PCB Milling with the Othermill

Version 0.3
12 February 2016

Written by Kristof Aldenderfer

Table of Contents

Introduction

Welcome to PCB MIlling with the Othermill! In this course, you will be setting up and using the desktop CNC mill from OthermachineCo. With this machine at your disposal, you will be able to fabricate your own PCBs in-house!

There are several steps to creating a fully-functioning PCB prototype:

1. Design the board; that is, digitally model of it (which was done in *Circuit Design with EAGLE*)
2. Fabricate the board; that is, physically create the board out of copper and insulating material
3. Assemble the board; that is, place and solder on all the components

There are fabrication houses that will take care of either steps 2 or 3, or both. Typically, it will take several weeks to receive your prototype from these companies; they may also offer expedited fabrication (and possibly assembly) which will but the turnaround time to less than a week, but this generally will cost quite a bit more.

This is where a desktop CNC mill like the Othermill comes into play. Using this machine cuts your turnaround time from 3 days (or three weeks) to three hours, and at a fraction of the cost of typical fabrication.

What concepts are we going to cover?

- Basic CNC
- Techniques for milling PCBs
- Limitations of PCB milling

In what context are we going to be covering them?

- Setting up the Othermill hardware
- Setting up the Otherplan software

What should I know before taking this course?

You should have already taken Circuit Design with EAGLE, or have used a similar EDA to do schematic capture and PCB layout.

Where can I go from here?

If you've gotten this far, you have completed all the TechShop Electronics and Electrical Engineering courses; you should be well-prepared to design from scratch, fabricate, and test your very own prototypes!

Let's get started!

Part 1: A brief tour of the Othermill

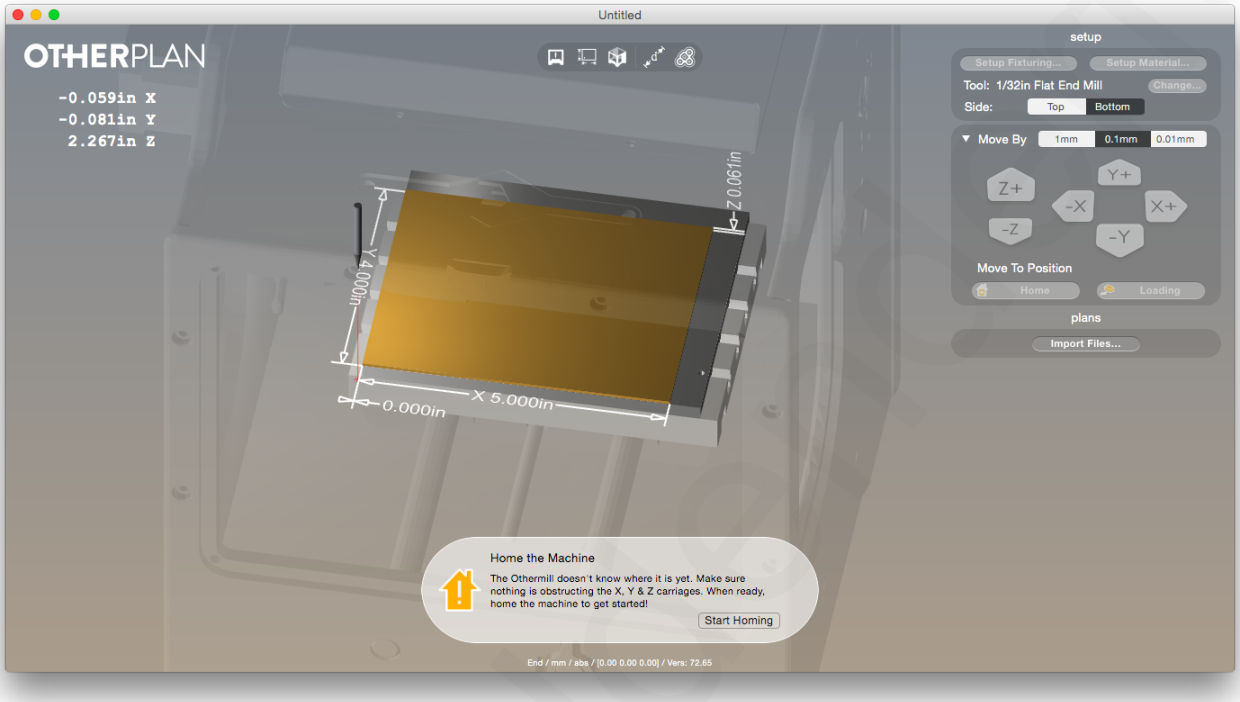
The Othermill is, at its heart, just a classic CNC machine: X, Y, and Z stepper motors for the **feed**, and a spindle motor for **speed**. What sets it apart from other CNC machines is fourfold:

1. It is small enough to be fit on a desk
2. Its software suite accompaniment is very user-friendly
3. It can actually cut PCB material
4. It is (relatively) inexpensive

The software used to control the Othermill is called Otherplan, and it is currently only for OSX. (OthermachineCo does have a beta for both Windows and Linux distros, but this only allows for the import of straight GCODE files. According to the company, BRD and Gerber support will happen soon, but in the meantime, we'll be using OSX to control the machine.

