CWC 3D Generator Instruction Manual

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1: Outsourced Material

To successfully print and assemble this 3D printed electric motor, the following list of items are required to be purchased externally. Note: The grade of magnets specified are encouraged but not a requirement and Polycarbonate/ABS blend is substitutable with ABS filament if needed for printer requirements.

#	Description	Quantity
1	N52 Grade Neodymium Magnets (0.25inX0.125inX1in)	24
2	24 AWG Enameled Copper Wire (1 pound)	1
3	500g Polycarbonate/ABS blend filament	1
4	500g Iron-filled PLA filament	1
5	8mm ID, 12mm OD 3.5mm thick ball bearing	> 2
6	8mm OD linear motion shaft (hardened steel) 200mm long	1
7	Banana plugs (Male and female)	3
8	Heat-shrink tubing	7
9	Plastic epoxy	1
10	Nylon spacer (8mm ID, 12mm OD, 10mm long)	1
11	E-clip retainer (substitute with 8mm ID collar if needed)	1

2: 3D-Printing and Print Settings

Note: This motor's main components are 3D-printed and are critical to the performance, safety, and functionality of the motor.

Step 1: Printing the backplate

In this step, the backplate should be printed in the Polycarbonate (PC) ABS blend. Printing this part before the rotor will help prevent failure when printing the rotor.

Load the part into a slicer software that is compatible with the printer that will be used. Before printing the part, make sure that the print temperatures are within the range specified on the PC/ABS or ABS filament. Scaling the model uniformly to 101.5% is recommended as a start point to compensate for print shrinkage and warping. When printing, orient the backplate with the square end facing upward as shown in figure 1 below, make sure that the print is at 100% infill. The proper scale has been reached when the bearing fits into the back of the backplate with very little to no force required.

Figure 1: Backplate

Note: Printing PC/ABS or ABS does not require an enclosure but is recommended to reduce warping.

Step 2: Printing the Rotor

Now that that the print settings have been tuned to your printer, the correct fit of the bearing in the backplate, and a quality print has been achieved, the rotor will be printed next. To print the rotor, orient the part so that the face with the pentagons is touching the build plate as shown in figure 2. Use the same print settings that were used to print the backplate with the rotor (make sure it is printed with 100% infill).

Figure 2: Rotor Print Orientation

Note: Printing PC/ABS or ABS does not require an enclosure but is recommended to reduce warping.

Step 3: Printing the Stator

To print the stator, the iron-filled filament will be needed. Although the iron filament is encouraged, regular PLA filament can be used but decreased performance is noticeable without the iron filament. When switching from PC/ABS or ABS to PLA make sure that the old filament is completely out of the nozzle to prevent clogging while printing. Import the stator into the slicer and orient the part as shown in figure 3 below with the square end facing up. With the stator, two options are available for infill. The first option is to make the part 100% infill. And the second option is to increase the number of perimeters between 10-15 and set the infill value to 50% (the infill pattern does not matter).

