximity sensor, for homing the Z axis, and for bed levelling. The paper targets are on top of the glass, not underneath, so we can use the close accuracy of the proximity sensor.

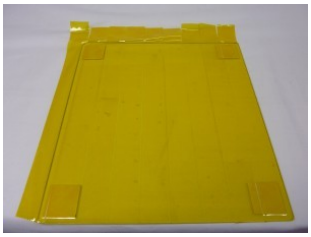


Cover the glass plate and paper targets with one layer of Kapton tape. We stick the Kapton tape to the top edge of the glass, then pull enough out to cover one length. Put a ***little*** tension on the tape to keep it straight, then lower it onto the glass. Work down the tape with your finger, flattening it onto the glass, and pushing out any air bubbles.

We find it easiest to work on the edge of the table, to drop the Kapton tape roll over the edge. Trim the excess off as we go. Take care to exclude bubbles; working on a white surface helps to spot them. Don’t pull the tape too taught before you lay it down. Gaps between the strips are preferable to overlaps.

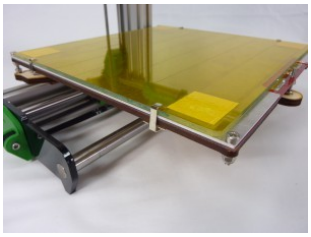


Completely cover the glass, then trim any excess off flush with the edge. Try not to wrap the Kapton tape under the glass. Another way to apply the Kapton tape is to slide it on with soapy water, move it into position, then squeegee out the water. You have to wait for it to dry out before use.



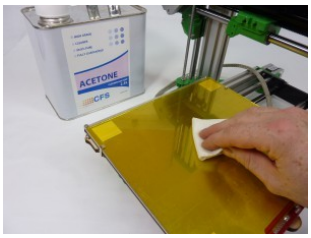
The Kapton is used as the print surface, so the bed should be installed Kapton-side-up. The other side is plain glass, and sits against the aluminium heat spreader. The paper targets should be on top of the glass, and the Kapton on top of the paper targets and glass.

Install the print surface on the heated bed with the clips provided. The glass side should be in contact with the aluminium heat spreader. The clips go around the glass and the heated bed.

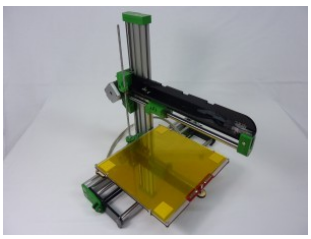


Locate the tab on the end of the clip in the hole in the MDF, which will hold the clip in place.

It is important that the print surface is kept free from dirt and oil, including fingerprints; these will stop your prints sticking to the bed. Wipe it clean with a paper towel and acetone (commonly found in nail polish remover, though be careful that does not contain lanolin or any other oil or grease – read the ingredients on the label). isopropyl alcohol, white methylated spirits and white vinegar should also work – all of these are organic solvents, and dissolve oil and grease into the towel before the residue evaporates. Don’t use Windex/Windowlene or polish; they often have a non-stick component!



The completed assembly.



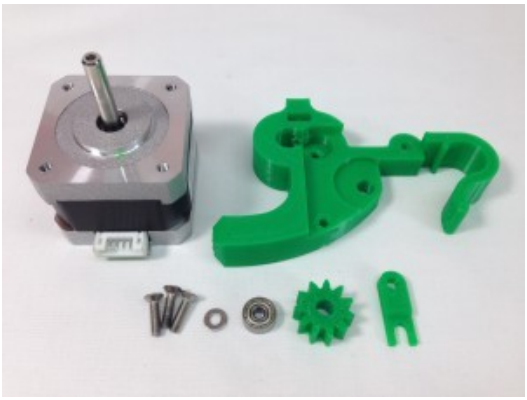
Extruder Drive Assembly

This section shows you how to assemble the extruder drive. All the parts for the extruder drive, except for the NEMA17 motor, should be in the bag labelled ‘Extruder drive set’.

