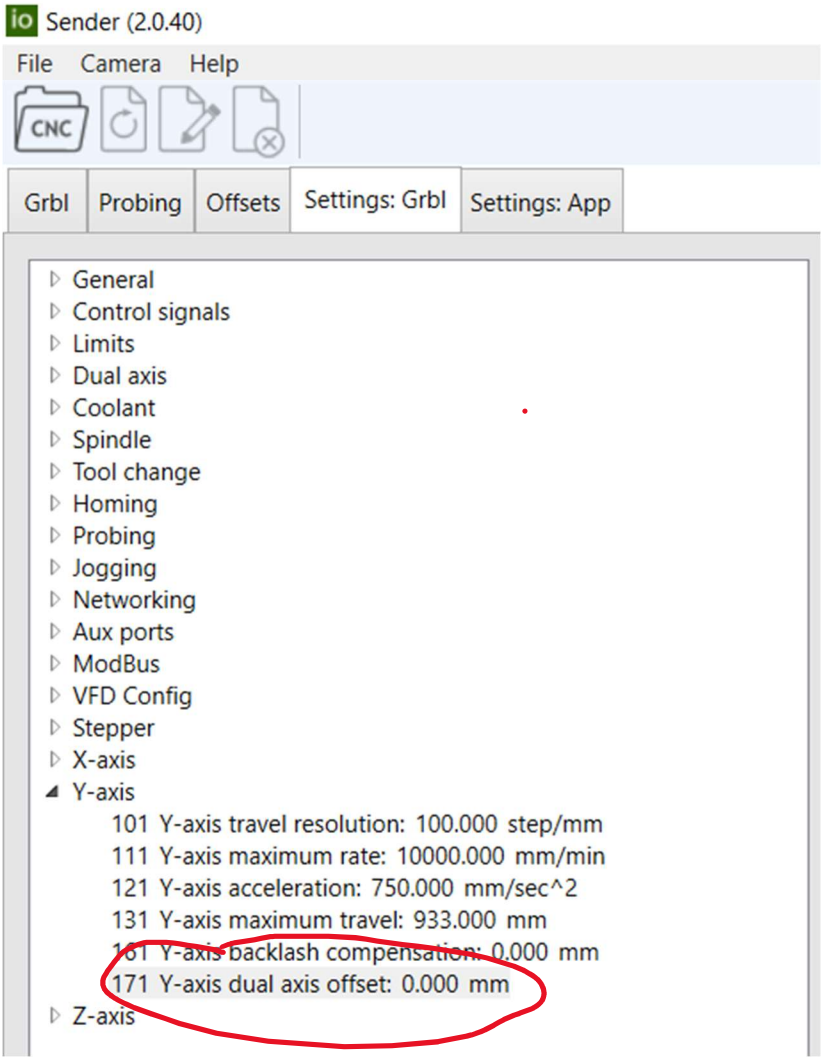
Squaring your CNC X Gantry Using a Probe & The Power of Math

How to get the Y2 offset to ensure the X gantry is square to the Y rail, using a probe and an on-line triangle calculator to do some fancy pants trigonometry. Come for the fancy-pants, stay for the Y offset. Assumes you are using grblHAL as your controller and IOSender as your Sender software.

2022/08/08 – Rev .1

Step 1 – Make sure you don't have a value set already; we need to start from scratch

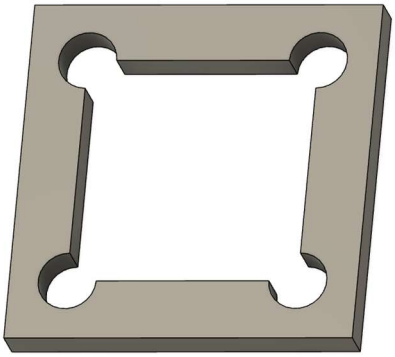
Open IOSender and check that your Y dual axis offset ($171) is currently set to zero:



Step 2 – Secure your reference square surface to your work area with an MDF pocket

