Ender 3 Syringe Pump Build Guide

In this build guide, the build process of the Ender 3 based pump system will be explained. Assembly instructions, as well as indications of how to disassemble and reuse existing parts will be given. The guide consists of 37 steps and will result in three pump channels, as well as a Control Unit.

Step 1: Layout

Start with laying out all the parts and part bags included in the kit (figure 1).

Figure 1 All parts included in the Ender 3 kit.

Step 2: Collect the necessary parts for the E Plate Pump frame

To build the Extruder Plate Pump frame, take the extruder head, the long 20x20 mm rail, the bag of M4x16 machine screws and the 3D printed parts for this pump channel.

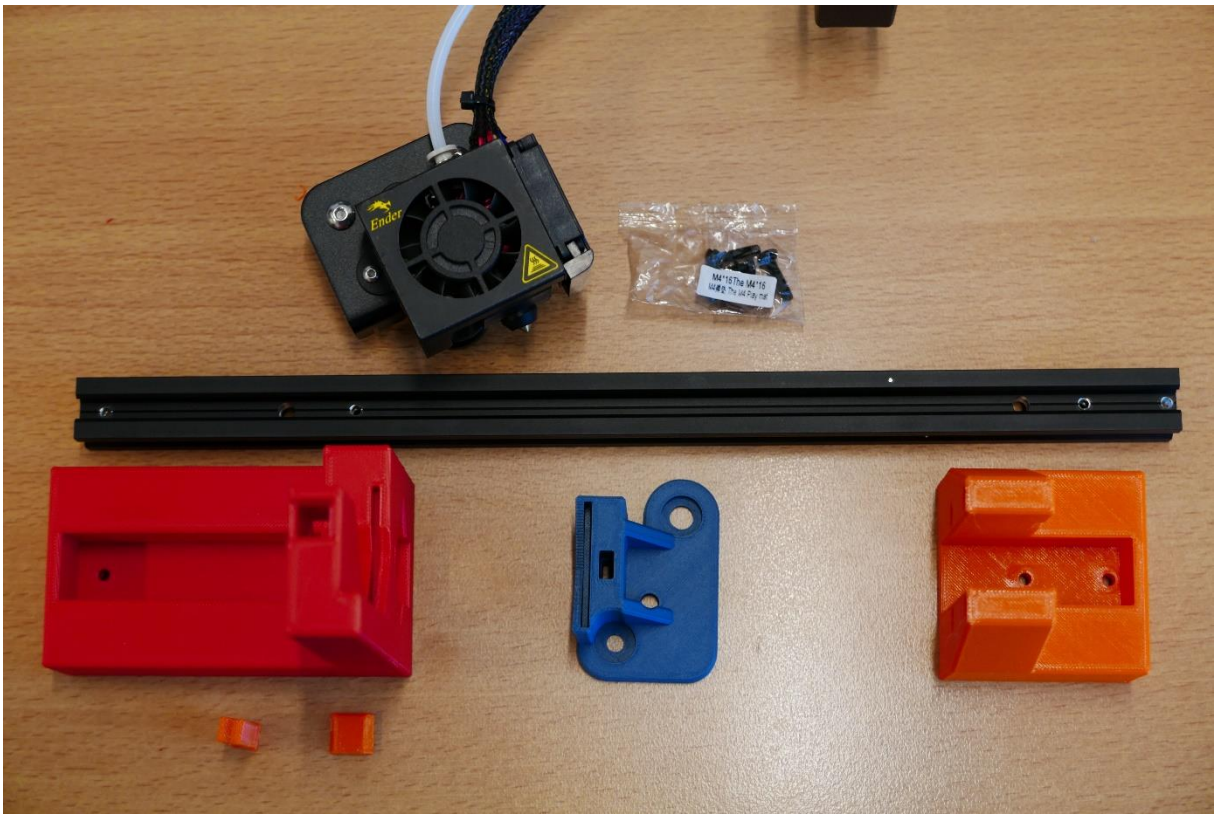

Figure 2 Necessary parts to build the Extruder Plate Pump Channel frame: Extruder head, M4x16 screws, 20x20 rail, E End Mount, E Slide Mount, E Stepper Mount, Clamp Bar and Dovetail Cap.

Step 3: Remove unused parts from the E Plate and mount

To prepare the E Plate, remove all the unnecessary parts. Start by removing the two M3 screws (***save these screws for later use***) (fig 3B). Now remove the hotend shroud/fan mount. Next, remove the hotend (fig 3C). Finally, remove the two screw indicated in red circles (fig. 3D). The E Plate is now ready to be used in the pump channel.

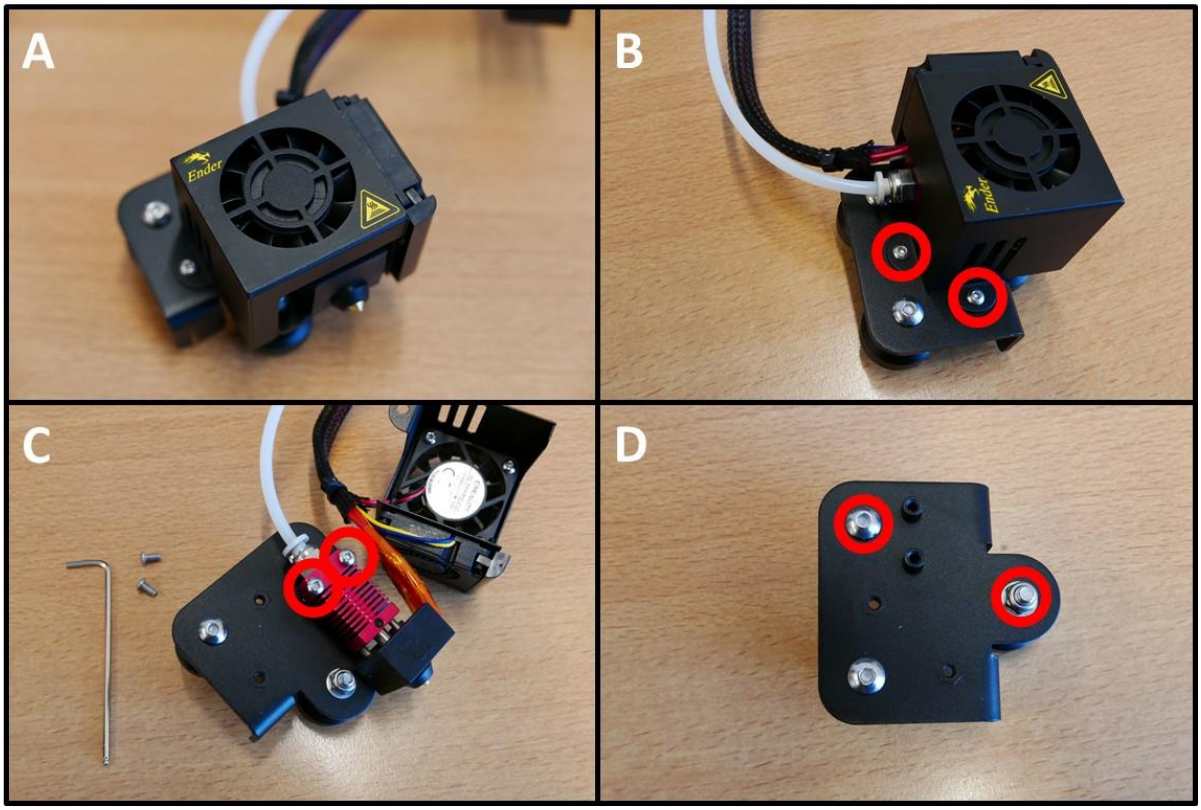

Figure 3 Preparing the E Plate for use in the pump. A) Extruder head overview. B) Removal of hotend shroud screws. These screws need to be saved for later use. C) Removal of the hotend. D) Loosening two screws in preparation for the Slider Mount.

Step 4: Install the E Slide Mount on the E Plate

Take the E Slide Mount and fit it on the Extruder Plate (fig. 4A), by replacing the two removed screws from figure 3D. Note the eccentric hexagonal adjuster that will be used later to remove slop in rail guidance mechanism.

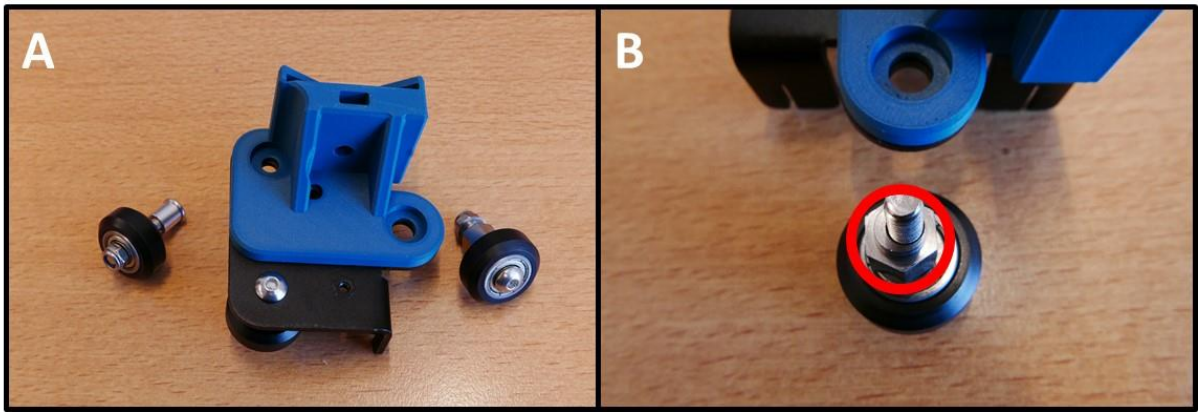

Figure 4 Mounting the E Slide Mount. A) E Slide mount fitted to the E Plate. B) Eccentric adjuster for the guidance mechanism.

Step 5: Install the E Stepper Mount

Install the E Stepper Mount using the M4x16 screws (fig. 2). Slide the mount onto the rail and tighten the screws on the bottom (fig. 5C).

Figure 5 E Stepper Mount installation procedure. A) E Stepper Mount and 20x20 rail. B) Rail slides into E Stepper Mount. C) E Stepper Mount secured with M4x16 screws.

Step 6: Install E Slide Mount on rail

Install the E Slide Mount assembly onto the rail, with the 3D printed mount facing away from the E Stepper Mount. Adjust the tension on the rollers by turning the eccentric hexagonal nut (fig. 6).