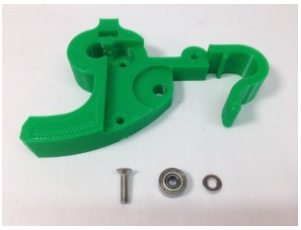
Extruder body

The extruder body holds the stepper motor, which drives the plastic filament.

#	Component	Qty	Type
	NEMA17 motor	1	Hardware
	Extruder drive block	1	Extruder drive
	Extruder small gear	1	Extruder drive
	Retaining tongue	1	Extruder drive
	623 bearing (10mm diameter)	1	Extruder drive
	M3 washer	1	Extruder drive
	M3x12mm countersunk socket screw	3	Extruder drive

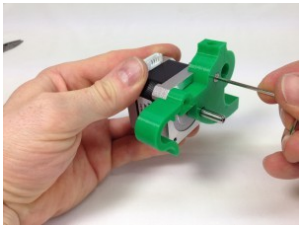


Take the extruder body, one M3x12mm countersunk screw, the 623 bearing and an M3 washer.

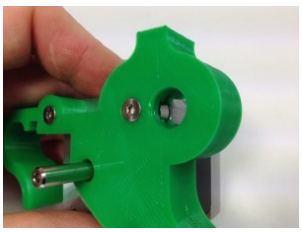


Put the screw in from the back, in the hole in the corner of the extruder block. Put the 623 bearing in the hole, on the screw. Put the washer on top of the bearing, as shown. This washer is sandwiched between the bearing and the motor; without it, the bearing will bind on the motor and not turn, and the extruder drive will function poorly.

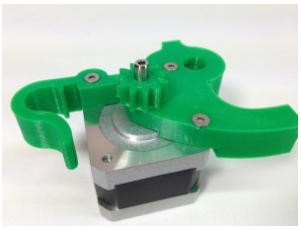
Fit the motor on top of the washer and bearing. Do the screw up loosely.



Screw the other two M3x12mm countersunk screws through the extruder body and into the motor, to mount the motor solidly. Tighten all three screws. Check that the bearing can turn freely.



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. There should be a small gap (0.5mm to 1mm) between the gear and the face of the extruder body. If you put a piece of folded paper under the gear when you push it down this will set that gap. Pull the paper out. Check the motor turns freely.

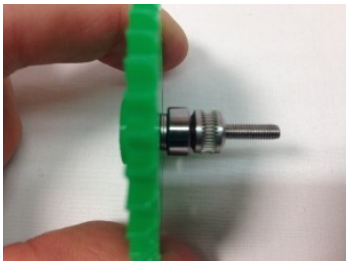


Large extruder gear

The large extruder gear drives the filament through the Bowden tube and into the hot end.

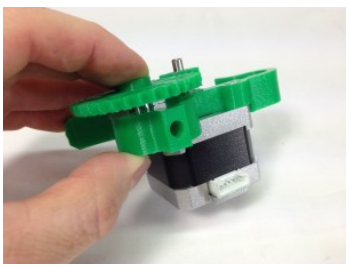
#	Component	Qty	Type
	Extruder large gear	1	Extruder drive
	Hobbed insert	1	Extruder drive
	M3 washer	2	Extruder drive
	M3 nyloc nut	1	Extruder drive
	M3x25mm hex head screw	1	Extruder drive
	MR93ZZ bearing (9mm diameter)	2	Extruder drive

Push the M3x25mm hex head screw through the gear. The hexagon head of the screw should be held tightly by the plastic part. Slide the two M3 washers on to the screw, followed by one MR93ZZ bearing, then 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. Most pairs of pliers have half-round holes in their jaws; use these to grip the hobbed insert. Tightening the insert pulls the hex head screw into the gear, and locks the bearing and hobbed insert in place.

