

VFD Spindle Kit

INSTALLATION GUIDE



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Welcome and Congratulations

The long-awaited VFD spindle kit has arrived. It's more powerful and has quieter, smoother operation than a standard trim router, and it's plug-and-play to boot. We've handled all of the testing, integration, and wiring for you. All you have to do is set it up.

In this guide we'll walk you through the super-simple installation and setup of your new VFD Spindle kit. Additionally, you're also welcome to check out the VFD Spindle Kit Installation video at youtu.be/lf23E374dAU. If you encounter any issues during installation or setup, contact our tech support team at support@carbide3d.com and we'll get you up and running ASAP.

Details & Specs

The VFD controller includes custom electronics to reduce electrical noise and a custom controller board to make the system plug-in compatible with a Shapeoko so that your spindle RPM is controlled by your G-code. In addition, we provide a 6-month warranty on the spindle and VFD.

VFD Spindle Specs:

- 65mm Air-cooled 1200W spindle.
- Uses ER-11 collets.
- 110V, 12A draw.
- 8k–24k RPM.
- RPM is fully controlled by your G-code.
- VFD controller has built-in AC filtering.
- VFD controller has built-in adapter board for speed control from Carbide Motion.

NOTE: In an attempt to make the VFD spindle kit as plug and play as possible, and to ensure that we can support it properly, the VFD controller comes preprogrammed with the parameters locked. This protects against accidental changes to the configuration.

Compatibility & Software Requirements

Carbide Motion version 551 or higher is required for the VFD spindle.

The VFD spindle is 65mm in diameter, so it should fit any Shapeoko 3, 4, or Pro. That said, it is significantly heavier than a standard trim router, so we prefer to pair it up with an HDZ—although the Z-Plus works well too. We do not recommend adding the VFD spindle to the original Shapeoko 3 belt-drive Z-Axis.

NOTES:

- The 65mm VFD spindle is compatible with Sweepy 65 for dust collection.
- If you have Shapeoko 3 with a V2.3 board and below (Shapeoko 3 machines purchased before Black Friday 2019), you will also need to purchase a Carbide Motion PCB with enclosure, which includes a new circuit board with the BitRunner connector installed.

VFD Spindle Kit Contents

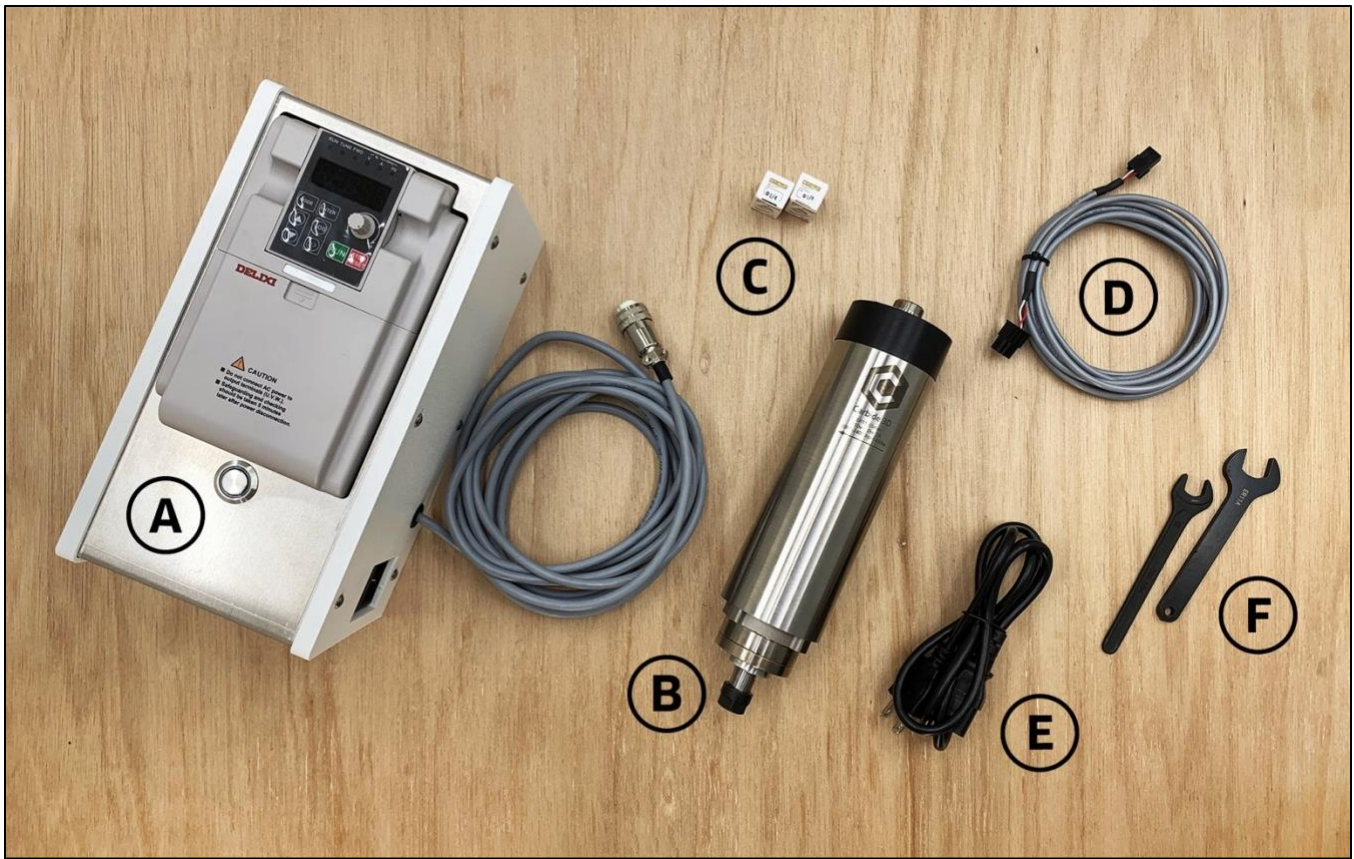


Figure 1

| Item | Description | Qty |
|------|--|-----|
| A | VFD Controller (with Built-in Speed-control Board and AC Filter) | 1 |
| B | 65mm Air-cooled 1200W Spindle (with Collet and Collet Nut) | 1 |
| C | ER11 Precision Collets (¼" and ⅛") | 2 |
| D | 6-pin Logic Cable | 1 |
| E | VFD Controller Power Cable | 1 |
| F | Spindle Wrenches | 2 |

NOTE:

- If any items are missing or damaged in shipping, contact us at support@carbide3d.com and we'll ship you a replacement ASAP.

Step 1: Remove the Old Router

1. Power off and unplug the machine and the router.
2. Clip any zip ties securing the router power cable to the machine.
3. Measure (approximate is okay) how much of the router is showing below the spindle mount. (You will need this measurement in order to install the VFD spindle in the spindle mount.)

Shapeoko 3 Machines ONLY

4. Use a 4mm hex key to loosen the two M5 screws securing the old router, and remove it from the spindle mount.
5. Go ahead and skip ahead to **Step 2: Installing the VFD Spindle** on page 10.

Shapeoko Pro & Shapeoko 4 Machines ONLY

4. Use a 5mm hex key to loosen the two M6 screws securing the old router, and remove it from the spindle mount. See *Fig. 2*.
5. Follow the steps on the next pages to remove and reinstall the router drag chains.