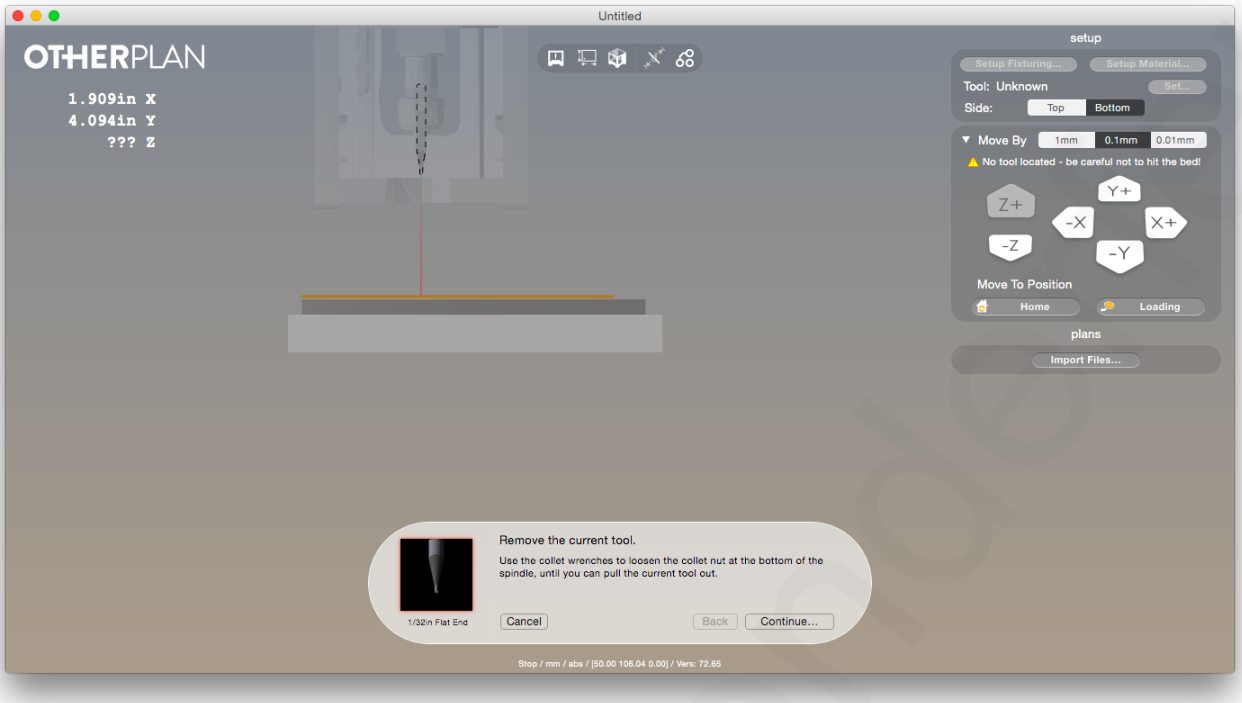
Part 2: Set up the machine

Assuming you've plugged in a USB to your computer and started the Otherplan software, you're now ready to set up the machine! You will be prompted with a "Home the Machine" dialog. Click "Start Homing". The spindle will move all the way to the left, and the bed will move all the way back.

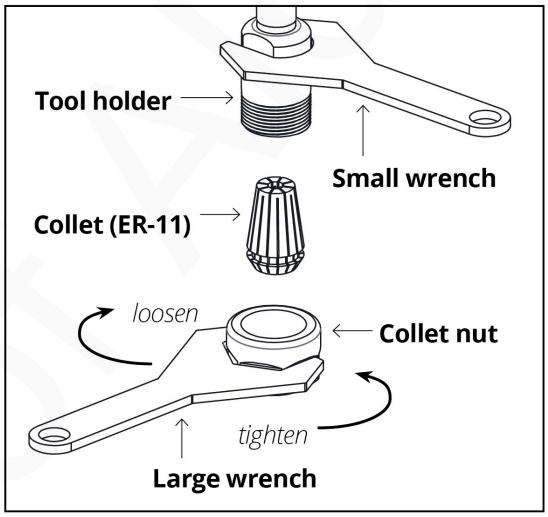


Select and install a tool

Next, you want to set up the tooling. At the top right of the UI, you will see a "Setup" section. Inside, there is a "Tool" label; it will likely say "1/32in Flat End Tool". Hit the "Change" button.



