Z-Axis Assembly

The Z-axis assembly is comprised of several sub-assemblies. When assembling it, it is best to select a Motor Mount Carriage (PS20022) which already has a stepper motor in place.

**Note:** You will need to have at least your Z-axis MakerSlide tapped before completing this step. It is probably best to begin tapping well in advance of needing parts, so as to ensure that one works slowly,
carefully and patiently at tapping, especially if one initially lacks experience at it.

Z Assembly Carriage (PS20021)

Requirements

Parts

1. 26029-01 Motor Mount Plate (12ga)
2. 30158-01 Eccentric Nut x 2 pcs.
3. 25203-02 Dual Bearing V-Wheel (assembly) x 4 pcs.
4. PS20004 M5 x 20mm BHCS x 4 pcs.
5. 25287-02 M5 Flat Washer x 6 pcs.
6. 25284-02 M5 Hex Nut x 2 pcs.

This is the plate the Z-axis will attach to (it is identical to the Motor Mount Carriage (PS20022) assembled in the previous step, but without smooth idlers. It sits on the front of the gantry and will be connected to the X-axis motor mount plate via rigid aluminum spacers. We will build the plate first, and then attach the two together.
Connect V-Wheels (#3) to the plate (#1)

- two static at the top (using M5 Hex Nuts (#6))
- two eccentric at the bottom in the larger holes (using Eccentric Nuts (#2))

Spindle Carriage Assembly (PS20029)
Requirements

Parts

1. 30287-01 **Spindle Mount Plate** (12ga) x 1 pcs.
2. PS20010 13mm x 35mm x 20mm **Delrin Lead nut** x 1 pcs. --- check that the threaded rod fits (see below)
3. 25287-02 **M5 Flat Washer** x 10 pcs.
4. 25284-02 **M5 Hex Nut** x 6 pcs.
5. PS20012 **Universal Spindle Mount** x 2 pcs.
6. 30158-01 **Eccentric Nut** x 2 pcs.
7. 25203-02 **Dual Bearing V-Wheel (assembly)** x 4 pcs.
8. 25196-01 5mm x 16mm x 5mm Bearing (x 8 pcs. **contained in #7. above**)
9. 25201-01 Precision 1mm spacer (x 4 pcs. contained in #7. above)
10. 25312-14 3/8" x 5/16" x #12 bore, **Aluminum Spacer** x 4 pcs.
11. 25286-05 **M5 x 30mm, BHCS** x 4 pcs.
12. 25286-02 **M5 x 12mm, BHCS** x 6 pcs.
13. PS20013 **Universal Spindle Mount strap** x 2 pcs.
14. PS20005 **M5 x 45mm, SHCS** x 4 pcs.
Place the V-wheels (#7) and the Delrin Lead nut (#2, for the Z-axis Rail Assembly, see below) on one side of the Spindle Mount Plate (#1) and the Universal Spindle Mount (#5) and Straps (#13) on the other. Be careful when tightening the M5 SHCs which hold the Delrin Lead Nut so that you do not deform the plastic nut --- probably best to not tighten them fully until the Z-Axis Rail Assembly’s threaded rod is inserted. The Eccentric Nuts (#6) go in the larger holes. **Note:** Be certain to use the aluminum spacers (#10) which set this plate off from the Z-axis rail assembly, allowing room for the threaded rod) and ensure that all V-wheels are vertically aligned with each other (be careful of washer placement/order).

Z-Axis Rail Assembly (PS20028)
Note: The above exploded view does not show the wavy washer (PS20017) which goes on top of the flanged bearing.

One should also attach the motor for the Z-axis at this time.

Requirements

Parts

1. 25142-07 Z Axis Rail MakerSlide Extrusion 200mm x 1 pcs.
2. 25772-02 Z-Axis Flexible Coupler 5mm–8mm bore x 1 pcs.
3. 30288-01 Z-Axis Motor Mount Plate (12ga) x 2 pcs.
4. 30169-01 8x22x7mm flanged bearing x 1 pcs.
5. 30289-01 Z-Axis Shim Plate (12ga) x 1 pcs.
6. PS20011 M8 Threaded Rod Stainless Steel, 200mm x 1 pcs.
7. 25287-02 M5 Flat Washer x 2 pcs.
8. PS20014 Brass Standoff spacer M3 male x M3 female 50mm x 3 pcs.
9. PS20016 5mm x 10mm x 1mm thick, Nylon Spacer x 4 pcs. (these are used for the M5 BHCS (#10. below) which hold the Z-Axis Motor Mount Plate to the MakerSlide)
10. PS20004 M5 x 20mm BHCS x 2 pcs.
11. PS20015 3mm x 8mm x 1mm thick, Nylon Spacer x 6 pcs. (these are used with the M3 SHCS (#12. below) which attach to the Brass Standoff spacers)
12. 25285-10 M3 x 12mm, SHCS x 3 pcs.
13. 25287-03 M3 Flat Washer x 3 pcs.
14. PS20007 M8, Hex Nut x 2 pcs.
15. PS20017 Wave Disc Spring, .901"ID, 1.159" OD, .013" thickness (please note that this is not shown in the diagram, it is placed on top of the flanged bearing)

Electronics

- Stepper Motor (it is all-but impossible to attach the motor after the fact without disassembly)
- 25287-03 M3 Flat Washer x 3 (or more, see below) pcs.