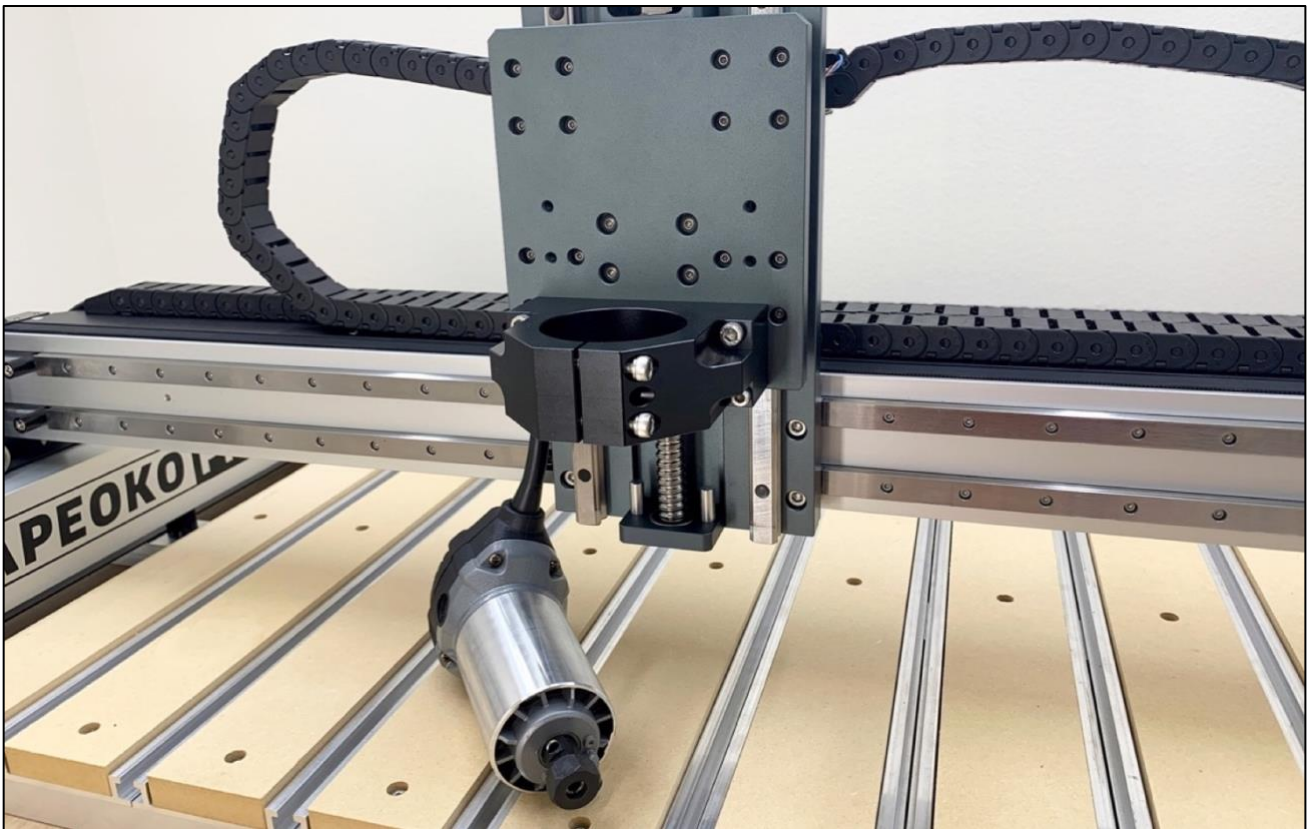


Figure 2

6. Remove the X-Axis router drag chain. See **Fig. 3**.
 - a. Use a 2mm hex key to remove the two M3 screws securing the X-Axis head to the bracket on the back of your Z-Axis.
 - b. Use a 2mm hex key to remove the two M3 screws securing the tail to the drag chain support panel.
 - c. Set all of the screws aside for reinstallation.

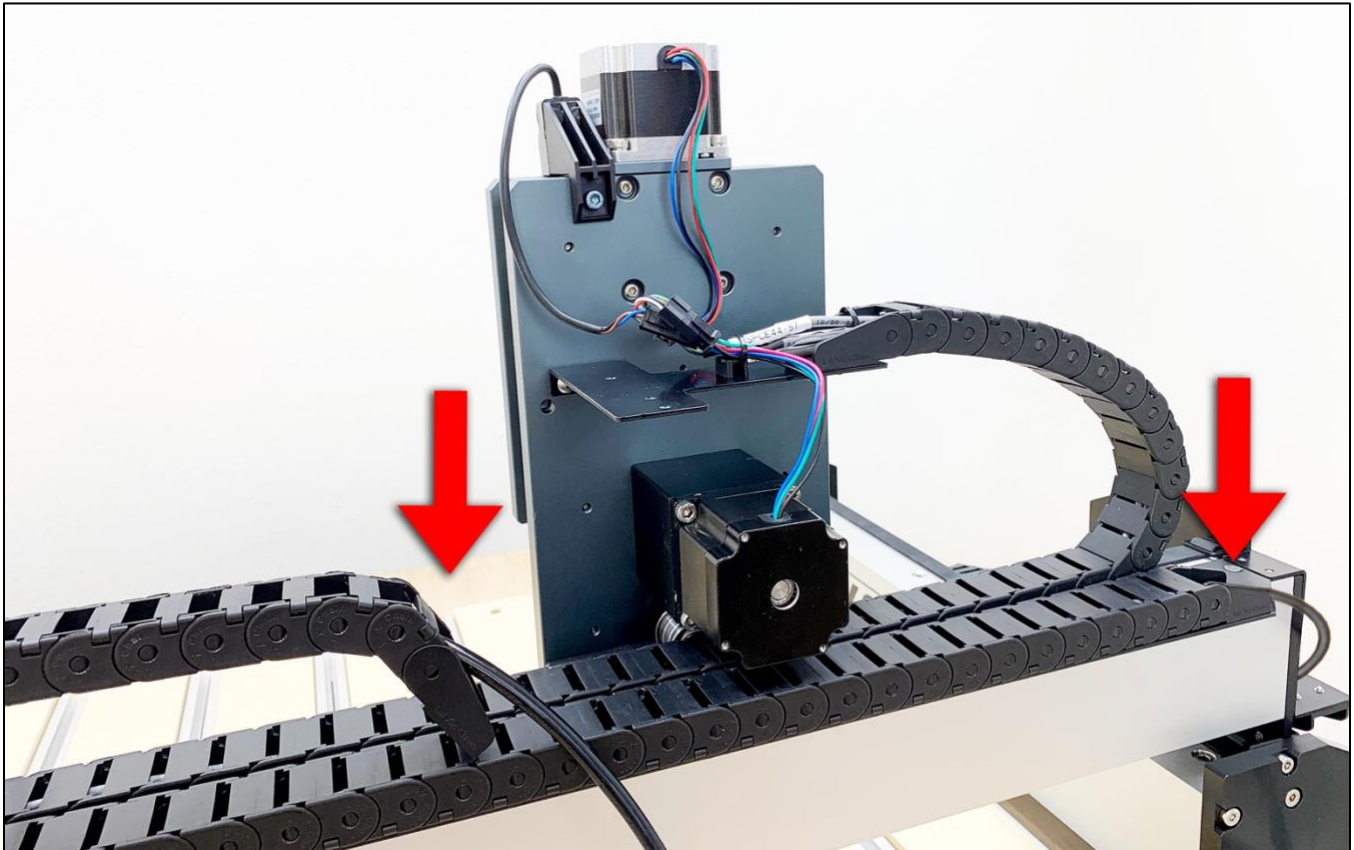


Figure 3

7. Remove the Y-Axis router drag chain. See **Fig. 4**.
 - a. Use a 3mm hex key to remove the two M5 screws securing the X/Y transition bracket to the Y-left gantry plate.
 - b. Use a 2mm hex key to remove the two M3 screws securing the Y-Axis tail to the drag chain support panel.
 - c. Set all of the screws aside for reinstallation.