You will be prompted to remove the current tool. (If there is a tool in the collet, continue along. If not, skip forward to "Z-homing".) This involves using the two wrenches (which live magnetically attached to the top of the machine at all other times).

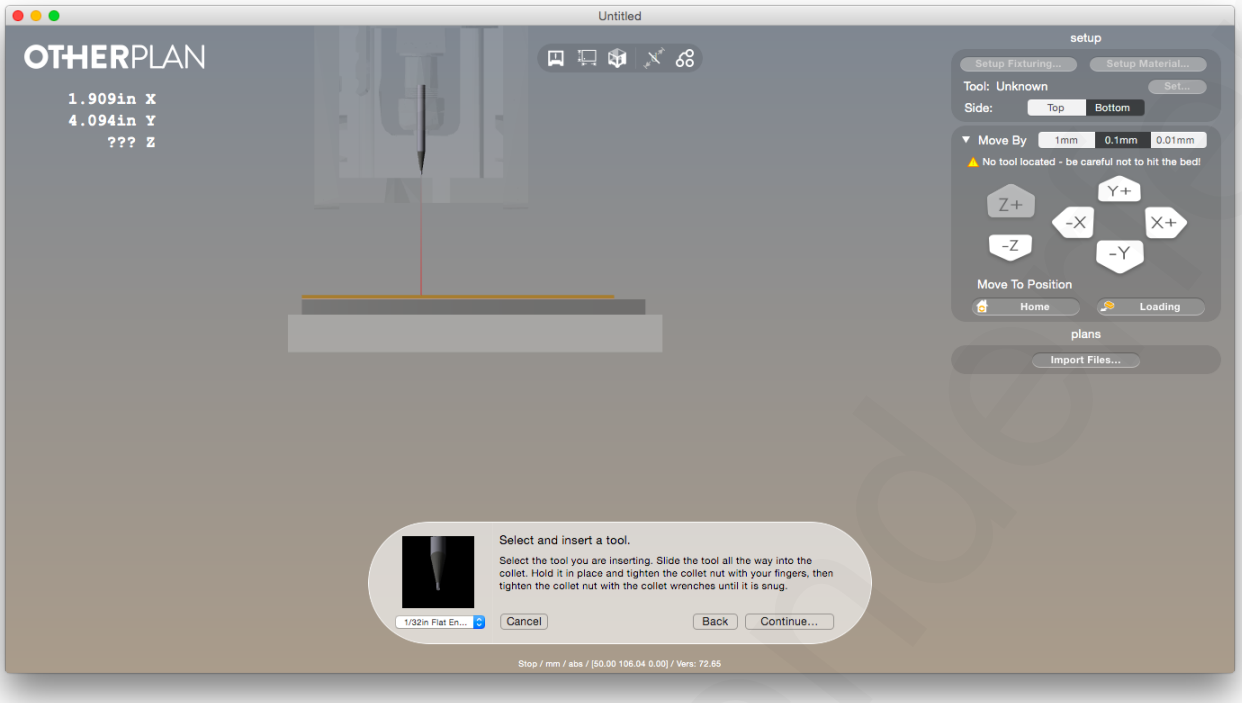


[1]

Note their inside diameters, and then slide the smaller onto the spindle holder (and to the right), and the larger on the to collet nut (and to the left). Then gently turn both of them away from each other until you feel a release of pressure: the nut has now been loosened, but the mill has not been released from the collet. You will need to repeat this procedure, but this time, keep a finger directly underneath the tip of the mill so that it will not fall out of the collet. Hit "Continue" in the software. Carefully set the mill aside.

Now grab a mill (in this case, the 1/32in), insert it into the spindle, and use your fingers to tighten the collet nut. Reposition the wrenches, and then turn them toward each other to tighten. Then hit "Continue".

