Milling Machine Tutorial
A basic how to guide

Here is all the information you'll need to get started using the ELEG PCB Milling Machine. Please be sure to read **ALL** the information in this tutorial.

> *Failure to follow these instructions will at best result in wasted time and materials on a failed milling attempt, and at worst will result in damage to the machine or your person, and loss of all milling privileges.*

Prepare

Before using the milling machine, you will need a few things.

1. **Gerber Files:** You will need to have your gerber files already generated before going to the milling room to process your board. The computer uses a single login for operation, so storing on your L: or Mydocs drive isn't recommended. USB memory sticks or your box drive are the recommended storage methods.

   > *Naming your individual files based on function and layer is highly recommended, as this aids in importing into the milling software. (ex. TOP, BOTTOM, DRILL, OUTLINE, etc...)*
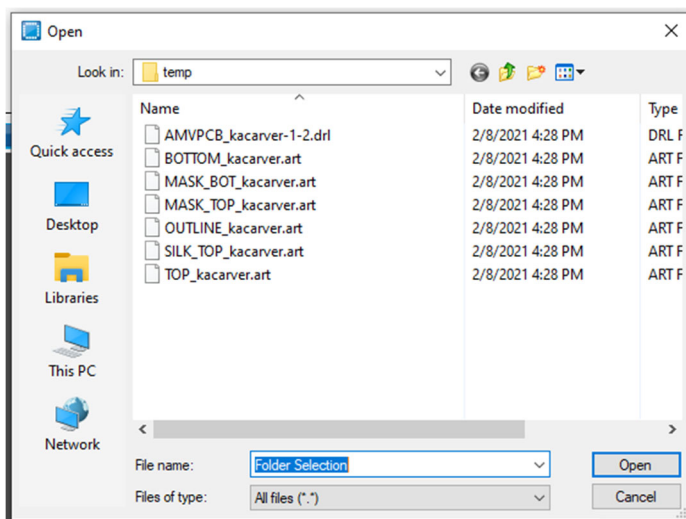
2. **Login.** This computer uses a single account, for the purpose of licensing the milling software. Please do not log out of this account. The computer should automatically log in on reboot or time out, but should the account become locked or signed out, here is

the account info:
USER: ELEGMill
**PASSWORD: Milling**

Milling Machine

Lets go over some of the parts of the Milling Machine and tools that you'll interact with.

1. Here is the Milling Machine you'll be working with.

For safety purposes the machine will not move while the cover is open. It is important NOT to open the cover while the machine is moving. It will immediately stop, which can put extra strain on some of the mechanisms.

**2.** The air permeable sacrificial surface.
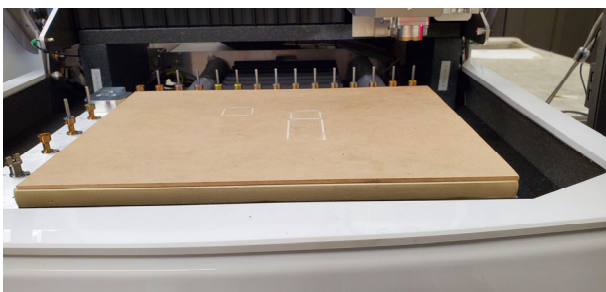
This material sits on top of the machine table loosely until the vacuum table is turned on in the milling process. Your PCB material will sit on top of this material. It is

recommended to use a few small pieces of painter's tape to secure your PCB material to this layer. The material protects the machine table from damage by the machining process. Should the material be too worn, it can be flipped over, or contact eleghelp@uark.edu for assistance.

3. Tools and Materials

There is painter's tape available for holding down your PCB material. Steel wool, and scotch bright pads are used for knocking off burs from the milling process. The milling machine uses a camera to calibrate locations and tool path widths, burs can sometimes cause the readings to be incorrect. The brush should be used to clean off the Table surface prior to placing your PCB material, and after you have finished your board milling.
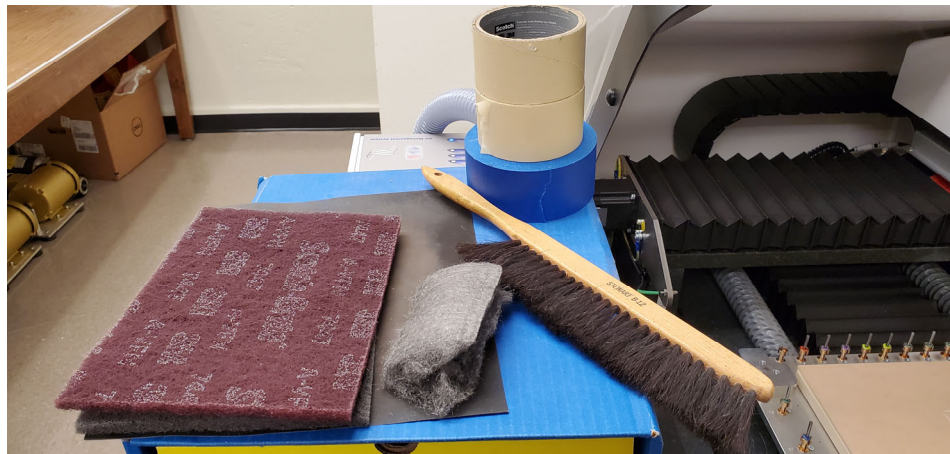
And lastly is the hole guide.
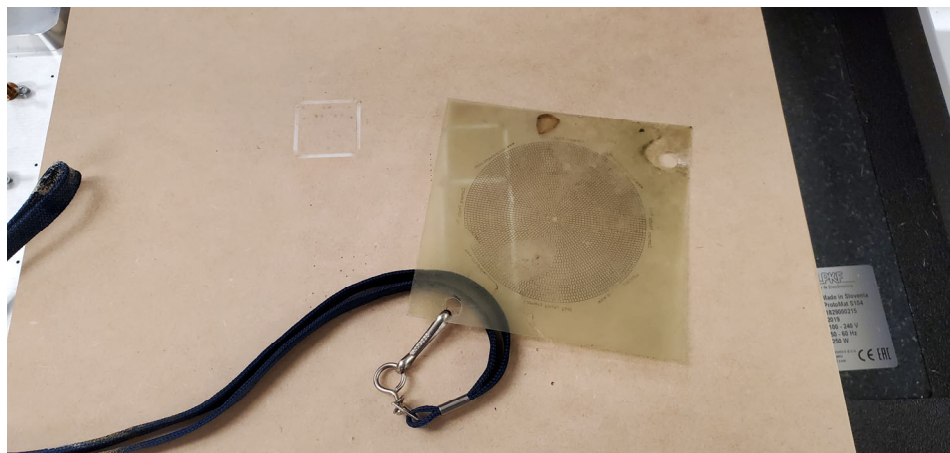
This helps with manual alignment of fiducials should it be necessary.   **DO NOT LEAVE IT IN THE MACHINE!** This will damage both the guide and quite possibly the machine.