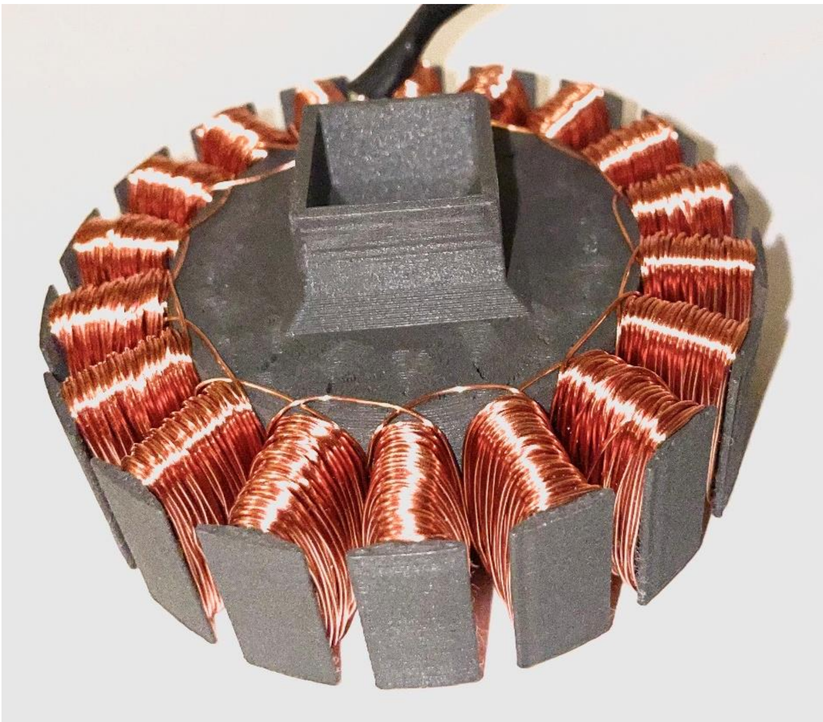

Figure 3: Stator Print Orientation

Note: Printing a test piece with this filament to achieve correct tolerances may be required to avoid post-processing

Warning: Printing Iron-filled filament will cause aggressive wear to brass nozzles and a hardened steel nozzle is highly recommended.

3: Assembly

Step 1: Winding the stator

Before winding the stator, make sure that the square extrusion on the stator is facing you and that you have the copper wire at hand. To begin the windings of the three-phase motor, orient the stator with the dots facing you and the slot cut-out at the top as shown in figure 4. To begin winding the first phase, tape the cut end of the wire to the square extrusion to keep it out of the way. To begin winding the first phase, locate the single dot at the top of the stator which indicates phase 1. Starting on the left-hand side of that tooth, begin winding the copper wire in a clockwise fashion while being sure to make the wire as compact, neat, and as evenly distributed as possible. Continue winding that tooth for 75 turns. Once that tooth has been wound 75 times make sure that the wire is coming towards you. Continue this pattern on the next single dot clockwise from the tooth just wound, making sure to wind clockwise and exactly 75 turns. Continue this pattern going clockwise until all of the 1-dot slots have their windings. When the first phase is done, cut the wire making sure to leave excess. Repeat this process for the second and third phase by starting the windings on the two-dot and three-dot slots to the right respectively.

Figure 4: Winding Orientation and Final Configuration

Step 2: Soldering

The next step is to solder the ends of the three phases together leaving three outputs as a result. The three ends of the phases should be the three ends to the left of where you began making the windings. Leave two to three inches of wire that will be soldered together. Strip the wire to remove the enamel coating by using a razor blade or knife. Twist the three wires together and solder them. The next three things that are needed to be soldered are the outputs. Use the three banana plugs and the heat shrink for this step. Make sure to strip the ends of the three output wires to ensure a good connection. Apply heat shrink tubing to all soldered connections to prevent shorting. Once this step has been completed the stator should like figure 5.

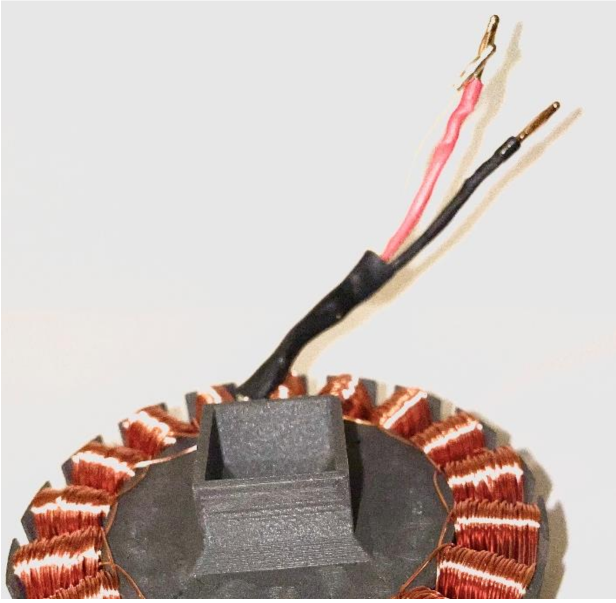

Figure 5: Heat Shrink/Banana Plugs

Step 3: Installing Magnets

This step will be installing the 24 magnets into the rotor. Proper pole orientation is critical to the motor's safety and performance. First, number each magnet on the North pole from 1 to 24. If you have access to a scale, measure the mass of each magnet in grams and keep a record. To balance the motor's magnets, use the included MATLAB script which will calculate the counterweight's mass and location to balance the rotor. Once that is complete, install the magnets with opposite polarities for example (NSNSNS). When installing the magnets, make sure that they are flush against their spots and not protruding. To secure the magnets, apply a drop of epoxy on the underside of the magnet touching the rotor.