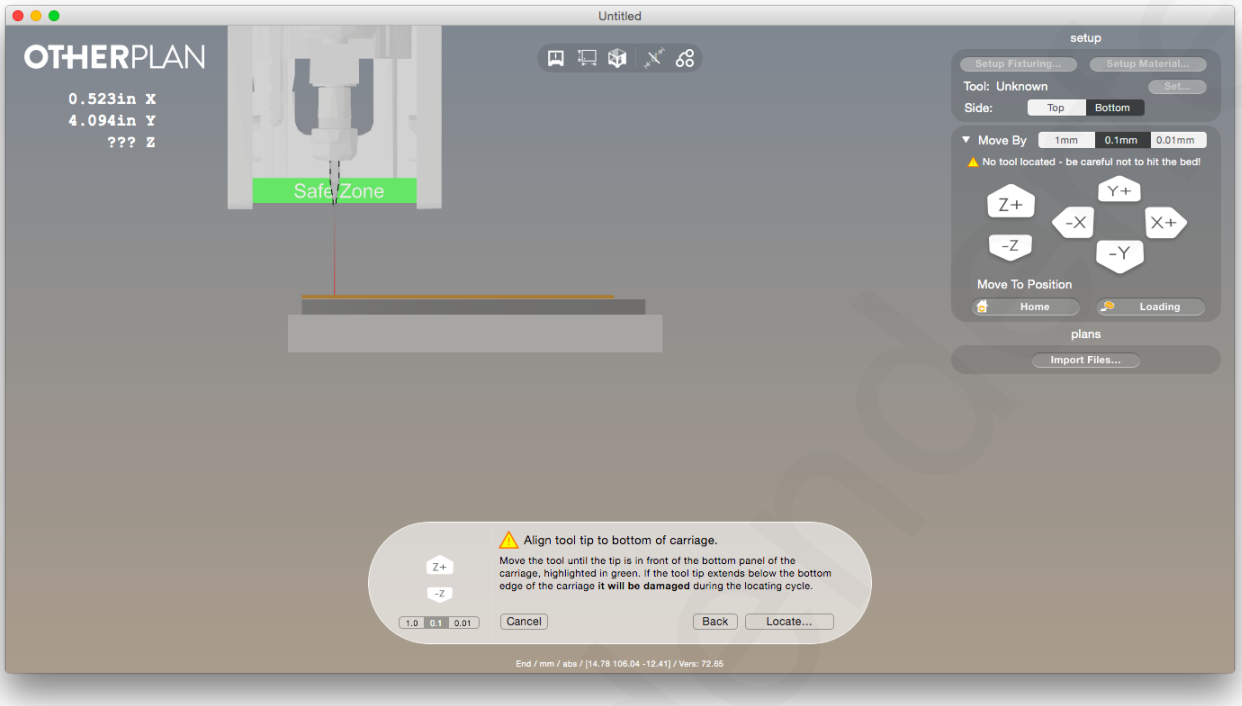
[1] Image source: https://othermachine.co/support/basics/welcome/



Z-homing

The machine will now re-home itself in both the X and Y axes. You are going to Z-home the machine. This is done by touching the tool to the bed (using electrical conduction as a sensor). As such, they will need to have an unobstructed path to each other. This dialog is just asking you to make sure that there is nothing in the way of the vertical path of the mill. Before hitting “Continue”, verify that the mill has an unobstructed path to the bed.

The mill's tip must also be within a certain distance from the bottom of the carriage, or the carriage itself will crash into the bed. Use the green area in the diagram as a reference for where the tip should be positioned physically; do not use the drawing of the tip as a guide! Drop the mill until the tip is in the green area indicated. Then hit "Locate...".



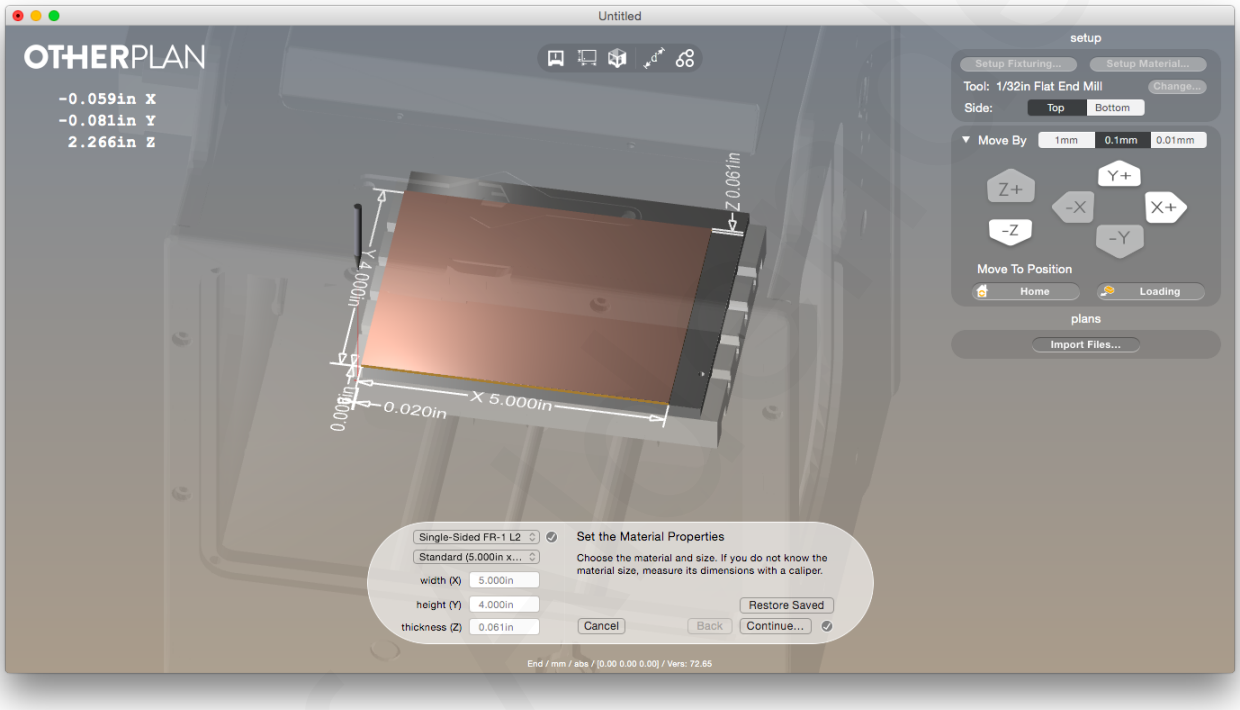
Congratulations; the machine is set up!