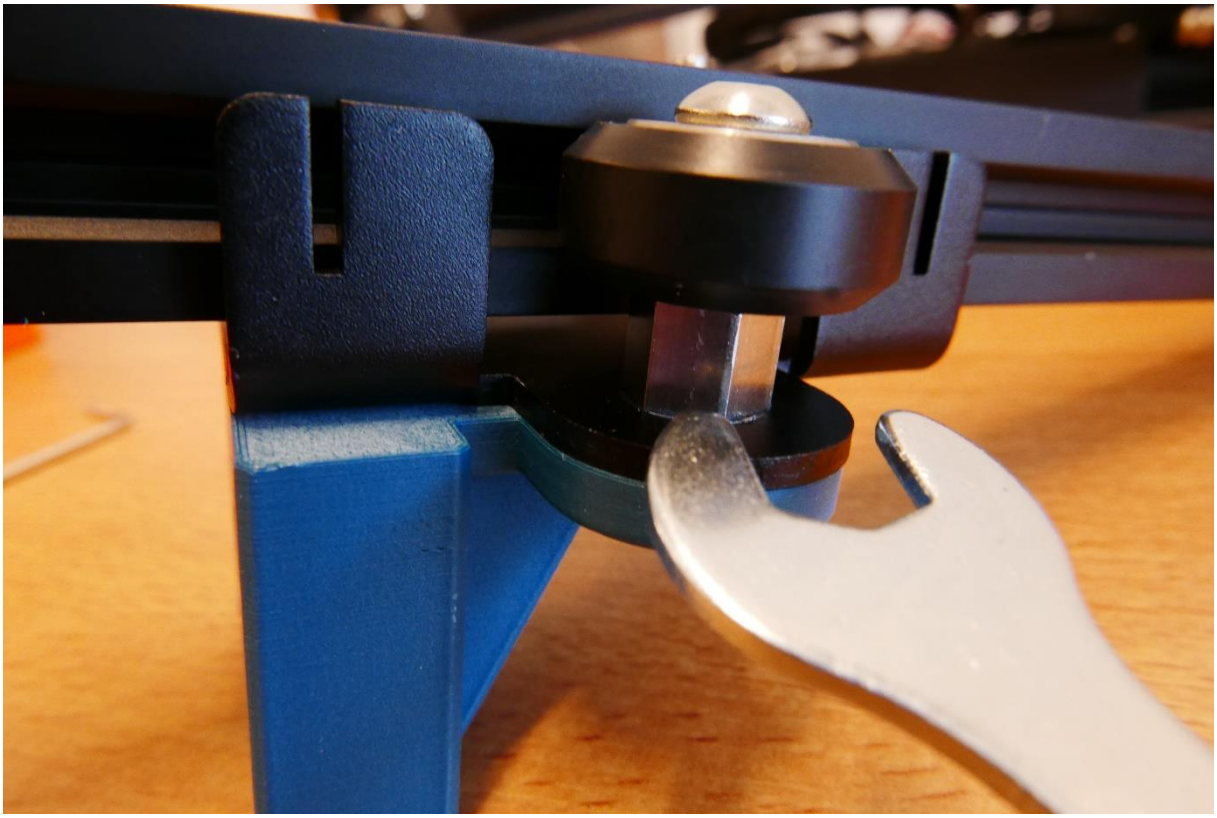

Figure 6 Tension adjustment of the E Slide Mount rollers.

Step 7: Install the E End Mount

Finish the frame of the E Plate Pump by installing the E End Mount. Slide the mount on the rail (fig. 7A) and use the remaining M4x16 screws to attach the mount (fig. 7B).

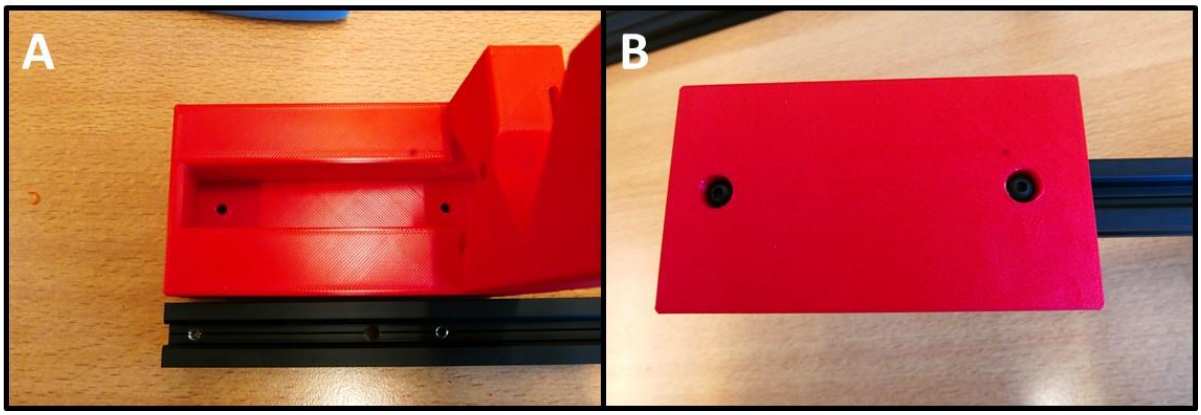

Figure 7 A) E End Mount next to 20x20 rail. B) E End Mount fastened using 2 M4x16 screws.

Step 8: Remove unnecessary parts from stepper motor

Take the stepper motor shown in figure 8A. Remove the screws circled in red (fig. 8B). Then, loosen the grub screws in red (fig. 8C) and remove the coupler. The stepper motor is now ready (fig. 8D).

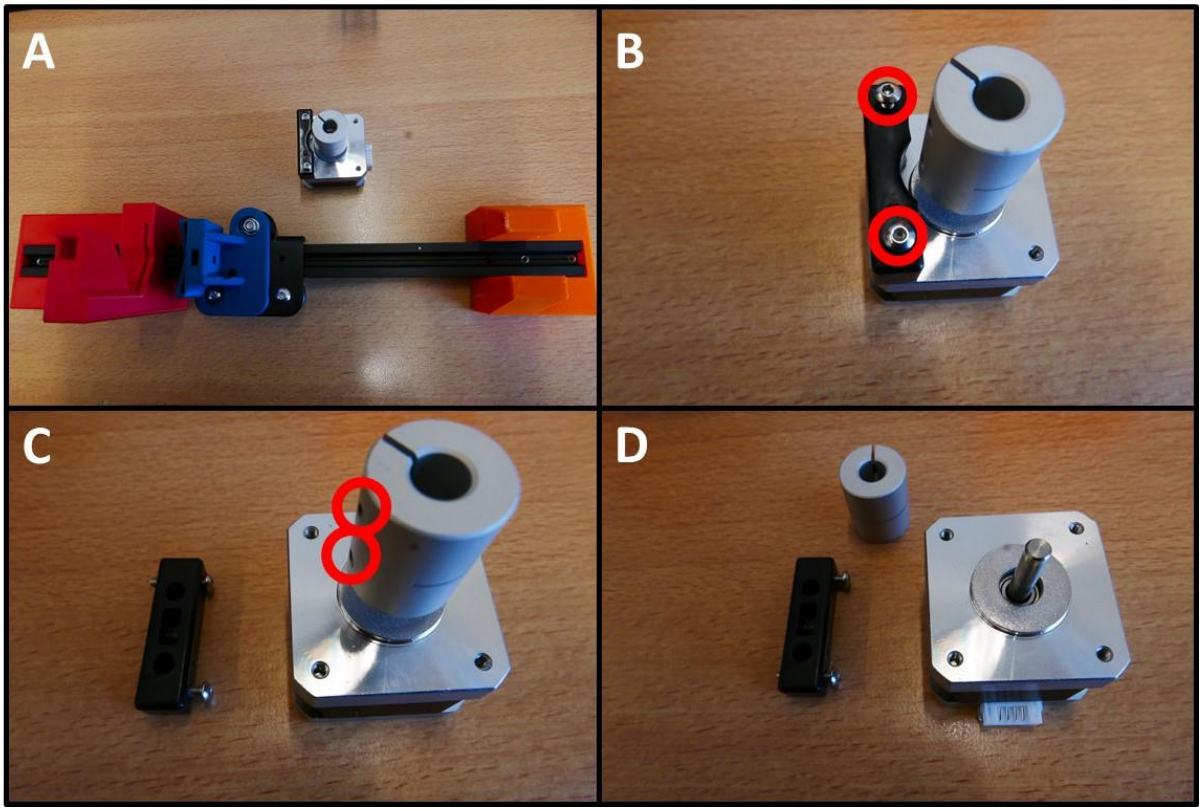

Figure 8 Preparing the stepper motor for installation. A) Overview of the E Plate pump and stepper. B) Removal of bracket. C) Removal of shaft coupler. D) Stepper ready for use in pump.

Step 9: Install stepper motor on the E Stepper Mount

The stepper motor is now to be installed on the E Stepper Mount. For the installation, 4 M3x6 screws are required. These can be taken from the Y stepper motor, shown in figure 9A. Save the Y stepper for later use. Figure 9B shows the E Stepper Mount, the stepper motor to be installed and the M3x6 screws. These screws can be inserted in the counterbored holes of the E Stepper Mount and tightened, to affix the stepper motor.

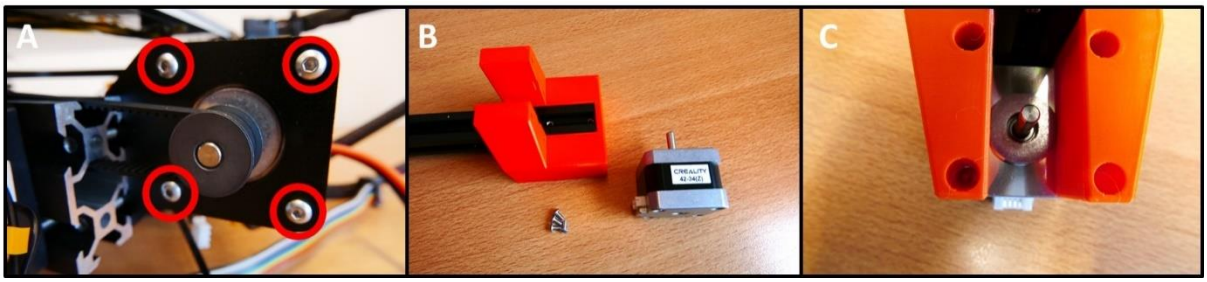

Figure 9 Stepper motor mounting. A) Gathering M3x6 screws from the Y stepper. B) All parts to be combined. C) Stepper motor mounted on the E Stepper Mount.

Step 10: Cut the M5 threaded rod to size

For the drive rod, an M5 threaded rod needs to be cut to size. This can be done using a hacksaw or a power tool such as a cutoff wheel. Before starting the cut, thread on an M5 nut onto the rod. Cut the rod and clean off the sharp end with a file or sandpaper. After cutting and filing, the nut can be threaded over the cut end. This will straighten out the threads. 2 rods of 27 cm and 1 rod of 22 cm are needed to complete all three pumps (fig. 10).

Figure 10 M5 Threaded rods cut to length. Two 27 cm rods for the X Plate and X Motor Plate pumps, 22 cm rod for the E Plate pump.

Step 11: Install the threaded rod

To install the threaded rod, take the 22 cm threaded rod, 1 M5 nut and a shaft coupler (fig. 11A). Install the shaft coupler onto the stepper motor by tightening the two grub screws (fig. 11B). Slide the threaded rod through the E End Mount, up to the E Slide Mount. Lay the assembly on it's side and push in the nut, centering it with the through-hole for the rod (fig. 11C). Thread the rod through the nut, all the way up to the shaft coupler. Tighten the grub screws to install the threaded rod (fig. 11D).