Getting Started

Sitting at the computer, you should see the milling machine software on the desktop screen.

Make sure the lid on the machine is closed and double click the LPKF CircuitPro Icon to launch it. It will begin the start up and connection process to the machine. This will take just a couple of minutes.

In the startup process, the software may bring up a dialog box stating that a tool is in the spindle and wants to know which tool it is. If you look near the tool holders, there are numbers engraved beside them.
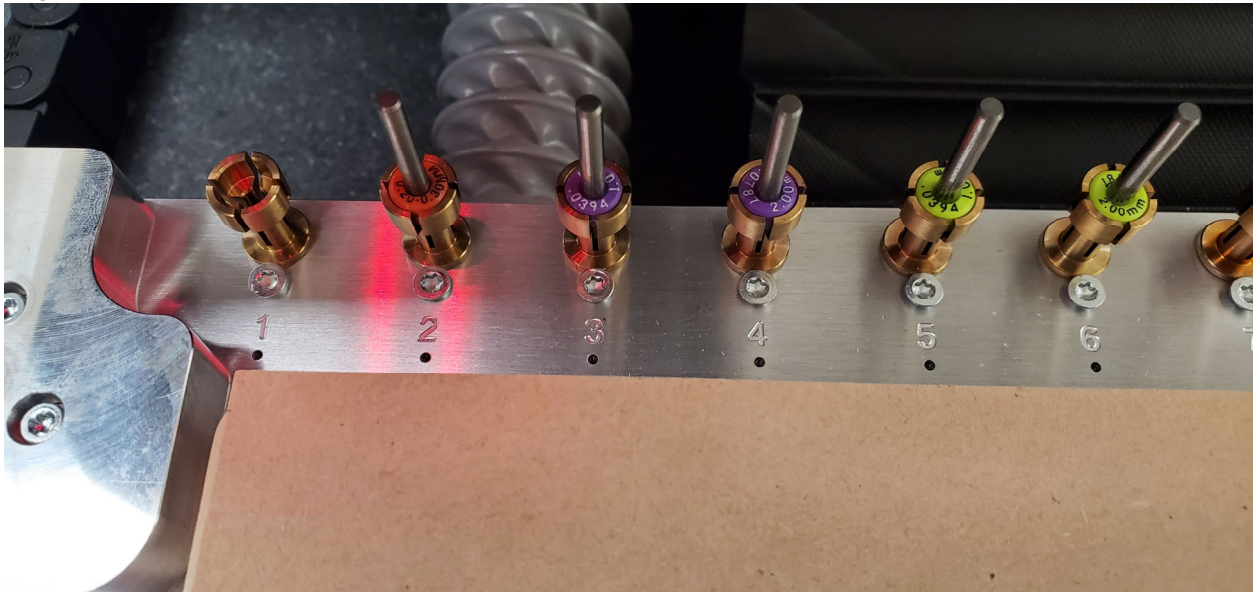

Look for the empty holder (1-20) and select its number on the dialog box.

Note: Holder 19 is a tool cleaning device, no tool ever resides there.

Once startup is finished it will bring up another window. Here you can open a previous project or in this case, select a template.
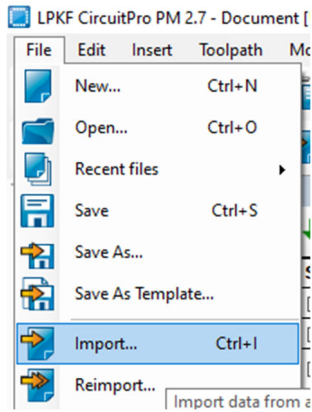
1. Click the Template tab

2. Select the appropriate type, either SingleSided_Top, or DoubleSided_NoTHP (through hole plating)
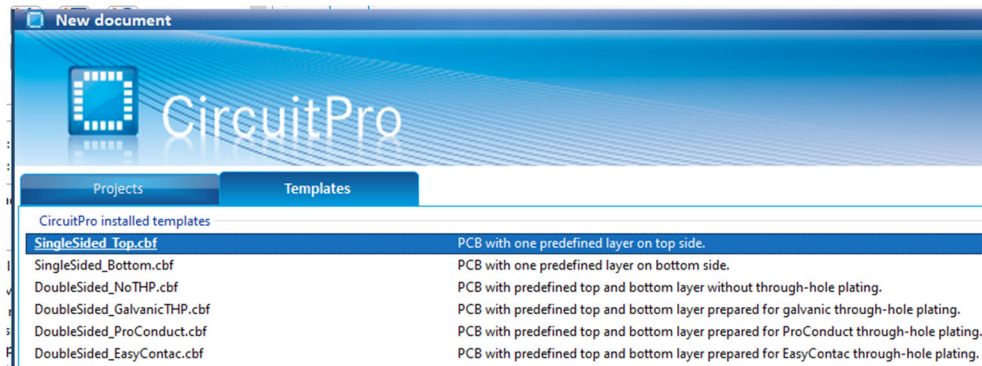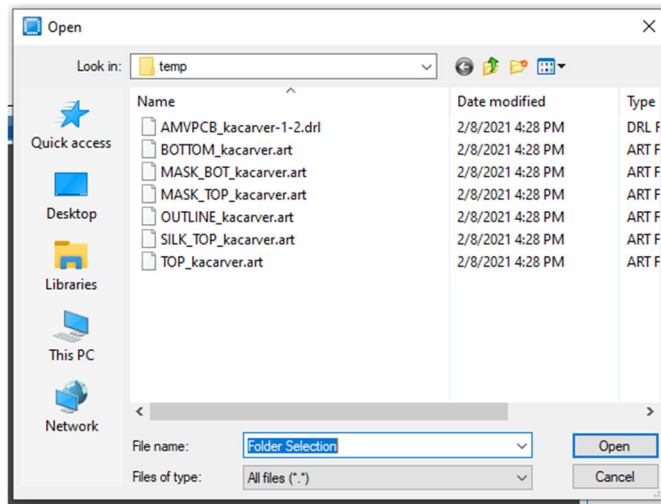

Importing Your Design

Next you will need to import your gerber files into the Circuit Pro software.