Tools
- 13mm (or 1/2") open end wrenches x 2 pcs.
- M3 Hex Key (for the M5 BHCS)
- M2.5 Hex Key (for the M3 SHCS and coupler set screws)
- 5mm open end wrench, adjustable crescent wrench or pliers (ideally nylon-jaw parallel) to tighten the M3 brass standoffs

**Note:** Depending on how deeply tapped on the stepper motor and how long the threads are on the brass standoffs, it may be necessary to add additional M3 washers when attaching the motor using the brass standoffs.

**Note:** Check your rod's straightness (one way is by rolling it on a flat surface) before assembly and check to see that the threaded rod runs smoothly on the Delrin Lead nut --- if it doesn’t, run the nut along the rod until it does. Using a drill is one option. Be certain the nut is free of debris or other materials. It’s also possible that the rod may be out-of-spec rather than the nut --- you may want to consider taking the nut to a local hardware store and trying it on their stock of M8 all-thread to see if it works better on one of them.

---

The Z-Axis Rail Assembly is the most intricate and complex assembly, and requires patience to assemble. One way to do this is to assemble it from the inside out, starting with the smallest pieces. One could of course try top-to-bottom or bottom-to-top --- just follow the diagram (and remember to add the Wave Disc Spring) and be careful to use equal numbers of spacers/washers for each connector and to not damage or bend the brass stand-offs.

1. Take one Z-Axis Motor Mount Plate (#3, this will become the bottom)
2. Place M3 washers (#13) onto the 12mm M3 screws (#12) and place them in the appropriate holes
3. Stack the Nylon Spacers (PS20015) (#11) onto the screws (note that an equal number of spacers is used for each screw, including the M5 bolts which will go into the other plate from the other side
in a later step)
4. place the Wave Disc Spring (#15, not shown in the diagram) onto the narrow part of the flanged bearing (#4) --- it would be to the right in the diagram
5. insert that into the second Z-axis Motor Mount Plate (#3)
6. insert the two M5 bolts (#10) and M5 washers (#7) from the other side of that plate
7. add the last Nylon Spacers (#9) to the end of each bolt (#10) and slide the top and bottom Z-axis Motor Mount Plates together --- carefully set this sub-sub-assembly aside
8. Attach the Flexible Coupler (#2) to the stepper motor
9. Place an M3 Washer (#13) onto a Brass Standoff Spacer (#8) and test fit it into the stepper motor --- if it bottoms out, add another washer and try again --- repeat for the other brass standoffs. Use an equal number of M3 Washers when attaching the Brass Standoff Spacers to the stepper motor --- if a brass standoff doesn’t seat as deeply as it should, because the threads aren’t well-formed, use a die (or very carefully, a steel nut) to re-thread.
10. After the successful test-fitting, attach the brass standoffs to the sub-sub-assembly from Step #7 --- make sure not to force anything when tightening the standoffs, remember it’s only brass and can snap off inside the motor if you’re not careful enough. The standoffs should need only to be snug, as the screws on the other end prevent the standoffs from rotating. Be careful of the orientation of the sub-sub-assembly, not to lose the M5 bolts and plastic spacers.
11. After determining the spacing for the Threaded Rod (#6) (see below) thread on one M8 Hex Nut (#14) to the top position on the Threaded Rod
12. Slip the Threaded Rod through the Flanged Bearing of the sub-sub-assembly from Step #7 above
13. Thread on the second M8 Hex Nut
14. Fasten the stepper motor using the M3 screws onto the Brass Standoff Spacer (#8)
15. Place the Z-axis Shim Plate (#5) on top of the Z Axis Rail (#1, 200mm MakerSlide) and attach it using the M5 bolts (as noted above, the Z-axis must have threads for these bolts at this point, cut in by tapping) --- be careful of the orientation of the MakerSlide, the V-rails must be oriented as shown in the diagram so that the Spindle Carriage Assembly (see below) V-wheels will fit.

Review all connectors to make certain that everything is tight --- be careful not to bend the threaded rod or strip any screws.