Warning: N52 Neodymium magnets are extremely strong and dangerous. Keep away from electronics, metal surfaces, and do not handle if you have a pacemaker.

Step 4: Installing E-clip, Nylon Bushing, and Rear Bearing

On the side of the shaft with a groove cut, push the E-clip on until it snaps into place (this may take some force). Next, on the opposite side of the shaft, slide the nylon bushing onto the shaft until it makes contact with the E-clip. Finally, in the same fashion, install the bearing on the shaft. Once all of this has been done, the shaft should look like figure 6.

Figure 6: Shaft Assembly

Step 5: Backplate installation

To install the backplate, slide the shaft through the flat end of the backplate until it stops (this should not require much pressure). Make sure that the new assembly looks like in figure 7.

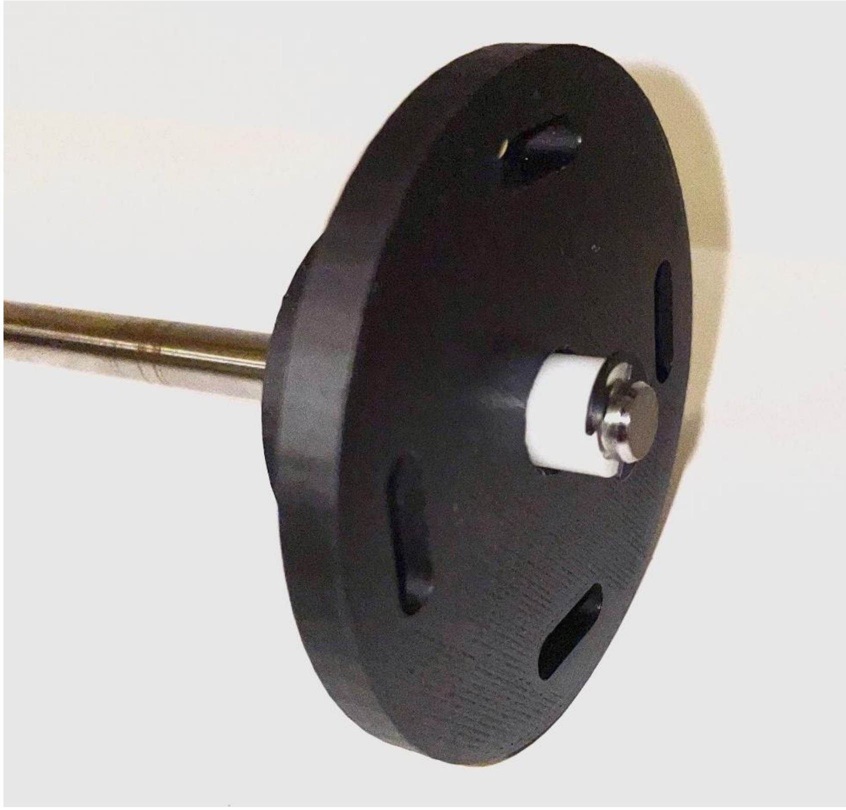

Figure 7: Backplate and Shaft Assembly

Step 6: Stator Bearing

On the flat face of the stator, place the second bearing into the hole, making sure that the bearing is flush to the surface of the stator (do not force the bearing into the hole with excessive force). The stator should look like figure 8.