1. Click on "File" and select "Import"

2. It will open a new window. Navigate to where your gerber files are located, select them all and click "Open"


3. The next window will ask you to assign files to layers. Under the "Layer / Template" column, select the appropriate layer for each file. The default for drill files should be "DrillUnplated" unless you plan on manually plating your vias later on.
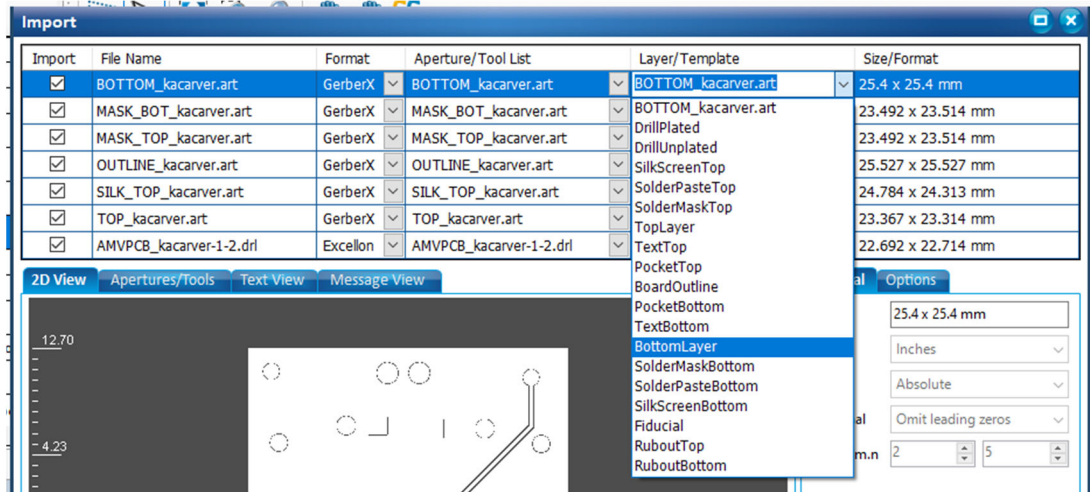
Note: If you have put text on your silk screen layers and you want it milled out, you will need to select "TextBottom" or "TextTop" instead of silk screen. Verify that other objects typically present on a silk screen are not present as they will be milled out, typically ruining a board.

Rubout Selection

Should you have the need to remove all excess copper from an area, you would click the "Define Rubout Region" button to do so.
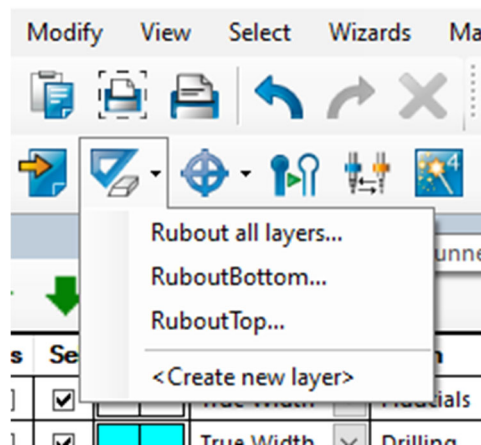
Note: Unless it is necessary to the function of your board to have all excess copper removed, it is highly encouraged **NOT** to do a rubout. This will save you time, and save the tools from excessive wear.

1. Click the Rubout button and select if you need a rubout on top, bottom, or both in an area.

2. When the dialog appears to "Create Rectangle" click once in one corner of the region, and once in the opposite corner of the desired region.
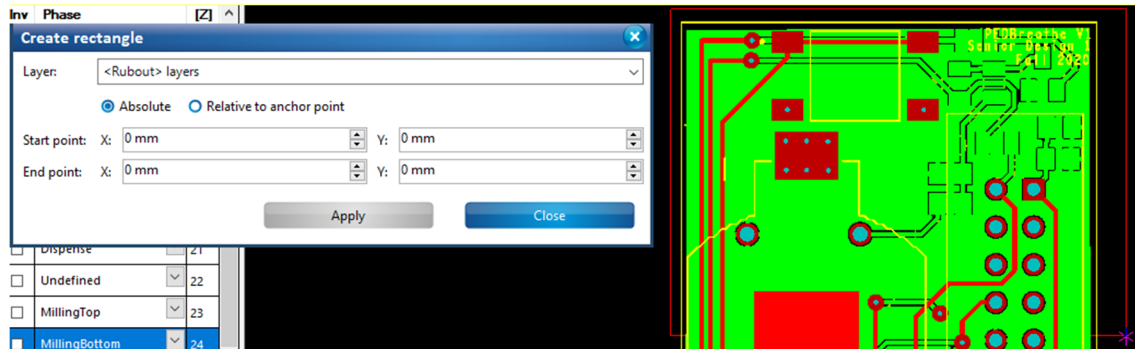

3. Click "Close" once the rectangle has been drawn.

   Note: Rectangle color will depend on the layers selected for rubout. Against initial instincts clicking "Apply" is only for defining a rubout region via the X and Y starting and ending point boxes.

Creating Fiducials

If you are milling a double sided board, the machine will need a way to reorient the design with the physical placement of the board after it has been flipped over to mill the other side. This is accomplished by fiducials (Holes drilled for orientation)
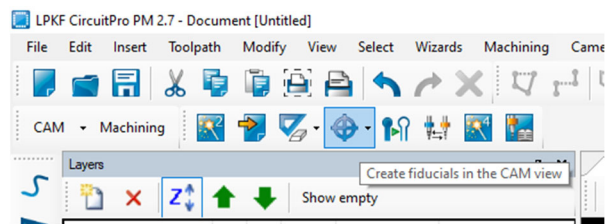
1. Click the "Create Fiducials" button