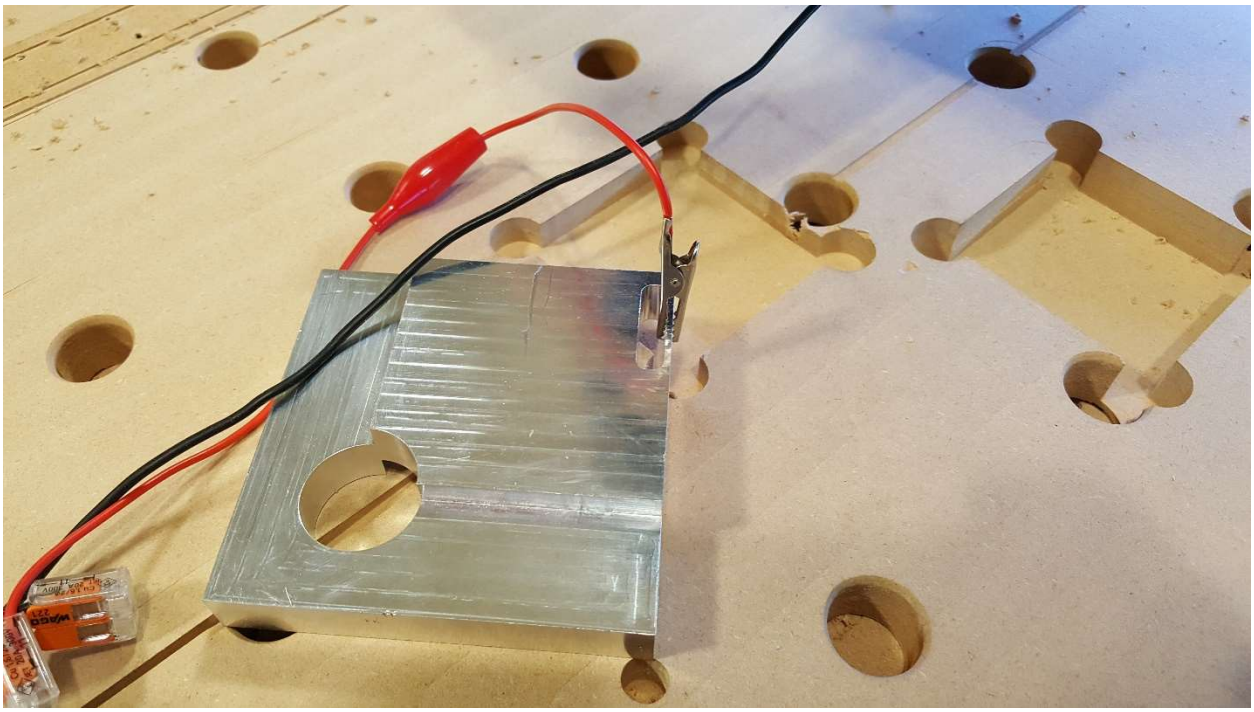
Use Fusion to design a pocket for a piece off scrap MDF that can hold the reference block while still exposing at least 8mm of the conductive side above the table surface.

If the reference block has square corners, add circles centered on the corners to allow clearance for it to fit snugly in the pocket and to give you a way to get a hold of it to remove it.