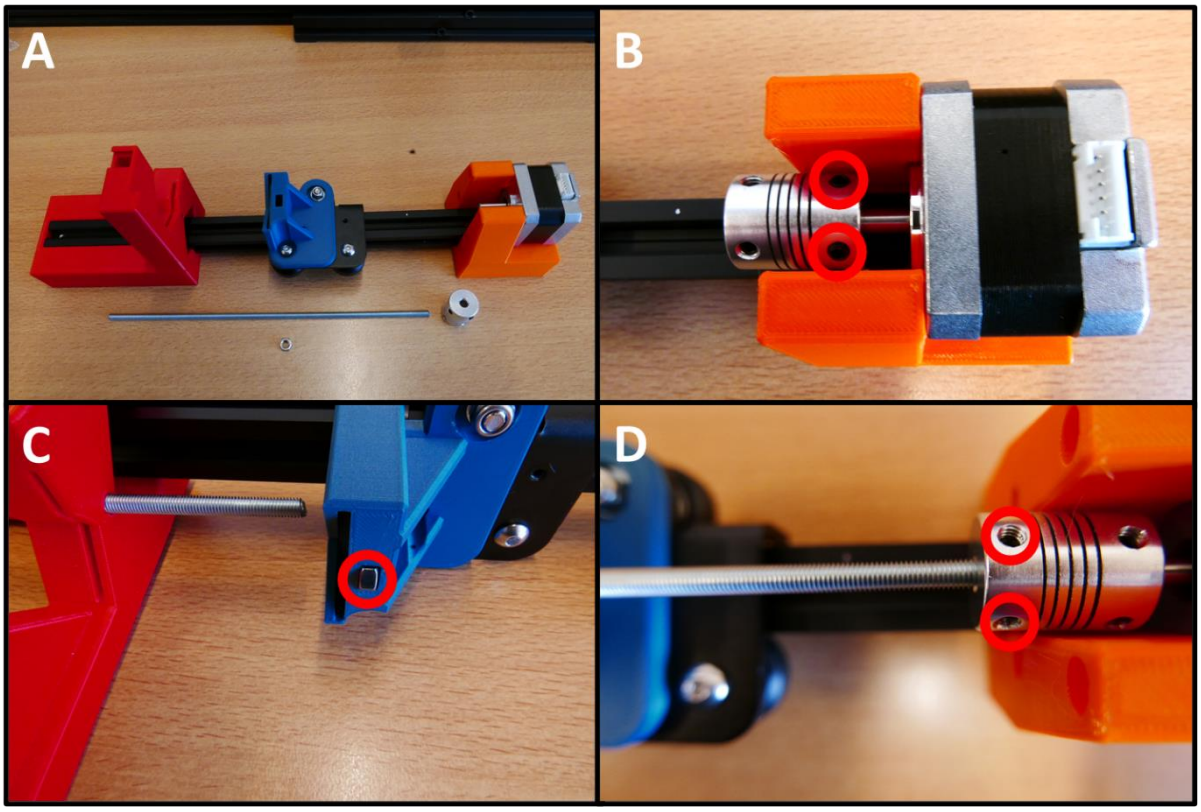

Figure 11 Installation of the threaded rod and shaft coupler. A) All components laid out. B) Shaft coupler installation. C) Fixing the threaded rod to the E Slide Mount using an M5 nut. D) Threaded rod clamped in the shaft coupler.

Step 12: Collect the springs for the syringe clamp

To clamp the syringes in place, the springs from the bed levelling mechanism will be used. Start by removing the clips and printbed cover (fig. 12A). Unscrew the large plastic wheel (fig. 12B). Next, remove the machine screw to free up the spring (fig. 12C). The spring can now be removed (fig. 12D). Repeat this process to collect 3 springs in total.

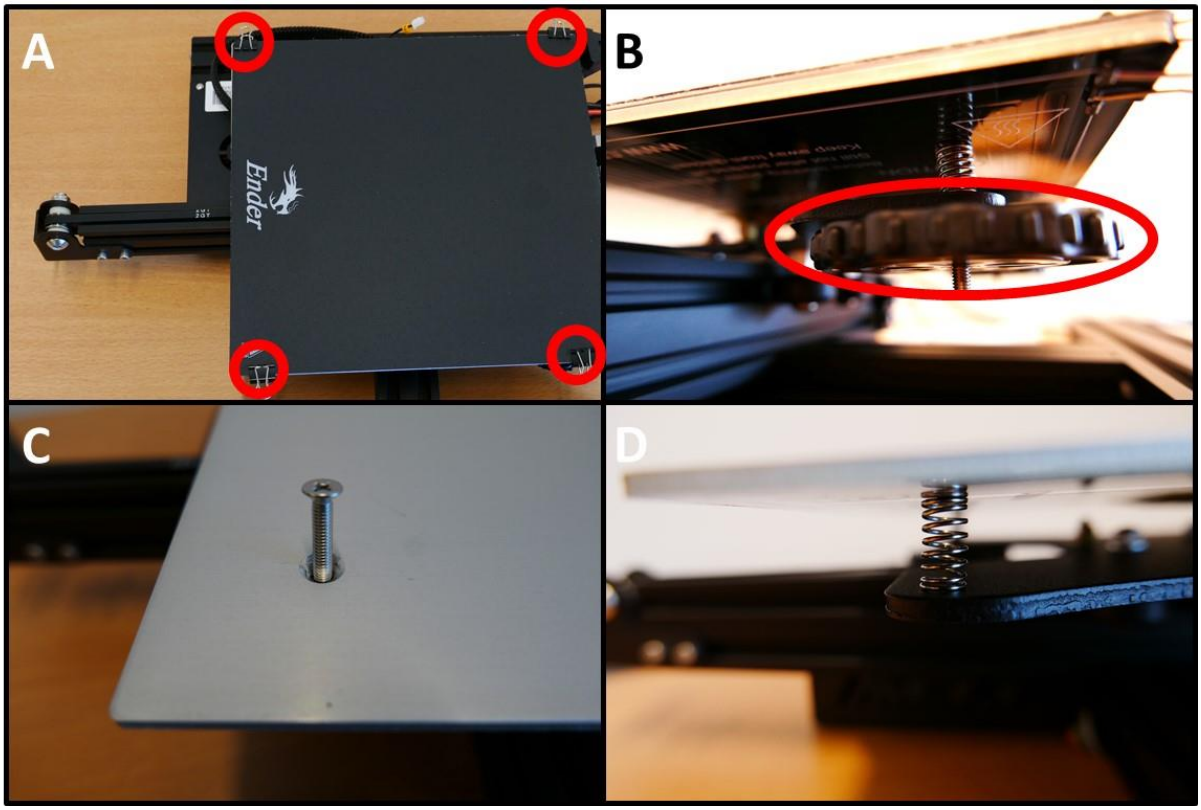

Figure 12 Obtaining the springs for the syringe clamp mechanism. A) Remove the spring clips holding the printbed cover. B) Remove the plastic handwheel. C) Remove the machine screw. D) The spring can now be removed and used in the pump.

Step 13: Install the syring clamp mechanism

The syringe clamping mechanism can now be installed. This mechanism consists of a Clamp Bar, Dovetail Cap and one of the springs (fig. 13A). Slide the clamp bar into the slot on top of the E End Mount (fig. 13B). Next, place the spring on top, in the square hole (fig. 13C). Finally, close the top with a Dovetail Cap. The pump channel is now ready to be used. Different length Clamp Bars can easily be exchanged to accommodate different syringe diameters.

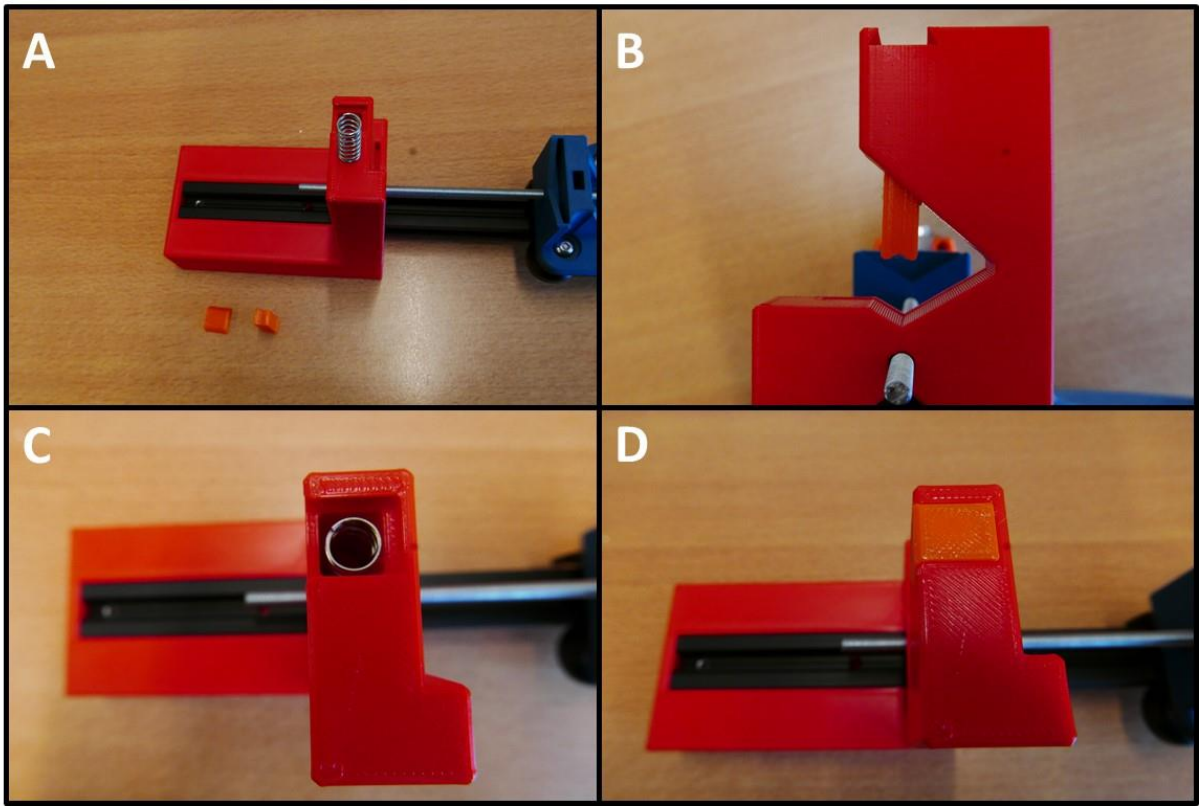

Figure 13 Fitting the syringe clamping mechanism. A) The necessary parts: Spring, Clamp Bar and Dovetail Cap. B) Clamp Bar installed in the slot. C) Spring placed on top of the Clamp Bar. D) The slot closed off with a Dovetail Cap, securing the mechanism in place.

Step 14: Collecting the 40x40 rails

To build the X Motor Plate pump, a 40x40 rail is needed from the Ender 3 frame (fig. 14A). Loosen the two M5x45 screws that are holding this piece and save the screws (fig. 14B). Use one of the hex wrenches to push out the end cap (fig. 14C).

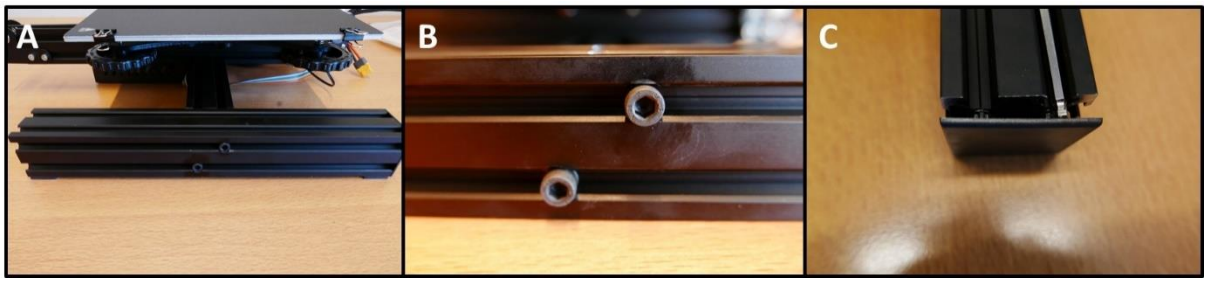

Figure 14 Gathering the 40x40 rail. A) The rail still mounted to the Ender 3 base. B) Loosen the M5x45 screws to remove the rail. C) Using a hex wrench, the end cap can be pushed out.

