

PROMETHEUSTM



Prometheus Manual + Walkthrough
Last Edit: November 2021

View the most up-to-date version at <https://www.zippyrobotics.com/download/>

Packing List

Inside This Box

1. 1x PROMETHEUS PCB milling machine
2. 1x Starter pack of bits
3. 1x USB cable
4. 1x Power cable
5. 1x USB adapter (used for any potential future firmware upgrades)
6. 1x Mineral oil squeeze bottle (without oil)
7. 1x Double sided tape
8. 1x Bit clamp with bearing
9. 1x Brush
10. 1x Plastic sacrificial layer
11. Sample Copper-clad boards
12. 1x Alligator clip wire

Not in the Box

- Mineral oil
- Vacuum with HEPA or ULPA filter (needed when drilling or routing through the board)
- screwdriver/ something to pry up the board
- Alcohol as release agent for the tape or to clean the board or table, if needed
- Paper Towels

Thank You

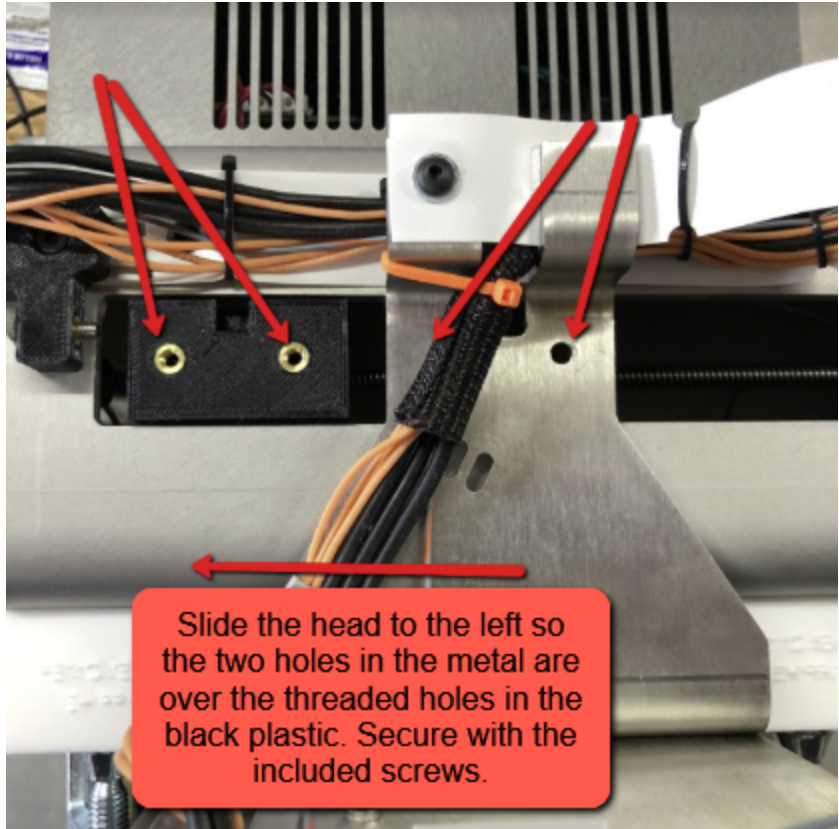
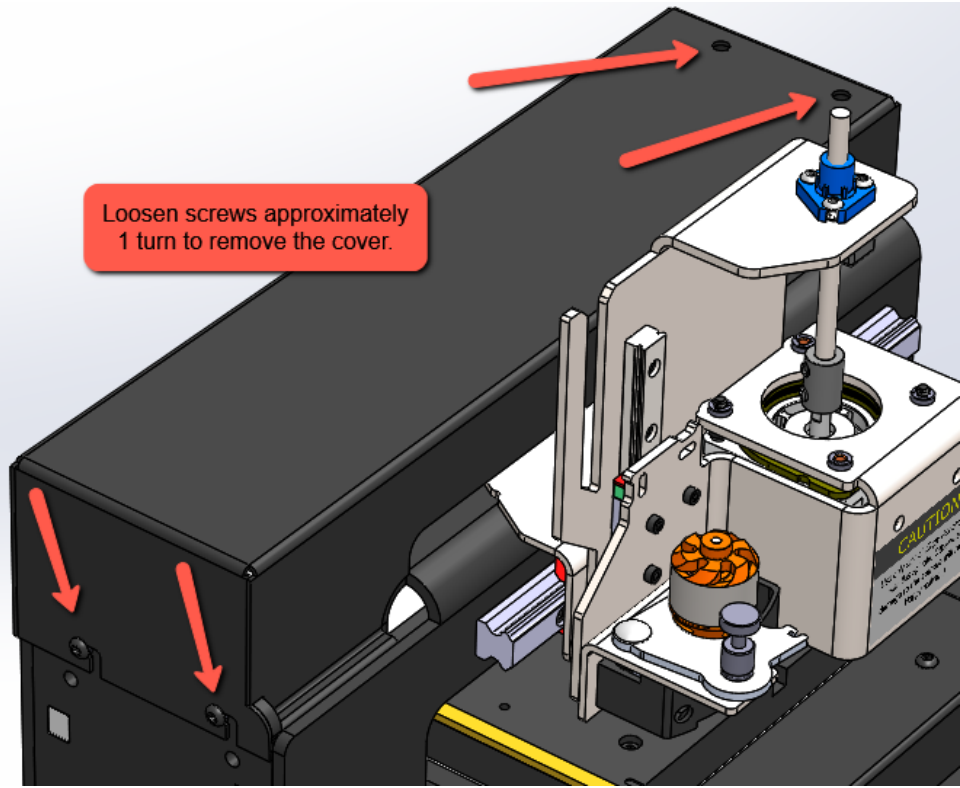
With your purchase of Prometheus you are taking control of the speed at which you can prototype your PCB designs. Prometheus is not a toy. It is a precision instrument with moving parts and deserves attention during operation for your safety. **Read this manual in its entirety before operating Prometheus.**