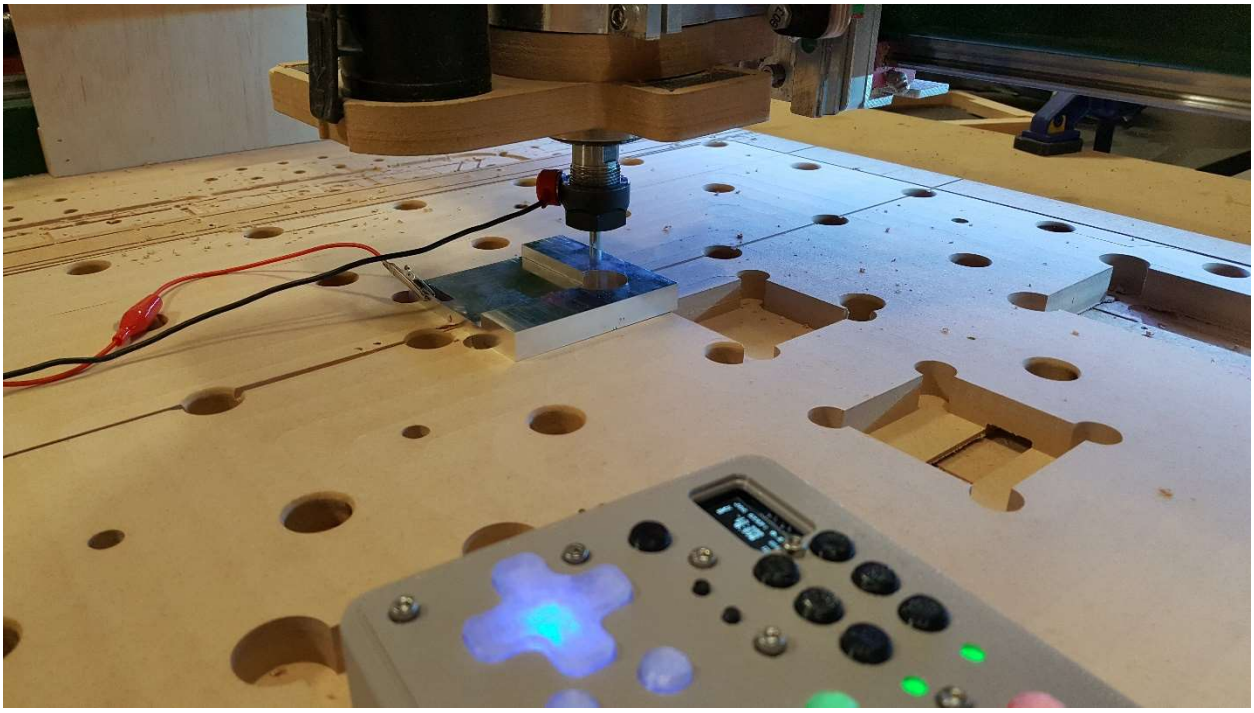


Position your pocket on the workpiece in a location that allows you to cut the same dimension pocket in multiple locations so you can check the results after applying them.

Mill the pocket into your workpiece and leave it screwed down.



Place your reference square into the pocket and ensure it is secure and has no play when pushed from the sides.



Put a piece of smooth steel rod or your preferred probing bit into your spindle and connect your probe line to your conductive reference block. Attach the other end of the probe line to your spindle, as you would when finding a corner or setting WCS Z0.