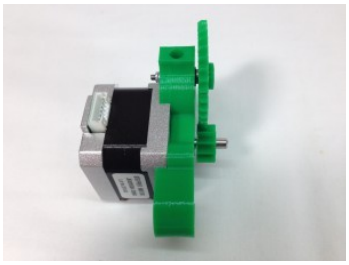


Slide second MR93ZZ bearings on, followed by the M3 nyloc nut. Tighten the nut hard against the bearing. Don't hold the hobbed insert to tighten this nut, as that will tend to loosen the insert. Hold the gear instead.

Now push the large extruder gear sub-assembly into place in the extruder body. With filament loaded, the gear can't come out, but without filament, you should be able to pull the gear off for easy cleaning of the hobbed insert.



Make sure the gap behind the gear is correct, and turn the large gear a few times to check it is meshing smoothly with the small gear. If it isn’t, check that the large gear isn’t too close to the extruder body; it may bind with the lip on the bottom of the small gear. You may also need to file the teeth of the small or large gear, if there are any inconsistencies due to manufacture. Feed a short length (200 mm or so) of filament into the drive. When it is engaged with the hobbed insert and you hold the large gear still it should be impossible to pull the filament out of the drive using your fingers. Wind the test filament out.

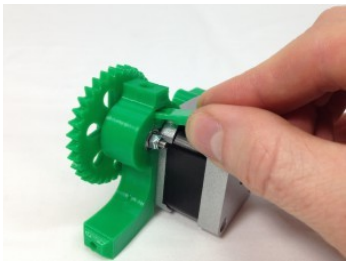


The retaining tongue

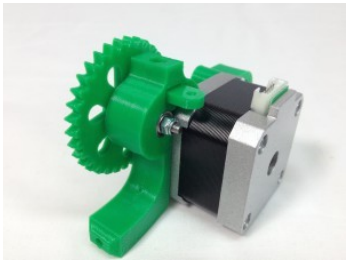
This secures the Bowden cable from the hot end into the extruder drive.

The retaining tongue that is included in the extruder drive set.

For safe keeping, insert it in the drive. It goes in with the forks of the tongue upwards.



It should hold itself in the drive.

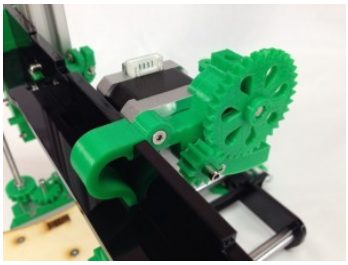


The finished assembly.

Mounting the extruder drive on the printer

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

The x-axis-plate has three slots that the extruder drive can fit into. The standard wiring will reach to the first or second slot. Drop the drive into the first slot, then the end of the extruder body fits into a slot in the x-rib. It is held in place by the weight of the motor.



Hot End Assembly (Quick-set)

Which hot end?

All Ormerod 2 528.5 and onwards kits ship with the new ‘Quick-set’ nozzle. This page has the instructions for that nozzle.

This is the Quick-set nozzle, supplied with Ormerod 2 528.5 and onward kits. If your nozzle looks like this, please use the instructions on this page.

This is the one-piece stainless steel nozzle. If you nozzle looks like this, please use the instructions on the ‘Hot end assembly‘ page.

Building the hot end

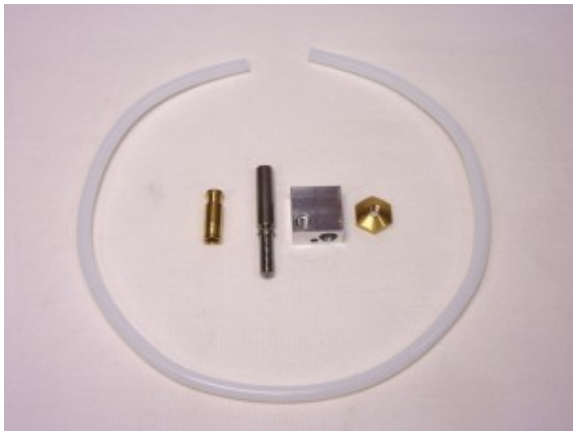
Assembling the hot end parts

All the parts for the hot end, like the extruder, come in one bag.