Unpacking and Setup

Your Prometheus machine comes fully assembled save for two screws that you must use to attach the machine's head to the X-axis lead nut mount. It is shipped this way to isolate any force of the machine head acting on the lead nut mount while the machine is in transit. The head of the machine is positioned all the way down onto the table for shipping. You'll later use the ProCAM's "Retract Z" button or the Z-axis jogging buttons to move the head up along the Z-axis.

To attach the head:

- Place Prometheus on a flat, level surface.
- Use the included hex key to loosen the four screws that hold the top cover down about one turn (do not remove them completely). Then push the cover towards the back and lift it up to remove it.
- You will now see the two threaded holes on the top of the X-axis lead nut mount. **Don't slide the head off the rail towards the right (this is to protect the linear guide block).**
- Slide the head of the machine over the lead nut mount so you can fasten the head to the lead nut mount using the two included screws.
- Remove any shipping foam and replace the cover and re-tighten the screws.




Slide the head over and fasten to the lead nut mount (shown in black) using the two screws.

Plug in the power cord and connect Prometheus to your PC with the included USB cable. The switch above the power cord inlet will turn Prometheus on/off. When connecting Prometheus to your PC for the first time you should see Windows automatically install the USB drivers. There are no additional drivers to install; Prometheus is plug-and-play like a mouse or keyboard. Nice, right?

To control Prometheus and make PCBs, you'll need to download ProCAM (Prometheus Computer Aided Manufacturing software). Visit www.zippyrobotics.com/download to download it. You will see a text document in the downloaded folder also. Follow the instructions in that document to install it correctly (video [here](#)).



 If you're looking at a print version of this manual, QR codes like the one on the right can be used with your smartphone to quickly take you to a how-to or informational video. If you're viewing on a PC you can instead click on the video link.

After installation, launch ProCAM. Check that Prometheus's power cord is plugged in, the switch is on, and connect Prometheus to your PC via USB. You'll hear 5 beeps coming from the spindle motor when power is applied. In ProCAM, click the "Calibrate" button at the bottom of the application window. This launches the Calibrate window. The top-most button in the "Move Tool Z" field will move the spindle up (figure 1). Since the machine is shipped with the spindle all the way down, you'll want to move it up by clicking this button a few times until you have about 1 inch of clearance (the exact amount isn't important). The lower buttons will move the spindle down towards the table which is *not* what you want to do at this time (since the spindle is already touching the table - that would just crash it into it). Edit: in the latest version of ProCAM, you'll now see that a "Retract Z" button has been added that will move the head all the way up in one click.

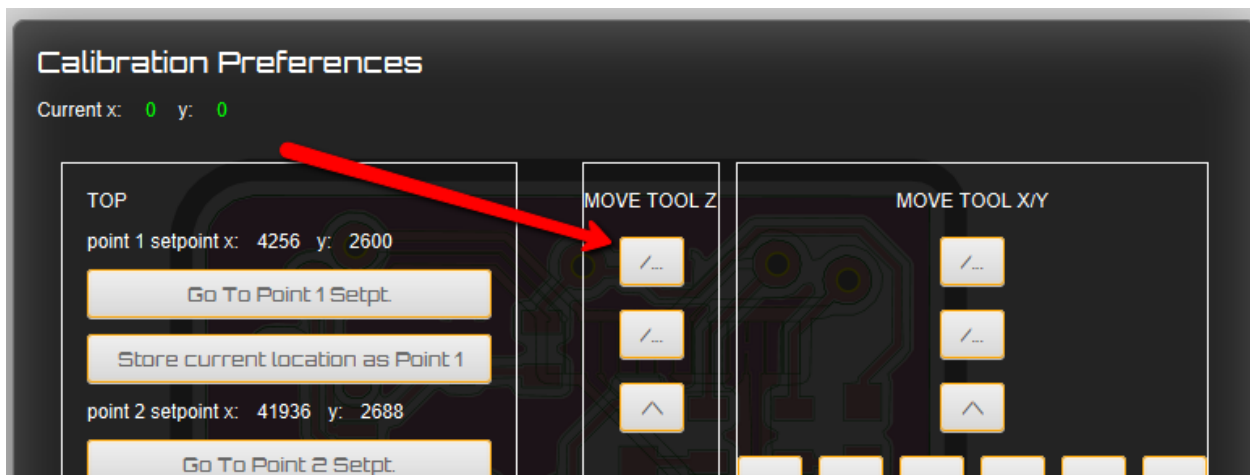


Figure 1: Use these buttons to move the spindle. The moves are short and controlled so you can avoid crashing against the limits.