2. Click on 3-4 locations outside, but close to your design
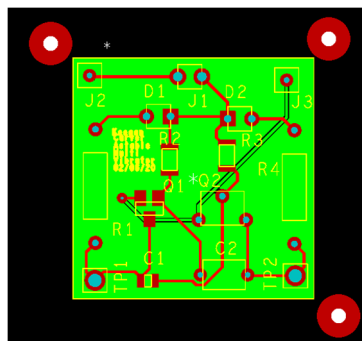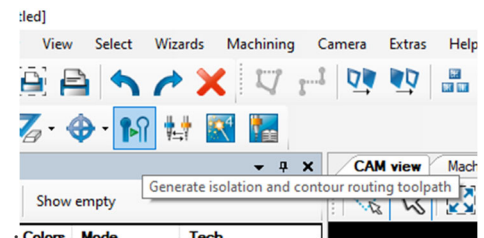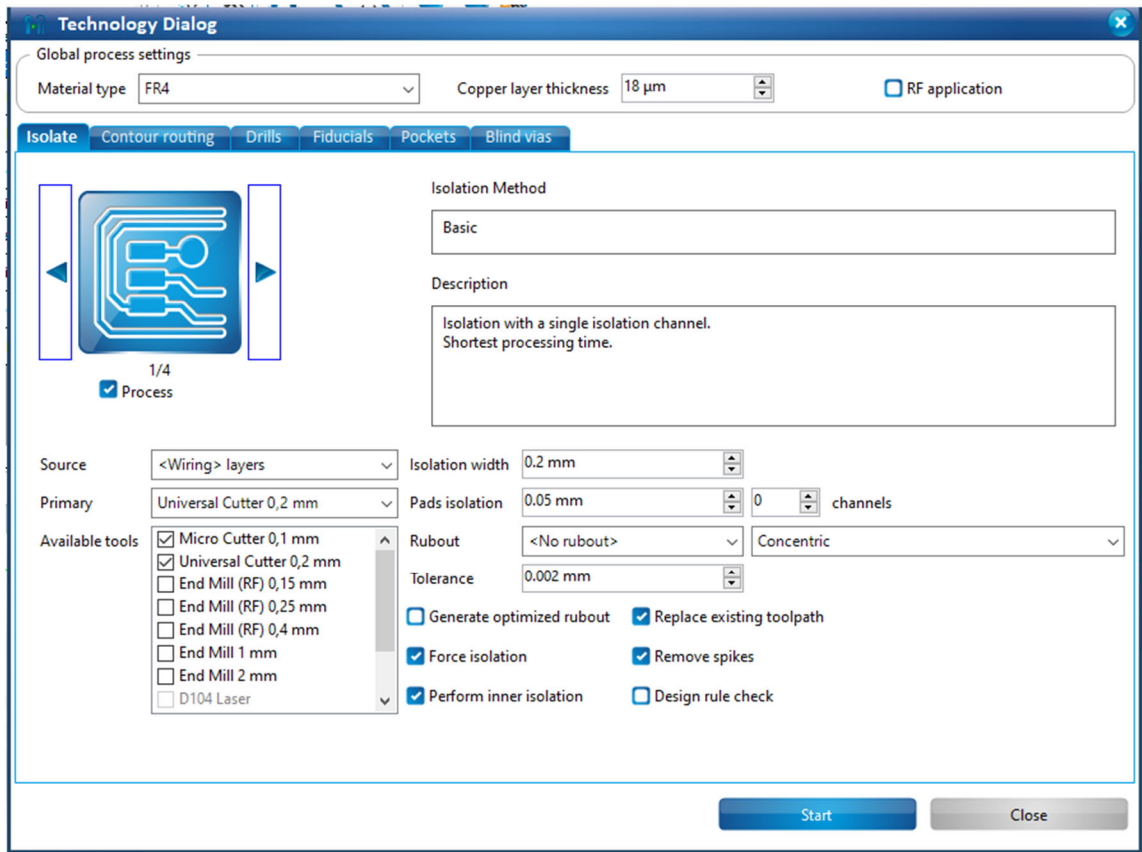
3. Click close
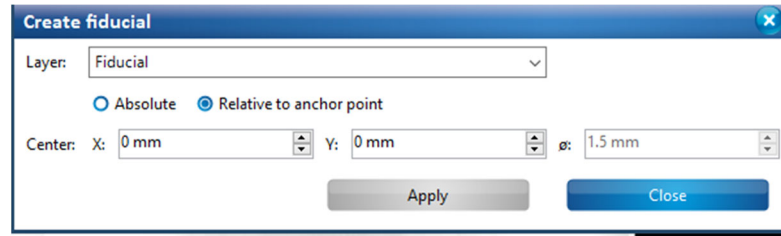
Note: Clicking "Apply" will stick a Fiducial right in the middle of your design. If done by mistake, click close, then click on the parts of the fiducial on the design and hit delete.

Generating Isolation and Toolpaths

Next, we need to assign tools, set isolation width, and patterns.
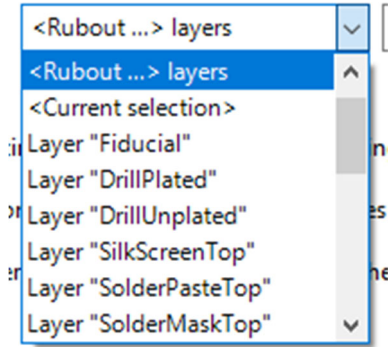

1. Click the "Generate Isolation" button

2. On the Isolate tab the defaults typically are fine, however you can set the isolation method to either 1 "basic, or 2, "basic, pads double" on the upper left side with the left and right arrows, granting you a little more room around pads.
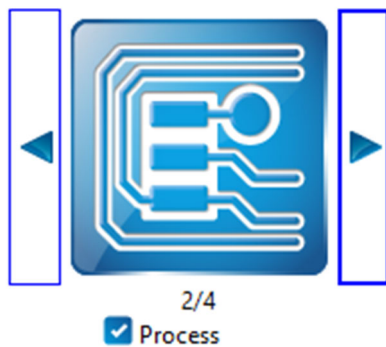

3. If you have a rubout that you assigned, click the dropdown next to "Rubout" and select "<Rubout ... > layers"

4. Click Start.

   Note: Settings on all other tabs should be left at default. Different isolation widths are possible by changing the values, as well as selecting different tool. If these values need to be changed from the default, clicking "design rule check" is highly recommended. Keep in mind, the more tool changes and more tool passes there are, the longer the mill will take. Defaults are recommended.

5. Depending on your design you may have 1 or more vias that don't match the tools available in the machine. If this happens, the software will ask you if you would like to use the universal cutter, or abort. The universal cutter can be used to drill any hole .2mm and up, but not smaller. Either click "Accept", or "Abort" and you can redesign.
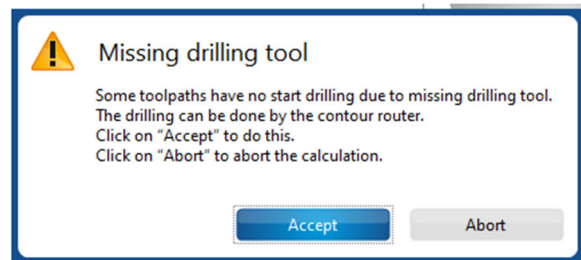