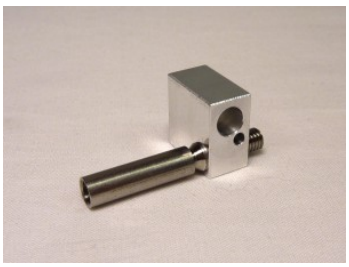
The Bowden tube and nozzle

The Bowden tube guides the filament from the extruder to the hot end, where the filament is melted and extruded through the nozzle.

#	Component	Qty	Type
1055	4mm PTFE Bowden tube	1	Hot end
106.1	Brass Bowden start	1	Hot end
738	Quick-set nozzle (0.5mm)	1	Hot end
739	Quick-set heater block	1	Hot end
794	Quick-set Tapered brass M4 nut	1	Hot end



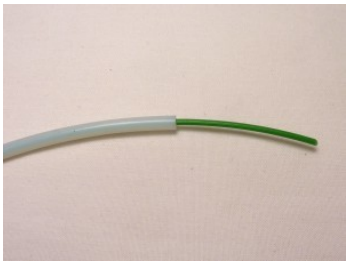
Start by building the hot end. Take the nozzle, aluminium heater block and tapered brass nut. Screw the heater block onto the nozzle, as tight as you can, but with fingers only. If you use pliers to hold the nozzle, and a spanner on the heater block, you may break the nozzle at it's thinnest part! Note the small hole in the heater block is towards the tip of the nozzle.



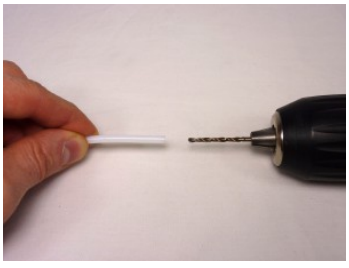
Holding the heater block in a 14mm spanner (or an adjustable spanner), screw on the tapered brass nut. Tighten the tapered brass nut against the heater block, with a 10mm spanner. This DOES need to be done up tight; the heater block and tapered brass nut lock together, tight on the thread of the nozzle, to ensure good heat transfer from the heater block into the nozzle. The heater block may unscrew a fraction on the nozzle as you do this, but that's okay.

The cone of the nozzle should continue the cone of the nut, or as close as possible. There shouldn't be a shoulder between the two, nor should the nozzle be down inside the nut.

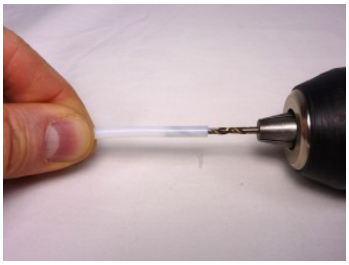
Take the PTFE tube. Make sure the ends of the PTFE tube are cut square. (Filament has been inserted into tube just to show the tube against the background.)



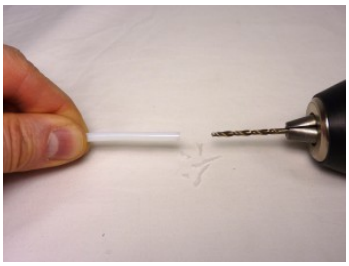
You are going to screw the brass Bowden start and the nozzle onto each end of the tube. This will compress the PTFE tube's inner hole. To allow the filament to run freely in the tube, you need to open out the ends of the PTFE tube first. Use a **2.5mm** (2mm is too small, 3mm is too big) drill bit in a small hand chuck, or a slow electric drill.



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, to a depth of around 15mm. Try to keep the drill as straight as possible into the tube.

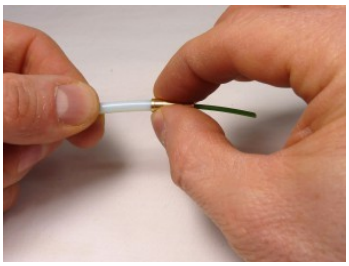


Take several goes at it, going a couple of millimetres deeper each time and drawing the PTFE swarf out by keeping twisting clockwise and pulling. The drill should pull the PTFE swarf out with it. Repeat the process at the other end of the PTFE tube.