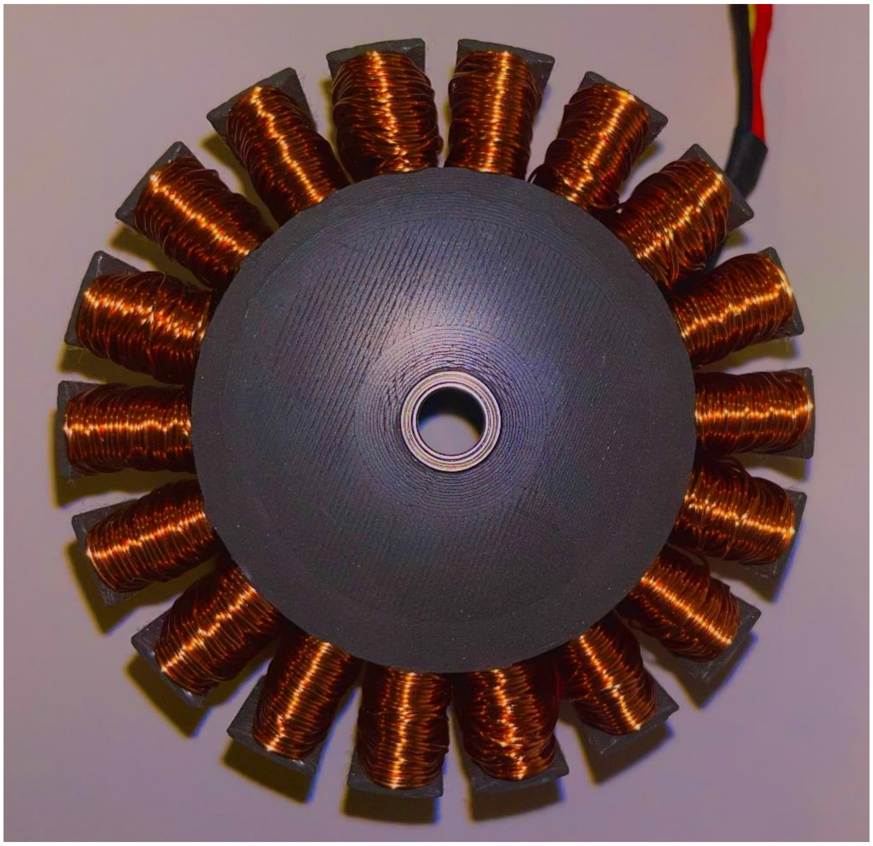

Figure 8: Stator Bearing

Step 7: Stator Installation

To install the stator on the new assembly, slide the stator on the free end of the shaft with the square extrusion facing the backplate. Next, align the stator and backplate so that the male and female ends meet and are friction fit together. Once complete, figure 9 is how it should look.

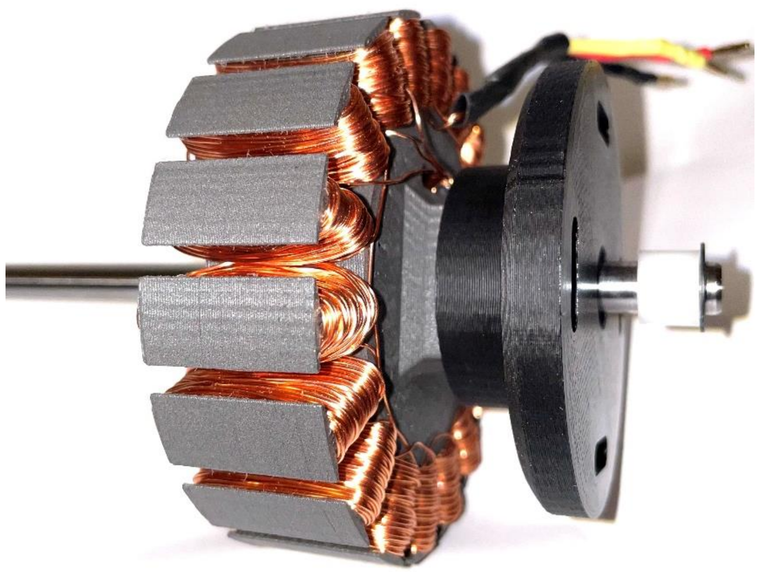

Figure 9: Stator Installation

Step 7: Rotor Installation

The final assembly step is to install the rotor. To install the rotor, orient the rotor on the shaft so that the magnets are facing the stator and so that the stator can fit within the rotor. Slide the rotor into the shaft completely until it does not go any further. Before epoxying the rotor to the shaft, a function check should be performed. Figure 10 shows the completed assembly.