   If you choose to accept, a window with warnings. Under "Drilling" click the dropdown and select "Universal Cutter 0.2 mm" Then click "Calculate" on the right side.
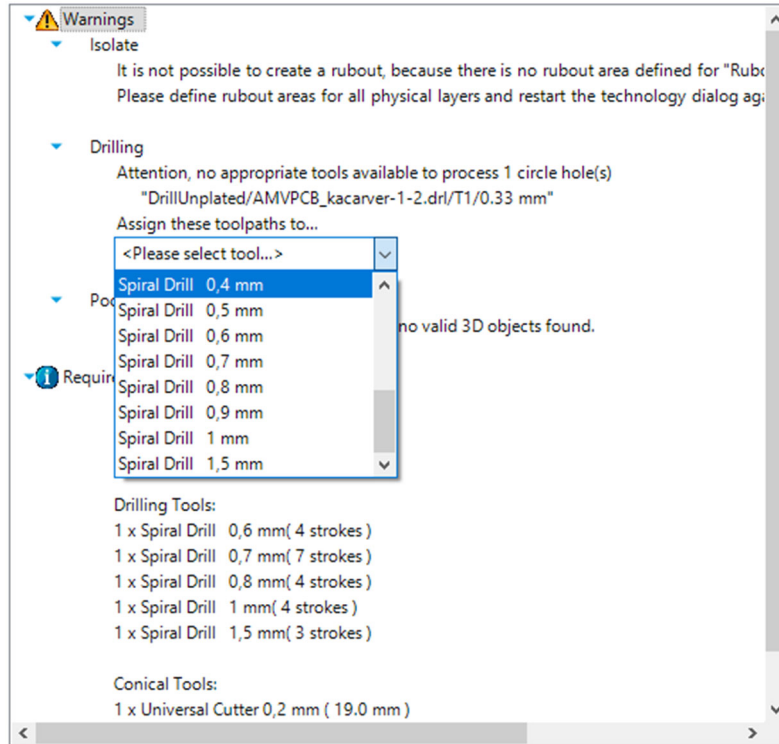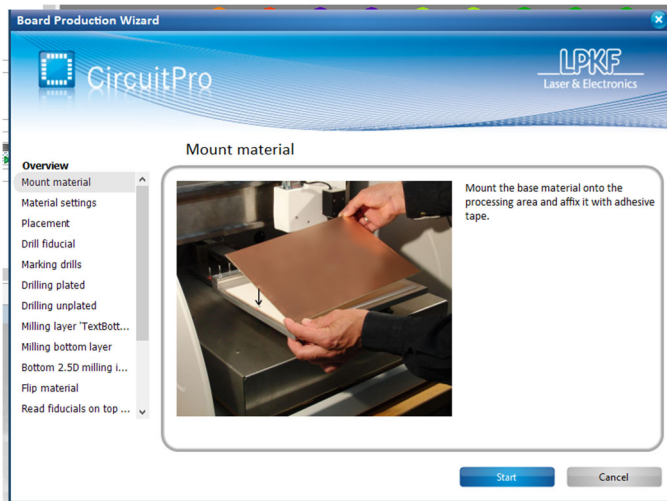
It will prompt you again asking if you'll accept the universal cutter. Click "Accept" again. So long as there aren't any more warning or errors you can click "Close"

Board Production

Next we will select the "Board Production Wizard" to finish setting up the machine.
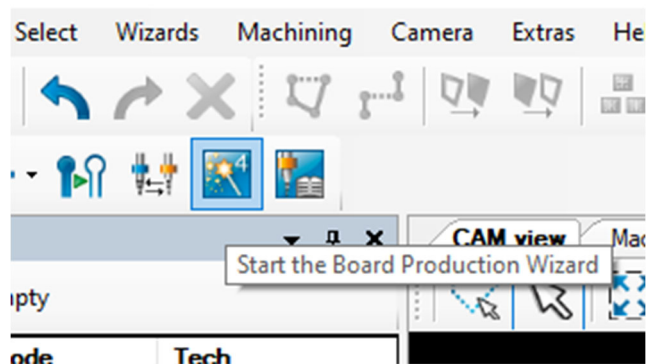
1. Click the "Board Production Wizard" button.

**2.** This wizard will walk you through all of the next steps one by one. First thing is to put your PCB material on the work surface. Use a couple of pieces of painter's tape on the corners or edge of your PCB material to help hold it in place. Click "Start"
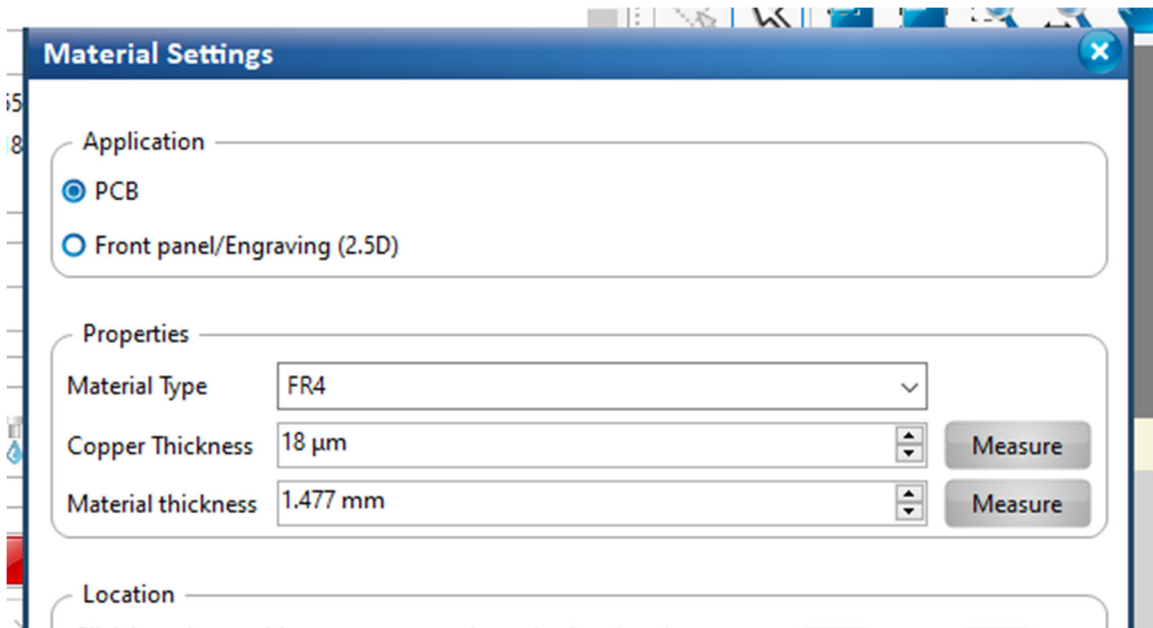