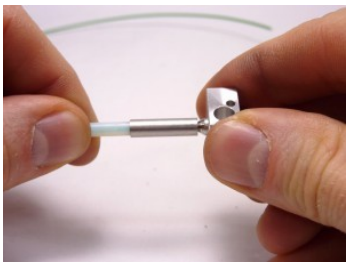


IMPORTANT! The PTFE tube MUST BE CLEAR OF ALL PTFE SWARF before screwing the nozzle on! Push a piece of filament (use the 50cm piece you cut for the extruder testing) through the tube, which should push out any remaining PTFE swarf. Blow down the tube, from both ends, as well. It is very important to get any PTFE swarf out of the tube, otherwise this will end up in the nozzle the first time you print, blocking it!

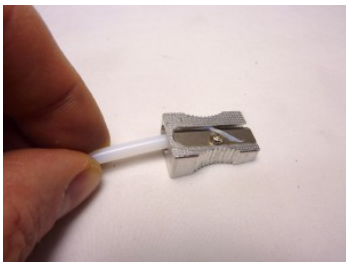
Now you're going to screw the brass Bowden end and the nozzle onto the PTFE tube. To help guide them onto the tube straight, put a piece of filament into the PTFE tube. This will keep the brass Bowden end (and nozzle) and PTFE tube axially in line; you don't want them screwed on at an angle. Push the brass Bowden end up to the PTFE tube, and push while turning it clockwise. It will start to cut its own thread into the PTFE tube.



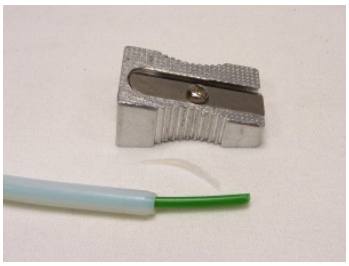
If you have difficulty gripping the brass Bowden end, you can use the nozzle instead. With the heater block on it, it is easier to turn. You will have to remove it afterwards, and put the brass Bowden end back on, but it will be much easier the second time.



If you have trouble getting the brass Bowden end started on tube, you can use a pencil sharpener to make a cone on the end of the tube.

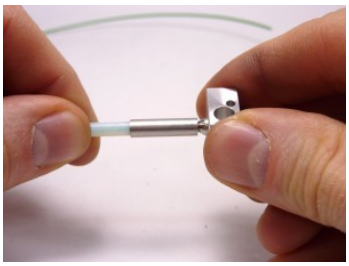


Don't cut too deeply with the pencil sharpener, which will make the cone too deep and long, or it will compress onto the filament when the brass Bowden end, or nozzle, are screwed on.

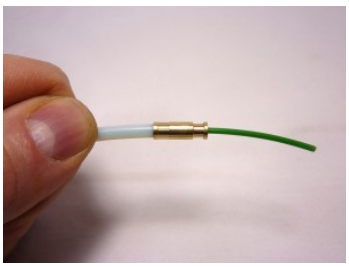


Keep turning until the Bowden end will not screw on any further. If you then remove the brass union, you should see that the Bowden tube end has been threaded, to a depth of around 8mm.

Using the same process, put the nozzle on the other end of the PTFE tube.



Push a piece of filament through the tube, to check that it moves smoothly, with little or no friction. Check it goes all the way down into the nozzle. It should move nearly as freely as when the brass Bowden end and nozzle were not fitted. If the filament is sticking, you may be able to release it by unscrewing the brass Bowden end and/or nozzle one turn.