Part 3: Set up your material

The next step is to tell the machine what material you're using. OthermachineCo has programmed in a large materials database with specific feeds and speeds so that you don't have to set them manually; all you need to do is tell it what material you're using.

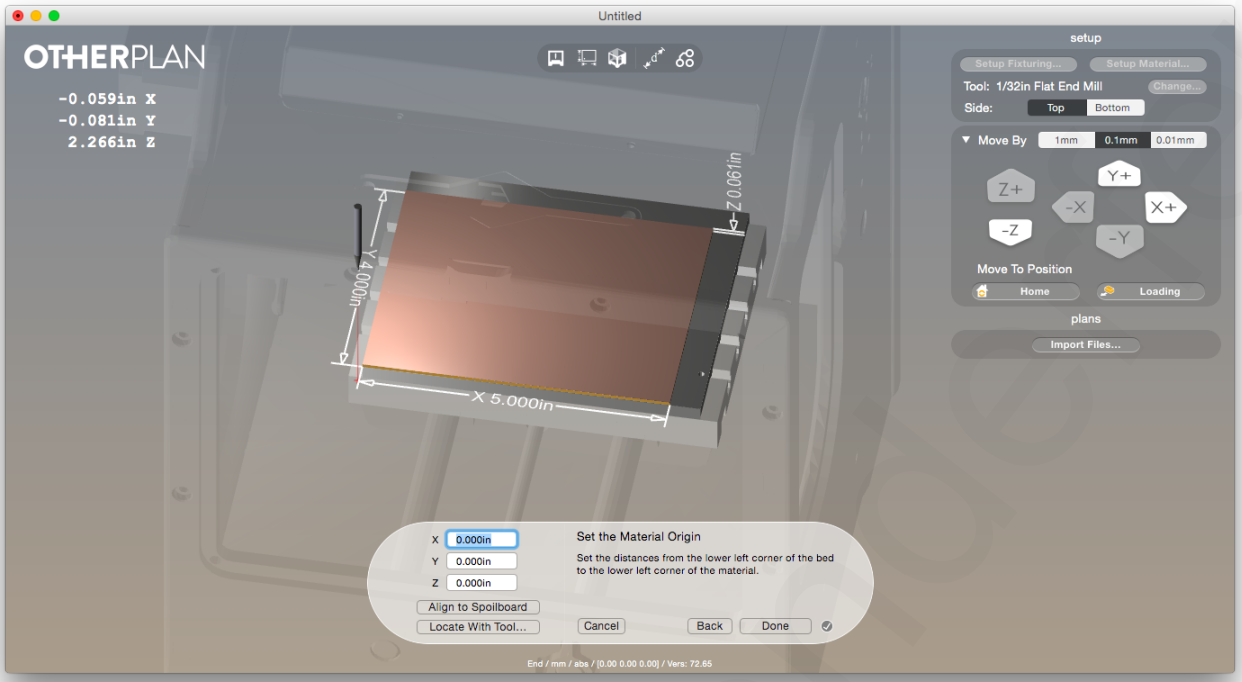
What material are you using?

Press the "Setup Material..." button the top right, and select "Single-Sided FR-1". (See Appendix A for more information.)



If you are using a fresh piece of material supplied by OthermachineCo, there is no need to change the dimensions. If you are using a piece of a previously-used material, or material from another source, you should use a set of digital calipers to measure its dimensions, and then enter them into this window.

Clicking "Continue..." will prompt you with the option for an origin offset; it's not necessary for this course. Keep X, Y, and Z at 0, and then click "Done".