If the spindle moves you've installed ProCAM successfully! Otherwise read the text file included in the download and see what's missing from the install. Check directory paths, and the DLLs.



Safety

- When dust is generated, **use a HEPA or ULPA compliant vacuum cleaner. This is for your health. Do not breathe in the dust.** For the milling operations we recommend using a pool of mineral oil on the surface of the board so milling is done submersed in the oil. This tends to keep all of the dust and copper in the oil and out of the air. It can then be wiped off later with a paper towel and discarded. You should use the vacuum with an appropriate filter for the drilling and edge routing operations.
- Keep hair and loose clothing away from moving parts. Be mindful of the Z-axis lead screw.
- Prometheus in operation represents a pinch hazard - keep hands away from moving parts.
- Keep hands away from the bit and spindle motor during operation.

If at any time you observe a dangerous condition turn the power switch off or disconnect power immediately.



Keep in mind that if you ever want to shutdown or restart abruptly, you should do the following: turn off power to Prometheus, quit ProCAM, unplug the USB cable, reinsert the USB cable, relaunch ProCAM, and apply power to Prometheus. *Do all of these steps, otherwise ProCAM will attempt to keep sending commands if all you did was cycle power to Prometheus.* The top hole just above the USB port is for resetting Prometheus which should also clear out any commands BUT you still should quit and relaunch ProCAM. The non-drilling end of a drill bit fits nicely in the reset hole.

The Prometheus PCB Milling Machine

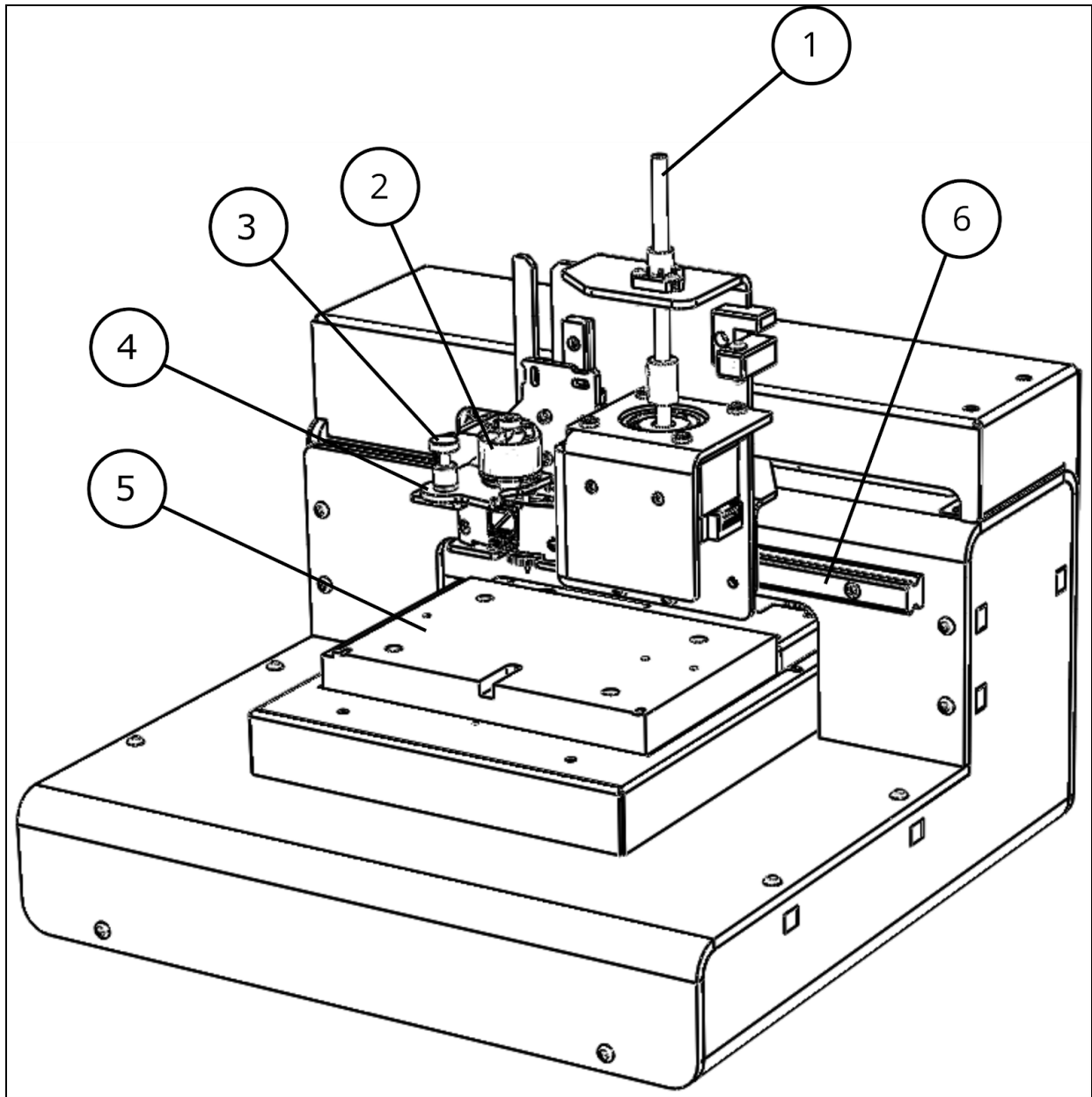


Fig. 2: Prometheus. Z-axis lead screw (1), spindle motor (2), motor plate plunger (3), motor plate (4), milling table (5), X-axis rail (6).