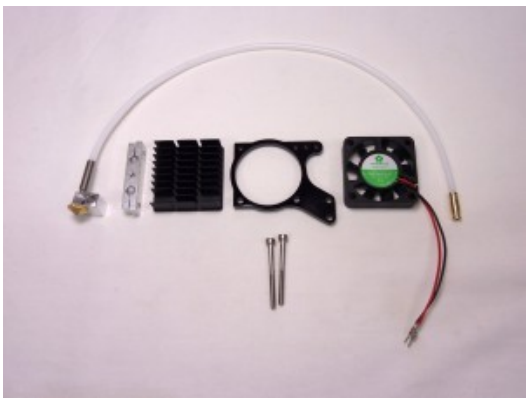


The finished Bowden tube and nozzle.

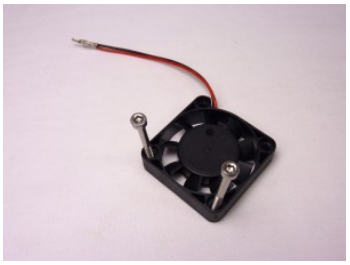
The cooling system

It’s very important that the top of the nozzle remains cold; if filament melts too high up, the pressure required to extrude will increase, and the nozzle will block and stop extruding.

#	Component	Qty	Type
	Bowden tube and nozzle	1	Assembled
736	Quick-set cooling block	1	Hot end
357	Heatsink	1	Hot end
741	Quick-set hot end fan spacer	1	Hot end
	Fan	1	Hot end
520	M3x35mm cap head screw	2	Hot end
Fan is 12V (#953) for Ormerod/Mendel, 19V (#846) for Huxley			

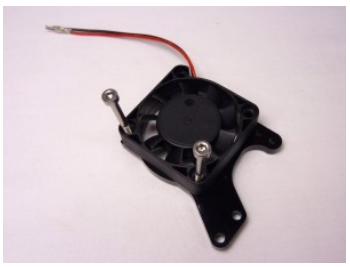


Take the fan, and push the two M3x35mm cap head screws through the holes in the fan furthest from the fan wire.

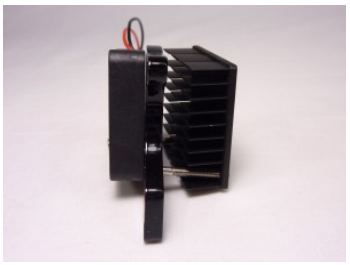


Remove any protective film from the acrylic fan spacer.

Place the fan on the fan spacer. Orient the fan spacer as shown. The sticking out part of the fan spacer is used to mount the proximity probe, which sets the nozzle height from the bed, and can automatically compensate for the bed level.

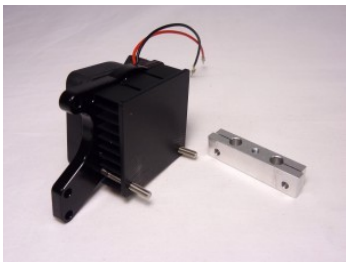


The heatsink goes on next, behind the fan spacer. It only has two holes in it; make sure the M3x35mm cap head screws go through. The fins of the heatsink should face the fan; the solid part is to the back.



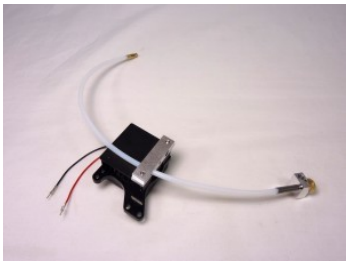
Next is the aluminium cooling block. The orientation of this is critical. The heatsink mounting holes are off-centre; orient the block so the holes are closest to the bottom. The long side of the aluminium cooling block will be in contact with the heatsink.

The cooling block mounting holes are only threaded on one side of the block; the cooling block also clamps the hot end in place. The threaded part should be AWAY from the heatsink. The M3x35mm cap head screws will push through the first half of the cooling block, before engaging the thread.