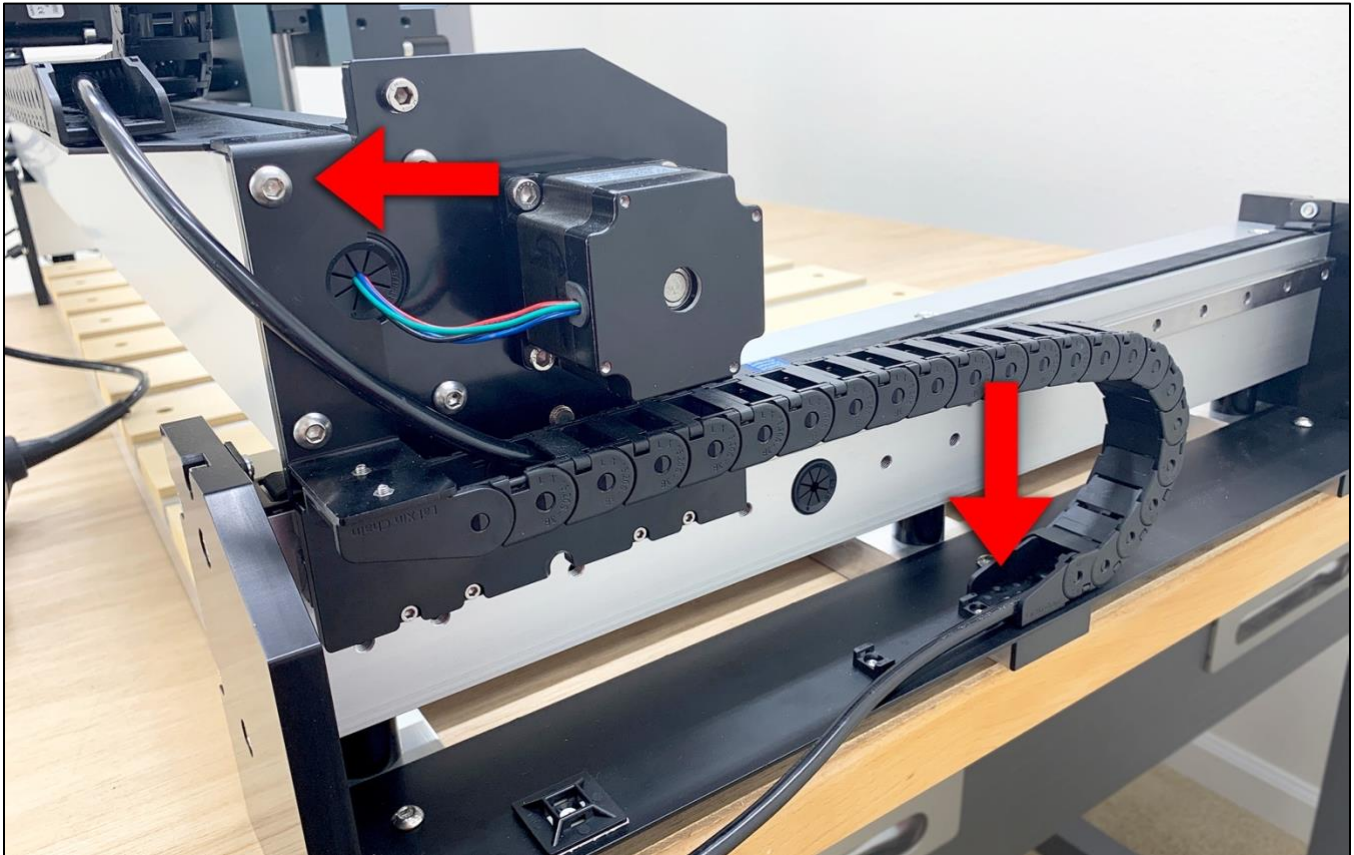


Figure 4

8. Open the both drag chains, remove the router power cable, and set the router aside. See **Fig. 5**.
 - a. Be sure to note which way the drag chains attach to the gantry to you can reinstall them correctly.
 - b. Use a medium size hex key to pry open the drag chain links from one side.
 - c. You may need to remove the tail links from both axes to be able to remove the power cord. See **Fig. 5**. Make sure to note their orientation so you can re-install them correctly. Use a small screwdriver to pry off the tail links.

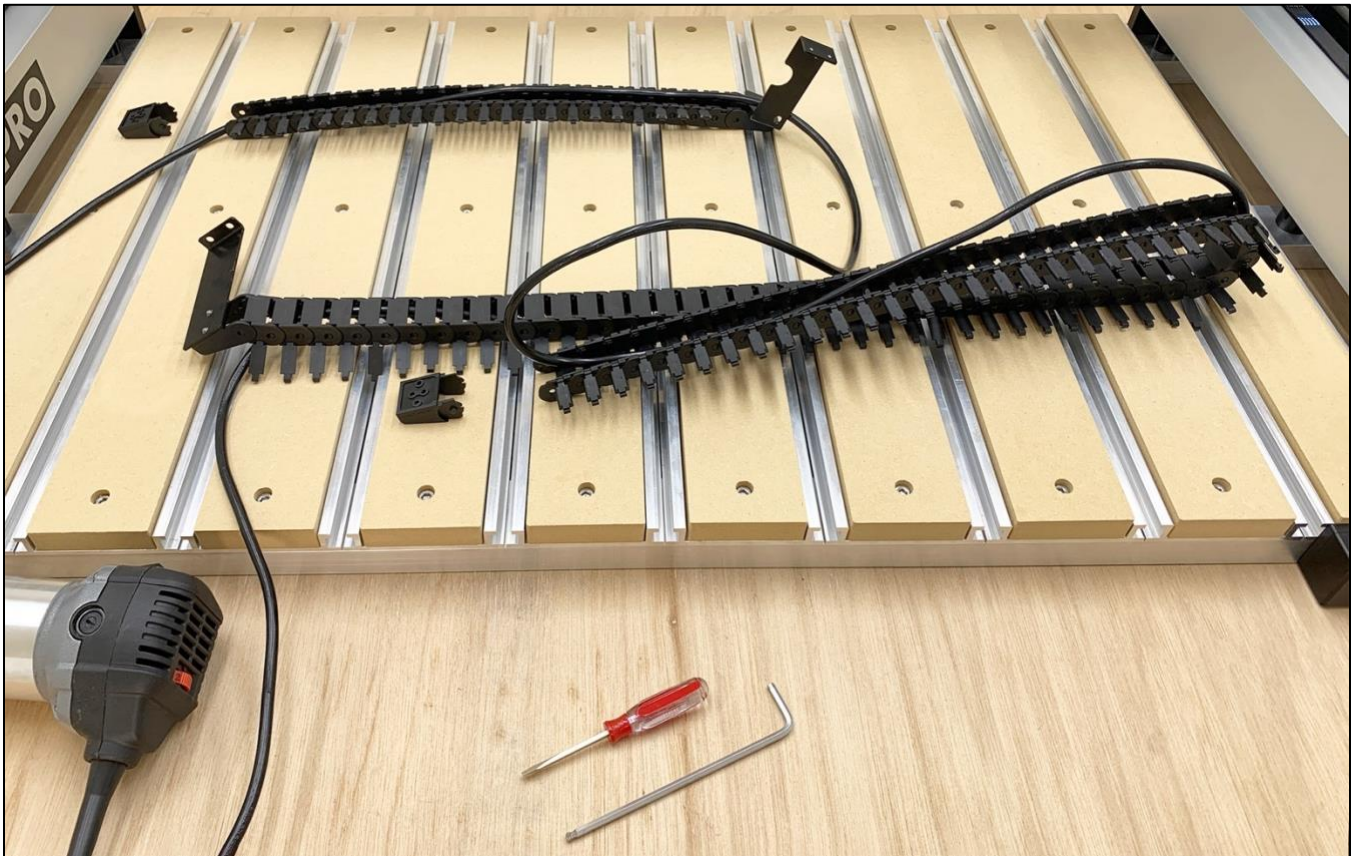


Figure 5

9. Route the gray spindle power cable exiting the side of the VFD controller through the drag chains. See **Fig. 6**.
 - a. The spindle power cable's screw-on connector and about 14 inches of cable should extend beyond the head of the X-Axis drag chain.
 - b. The VFD controller will be at the tail of the Y-Axis drag chain.