For the X Plate pump another 40x40 rail is need, from the other side of the base. Loosen the M5x45 screws (fig. 15A) and save them. Then, also remove the electronics case by removing the two screws (fig. 15B). Save these screws as well. Remove the end cap on the rail like in figure 14C.

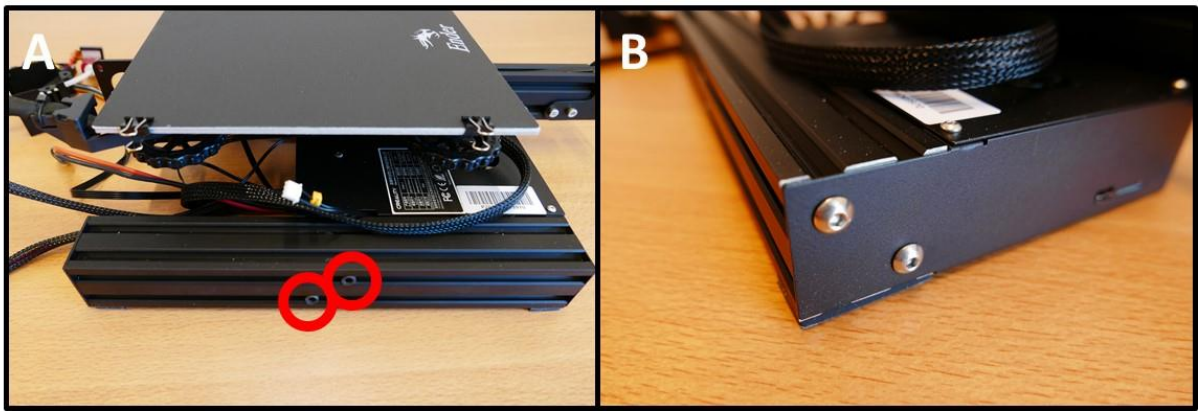

Figure 15 Gathering the second 40x40 rail. A) Removing the M5x45 screws. B) Removing the electronics case.

Step 15: Collect the parts for the X Motor Plate Pump

To build the X Motor Plate Pump, take the X Motor Assembly, 40x40 rail, X X Motor End Mount, X Motor Plate Slide Mount, X X Motor Stepper Mount, Clamp Bar, Dovetail cap and four M5x45 screws (fig. 16).

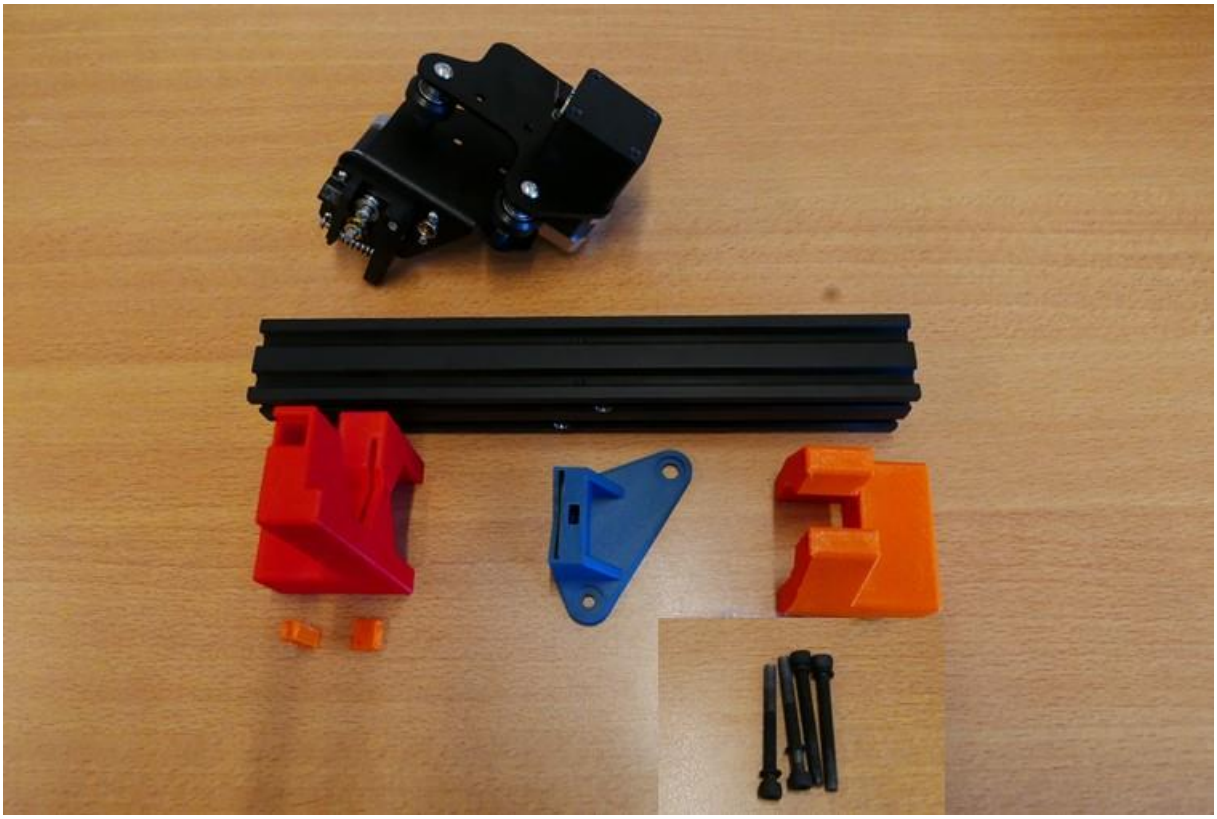

Figure 16 The parts needed to build the X Motor Plate pump.

Step 16: Remove unnecessary parts from X Motor Assembly

The X Motor assembly consists of many parts, that need to be removed in order to use the X Motor Plate in the pump. Start by removing the sticker covering the screws (fig. 17A). Next, remove the roller screws holding the two plates together (fig. 17B). Remove the screws from the pulley cover (fig. 17C). Save the stepper motor for later use (fig. 17D). Next, remove all the screws indicated in red in figure 17E, remove the spring as well. Finally, remove the last two screws holding the filament clamping mechanism in place (fig. 17F). **Save four M3x10 screws for later use (fig. 18).**

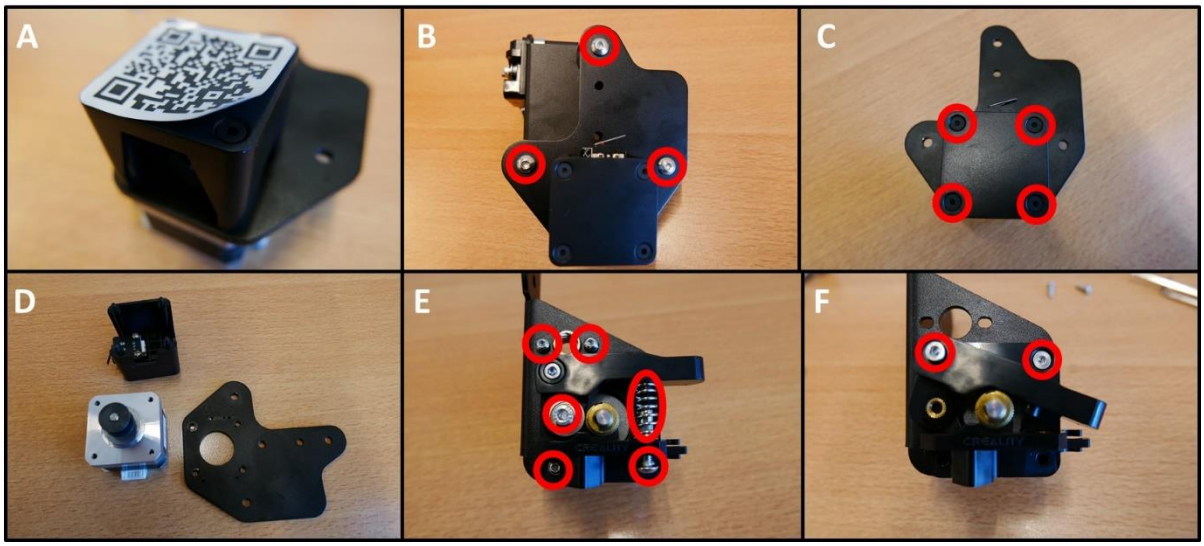

Figure 17 Procedure for disassembling the X Motor Assembly. A) Peel away the sticker. B) Remove the three roller screws. C) Remove the pulley cover. D) The freed up parts. Save the stepper motor. E) Remove all screws and the spring indicated in red. F) Remove the screws holding the filament clamp in place.

Figure 18 M3x10 screws to be used for later steps in the build guide.

Step 17: Install the X Motor Slide Mount on the X Motor Plate

Take the angle bracket X Motor Plate and mount the X Motor Slide Mount, similar to step 4 (fig. 19A). Slide the mount onto the 40x40 rail and adjust the tension. Make sure the countersunk holes on the rail are on the side of the single guide wheel (fig. 19B).

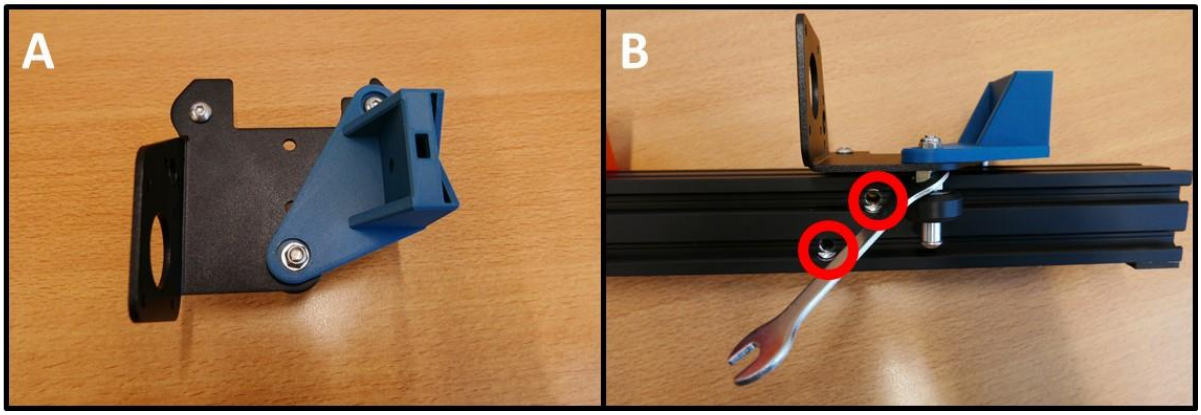

Figure 19 Installing the X Motor Slide Mount. A) 3D printed part mounted on the X Motor Plate. B) Fitting the assembly on the rail.

Step 18: Removing the press-fit pulleys from the X and Y Motor

Take the X Stepper from step 16 and Y Stepper from step 9. They have press-fit pulleys that need to be removed. This can be accomplished by using a pulley removal tool. A 3D printed version is available from https://www.thingiverse.com/thing:3593964. Print this tool at 100% infill (fully solid). To use the tool, an M5 nut and M5x45 screw can be used (fig. 20A). Press the M5 nut into the hexagonal slot (fig. 20B) and thread in the screw. Slide the tool around the pulley and align the screw with the stepper shaft. Turn the screw to apply pressure on the shaft (fig. 20C). With the pulley removed, the stepper is ready to be used in the pump (fig. 20D). Repeat this process for the second stepper.