The Spindle

Say hi to our spindle. It is custom made and there are no others like it. Instead of a traditional collet it uses what we call a “bit clamp”. Here is what the spindle looks like:

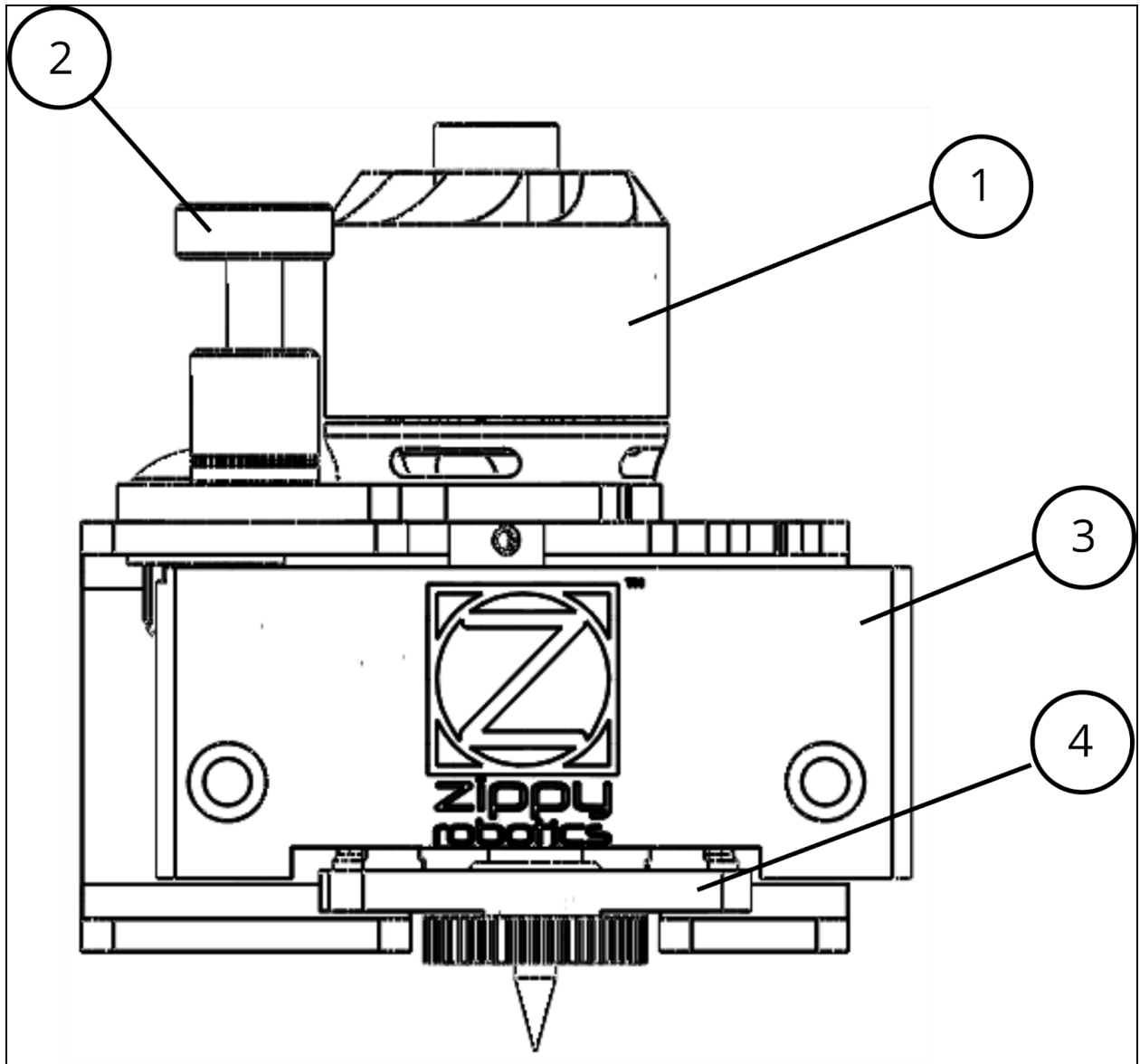


Fig. 3: The spindle motor (1), motor plate plunger (2), spindle housing (3), bit clamp (4).

We designed our spindle and bits to work together to provide you with fantastic specs at an affordable price. However, the trade-off made with this design is that **only our bits may be used with the Prometheus spindle**. It is absolutely crucial that the bit's shank diameter is slightly undersized what you typically find on the market, and the depth ring needs to be precisely placed. The spindle will not accept other bits and trying to force non-Zippy

Robotics bits into it could damage the spindle bearings. You can find more bits at our online store, shop.zippyrobotics.com.