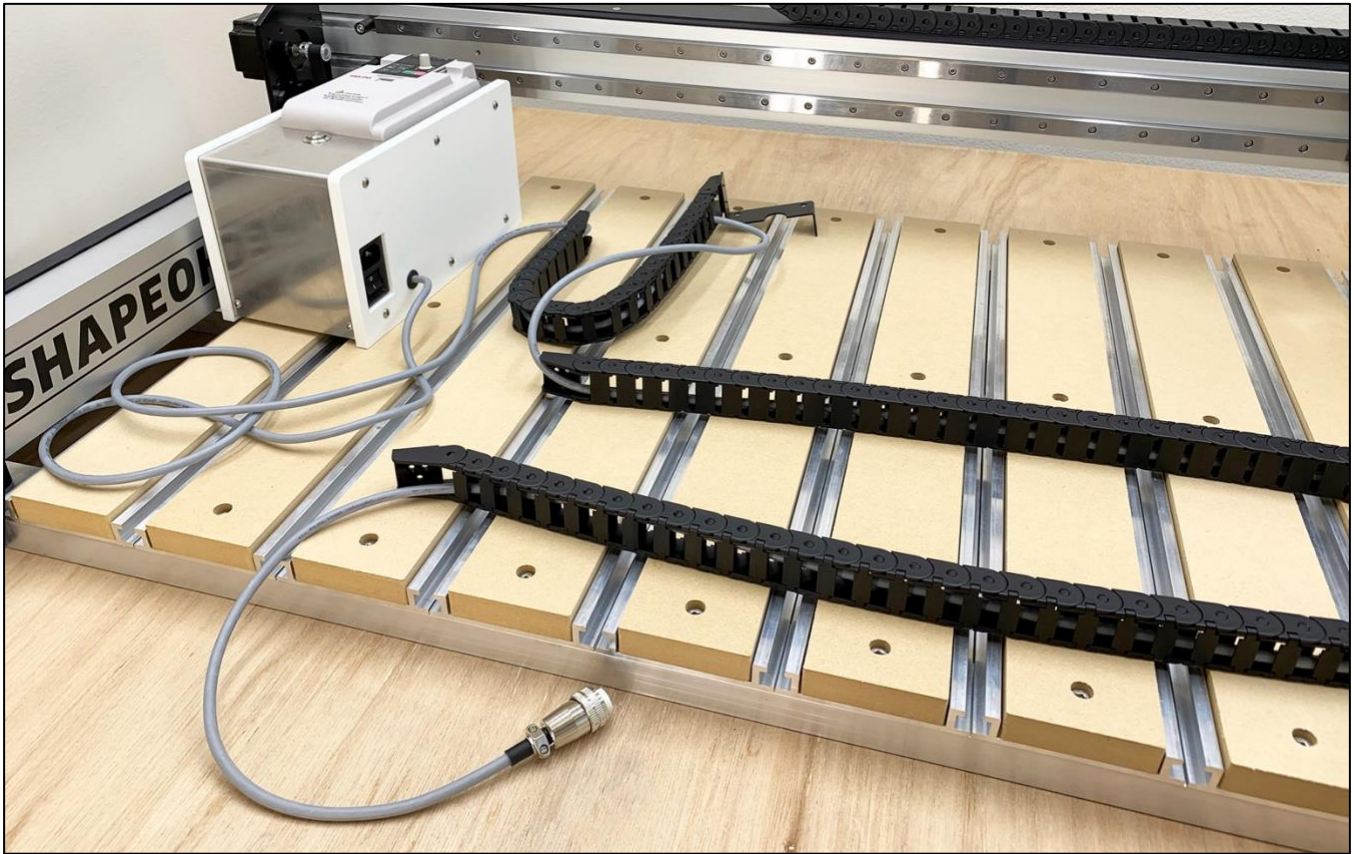


Figure 6

10. Reinstall the drag chains. See **Fig. 7** (Y-Axis) and **Fig. 8** (X-Axis).

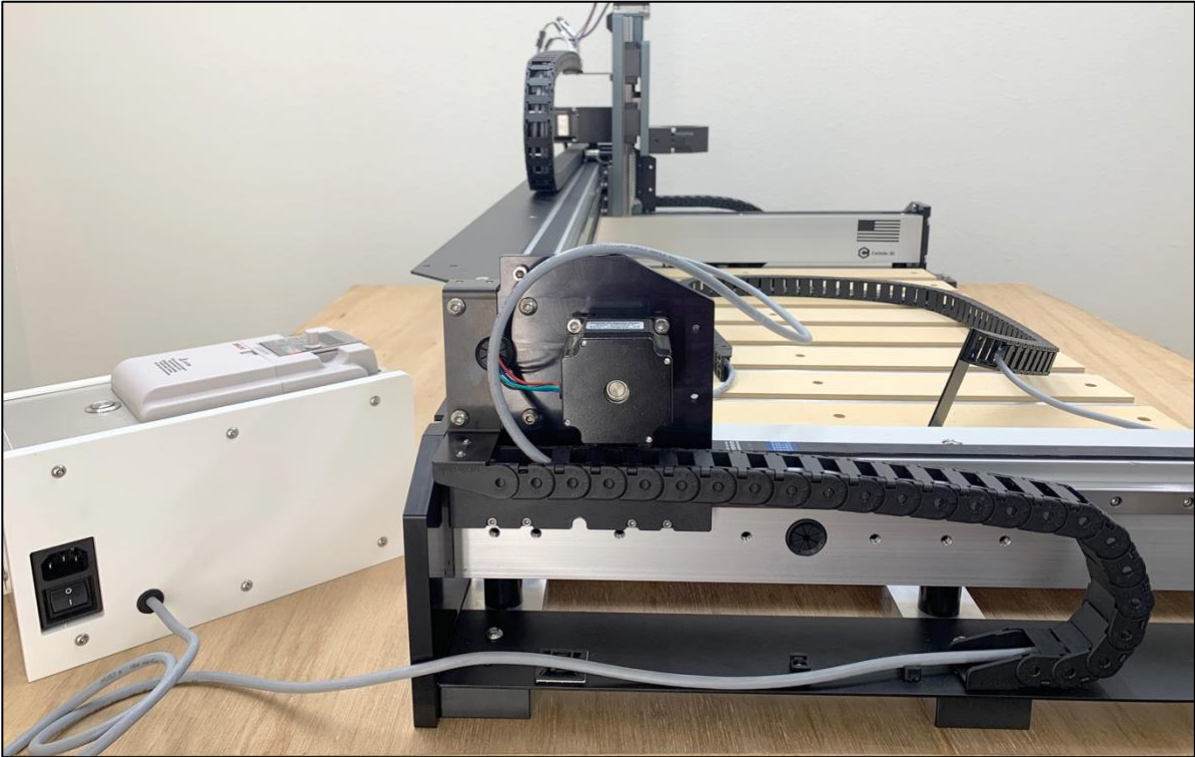


Figure 7

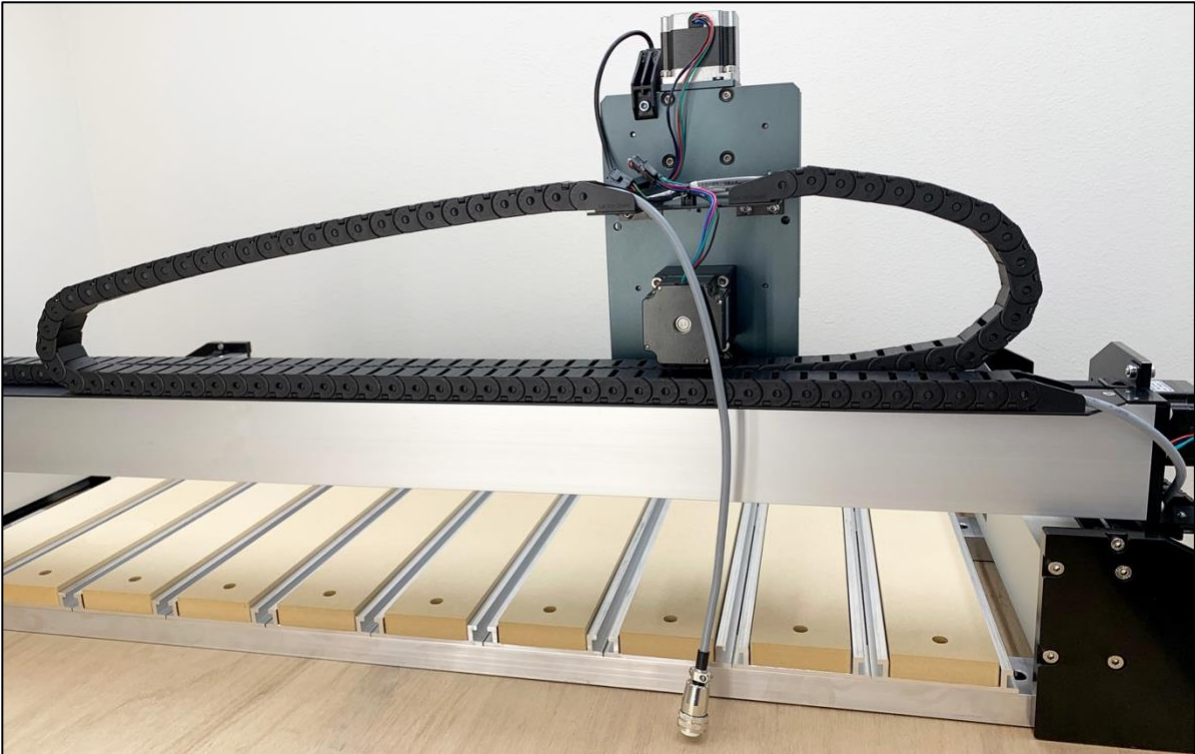


Figure 8

Step 2: Install the VFD Spindle

All Machines

1. Install the spindle in the spindle mount. See *Fig. 9*.
 - a. Position the VFD spindle in the spindle mount so that the amount of the spindle showing below the spindle mount is close to the setup of your old router (use your measurement from **Step 1: Remove the Old Router**).