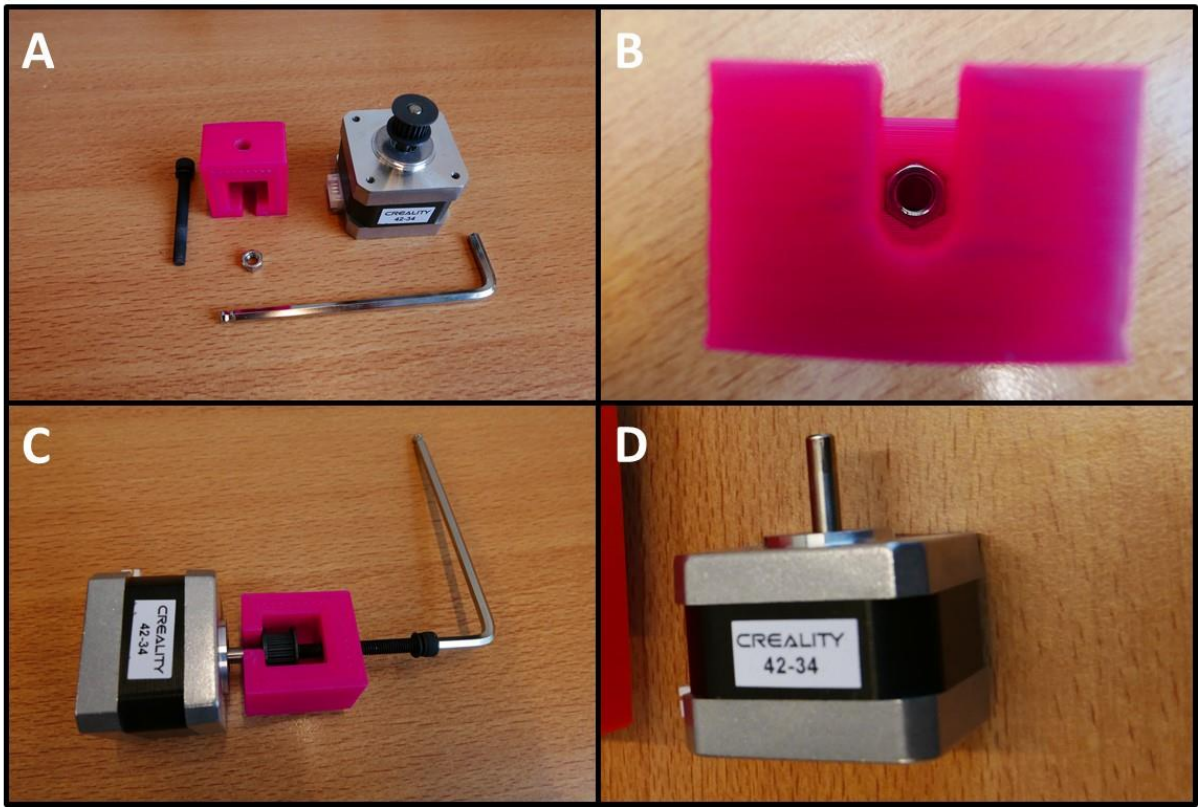

Figure 20 Stepper pulley removal process. A) Overview of the tool, parts and stepper. B) Fitting the M5 nut in the tool. C) Removing the pulley with the tool. D) Stepper motor ready for use in the pump.

Step 19: Install the X X Motor Stepper Mount

Slide the X X Motor Stepper Mount on the 40x40 rail and insert the M5x45 screws (fig. 21A). Fasten the screw, the X X Motor Stepper Mount is now attached (fig. 21B).

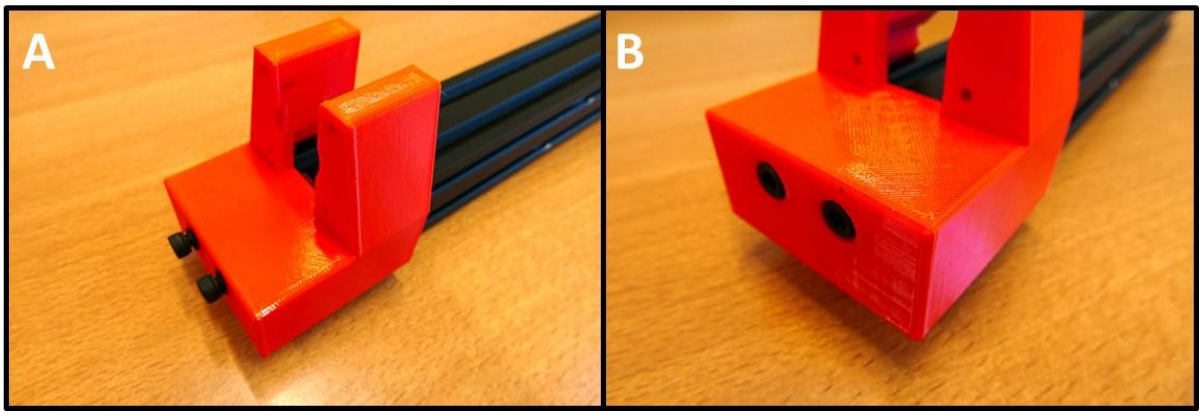

Figure 21 Installing the X X Motor End Mount. A) Fitting the mount on the rail. B) Fully installed.

Step 20: Install the X X Motor End Mount

Place the X X Motor End Mount on the opposite end of the 40x40 rail. Fasten the part with two M5x45 screws (fig. 22).

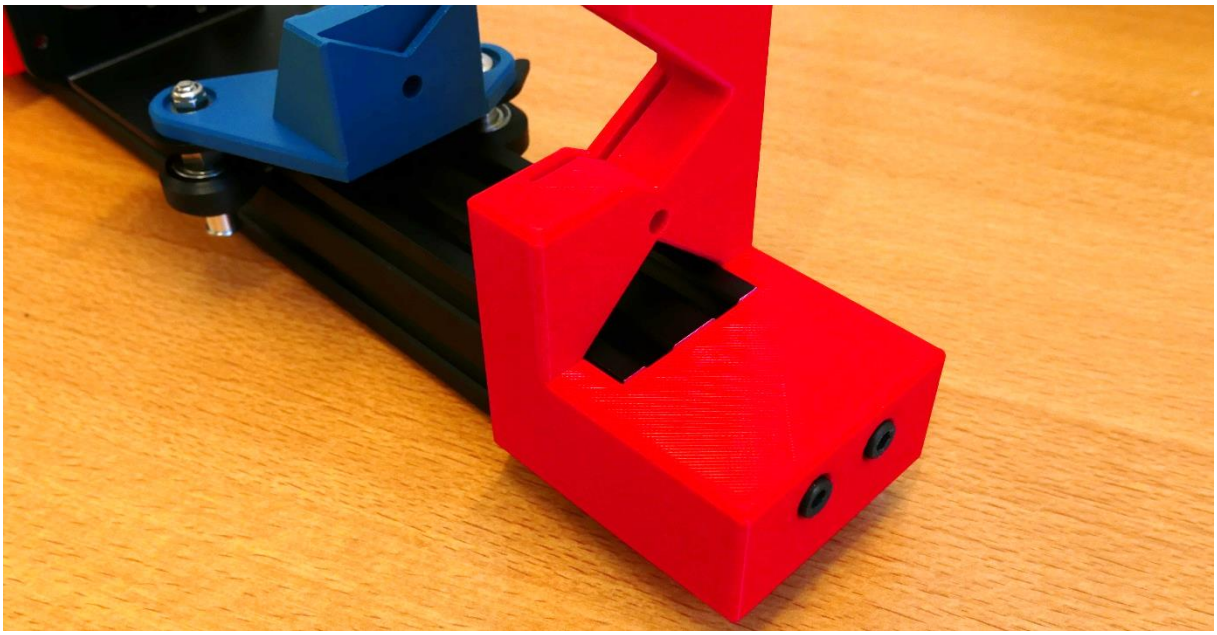

Figure 22 The installed X X Motor End Mount.

Step 21: Install the stepper motor

Install the stepper motor on the X X Motor Stepper Mount. Take 4 M3x1- screws by dismounting the Extruder Fan from the shroud (fig. 23A). Use these screws to install the stepper motor (fig. 23B).

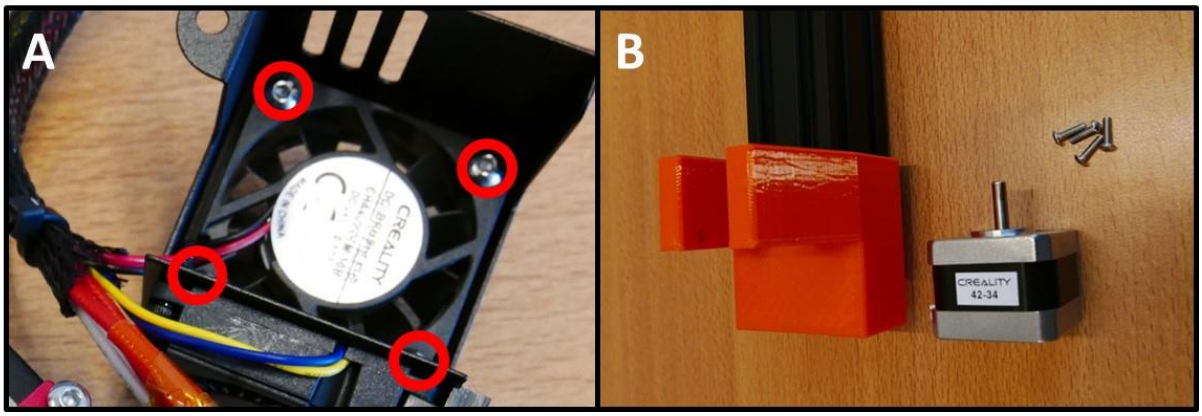

Figure 23 The stepper motor will be mounted with M3x10 screws. A) Take the M3x10 screws from the fan mounted on the extruder head. B) Ready to install the stepper motor.

Step 22: Install the threaded rod

Take one of the 27 cm threaded rods from step 10 and install it in the X Motor Plate pump, follow the procedure from step 11. The end result looks like figure 24.

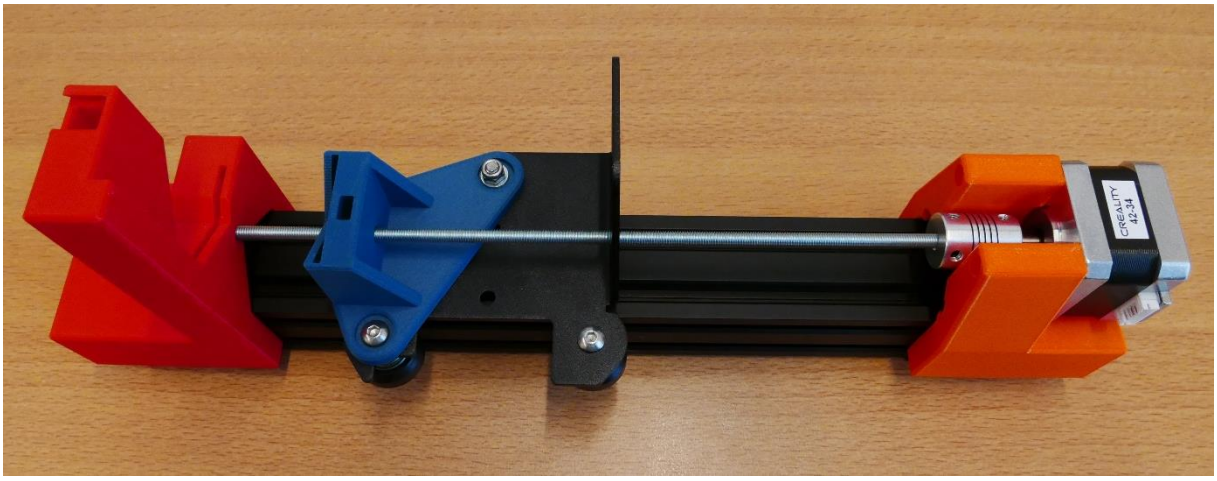

Figure 24 Installed threaded rod in the X Motor Plate pump.