3. The Material settings are next. FR4 is the default material type. Click "Measure" next to Copper Thickness.

4. On the machine view click roughly in the center of the design making sure the drill head is situated completely over copper. Adjust the cross hairs as needed to make sure it is lined up over copper then click "Measure"
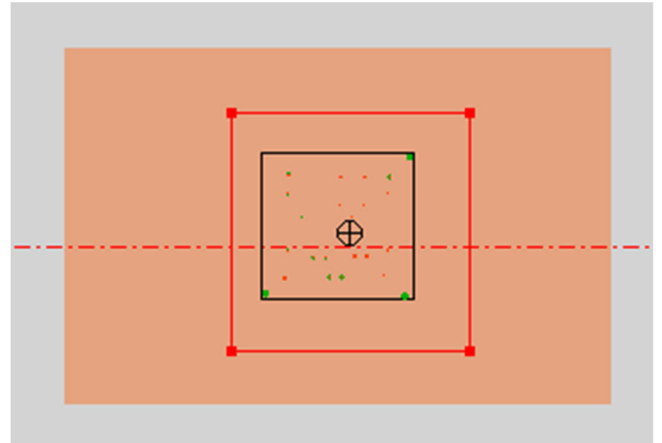
Your result will vary depending on material, for our 1oz copper it should be around .033 mm. Click "Save".
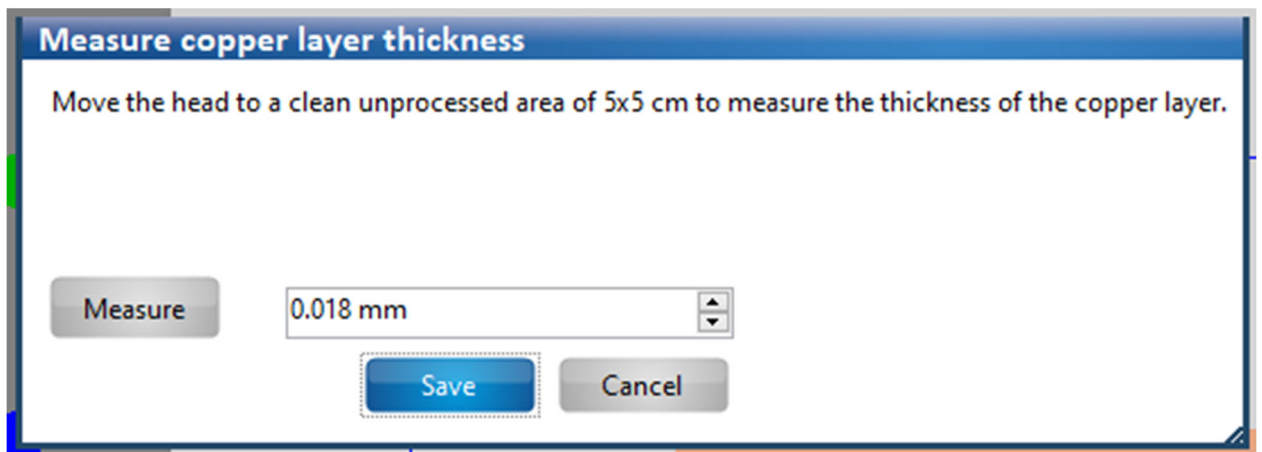
5. Click "Measure" next to "Material Thickness". The process is similar to measuring the copper thickness. Move the drilling head over clean copper then click "Measure." Our FR4 typically measures around 1.477mm give or take. Click "Save" then click "Continue"
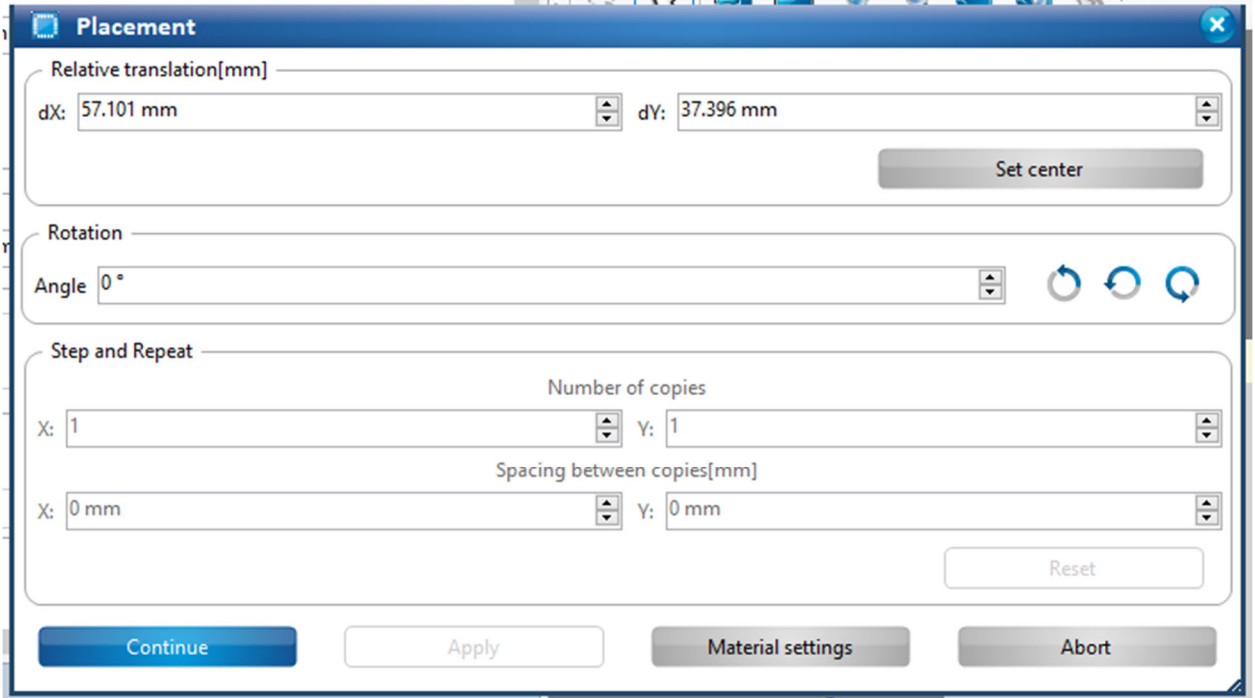
**6.**

Next is Placement. Click and drag the design on the screen to match up with the PCB material on the milling table. You can either use the movement arrows and set the movement increment, or click the "Mouse Cursor" button to toggle the machine moving to a mouse click. Move the drill head over one corner of your copper, then move your design to be inside the copper noting where the edge of the board is based on the crosshairs.
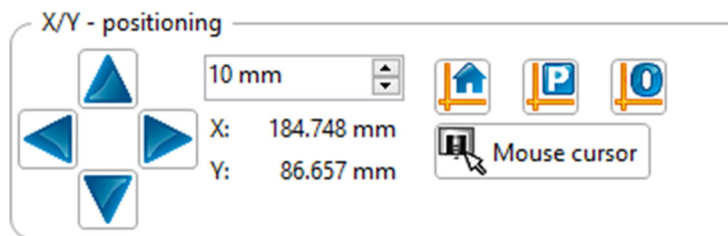
Once positioned click "Continue"

7. You will be prompted if you want to save the document before you continue. This can be helpful should you run into any issues or want to repeat a board.
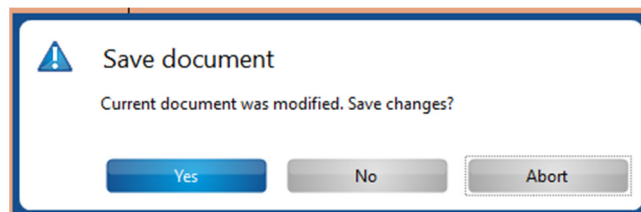
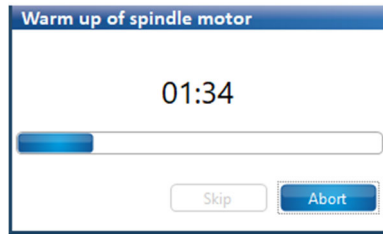**8.** If the machine hasn't been used recently it will go into its warmup phase. This takes 2 minutes and cannot be skipped.