Figure 9

2. Plug the spindle power cable's screw-on connector into the top of the spindle and tighten the threaded ring. See **Fig. 10**.
 - a. The screw-on connector is keyed and will only connect one way.
 - b. Don't secure the spindle power cable to the machine just yet.

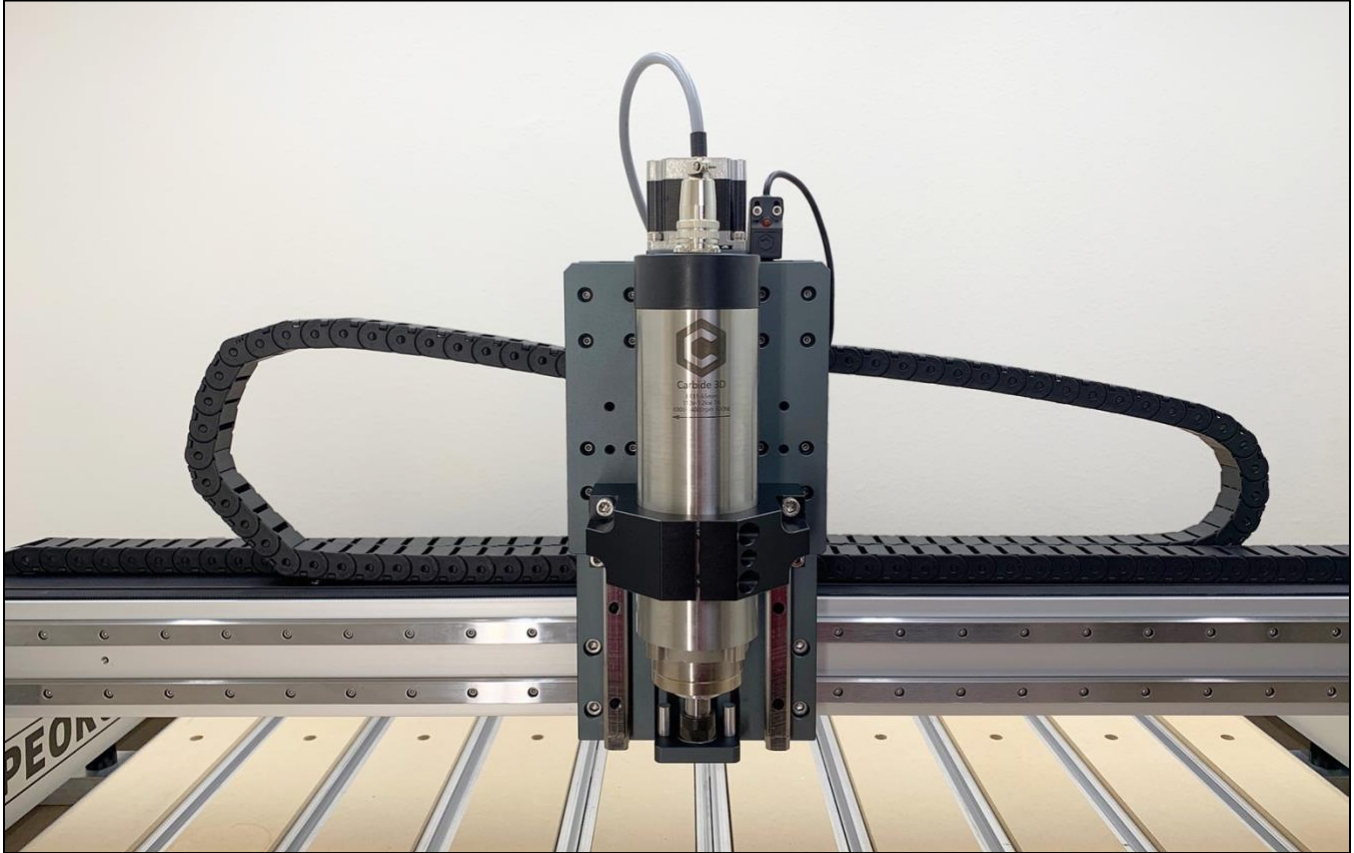


Figure 10

3. Plug the black VFD controller power cable into the jack on the side of the controller and then plug it into a wall outlet.
 - a. Make sure to insert the plug in firmly to seat it completely in the jack.
4. Plug in the male end of the 6-pin logic cable into the 6-pin jack on the other side of the VFD controller.
 - a. Make sure the small latch on the side of the connector fits properly into the notch in the 6-pin jack.

WARNING: The small triangular-shaped peg on the female connector must face **OUT**. The logic cable has reverse-voltage protection to prevent damage to the controller and VFD spindle in the event it is incorrectly plugged in. **However, if the cable is plugged in incorrectly, the VFD spindle will not operate.**

5. Connect the female end of the logic cable to the 6-pin male accessory connector protruding from the front-end of the Shapeoko controller. See *Fig. 11*.
 - a. Remove the Shapeoko controller cover.
 - b. Use your thumb and index finger to firmly support the accessory connector so it doesn't pull away from the Carbide Motion board as you connect the logic cable.
 - c. The logic cable's small triangular peg faces OUT (away from the rail). Make sure the cable is properly oriented to avoid damaging it, the VFD controller, or the Shapeoko controller.
 - d. The connector fits tightly. Press in and down firmly to get it to fully seat.

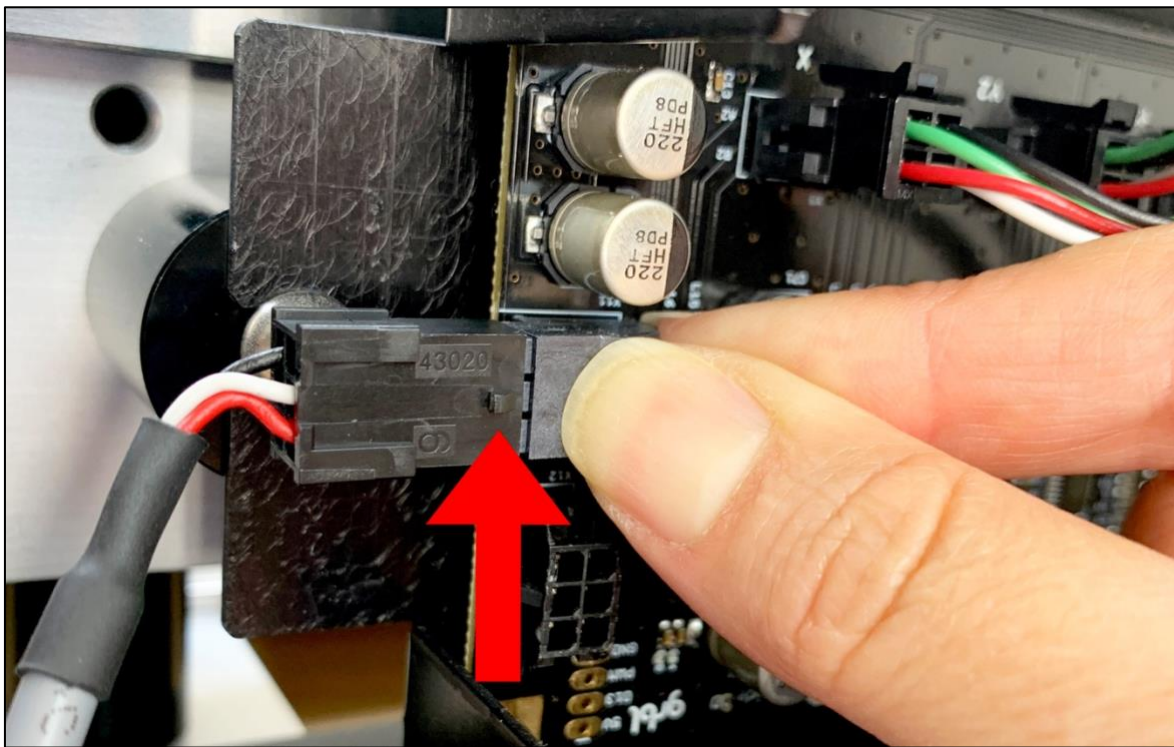


Figure 11

6. Set the VFD controller off to the side of the machine or mount it to the wall.
 - a. Make sure to set up where it will be safe from chips and dust.
 - b. Make sure there is plenty of clear space around the VFD controller to allow for unobstructed ventilation.
7. Clean up the cables as needed.
 - a. Before securing the spindle power cable to the machine, make sure it won't get caught on anything, including the Z-Axis motor, your dust collection system, or other parts of the machine.