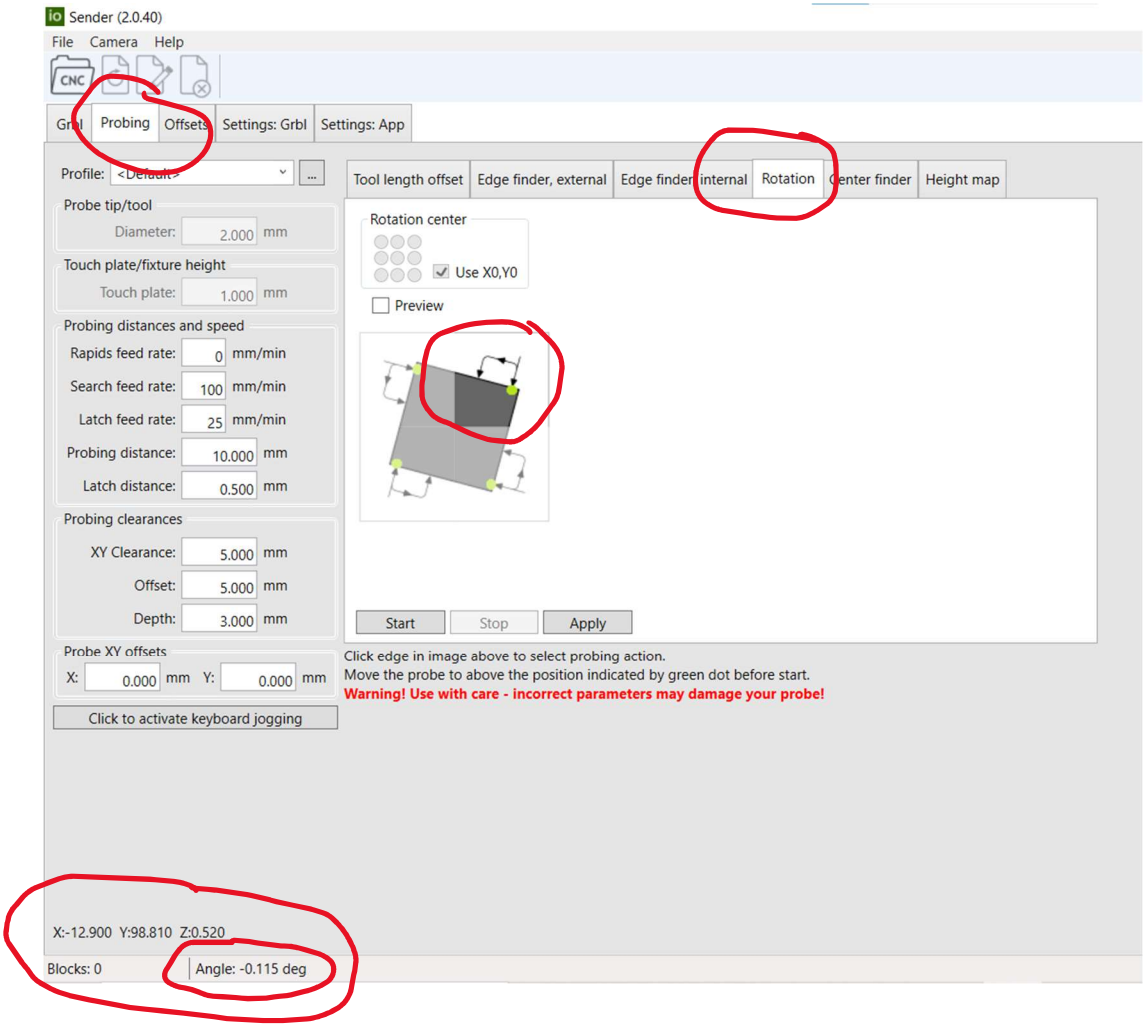
Step 3 – Setup and Perform the Rotation Probe

Place the probe at an appropriate Z height, just beyond the side of the reference block facing the rear of the table. You can do this mid-span in the X axis of the reference block.

You want the probe to start below the surface of the reference block and above the wasteboard, ensuring there is at least 4mm below the bottom of the probe, above the wasteboard, as IOSender will move the Z down 3mm (by default in the current rotation probe routine) from where you start the rotation probe. CAUTION: double check this so you don't crash your bit – don't run any programs you don't understand and are not confident in.

Now open the **Probing tab** in IOSender and **click on the Rotation Tab** in the large window on the right.

Next select the top surface on the example to tell IO Sender which side you are starting from with your probe. As we are trying to see how out of square the X gantry is, we are probing against the known surface of the reference block.



The probe needs to be quite close to the reference X surface so use very slow and small step jogs to put it a few mm off the reference X surface as a starting point. **Once you are comfortable it is positioned properly, double check that you have selected the correct side (top) in IOSender** and then you can press 'Start' and the probe will approach the surface, detect it, back off, reapproach slowly then move to the left in the X axis, approach a second point, detect, fall of and then do a slow approach and detect for the second point.

You can watch the position details on the lower left of the screen. When it completes the probe successfully, it will report the angle difference between the two points. In my case it was -.115 degrees. Write your own number down, you will need it for the calculation.