9. Once the warmup has finished it will begin milling the first side. For single sided, it is the only side, for double sided boards it is the bottom side.

IMPORTANT: If for some reason things are not milling correctly, click the "Stop" button and it will stop processing where it is so you can correct any issues and continue.
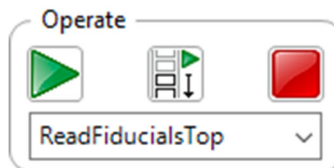
Only open the cover while the machine is milling if the machine is not responding to pressing stop or if it is causing damage to itself. This will throw the machine into emergency stop. **IMMEDATLY** contact eleghelp@uark.edu, either in person, phone (479) 575-7472, or by email. Under no circumstances should you reach into the machine.

Marking Drills

Once the fiducials have been drilled, it will move on to the marking drills. These are the isolation and rubout bits. These bits need to be calibrated.
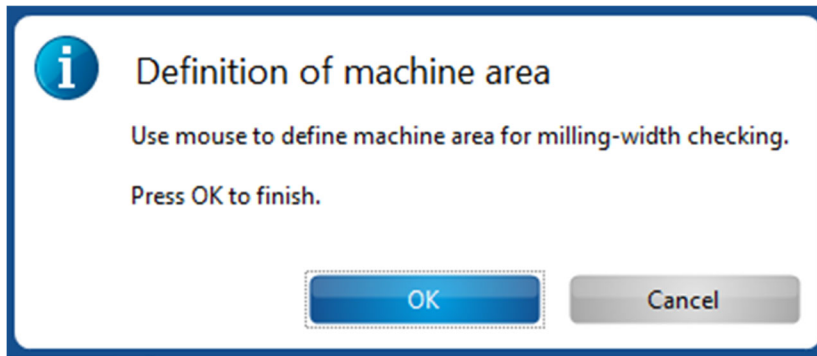
1. Select an area of bare copper outside of your design. Click "Ok" and it will mill a short line
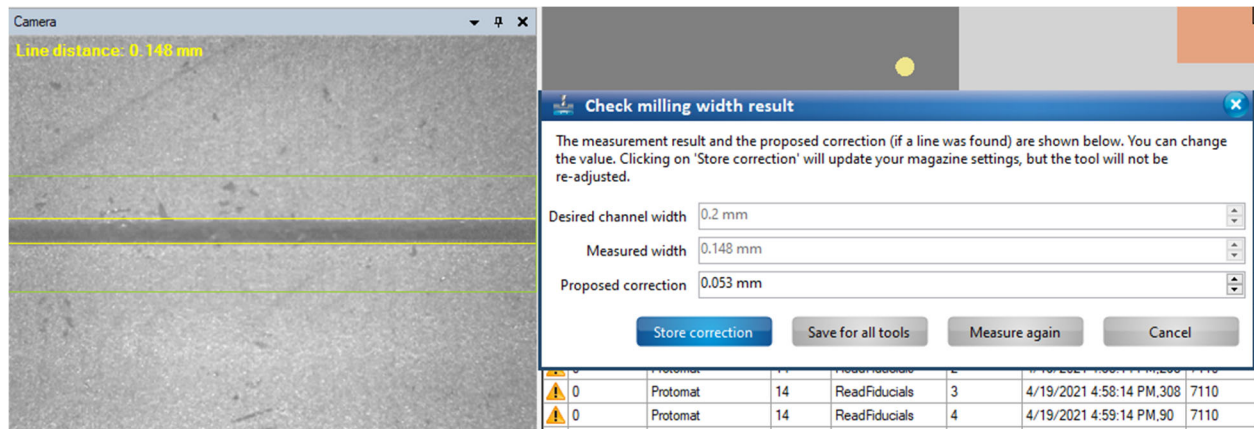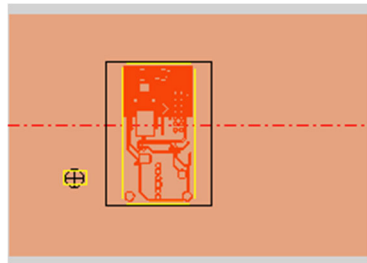
2. The camera will move to focus on the milled line. Once it focuses it will measure the width, as indicated by 2 yellow lines. If the lines match up with the actual milling mark, look at the milling results. If the line width was different than what the desired channel width was it will propose a correction. Click "Store Correction"

Note: If the yellow lines do not match the actual milled width, take a piece of scotch bright pad and gently rub over the surface of the copper to knock any burs loose that might be hampering accurate measurement. Then click "Measure Again"

Milling the Second Side.

Once the bottom side of the board has been milled, it is time to flip the board over to mill the other side.