Step 3: Enable the Spindle in Carbide Motion

All Machines

1. In Carbide Motion, connect to and home the machine.
2. Click **Settings** in the menu bar.
3. Select **VFD Spindle** in the *Spindle dropdown list*. See **Fig. 12**.
4. Carbide Motion will prompt you to select your Shapeoko configuration (machine type and Z-Axis).
5. Click **OK** to exit the settings window.

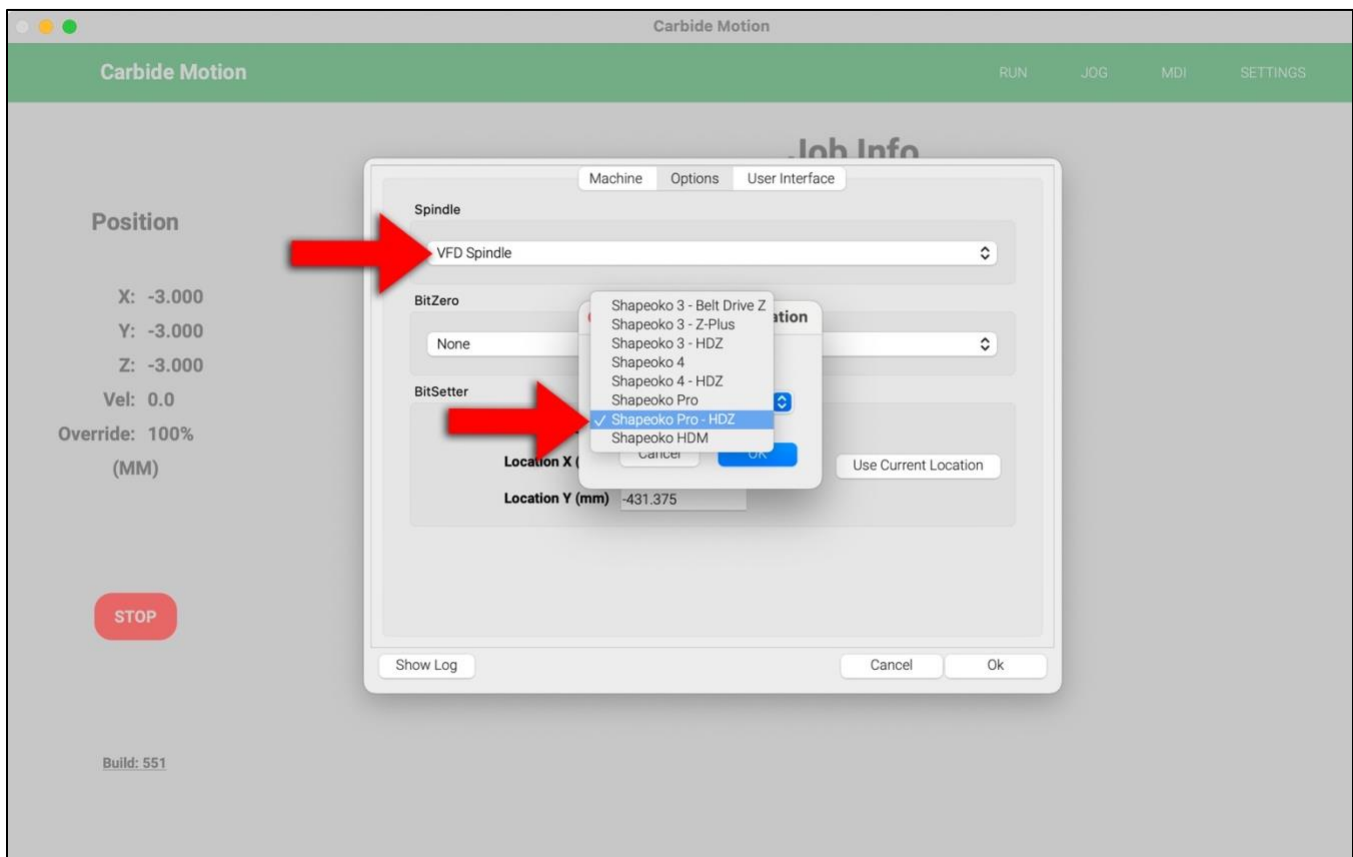


Figure 12

Step 4: Test the VFD Spindle

To check to see that the VFD spindle is working properly with Carbide Motion:

1. Flip the power switch on the side of VFD controller to the ON position.
2. Press the Spindle Enable button on front of VFD controller to enable the spindle. The spindle is enabled when the button is depressed and the button LED is on. The spindle is disabled when the LED is off.
3. Tighten or remove the collet nut to make sure it won't fly off.
4. In Carbide Motion, click **MDI** in the menu bar to open the *MDI screen*.
5. Type "M3S10000" in the command line and click the **Send button**. See *Fig. 13*.

The VFD should turn on after a few seconds. When viewed from above, you should see the spindle spinning clockwise. You can check the RPM on the VFD controller display for the commanded RPM, 10000 (the RPM shown on the display may fluctuate by up to 5% due to the resolution of the control signal and voltage variances).

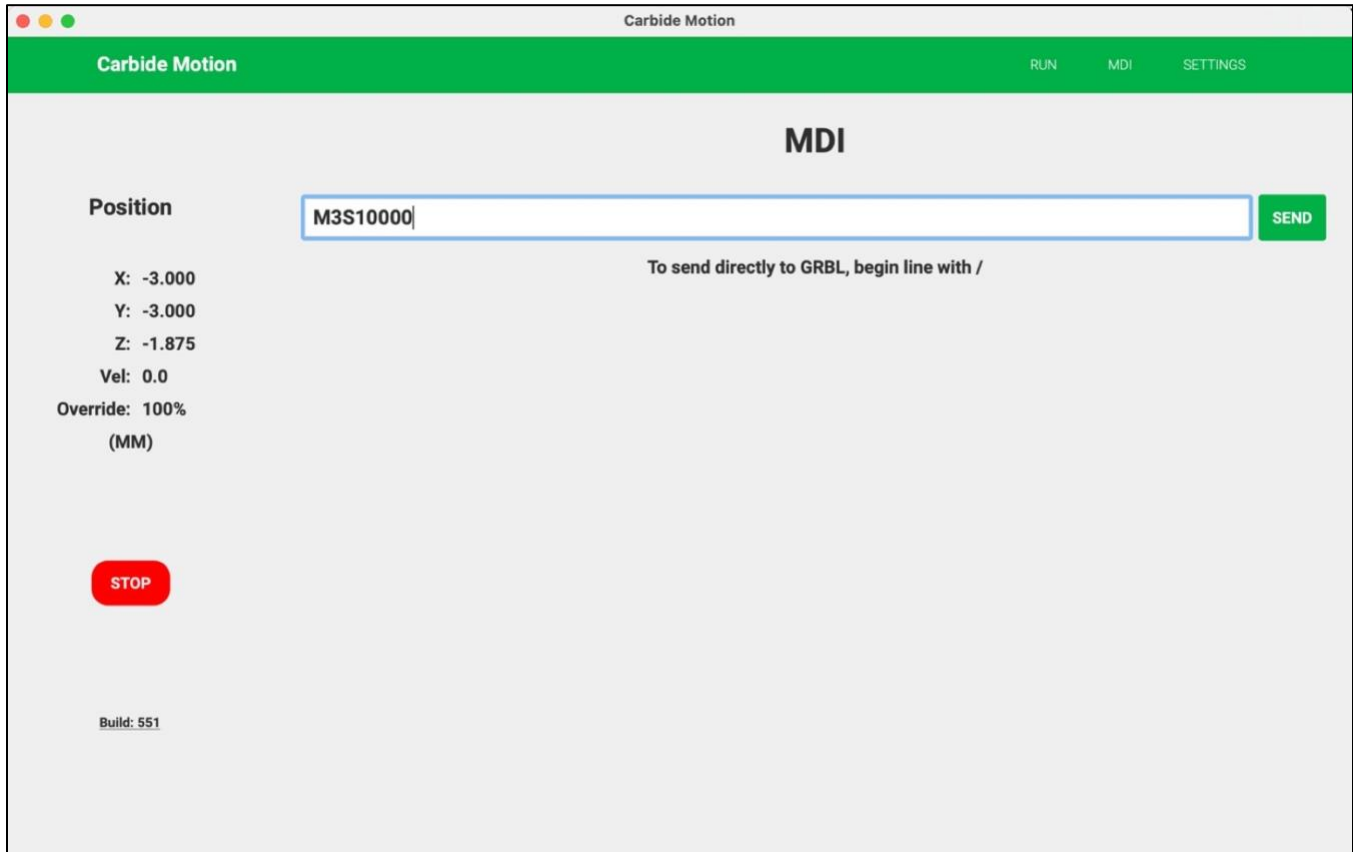


Figure 13

6. Type "M5" in the command line and click the **Send button** to turn off the spindle.
7. Press the Spindle Enable button again to disable the spindle.