Step 23: Install the syringe clamp mechanism

Follow step 13 and install the syringe clamp mechanism. The X Motor Plate pump channel is now finished (fig. 25).

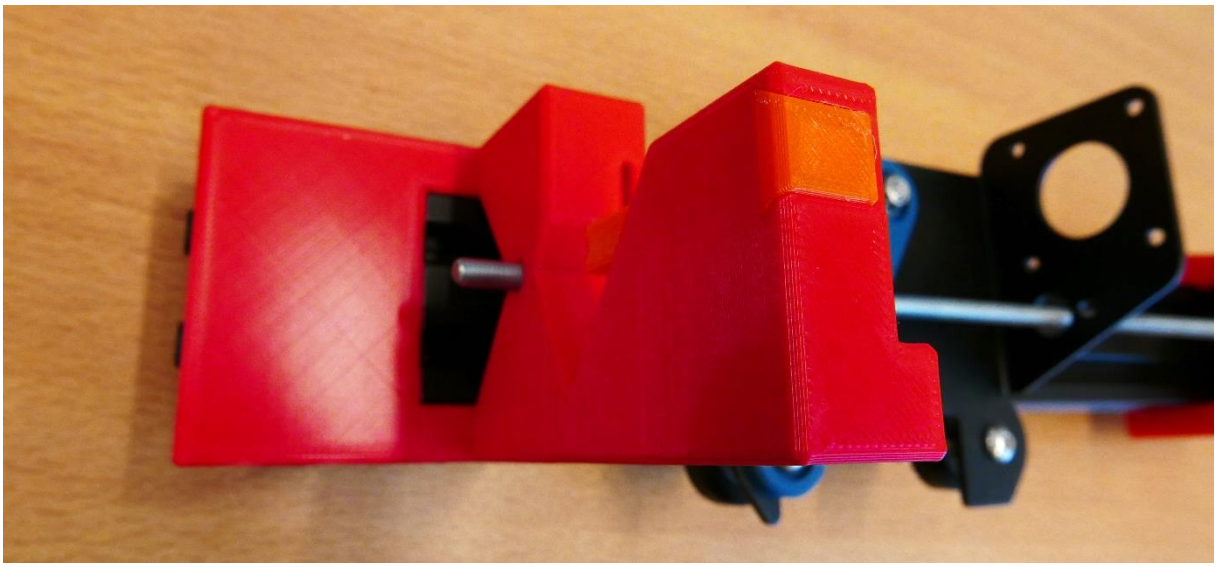

Figure 25 Installed syringe clamp mechanism.

Step 24: Collect the parts for the X Plate Pump

To build the X Plate Pump, Take the X Plate, 40x40 rail, X X Motor End Mount, X Plate Slide Mount, X X Motor Stepper Mount, Clamp Bar, Dovetail Cap and bag with four M5x45 screws (fig. 26).

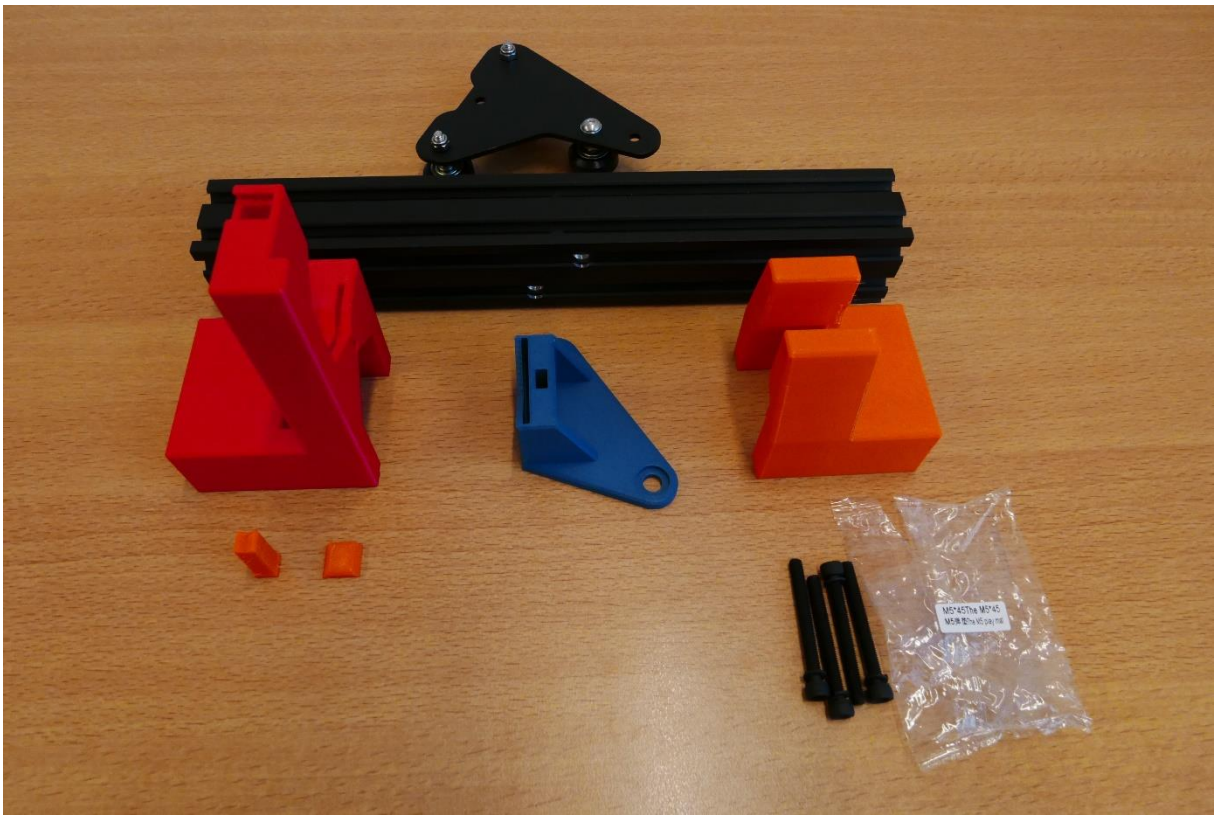

Figure 26 All the parts needed to build the X Plate Pump frame.

Step 25: Build the X Plate Pump according to previous steps

The X Plate pump construction is very similar to the X Motor Plate Pump. Mount the X X Motor Stepper Mount like in step 19 (fig. 27A). Mount the X Slide Mount according to step 17, in the correct

orientation (fig. 27B) and slide onto rail (fig. 27C). Install the X X Motor End Mount following step 20 (fig. 27D). The X Plate Pump frame is now finished (fig. 27E).

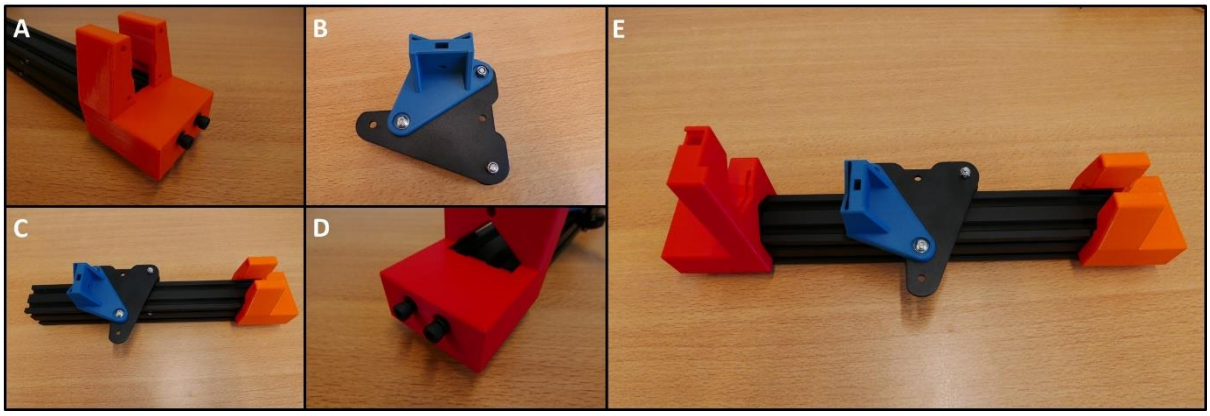

Figure 27 Building the X Plate Pump frame. A) X X Motor Stepper Mount installation. B) X Slide Mount orientation. C) Rail assembly D) Fastening the M5x45 screws on the X X Motor End Mount. E) Completed X Plate Pump frame.

Step 26: Install the stepper motor

Install the stepper motor using the four M3x10 screws that were saved in step 16, according to the procedure of step 21 (fig. 28).

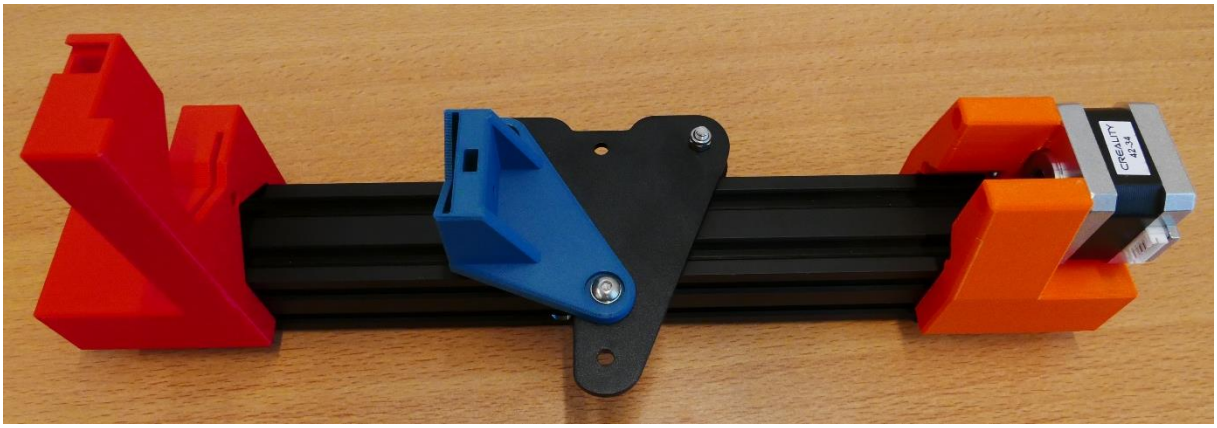

Figure 28 Stepper motor installed in the X Plate Pump frame.

Step 27: Install the threaded rod

Take one of the 27 cm threaded rods from step 10 and install it in the X Plate pump, follow the procedure from step 11. The end result looks like figure 29.