Installing Bits

To install a bit, insert a bit through the bearing held in the bit clamp ([video](#)).



Be careful if you're installing a delicate (small diameter) bit - you don't want to crash the tip of the bit into the bit clamp or the bearing - instead, you want to thread it through the bearing until the plastic depth ring on the bit touches the bearing.

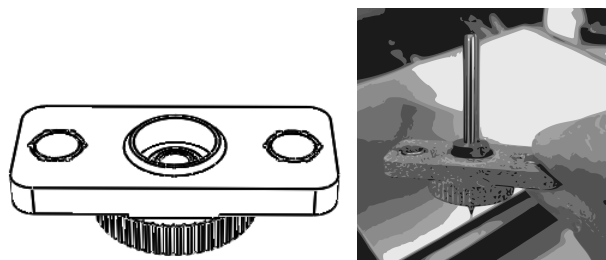


Fig. 4: The bit clamp and the bit clamp with bit inserted. Note the bearing in the center of the bit clamp. That bearing may come out when removing the bit from the spindle - that's fine - just put it back inside the bit clamp before loading the next bit.

Now you can insert the bit with the bit clamp into the spindle ([video](#)). To do so, push the motor swivel plate to the left to ensure the pin is down and holding the swivel plate away from the spindle block. Find the hole at the bottom of the spindle block and gently insert the bit into that hole by pushing the bit clamp upwards until the plastic depth ring prevents any further travel. Then, rotate the bit clamp so that it magnetically snaps in place.

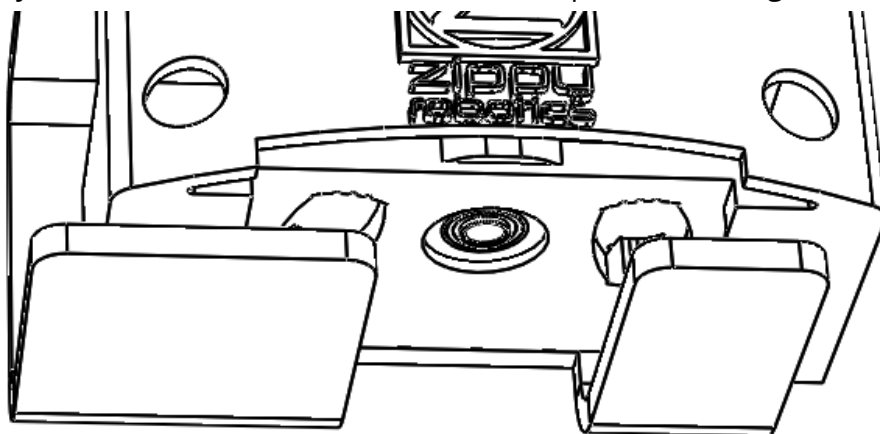


Fig. 5: The view of the spindle from the bottom. The bearing in the center has an inside diameter of .125 inches. That is where you insert the bit with the bit clamp.



The last step is to engage the motor. This is done by pulling the motor engagement pin up and allowing the swivel plate spring to pull the motor toward the bit. If you

forget to do this, your bit will break when Prometheus tries to mill or drill with it because it won't be spinning! To check that the motor is engaged you can rotate the outside can of the motor by hand and verify that the bit rotates.

The process to remove bits is the reverse of installing them. First, disengage the motor by rotating the plunger knob clockwise until it unlocks and then pushing the motor swivel plate to the left until the pin drops down to lock the plate in position.

Next, rotate the bit clamp 90° so that you can then slide it downwards. Sometimes the bit will come down with the clamp. If the bit is still held in place by the spindle block you can just hold it by the depth ring and slide it down.

Sometimes, the bearing which is normally seated in the bit clamp may become loose or remain on the bit when you slide the bit clamp away; this is okay. You'll just have to put the bearing back into place inside the bit clamp for the next bit.

The Worktable

The worktable has been milled flat for you at the factory. The brass bar that runs along the left side is used as a touch plate. It provides a consistent reference point for the height of the tool tip. It is how Prometheus "knows" where the tool tip is along the Z axis. Keep it clean and **ensure that tape or other objects do not cover it during operation.**

The other use of the brass bar is as a clamping point for the alligator clip. One end clips to the bar and the other clips to the copper-clad board during probing operations. ProCAM will remind you to check this connection with a pop-up. Don't forget it!

Probing



While Prometheus should be able to probe fine by just securing one alligator clip wire from the brass bar to the board, we have found after the first revision of this manual that due to varying resistance from the bit to ground from unit to unit, it is recommended that you *also* attach an alligator clip to the bit and to the the metal part of the Z-axis carriage as shown.