Step Four – Measure the Distance Between your Ballscrews

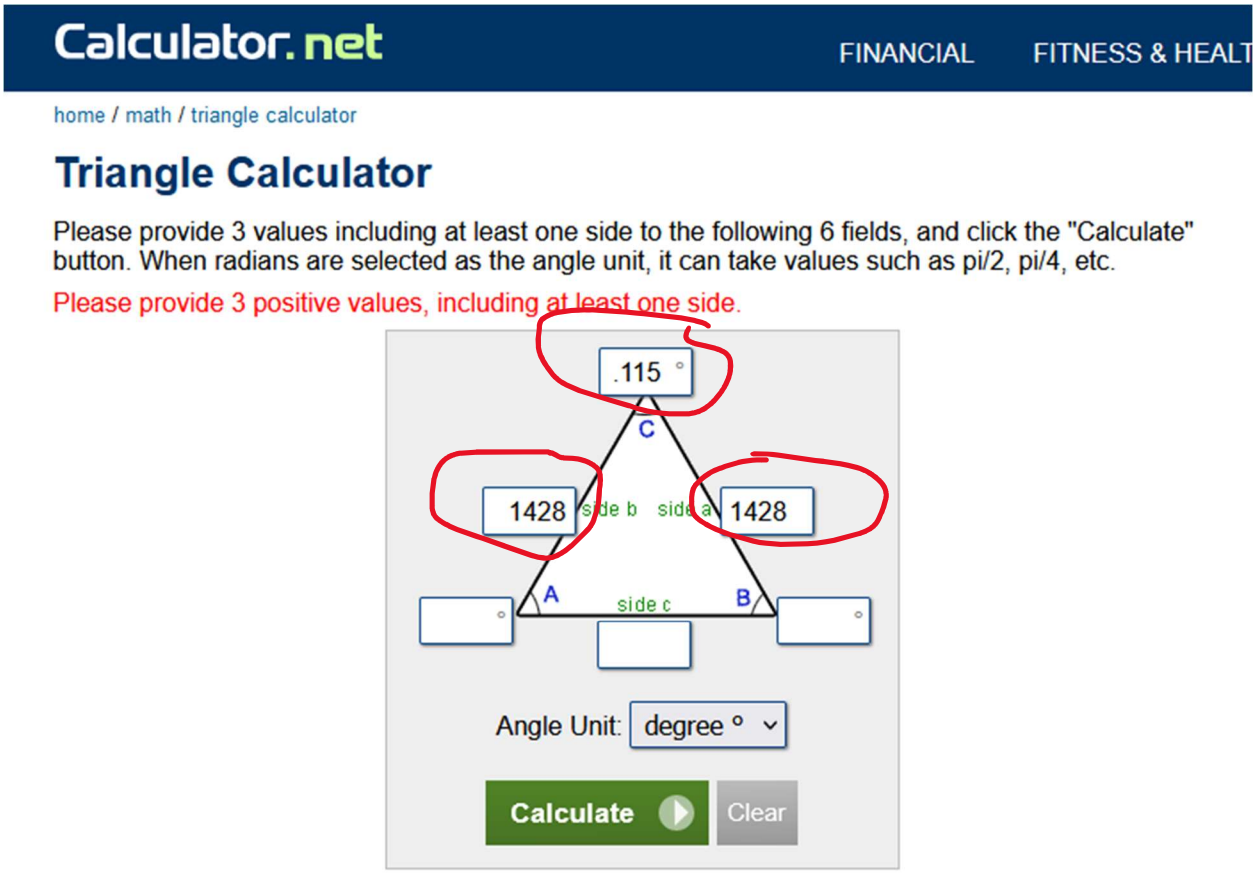
Next you need to measure the distance between your ballscrews, you will need that distance for the trig calculation. You can measure from the outside of your Y1 BK Block (the block in front of the Y1 motor) to the inside of the Y2 BK Block. This will give you the center to center measurement between your ballscrews. Write this number down, you will need it for the calculation. In my case the value was 1248 mm.

Step 5 – Calculate! That's the power of math (and the Interwebs)