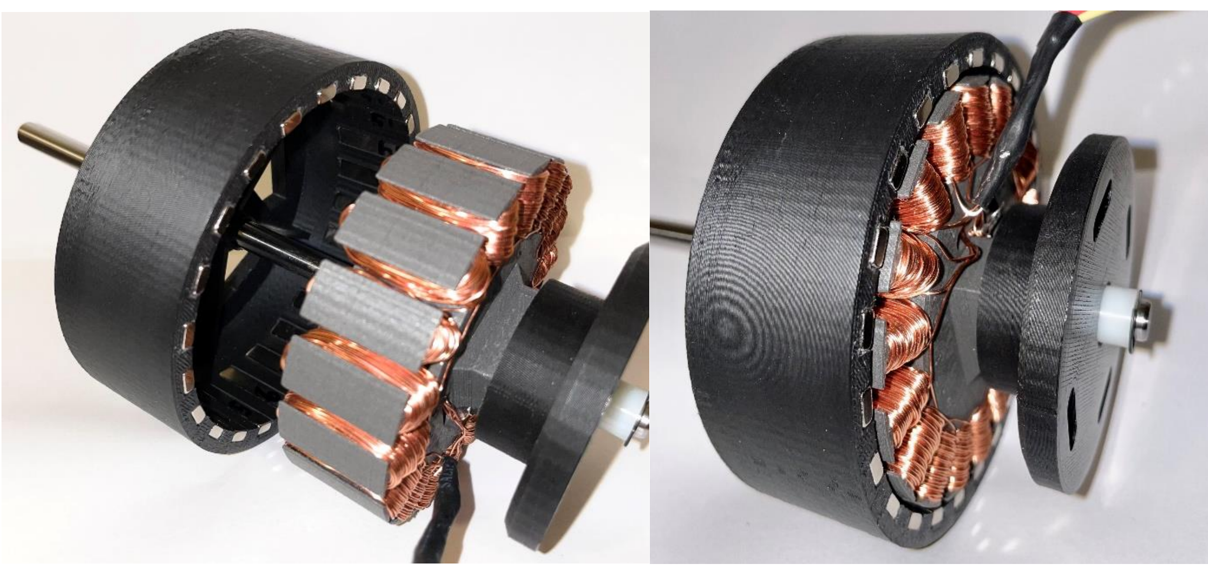

Figure 10: Final Assembly

4: Function Check

To confirm that the motor was assembled correctly, a few function checks are required to assure safe performance.

Check 1: Continuity Check

To measure the continuity, use a multimeter and change the mode to ohms (the lowest setting, usually 200). Next, probe the central point on the stator where all three phases meet and probe each of the three-phase outputs, making sure that the resistances for each phase are similar to each other.

Check 2: Clearance Check

This check will ensure that there is no rubbing of the rotor on the stator and will not cause damage. To do this check, simply rotate the shaft by hand and ensure that there is no rubbing or weird noises.

Check 3: Voltage Check

This check will confirm that the motor does produce voltage. Use a multimeter and change the mode to AC volts. Attach the probes to two of the phase outputs and spin the motor by hand, if there is a voltage reading, switch to another phase combination and make sure that the same voltage is being read. Once all three checks have been passed, epoxy the rotor to the shaft to secure it in place.

5: Troubleshooting

This portion of the manual will discuss some issues that may arise while assembly or testing and possible solutions to those problems.

Problem 1: No Continuity

When checking the stator windings for continuity and there are "infinite" ohms, possible sources for this are that there is a break in one of the windings. Check for broken wires in the stator. Next, make sure that the soldering connections are secure and that you stripped the wires well before soldering.

Problem 2: No Voltage

If you are not getting voltage during the voltage test, make sure that the magnet orientation for each magnet is alternating. A good way to test this is to take another magnet and place it in front of each magnet on the rotor, if the test magnet is attracted to every other magnet on the rotor then that implies that you installed the magnets correctly. If this does not happen, correct the misoriented magnets and try again.

Problem 3: Part Rubbing, Parts not fitting

If this problem occurs there are two courses of action. The first is to shave enough material off the part very slowly until the part fits correctly. The second is to reprint the part at a higher scaled percentage. We recommend that the rotor and backplate are reprinted first, especially if the stator is already wound and soldered.

Problem 4: No Current

Do not worry about this! We were not able to get current either! It's not you, it's us.