Step 5: Install a Collet

All Machines

1. Turn the collet nut counterclockwise to remove it from the VFD spindle shaft.
2. Place the collet nut and one of the ER11 collets right-side up on a flat surface. See *Fig. 14*.
3. Place the grooved base of the collet into the nut and use your thumb to press the top of the collet down. You will hear a “click” as the base snaps into the eccentric ring inside the nut. See *Fig. 14*.
4. Re-install the collet nut onto the spindle shaft. **Never fully tighten the collet nut without first inserting a tool or you can damage the collet.**

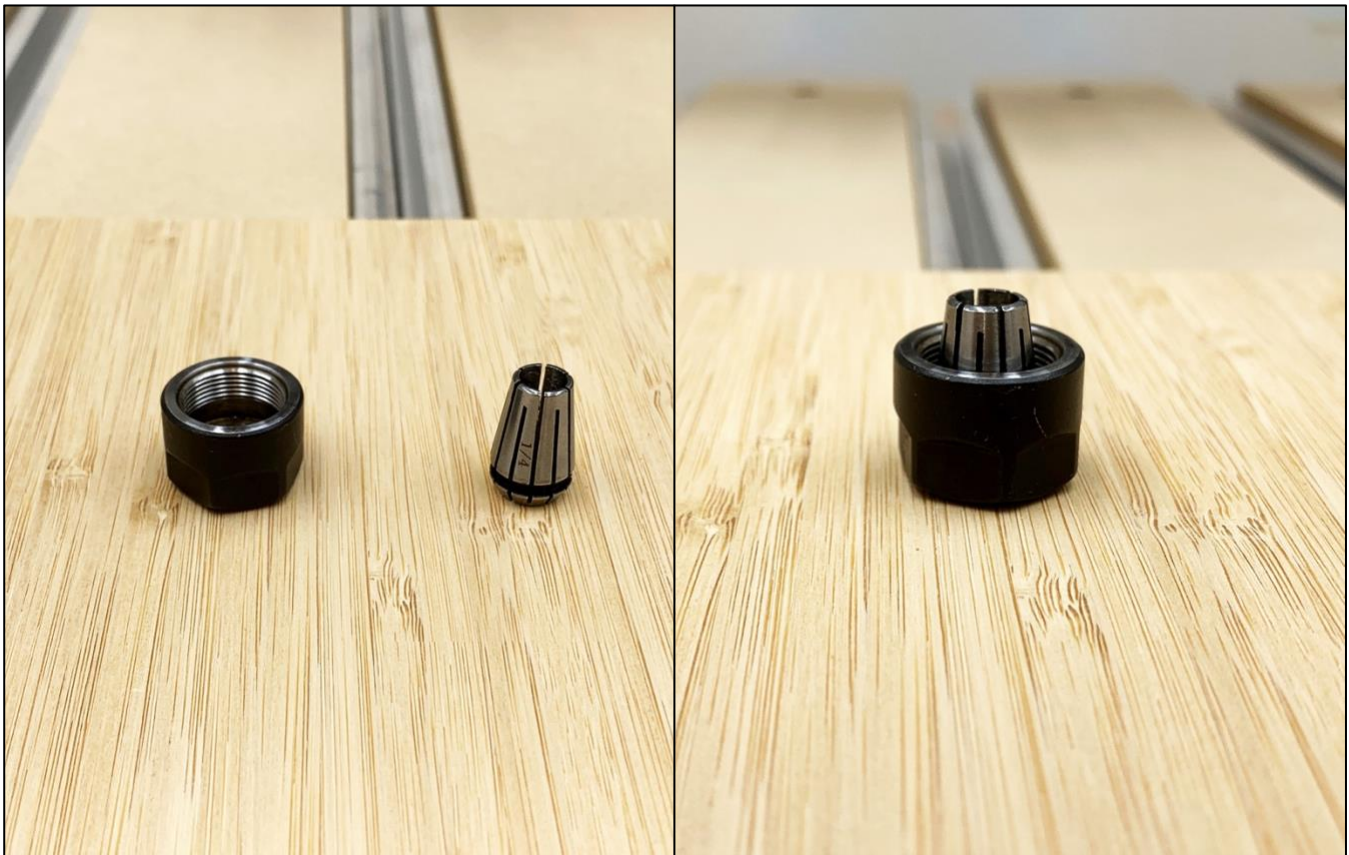


Figure 14

To remove an ER11 collet from the collet nut:

1. Use your thumb to apply sideways pressure in several places around the top of the collet to loosen it.
2. Remove it from the nut.

Controlling the VFD Spindle

Enable / Disable the VFD Spindle

The Spindle Enable button on the front of the VFD controller allows you to disable the spindle during tool changes and when using tools, such as drag bits, where the spindle stays off.

1. Press the Spindle Enable button to supply power to the VFD spindle. The red button LED will turn ON.
2. Press the Spindle Enable button again to cut power to the VFD spindle. The button LED will turn OFF.

Install an End Mill

1. Press the Spindle Enable button to disable the VFD spindle. The button LED will turn OFF.
2. Install the end mill.

Run a Project

The VFD spindle is about as plug-and-play as it gets. To run a project:

1. Connect to and home the machine.
2. Load the tool and your material, and zero the machine.
3. Flip the VFD controller power switch to the ON position.
4. Press the Spindle Enable button on the front of the controller. The button LED is ON when the spindle is enabled.
5. Click **Run** in the menu bar.
6. Click the **Load New File button** to load the project G-code file.
7. Press the **Start Job button**, then click **Start**.
8. The spindle will automatically start up at the RPM designated by the G-code. You can check the RPM on the display window at the top of the VFD controller. The G-code (or absence thereof) determines when the VFD controller cuts or supplies power to the spindle. If there is no G-code/.nc file being executed in Carbide Motion, then no power is supplied to the spindle.
9. When the project finishes, the spindle will turn off automatically.
10. Always press the Spindle Enable button to disable the spindle and flip the power switch on the side of the VFD controller to turn it off when done cutting.

Perform a Tool Change

WARNING: For safety, it is best practice to press the Spindle Enable button to disable the VFD spindle BEFORE installing an end mill or performing a tool change. The button LED is OFF when the spindle is disabled.

1. When the G-code reaches a tool-change command, Carbide Motion will pause the job, direct the VFD controller to cut power to the VFD spindle, and alert you that it's time to change the tool.
2. Press the Spindle Enable button on the front of the VFD controller to disable the spindle. The button LED will turn OFF.
3. Change the tool.
4. Press the Spindle Enable button again to enable the spindle. The button LED will turn ON.
5. In Carbide Motion, click the Resume button to resume cutting. The VFD controller will continue supplying power to the spindle until it's time to perform another tool change, load the next G-code file, or until the project is done.

Tramming the VFD Spindle

What is Tramming and Why Is it Important?

Have you ever seen small tool marks on your projects or found that the audible pitch of the router/spindle changes significantly when cutting in a certain direction? If you are nodding to either of these, then you may need to tram your machine.

As the end mill travels along the X/Y axis, the actual tip of the end mill should be parallel to the machine bed. When the bottom of the end mill is not parallel, the lowest edge of the end mill becomes the deepest part of the cut (*Fig. 15* shows an exaggerated view of this). When this happens, you get the issues described above.