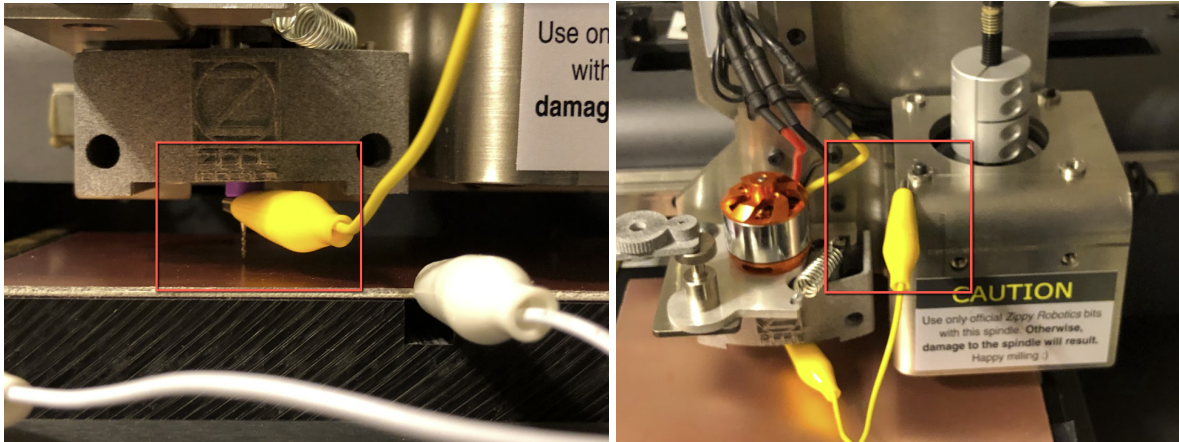


Fig. 6: The alligator clip wire shown clipped onto the bit (left). The other end is clipped onto the Z-axis carriage (right).

Notice in Fig. 6 that the bit clamp is not installed so we have room to secure the alligator clip. Instead, the bit is inserted and then the motor swivel plate is engaged to keep the bit from falling out during probing. **When the probing step has completed you must retract the spindle, remove the alligator clip, disengage the motor, secure the bit with the bit clamp, and then engage the motor before continuing to mill! Do not forget this!**

Walkthrough



How to Use PROMETHEUS

You're now going to complete a walkthrough to make a sample PCB in order to learn everything you need to know to operate PROMETHEUS (video [here](#)). You will use ProCAM to import Gerber files and choose cutting tools to generate the tool path to control PROMETHEUS. You will use PROMETHEUS to probe, mill, drill, and then flip the board and probe, mill, and route.



ProCAM requires that you use 6" x 4" or 160 mm x 100 mm (Eurocard) copper-clad boards, until a future software update. Otherwise, the tool will crash into the table during probing.

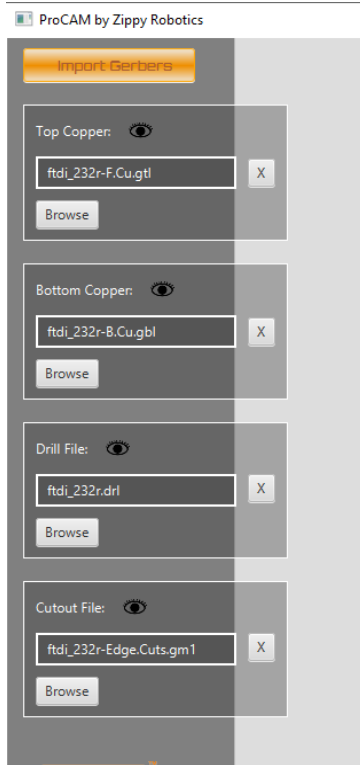


Did you know? "Tools" in this context refers to end mills, drill bits, and router bits. End mills are bits that are designed to cut from the side, unlike drill bits which are designed to plunge into a material to make holes. Our router bits are similar to end mills but we give them that name because they are specifically designed to cut all the way through the copper-clad laminate and cut out the border of your PCB. Our end mills are used to cut away the copper layer.

1. Load all your Gerber files located in C:\Program Files (x86)\Zippy Robotics



Load your files from top to bottom using the Import Gerbers menu on the left, omitting files if needed (for example, if your board does not have a bottom layer you would skip that one). *Why do we recommend this order?* Because some PCB design software generate drill files or cutout files that don't include units (inches or mm) or the format; in this case ProCAM uses what it detects in the top or bottom Gerber file, for instance, thus avoiding an error. For the sample files, .gtl is for the top layer, .gbl for the bottom, .drl for the drill file, and .gm1 for the edge (cutout) file.



Click on "Browse" for each item to load the appropriate file.

2. Choose the bits you want to use to mill the top and/or bottom.

You want to use the largest size that still lets you get into the smallest spaces. .0197" is probably quite good for most DIP through-hole boards and you may need as small as the .005" 15° tapered end mill for SMD boards. If the tool paths (shown as green lines around the copper in the images of your Gerber files) look good you may click "Continue" to go to the preview screen. For these sample files we'll choose .005" 15 deg. end mills for both top and bottom.

3. Secure the sacrificial layer onto the milling table.

We recommend at least 4 flat pieces of tape across the length of the sacrificial layer. Ensure there are no wrinkles or overlaps when applying the tape so that it makes good contact and doesn't introduce high spots/deflection in the board. Make sure it's adhered all across the milling table.



If you push down in one spot and the sacrificial layer lifts back up a bit, then it is not adhered well. It needs to be sturdy. The same goes for the copper-clad board in the next step.