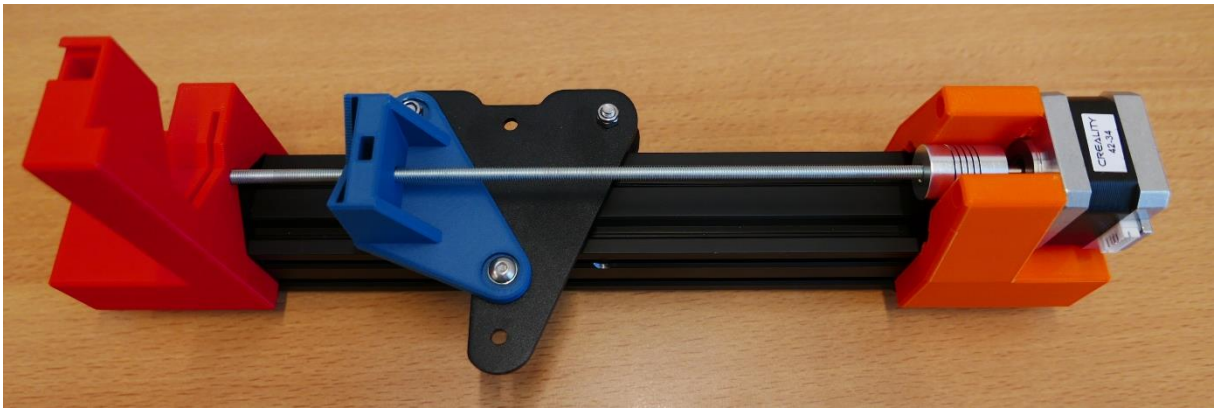

Figure 29 Threaded rod installed in the X Plate Pump.

Step 28: Install the syringe clamp mechanism

Follow step 13 and install the syringe clamp mechanism. The X Plate pump channel is now finished (fig. 30).

Figure 30 The completed X Plate Pump.

Step 29: Detaching the Electronics Box

Take the remainder of the Ender 3 base and flip it over (fig. 31A). Detach the cable from the Y limit switch (fig. 31B). Remove the M5x45 screws to free up the 40x40 rail (fig. 31C). **Keep the rail for later use.** Remove the screw on the fan-side of the Electronics Box (fig. 31D). Remove the screw on the other side of the Electronics Box (fig. 31E). The Electronics Box is now ready to open up.

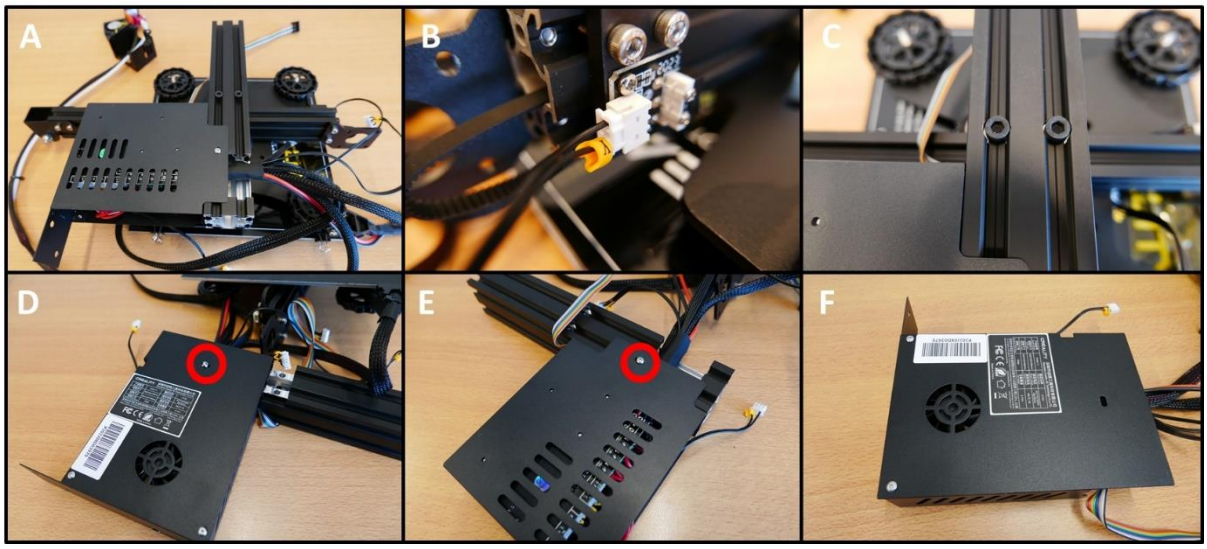

Figure 31 Removing the Electronics Box from the Ender 3 base. A) Overview of the underside of the base. B) Y limit switch connector. C) M5x45 screws, holding the base to the buildplate. D) One of the two mounting screws. E) Second mounting screw. F) The detached Electronics box.

Step 30: Removing the Electronics Board and cable restrictions

All the redundant connectors from the Electronics Board have to be removed. To do this, open up the Electronics Box (fig. 31A). Remove the screws holding the board in place (fig. 31B). Note the yellow circle, indicating the fan connector. The fan is temporarily removed to facilitate this and the next step. Next, cut the zip tie on the cable assembly (fig. 31C). Finally, remove the tape at both ends of the braided cable shield (fig. 31D).

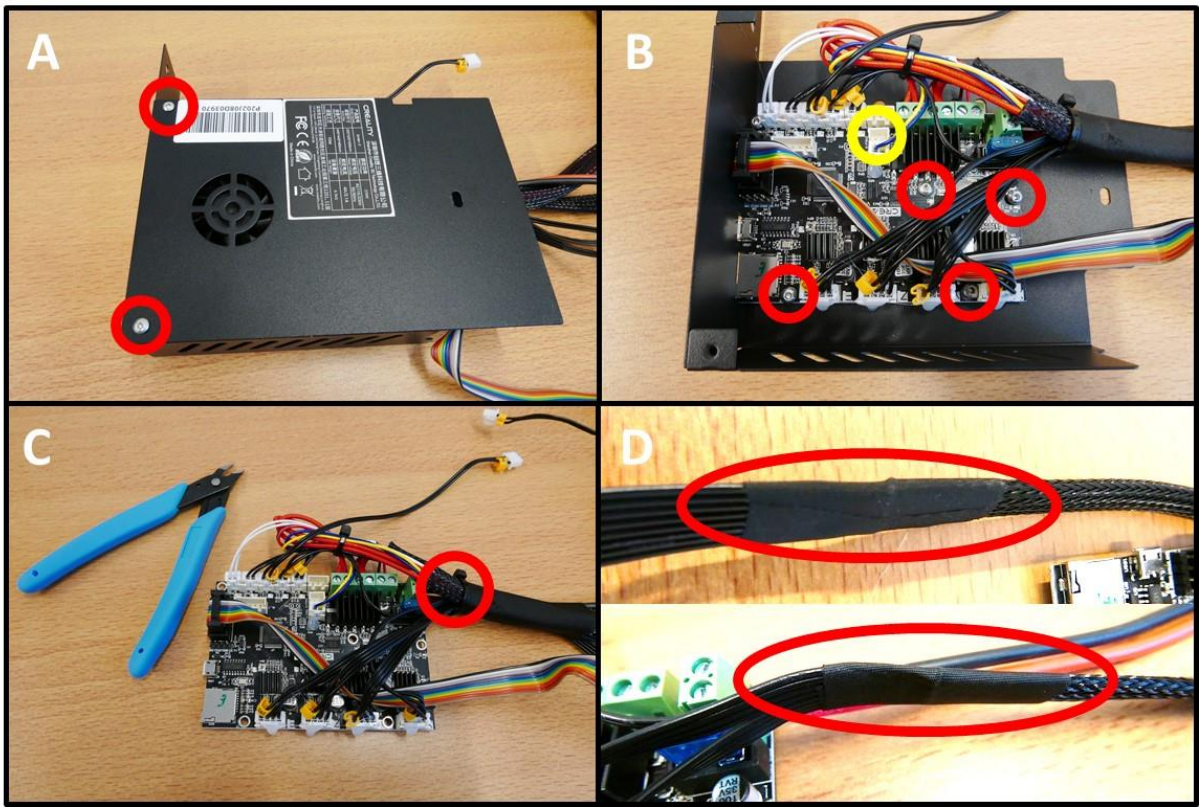

Figure 32 Freeing up the cable assembly to remove redundant cabling. A) Opening the Electronics Box. B) Removing the board mounting screws. Yellow circle indicates the removed fan connector. C) Cutting the zip tie. D) Removing the tape at the braid ends.

Step 31: Removing redundant cables

All cables along the top row of the Electronics Board can be removed, as well as the blue/yellow cable. These are indicated in red (fig. 33A). The board after removal of these cables is shown in fig. 33B. Next, remove the short Z stepper cable and replace it with the long E stepper cable.

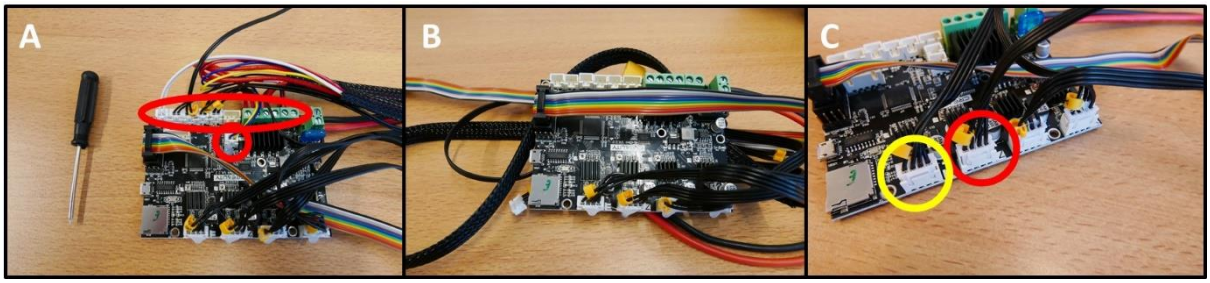

Figure 33 Removal of redundant cables. A) All cables to remove are indicated in red. B) After cable removal. C) Remove the Z stepper cable (red) and replace with the E stepper cable (yellow).

Step 32: Collect the components for the Control Unit

To build the control unit, take the Power Supply Unit (PSU), LCD Screen, 40x40 rail, Electronics Box and Board, bag of four M5x8 screws, bag of two M4x20 screws, X Belt Tensioner, six M3x6 screws from the Electronics box, the PSU base 3D print and Electronics Base 3D print (fig. 34).

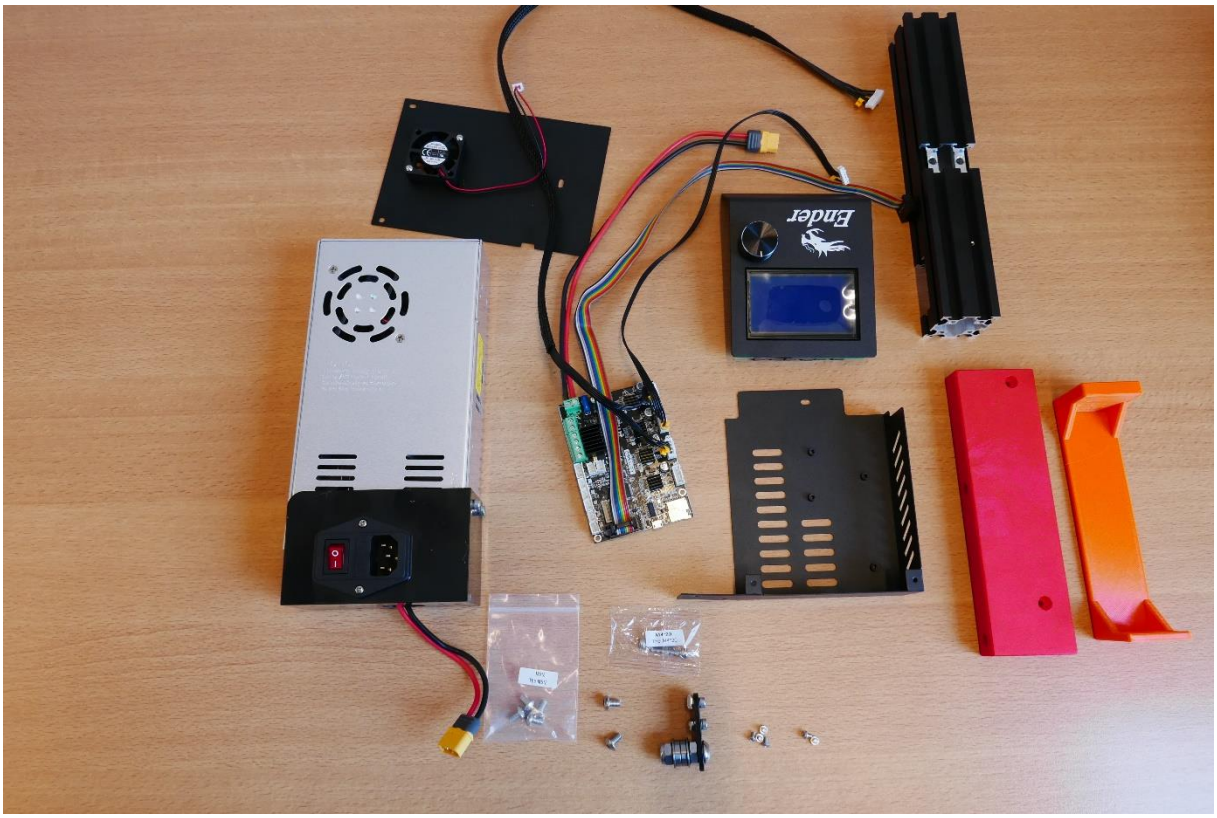

Figure 34 Overview of parts for the Control Unit.