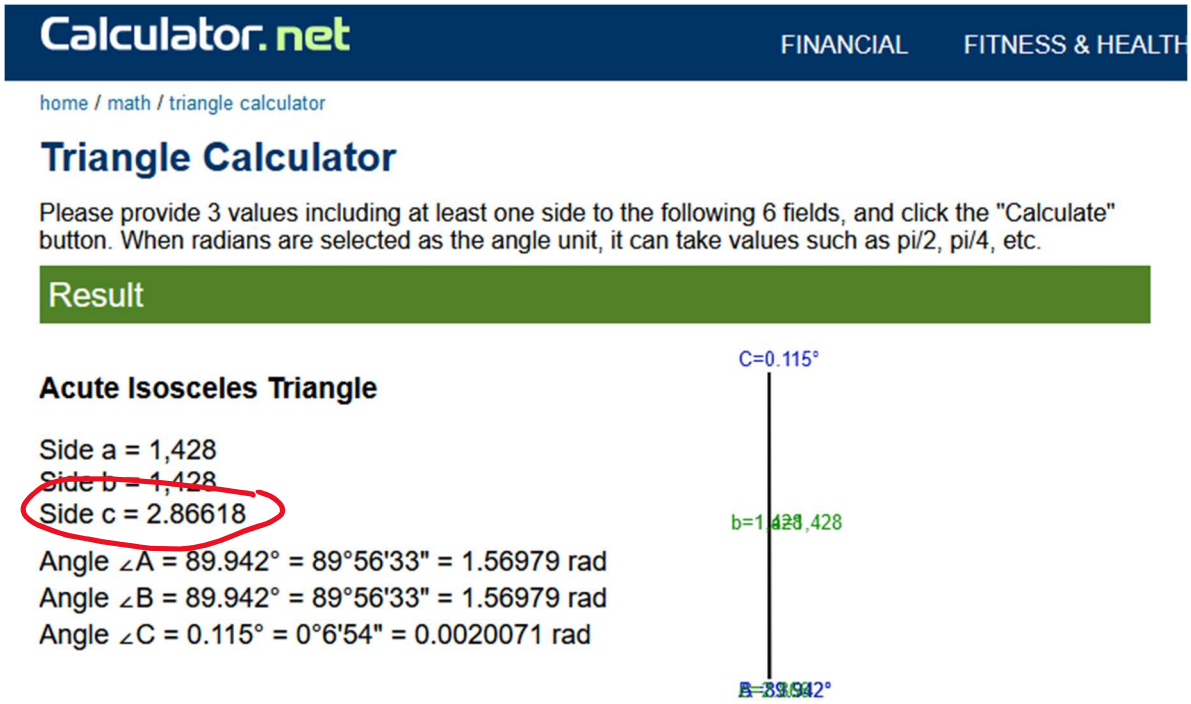
With appropriate credits the ancient greeks and romans, we will now use the power of math (or at least the power of math calculators on the Internet) to determine what our Y2 offset should be to bring the X gantry in to square.

Open the Triangle Calculator here: https://www.calculator.net/triangle-calculator.html

For the the angle 'C' at the top of the triangle, input your angle (.115 degrees in my case, positive values only). Set the values for Side 'A' length and Side 'B' length to be the distance you recorded between the centers of your ballscrews (in my case, 1428mm). It should look like this:



Confirm you values and then press 'Calculate' and record the result for "Side C". Side C is the value you need to apply to your Y offset in order to get the X gantry to square with it. Whether it will be positive or negative depends on which way your gantry is skewed. In my case my Y2 side of my X gantry is slightly further forward than the Y1 side so I need to push it back a bit after homing. My result was Side C = 2.866:



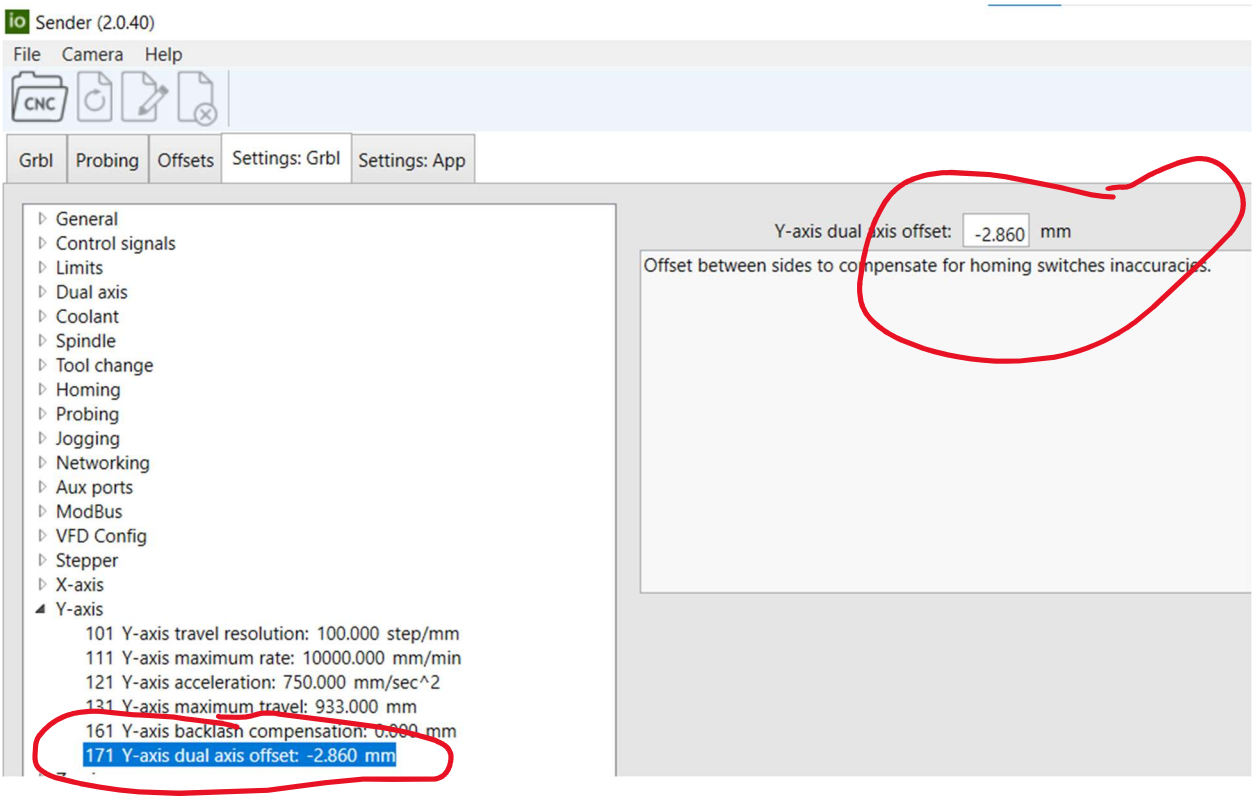
OPTIONAL: If you are feeling magnanimous, now would be a good time to write a quick apology note to your high school math teacher and admit that you now know the answer to "when is anyone ever going to use this?".

Step 6 – Apply the setting to your machine via IOSender

To apply the setting, go back to IOSender and enter the value in your 'grbl Settings' under the Y Axis. You want to update setting $171 – "**Y-axis dual offset"** with the value and the appropriate positive or negative sign based on what skew you observed. I will leave figuring that direction out as an exercise for the reader.

Remember to press "Save" at the bottom to record the change. Note: **This new value will not be applied UNTIL the next homing sequence.** Don't home your machine just yet, just be aware that after all the axis home, the Y2 gantry will be moved forward or backward by this value.

In my case:



CAUTION: Check that nothing is in the way on your machine bed, remove your probe cable if it is still attached and then Home your machine. Watch your Y2 axis and ensure the offset applies at the end of the sequence.

Step 7 – Cut a new pocket offset from the first, and use the probe process to confirm perfection – Heaven!

Switch out your probe for your preferred endmill and cut a fresh pocket identical to, but offset from, the one you made initially in Step 2, but now with your new squared gantry.

Place your reference surface in the new pocket and go back and probe the rear X face as you did previously in Step 3 and record the angle value.

Jog the machine away from the X surface, and then up and over to the a Y face (either works if your reference is square). Watch your speeds, don't snap your probe. Carefully place your probe near your selected Y face of your reference surface. **CAUTION: Remember to update the side you choose to probe in the IOSender Probe screen or you could crash your probe.**

Once you are comfortable it is safe, probe your Y face. Record the value and compare it to your X value. **We are not expecting zero. What we are looking for is for the two values to cancel each other out and equal zero. The individual values do not matter, their sum being zero is the goal.**

In my case my X value was 0.115° and my Y value was -0.115°. Perfect.

Your gantry is now square to your Y axis and you have a repeatable process for maintenance.