**Threaded Rod**
Compare the threaded rod (**#6**) to the assembly, thread on one M8 Hex Nut (**#14**), threading the latter far enough down to allow room for the flanged bearing, a second hex nut, and for the threaded rod (and the stepper motor shaft) to be just short of half-way into the flexible coupler (**#2**). Insert the threaded rod into the bearing, add the second M8 hex nut and tighten them with two wrenches, being careful not to bend the rod. Note

Tighten the coupler set screw holding the threaded rod using the 2.5mm hex key. If the flexible coupler doesn’t securely grip the threaded rod, wrap the end of the rod in some sort of metal, foil or tape to ensure coupler holds it securely. Make certain the coupler holds the rod squarely. One inexpensive source for metal shims is aluminum drink cans which are easily cut with appropriate tools (and wearing appropriate safety gear).

**Note** the nuts are commodity / off-the-shelf parts and have a fairly wide manufacturing tolerance. If your threaded rod wobbles unduly after assembly, mark the nuts so as to indicate their orientation and try swapping them around in terms of orientation and positioning, keeping notes on which you have tried --- you should hit upon an arrangement which allows the rod to run fairly true, or at worst case, not hit any other parts (some whipping is inevitable --- one simply wants to achieve a state where nothing will be damaged by the rod end). If nothing works, contact Inventables customer service, or try sourcing new nuts (one option is to take the bearing and threaded rod into a hardware store and try different nuts until you find a pair which works).

**Stepper Motor**

As noted above, one should attach the stepper motor during the course of the assembly if at all possible. If not... place M3 washers on the brass M3 standoffs --- if the standoffs bottom out, add sets of M3 washers to ensure the threads are well-engaged and not bottoming out. Ensure that the motor shaft will also fit just short of half-way into the flexible coupler and that the rod and motor shaft have a gap which will allow the flexible coupler to function without interference or binding. Tighten the
coupler set screw holding the motor shaft using the 2.5mm hex key.
Tighten everything. If the M3 screws bottom out in the stand-offs, add washers one at a time until everything is secure.

Z-Axis

1. PS20021 Z-Assembly Carriage x 1 pcs.
2. PS20028 Z-Axis Rail Assembly x 1 pcs.
3. PS20029 Spindle Carriage Assembly x 1 pcs.
4. 25287-02 M5 Flat Washer x 4 pcs.
5. 26016-01 M5 insertion nut x 4 pcs.
6. 25286-01 M5 x 10mm, BHCS x 4 pcs.

Insert the 10mm M5 bolts (#6) with an M5 washer (#4) into the Z-Assembly Carriage (#1) from the side the V-wheels are on, thread on the M5 insertion nuts (#5), then slide the MakerSlide of the Z-Axis Rail Assembly (#2) onto the nuts, align and center the assemblies and tighten.
Turn the eccentric nuts on the Spindle Carriage Assembly (#3) so that they move the matching V-wheels as far as possible from the opposing static V-wheels. Slide the Spindle Carriage Assembly onto the Z-Axis Rail Assembly, match it up with the Delrin Lead nut and turning the threaded rod using the flexible coupler, bring the Spindle Carriage Assembly up so that the V-wheels are completely on the MakerSlide V-rail. Be careful not to nick or damage the Delrin V-wheels, or to cross-thread the Delrin Lead nut.

Sub Gantry (PS20023)
Requirements

Parts

1. PS20021 **Z-Assembly Carriage** x 1 pcs.
2. PS20022 **Motor Mount Carriage** x 1 pcs.
3. PS20002 3/8” x 1-1/4” x #12 bore, **Aluminum Spacer** x 6 pcs.
4. PS20006 **M5 x 70mm SHCS** x 6 pcs.
5. 25287-02 **M5 Flat Washer** x 12 pcs.
6. 25312-20 3/8” x 1” #12 Bore, **Aluminum Spacer** x 6 pcs.
7. 25284-02 **M5 Hex Nut** x 6 pcs.
8. PS20030 **Complete Z-Axis Assembly** x 1 pcs. (not enumerated in the diagram)

If possible, select a Motor Mount Carriage (PS20022) which has a stepper motor attached. If using wiring option #2, there should be a terminal block attached to the right (on the side opposite the V-wheels and smooth idlers).
For each M5 x 70 mm SHCS (#4), place a washer (#5) then place them in the outer holes of the Z-Assembly Carriage (#1) from the side opposite the V-wheels. Then for each M5 bolt (#4), add the spacers (#3, & #6). Add the Motor Mount Carriage, then for each M5 bolt, add an M5 washer, and M5 hex nut (#7).
Next Step **Gantry**

To express concerns, post on the [forums](http://docs.shapeoko.com/zaxis.html), to suggest improvements without using github, edit [this wiki page](http://docs.shapeoko.com/zaxis.html).