Affix the material to the bed

The way FR1 is affixed to the bed of the Othermill is with double-sided tape. With only a few strips, it's actually strong enough to keep the material from shifting during milling. Flip your piece of FR1 over and apply 3 or 4 strips of double-sided tape.

In order to affix the FR1 to the bed, you'll need to first move the bed to the front of the machine so that it's more accessible. In the UI's control section, press the "Loading" button. This will move the bed forward.

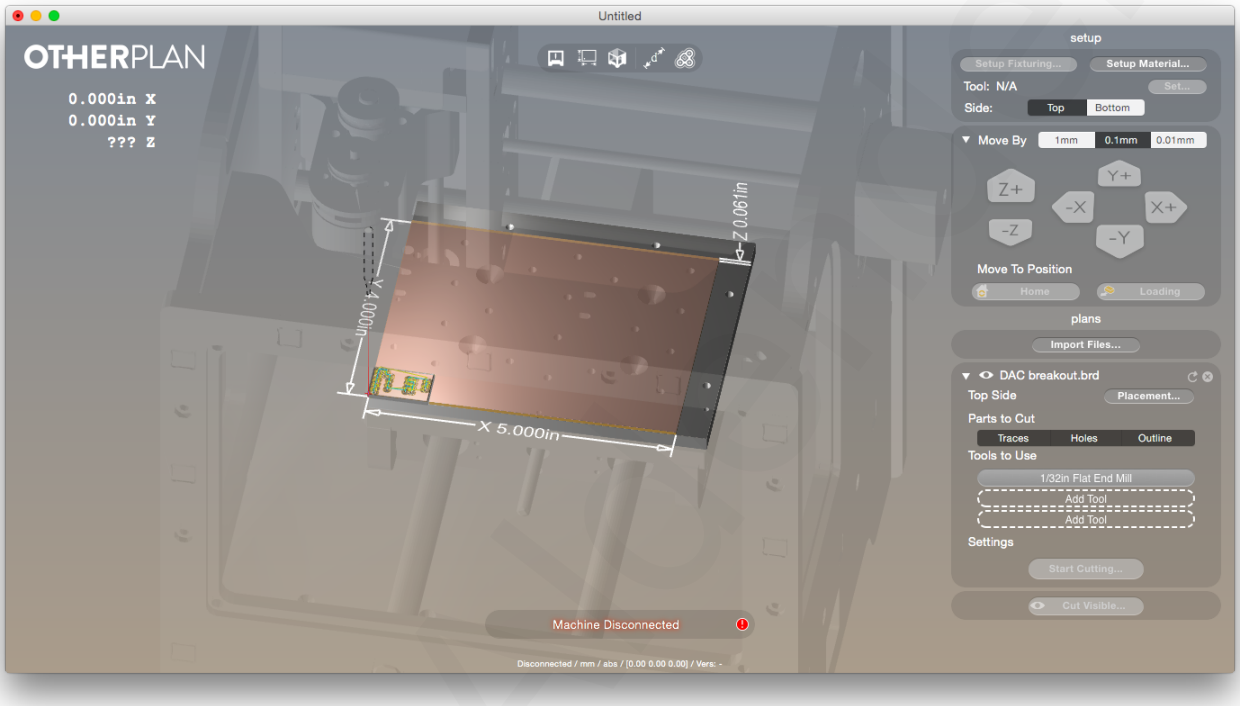
Remove the front clear panel from the Othermill. Pick up your FR1 and align the bottom left corner to the bottom left corner of the bed, then firmly press down to make sure it's level.

Part 4: Load your board file

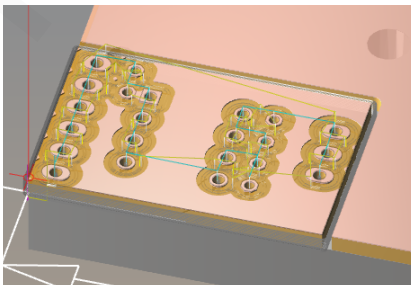
For this course, you'll be using the board you designed in *Circuit Design with EAGLE*: a DAC breakout board. The DRC file you used during that class was designed specifically for this machine and the 1/32in tool!