1. Open the machine cover, release the tape from your board and flip the board over so that the edge that is closest to the front of the machine is now towards the back.
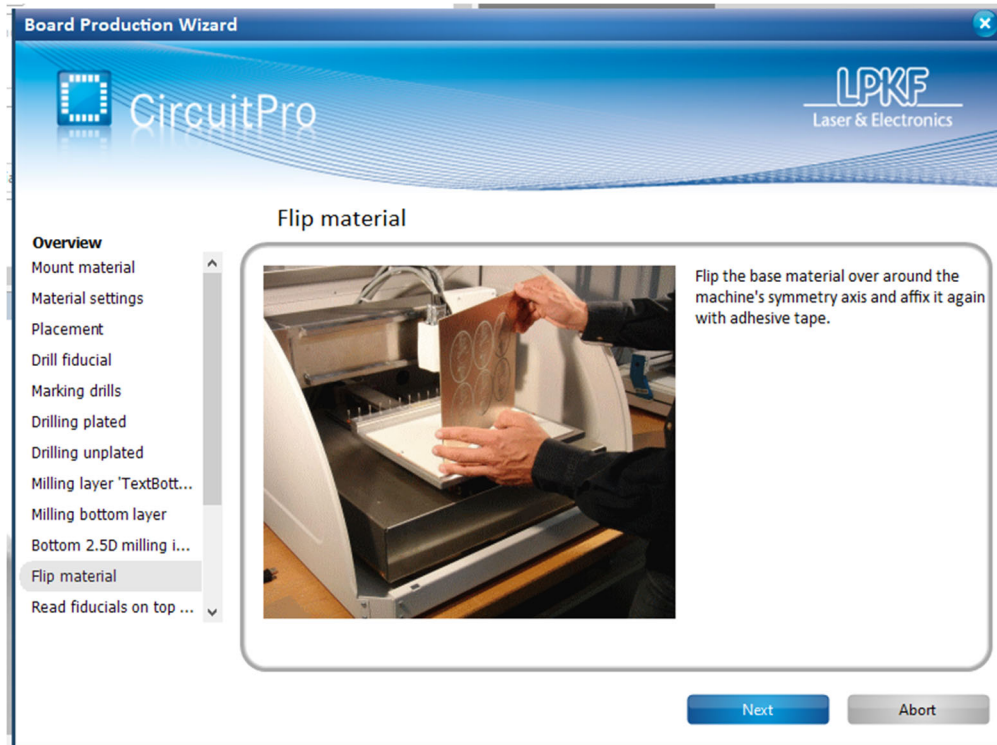
Attempt to place it in roughly the same location as before and place the tape back down. Click "Next"
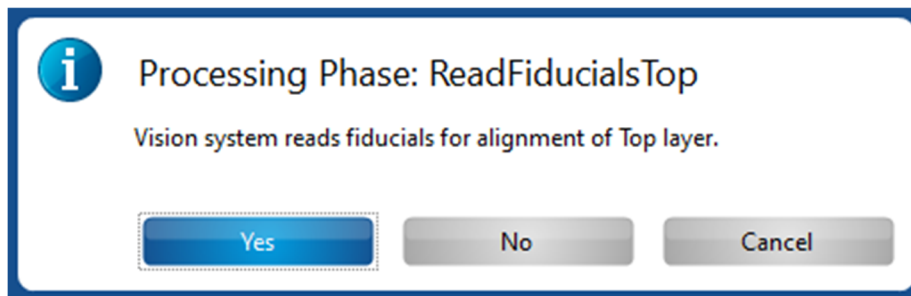
2.

The next prompt will indicate it wants to use the vision system to automatically find the Fiducials in the design. Click "Yes"
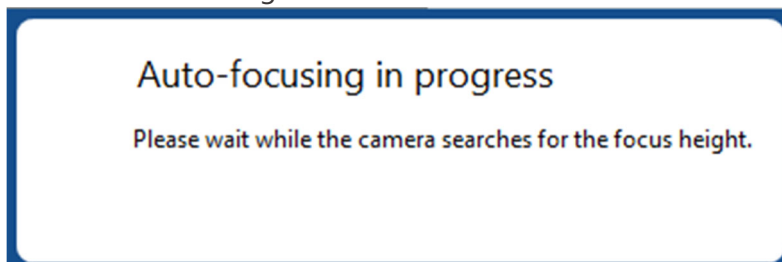
It will adjust the camera so that the image is in focus.
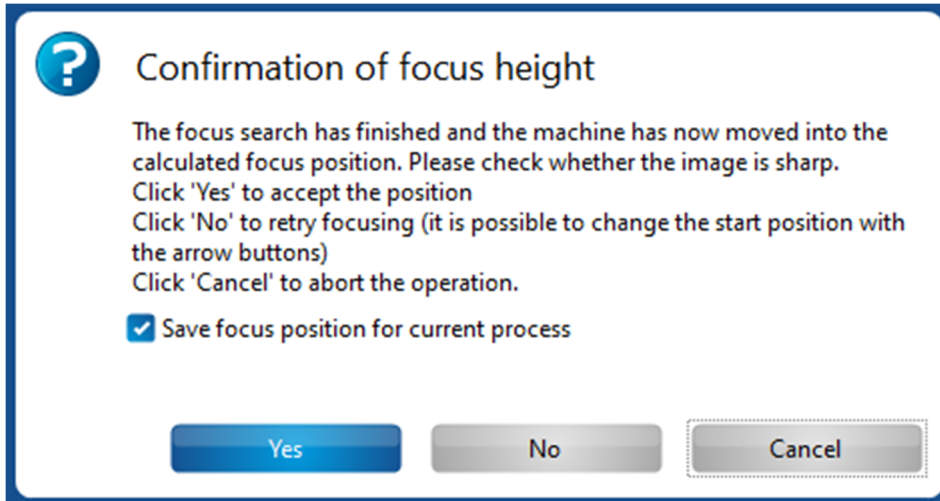
3.

If the image in the lower left is in focus click "Yes". The machine will then begin a spiraling search for where it thinks the fiducials should be.
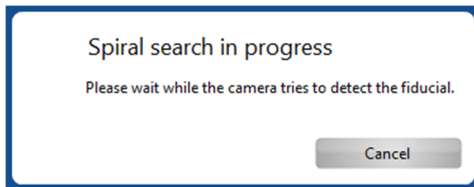
4. Once it finds one, it will ask you if it is correct in identifying one. If it is, click "Ok" and it will continue to look for the others. If it isn't the correct one, click cancel.

   a. If you click cancel, the Alignment dialog will appear. You can click "Retry" and it will attempt to locate the fiducial again, using a wider search path, or you can

manually locate the fiducial.

Alignment

Check alignment result. Click 'Accept Current Position' if the result is OK. Click 'Find and center' to find and then move to the center of the fiducial.

Fiducials: Phase "DrillFiducial"

DrillFiducial

Alignment parameters

Fiducials for step-and-repeat
- ○ Use fiducials of original project only
- ◉ Use outer fiducials of entire multiplied project

Diameter Tolerance	0.2 mm
Search Area Length	10 mm
Minimum Fiducial Quality	0 %
Minimum fiducial score	20
Distance for Direct Acceptance	0.1 mm
Show Fiducial Time	0 s
Maximum no. of centering tries	3
Manual centering if not found	◉ Yes ○ No
Ask for confirmation	◉ Yes ○ No

Find and Center

Accept Current Position

Retry

Abort

b. This can be done by opening the machine cover and placing the hole guide centered over the via it is attempting to locate. Close the cover and using the movement controls, move the camera (located directly in front of the milling head) over the hole guide. You should see a series of arrows all pointing towards the center. Simply follow the arrows until you reach the center.

c. Once you locate the fiducial has been located click "Find and Center" on the Alignment dialog window. It will center up over the hole. Click "Accept Current Position"

5. Once all of the Fiducials have been registered, the design will be reoriented and it will begin the final milling steps.

Finishing

1. Once the board is finished milling, open the machine cover, remove it and any painter's tape.

2. Close the Circuit Pro software. The machine will then gracefully power down.

3. Sweep up any dust and dispose of any tape and trash.

4. Do not leave scrap copper pieces laying around, if there is a large portion that is still usable, there is a box on the nearby work table labeled "Scrap Copper". It can be placed there to be squared off and used at a later time. If there isn't any usable space left, please dispose of in the trash.