These tool marks are more prevalent in harder materials like metals or composites than in wood because wood is softer. They will also be more prominent when using a larger stepover or a larger end mill.

Tramming isn't a new 'thing', every single CNC machine—even a \$150,000 VMC—will have been trammed upon setup and regularly thereafter as part of its maintenance cycle.

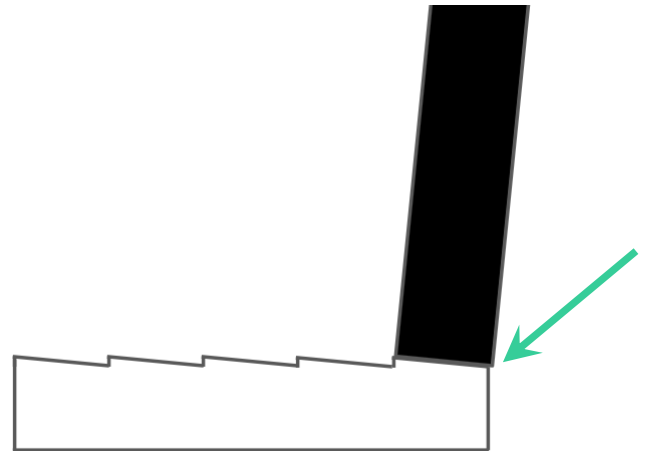


Figure 15

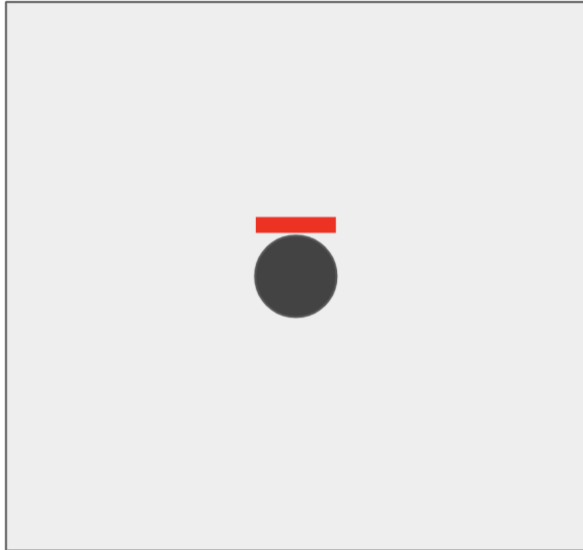
Identifying and Defining Tram

Below we will define the two types of tram and look at how you can correct them. To help visualize this, imagine the end mill is your head.

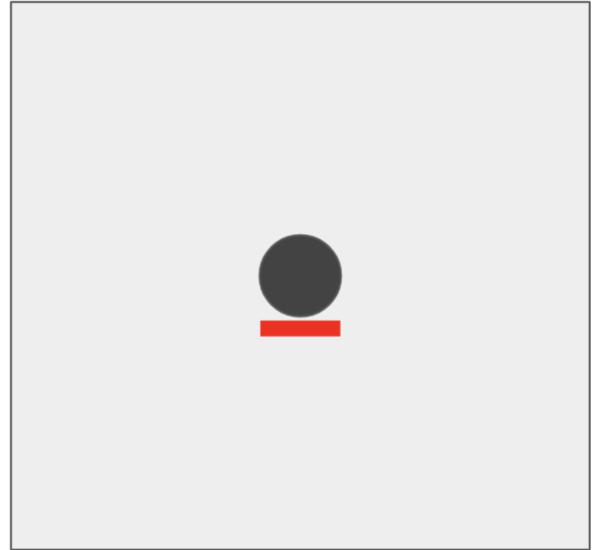
- **Nod:** Nod is where the spindle tram is out front-to-back. The spindle is nodding forwards or backwards.
- **Yaw:** This is where the tram is tilted from side-to-side. The spindle is tilted in a clockwise or counterclockwise direction.

On the next page is a quick guide to help you identify in which direction the tram is out. The guide shows a birds-eye view of the surface finish. The red line indicates where the cutter is cutting deepest.

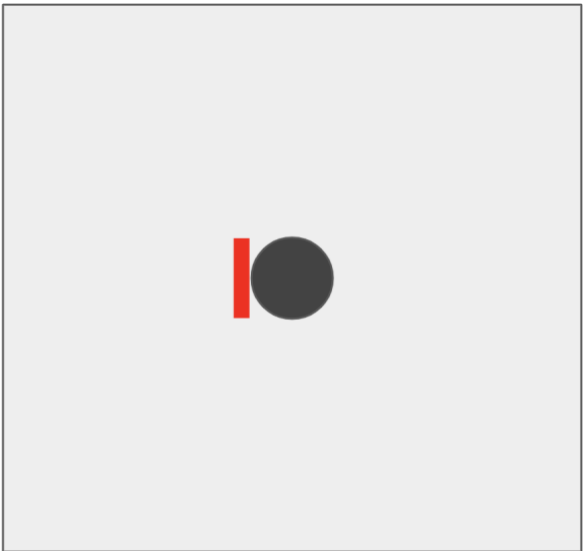
Spindle is nodding backward.
The rear edge is cutting deepest.



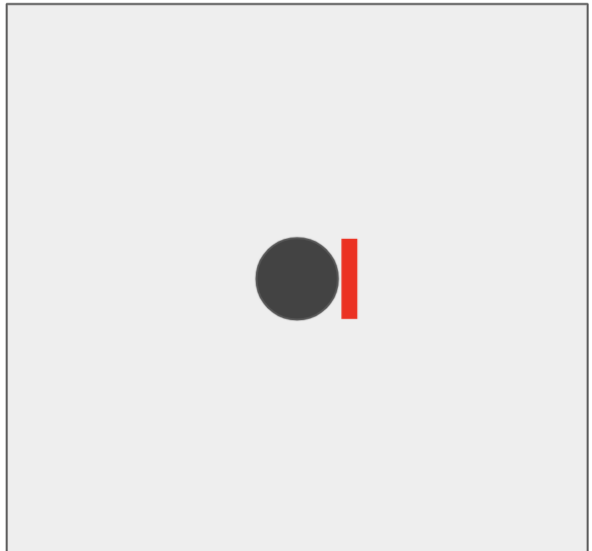
Spindle is nodding forward.
The front edge is cutting deepest.



Spindle yaw is counterclockwise.
The left edge is cutting deepest.



Spindle yaw is clockwise.
The right edge is cutting deepest.



Tramming

Once identified, it is easy enough to correct the tramming. Our entire Shapeoko range can be adjusted as needed. We recommend designing a basic square pocket surfacing toolpath for a small 2" × 2" square of stock and surface it using a ¼" end mill, with a depth of cut of 0.1mm (0.0039"), and a 6.35mm (¼") step over.

Adjusting Nod

Nod should always be adjusted first. To adjust nod, we recommend using metal shims. You can use standard kitchen foil which is usually 0.024mm (0.00094") thick. You may use specialist shims, if desired. These can be purchased from most machinist stores.

The shim should be the width of the spindle mount and one piece of foil can be folded over multiple times to build thickness, as needed.

1. Loosen the four (4) spindle mount bolts.
2. Place the shim between the Z-Axis carriage and the spindle mount, at either the top edge or the bottom edge of the spindle mount, depending on which way it needs to be adjusted.
3. Re-tighten the spindle mount bolts.
4. Check the tram.
5. Repeat steps 1–4, introducing more shim thickness, if necessary.

Adjusting Yaw

Yaw is a little simpler, it's just a matter twisting the spindle mount:

1. Loosen the four (4) spindle mount bolts half a turn so the mount is loose but still firmly on the machine.
2. With the palm of your hand or a soft rubber mallet, very gently tap the edge of the main body of the spindle/router in the correct direction.
3. Re-tighten the bolts.
4. Check the tram.
5. Repeat steps 1–4 to re-adjust, if necessary.

Tools to Help You Tram

There are a number of gauges out there that can help you tram to a very high level of precision.

If you want to calibrate your spindle head to a high precision, we recommend the Edge Technology Mini Pro Tram System (with ¼ shank). Other brands are available but we have found this one to be a high-quality, accurate tool, well suited to the machine size.

For instructions on how to use the tool, please consult the manufacturer's manual.