Import the board

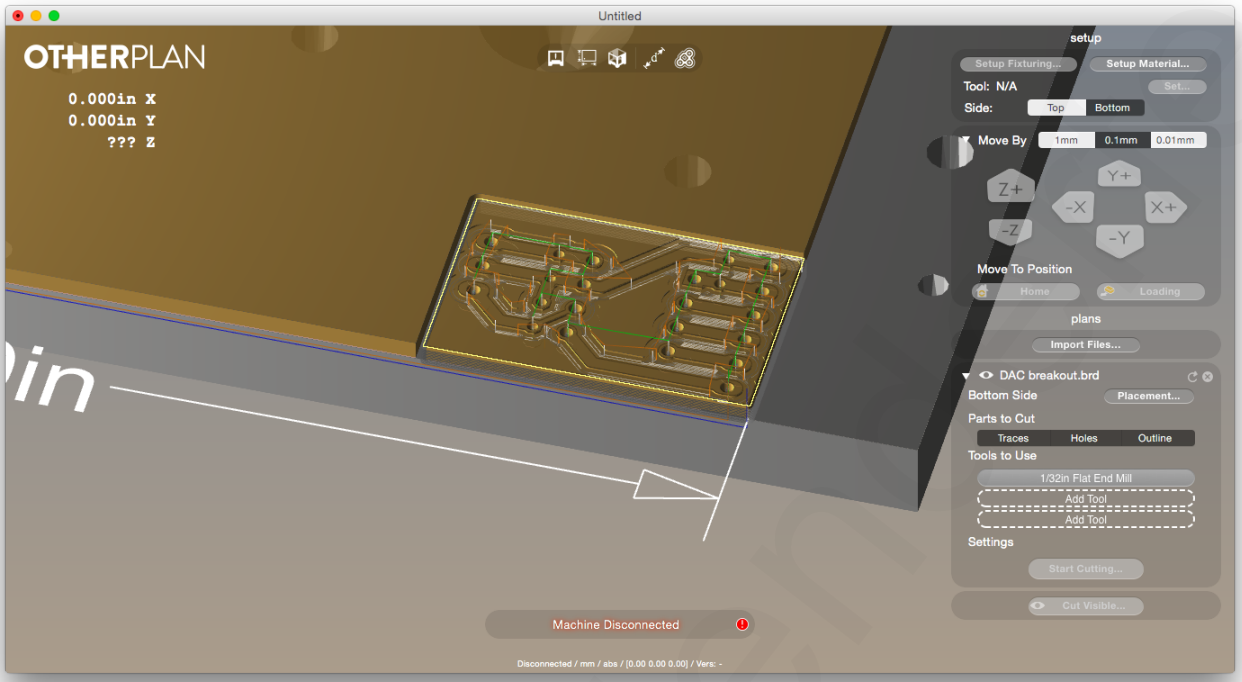
In the "plans" section on the right side of the UI, hit the "Import Files..." button; navigate to and select "DAC breakout.brd". A visual of the board will be created in the bottom left corner of the material.



Wonderful! But take a look at it; it doesn't seem to have any of the traces we created. That's because we're looking at the *top* layer, and all of the connections you made in your design are on the *bottom*! This means that the mill is currently set to cut the top copper layer, which is absolutely *not* what you want.