Step 33: Install the LCD on the 40x40 rail

Using 2 M5x8 screws, install the LCD on the 40x40 rail (fig. 35).

Figure 35 LCD mounted on the 40x40 rail.

Step 34: Install the PSU on the 40x40 rail

To install the PSU Mount on the 40x40 rail, take the M4 screws and M4 T nuts from the X Belt Tensioner (fig. 36A). Slide the T nuts into the bottom track of the 40x40 rail and put the screws into the counterbored holes (fig. 36B). Tighten the screws to affix the PSU Mount. Next, put the M4x20 from the plastic bag into holes to mount the PSU (fig. 36C). The PSU is now fixed to the rail.

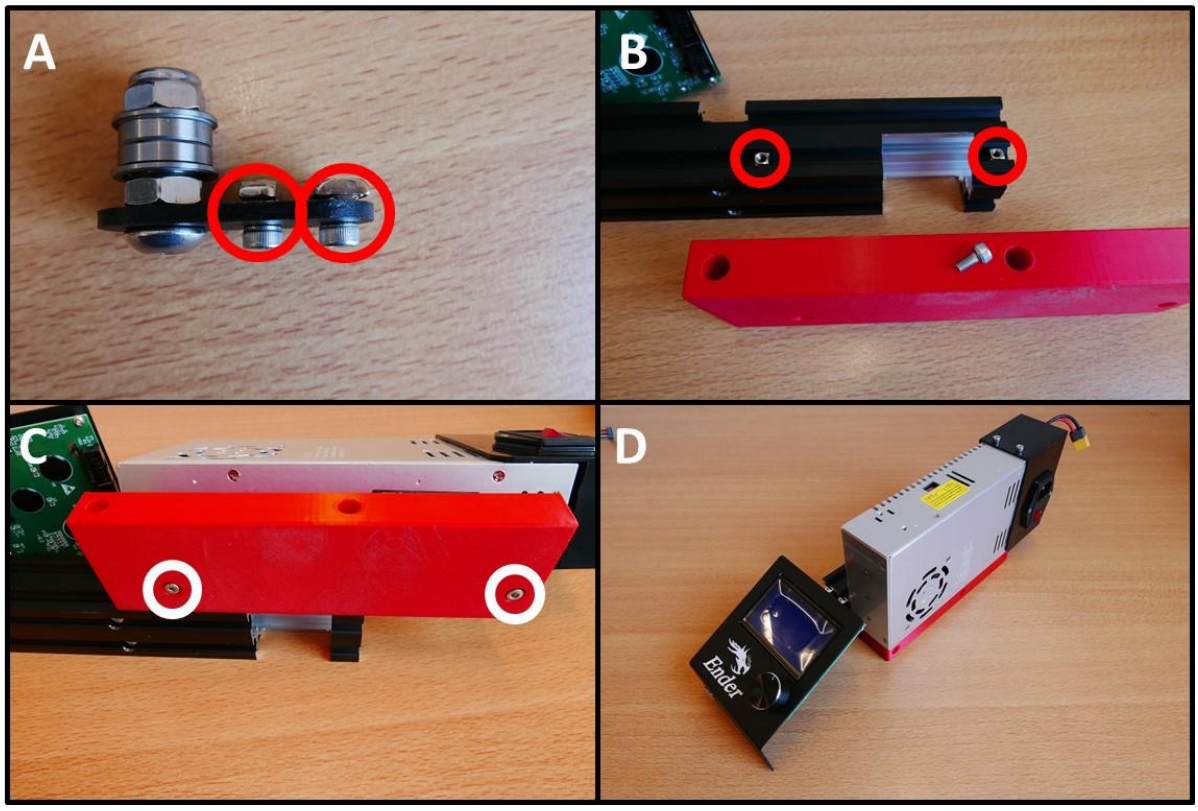

Figure 36 Installing the PSU on the 40x40 rail. A) Reuse the M4 screws and T nuts from the X Belt Tensioner. B) Insert T nuts into the rail and screws into the PSU mount. Tighten the screws. C) Screw the PSU to the PSU mount using the M4x20 screws. D) PSU mounted to the 40x40 rail.

Step 35: Rebuild the Electronics Box

The Electronics Box needs to be rebuilt before mounting it on the Control Unit. Put the board back in the case using the previously removed M3x6 screws. Reattach the fan connector (fig. 37A). Put the cover back in place with the remaining M3x6 screws (fig. 37B).

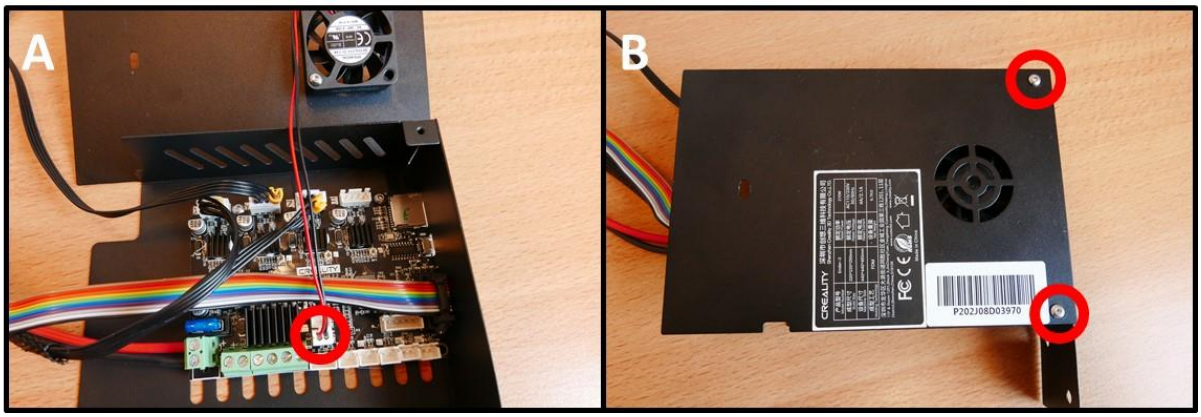

Figure 37 Rebuilding the Electronics Box. A) Electronics Board back in place, fan reattached. B) Cover replaced.

Step 36: Attach the Electronics Base and Electronics Box

To attach the Electronics Box and Electronics Base, sandwich the mounting plates and attach them to the free end of the 40x40 rail (fig. 38A) using two M5x8 screws. Attach the Electronics Board to the PSU (fig. 38B). Attach the rainbow colored cable to the rightmost LCD connector (above the 40x40 rail) (fig. 38C).

Figure 38 Attaching the Electronics Box to the Control Unit. A) Attach the Electronics Box and Electronics Base. B) Connect to the PSU. C) Attach the rainbow colored cable to the LCD.

Step 37: Attach the stepper motors to the Control Unit

The final step in the assembly process is to connect the stepper motor cables to the stepper motors themselves. The final result is shown in figure 39. The pump system is now completely built and ready to use.

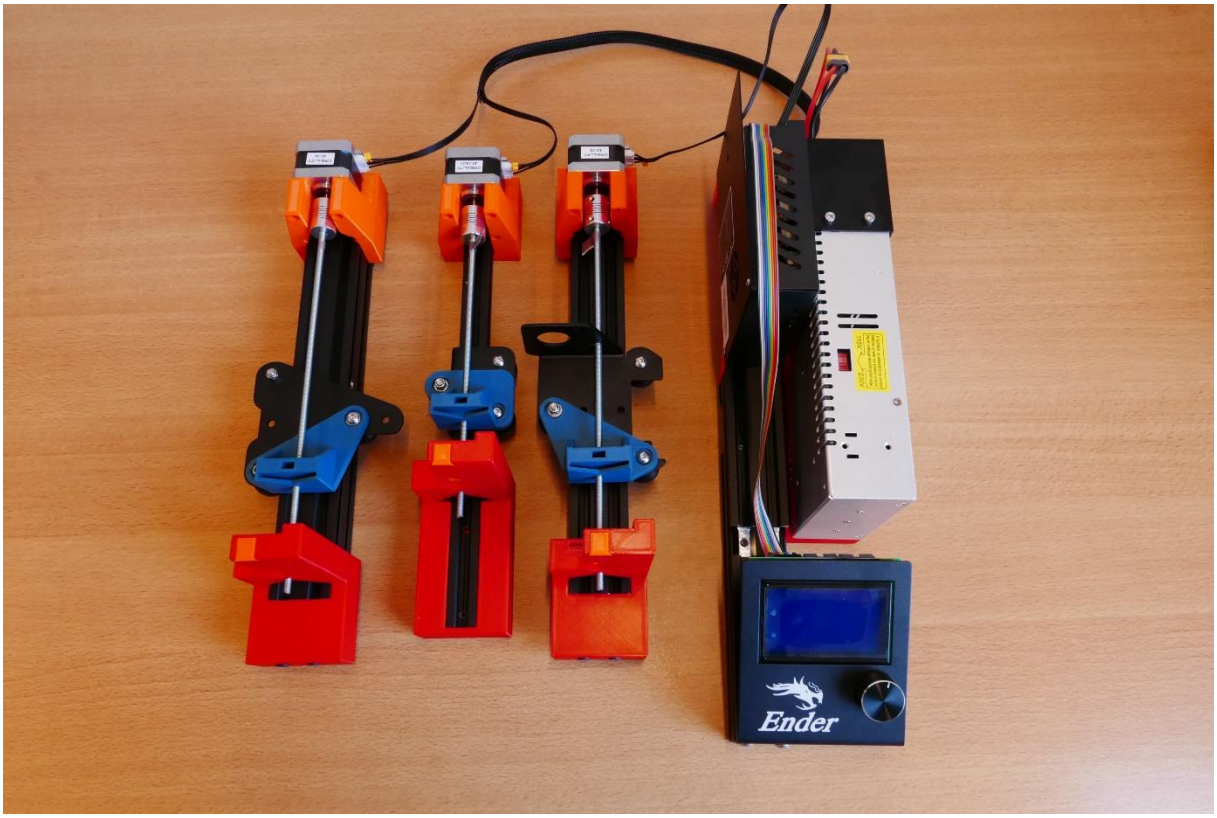

Figure 39 The fully assembled pump system, with the stepper motor cables attached.