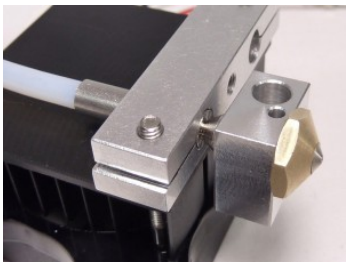


Push the two M3x35mm cap head screws through the four parts, and lightly screw it into the aluminium cooling block. Don’t tighten this up yet; it needs to clamp the nozzle in place. The bottom edge of the heatsink should line up with the bottom edge of the aluminium cooling block, and the solid part of the heatsink should be in good contact with the cooling block.

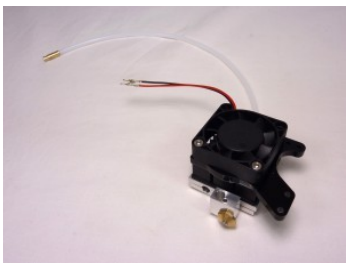
Now mount the Bowden tube and nozzle. Thread the slotted brass Bowden end up through the aluminium cooling block, followed by the Bowden tube, and then thread the nozzle into cooling block.



The hot end should be aligned with the bottom of the cooling block as shown, with the ‘neck’ of the nozzle just below the cooling block. Orient the heater block so it is under the heatsink and fan, rather than sticking out the back. Tighten the M3x35mm cap head screws, to sufficiently clamp the nozzle in place and pull the heatsink onto the aluminium cooling block, but do not over-tighten them – you will break the fan.



The hot end assembly so far.



Wiring the hot end

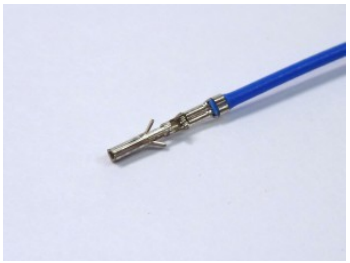
Thermistor wires

Older kits have the thermistor wiring pre-made. We changed the crimp on the current kits to improve the grip on the thermistor wire, but you’ll need to do the following.

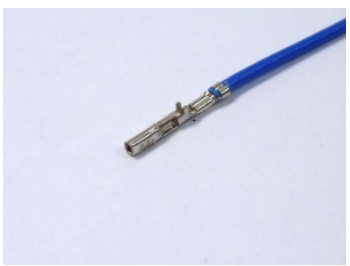
#	Component	Qty	Type
433	Thermistor wiring – 160mm	2	Hot end
197	2.4mm Black heatshrink	as needed	Hot end

New picture to come

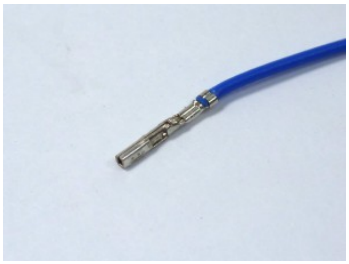
If your thermistor wiring is supplied without heatshrink on both ends, and the female end looks like this, do the following.



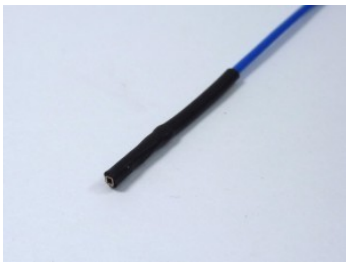
Fold in the two barbs that stick out the side, as shown in the first picture; a small screwdriver or tool with a point is easiest. They need to fold into the crimp, as they will hold the thermistor wire.



Also flatten the top two tabs, so the crimp is smooth. If you put the heatshrink on with them sticking up, they can cut through the heatshrink, and cause a short circuit if they touch other metal.



Put the heatshrink on the end of the wire, covering the crimp but leaving the end open.



Check that it holds the thermistor firmly. You will cover the thermistor with high temperature PTFE heatshrink in the next step; you want as little metal showing as possible between the PTFE heatshrink and the black heatshrink, to avoid short circuits to metal parts of the printer.

Heater block wiring

Wiring the hot end connector

Wiring diagram

Wire colours, related to hot end wiring loom

Final assembly and mounting

The tongue

Hot End Assembly

Electronics

Wiring

Commissioning

Calibration

Printing

Maintenance

Troubleshooting