4. Set the copper-clad board down with double-sided tape.

The board must be 6" x 4" or 160 mm x 100 mm (Eurocard) until a future ProCAM update allows it to be smaller. This has to do with avoiding damage during the later probing step. Same as the sacrificial layer, we recommend at least 4 pieces of double-sided tape that extend the whole length of the board. Ensure there are no wrinkles or overlaps when applying the tape so that it makes good contact and doesn't introduce high spots/deflection in the board. ProCAM *can* correct for a warped surface with its surface tracking feature, but we shouldn't try to make it more difficult. Most important - make sure the board is solidly adhered to the milling table (or sacrificial layer) everywhere. There should be no "give" or bounce when you press down on the corners/edges of the board. If there is, it may be because the tape did not adhere well and it is recommended to clean the surface and try again. *Why is this important?* Because otherwise, the board will move away from the milling bit when it tries to mill and it may not cut deep enough. The surface tracking feature can probe the peaks and valleys of the board to ensure a proper cutting depth throughout the board, but only if the board isn't moving away from the end mill when it plunges into it.

5. Click Continue to go to the Control Panel

You'll see a preview of the board after clicking Continue.

6. Probe the top side

Make sure the alligator clip wire is connected to the brass bar and to the copper clad. Also see the note about probing and Fig. 6.

7. Mill the top side

Apply mineral oil where needed, use eye and ear protection, click the "mill" button.

8. If double-sided, holes must be drilled

9. Remove the board

10. Secure the board bottom-side up using double sided tape

11. Use ProCAM to identify the bottom-side placement

Click "Locate Holes" and follow the video.

12. Probe the bottom side

13. Mill the bottom side

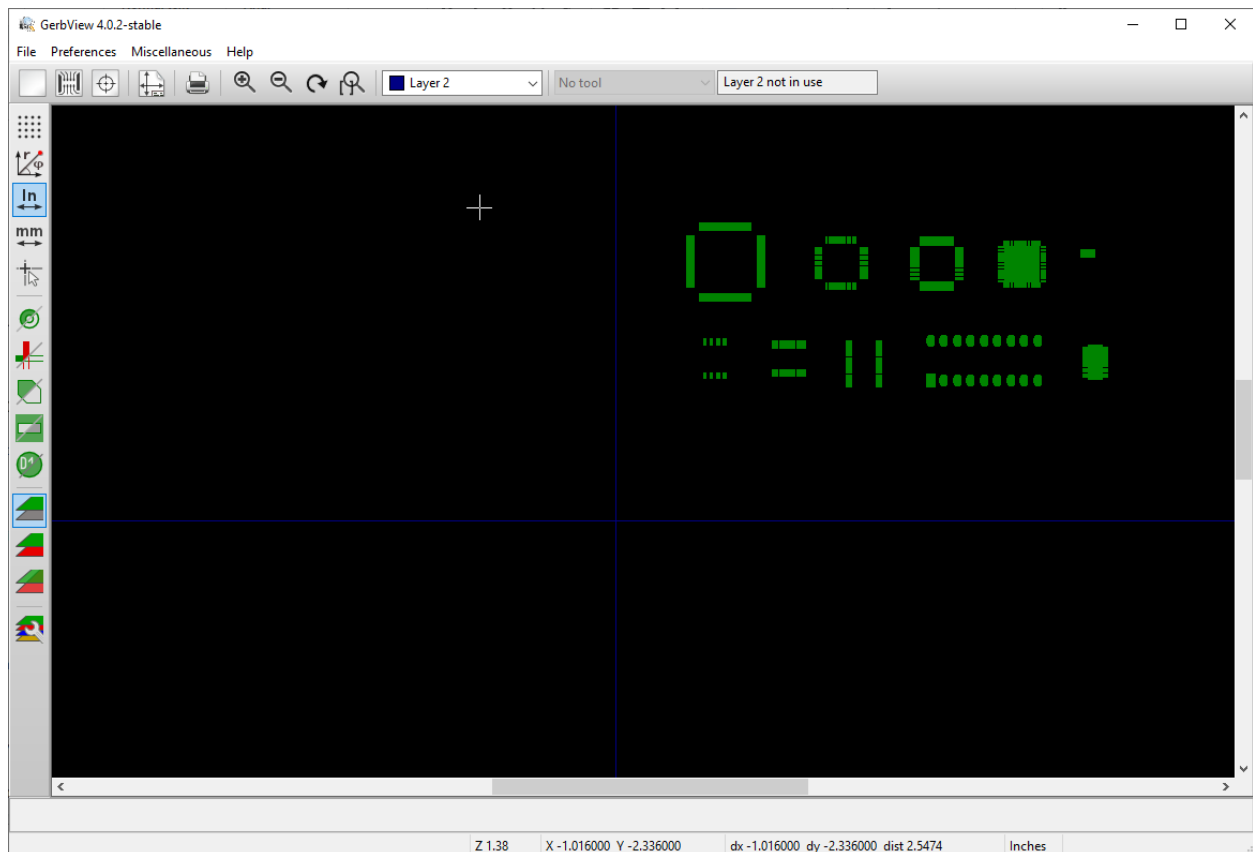
14. Route out the board

You're done! If you notice that your artwork is not perfectly square, (that is, that a shape with a right angle on the screen does not have a right angle when milled) see the Appendix on how to software calibrate Prometheus to correct for this.