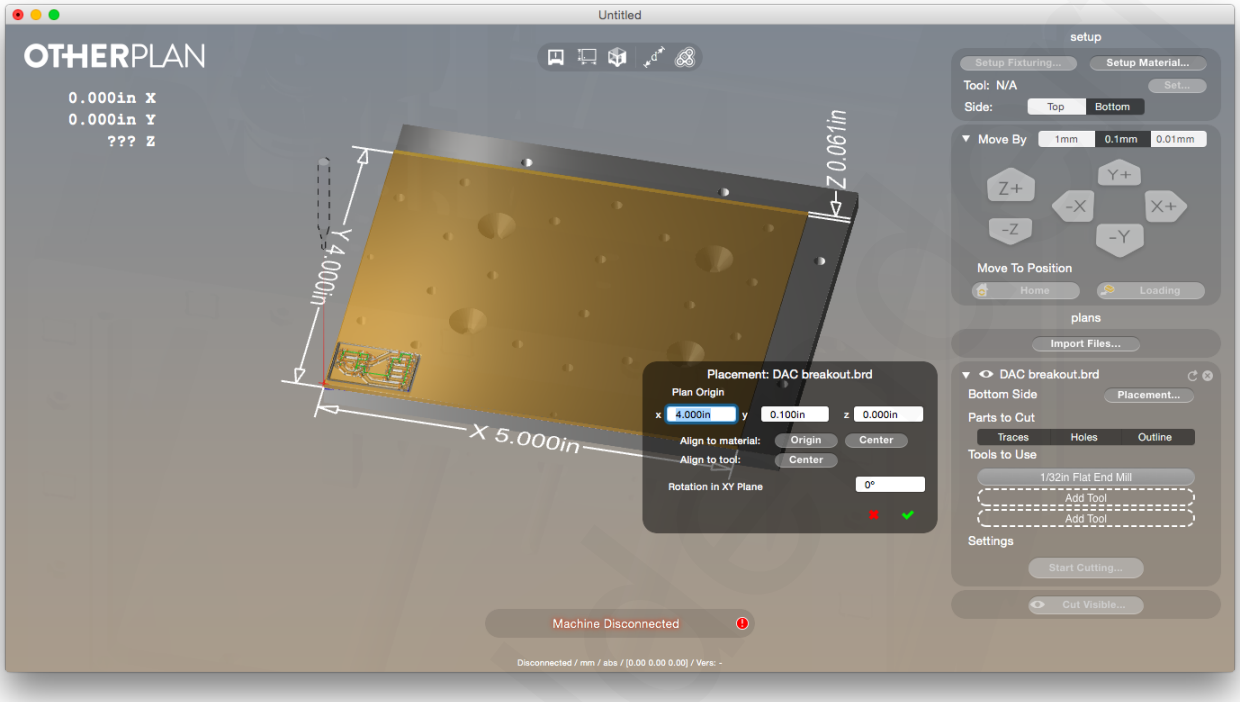


In the “setup” section of the UI, there is a toggle to switch between Top and Bottom layers. Click “Bottom”. Much better!



Relocate the board

You'll notice now that underneath the "Import Files..." button, a box has appeared which contains all the options available for the board you've just imported. Pressing the "Placement..." button allows you to change its position on the bed. Move the board from the bottom right corner of the material to the bottom left corner. Note that this can also be done by clicking on the board itself to select it, then dragging it into place



Set the milling options

Any and every board that you import will mill in three steps:

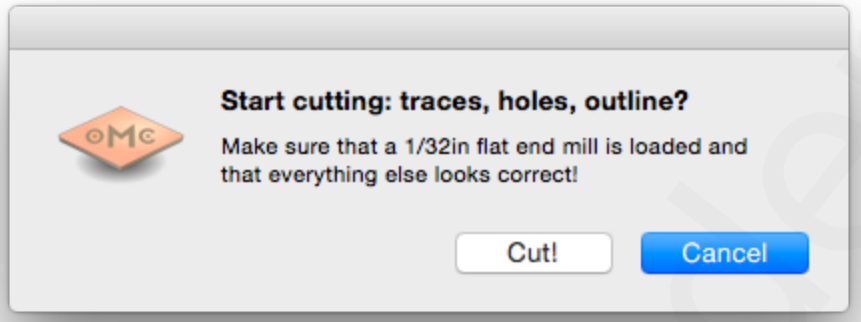
1. **Traces** - removing the top layer of copper around all traces, pads, and vias
2. **Holes** - drilling through the material for through-holes, vias, mounting holes, et al.
3. **Outline** - drilling the outline of the board

You can tell the Othermill to do one or more of these at a time by turning them on or off in "Parts to Cut".

You are using the 1/32in tool, which has already been selected in the "Tools to Use" section. If and when you design a board that requires a different tool, you will choose it here. You can also add multiple tools (and therefore tool changes) to have smaller mills take care of finely-detailed sections and larger mills take care of the coarser sections.

Part 5: Mill away!

It should take the Othermill approximately 11 minutes to mill all three steps. Press “Start Cutting...” to begin!



Part 6: Cleanup

Use small paintbrush to loosen all particulate, and then vacuum it all up.

[2]

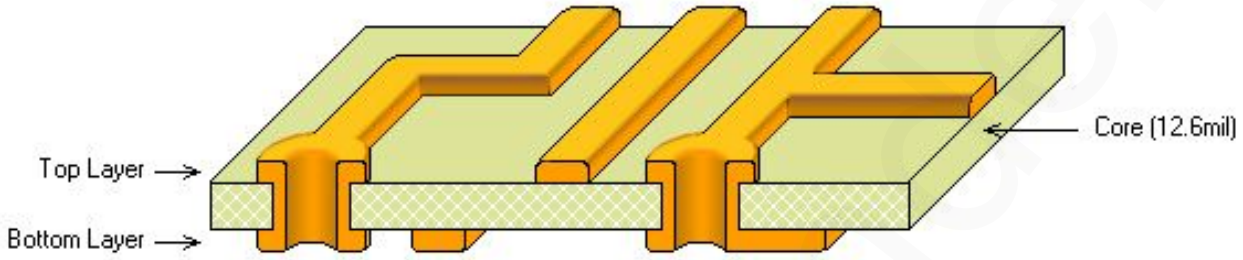
Place all parts back where you found them.

[2] http://product.circle-international.com/shop/solar-panel/cleaner/

Appendix A: PCB materials overview

PCB materials can come in all sorts of configurations; the only material approved for milling on the Othermill is called FR1. FR stand for **flame-retardant**, and the number denotes what the insulating substrate is made of.

What is insulating substrate?, you might ask. PCBs are multi-layered sandwiches of conductive and non-conductive materials.Let's take a look at the cross-section of a simple PCB:



[3]

[3] Image source: http://www.circuitdomain.com/Creating%20Artwork/Creating%20Artwork.htm