Generating Your Own Gerber Files for ProCAM

There are some things you must know about to import your own design files into ProCAM. We've tested ProCAM with many popular PCB design packages (Altium, Eagle, KiCad, Ultiboard, Diptrace, Upverter, etc) but If you run into issues please send us an email.

The most important thing is that you make sure that when you export your files that they are aligned and all the PCB artwork is in the positive quadrant of the X/Y axes.



GerbView showing the top layer Gerber of the footprint test file. The X and Y axes are shown in blue and the artwork in green. As you can see, the artwork is in the positive quadrant (the upper-right). This is correct. If any artwork extends into other quadrants, or is greater than a 6" X 4" rectangle in the positive quadrant then it will be clipped when importing into ProCAM. 6" X 4" is the maximum working area of Prometheus.

Appendix

If You Need to Software-Calibrate



Important - We have found after shipping many units since this manual was first created, that you almost certainly do not need to perform this calibration step. However, we will keep it in this appendix for reference. Think twice before spending time doing this - you probably don't need to.



If you notice a shear transformation on your milled artwork, meaning that squares become slanted due to the X and Y axes not being perfectly square, you can calibrate it (video [here](#)) using ProCAM (ProCAM will save it afterwards so you won't need to repeat this every time you use it). It appears this probably isn't necessary in the vast majority of cases, due to how the design of the machine lends itself to naturally being square, but if you encounter those issues mentioned above you'll want to do it. **If you move Prometheus from one PC to another, you will have to repeat this calibration, as the calibration data stays with the PC and not in Prometheus's hardware.**

The purpose of calibrating is to ensure that X and Y squareness is preserved in the PCB artwork, even if there is an angular misalignment between the X and Y axes. If you see a square on the screen, you want a square on the board - not some other quadrilateral. Calibrating ensures good front-to-back layer and hole alignment.

Start by clicking the "Calibrate" button on the lower part of ProCAM's window. You'll need to use the calibrate card for this procedure. The steps are as follows:

1. Ensure that the sacrificial surface is adhered to the milling table using double-sided tape ([video](#)). It may provide a better surface for which to place the calibrate card. We recommend at least 4 flat pieces of tape across the length of the sacrificial layer.
2. Position the calibrate card on the table top side up just as if you were preparing to mill a copper-clad board. Center the card between the two notches in the milling table. The number "1" on the card should be towards the lower-left corner of the table.
3. Retract the spindle upwards along the Z axis by clicking the buttons in the "Move Tool Z" section. Install a small diameter bit once you have enough room to do so. In this case of calibrating (and this case only) you may find it helpful to *not* secure the bit with the bit clamp. engaging/disengaging the motor will hold the bit in place. This gives you the flexibility to disengage the motor and slide the bit down by hand to touch the card and check that you're exactly where you want to be. This will make more sense in later steps. Not securing the bit with the bit clamp is only acceptable



because we aren't actually turning the spindle on. Never attempt milling/drilling/routing without the bit clamp and its bearing in place.

4. Click "Go To Point 1 Setpt" if it's safe to do so. "Safe" means there's nothing in the way of the spindle or table because they are going to move to position the bit near point 1 on the calibration card. The bit will move once you click "Go To Point 1 Setpt", to the setpoint marked "1". It will not position the bit exactly over #1's crosshairs, but it will save you time for the next step.
5. Use the "Move Tool X/Y" section of buttons to move the bit in X (left/right) and in Y (away/towards you) directions. You must position the bit so it's X/Y coordinates put it directly above the crosshairs near point #1. It'll be helpful to control the Z-axis as well. Don't go down too close using the Move Tool Z buttons because you don't want to accidentally crash the bit into the table and potentially break the bit. Instead, you can disengage the motor and manually drop the bit during the last $\frac{1}{8}$ " or $\frac{1}{4}$ ". You can also manually turn the Z-axis lead screw. Look at the bit from the front and the sides to ensure it's centered above the crosshairs. Once it's centered, click "Store current location as Point 1". This will save your measurement.
6. Make sure the bit is fully inserted again and the motor is engaged so it doesn't fall out. Make sure there is enough clearance between the bit and the table for the next move, by using the Move Tool Z buttons or manually turning the Z-axis. Then click "Go To Point 2 Setpt" to move to the approximate point 2 location of the calibrate card. In this step you don't need to center above the crosshairs for point 2. Instead, simply move the tool left and right to get it directly above the line that connects point 1 and point 2, going through both crosshairs. This is easier to do because you only have to move along one axis. Once the bit is directly above the line, click "Store current location as Point 2". This will save your measurement.
7. Repeat the previous step for point 3. Again, don't center over the crosshairs; position over the line, with the bit *near* point 3 just like it was near point 2 before.
8. With all 3 points stored, you are now calibrated! Move the bit up along Z and remove it. Close the Calibration window. You will not have to repeat this (unless you move Prometheus to another computer). It might make sense to record the X and Y values for each of the 3 points, so if you have to enter this in a new PC you can skip mounting the card and just jog the bit to each point and click the store buttons.