Mach3 X Axis Screw Mapping, version 1.1

By R. G. Sparber

Copyleft protects this document.[1]

This article is a continuation of the concepts presented in "Mach3 Z Axis Screw Mapping" which can be found at http://rick.sparber.org/ZSM.pdf.

In theory, mapping one axis should be the same as mapping another. But in reality, I found a whole raft of new problems as I went from the Z axis to the X axis.

For starters, I thought it would be handy to define Home as the table moved all the way to the right. The left end of the table would be lined up with the flank of the apron. It would then be easy to put a flat block across the end of the table and apron to feel when they are lined up.
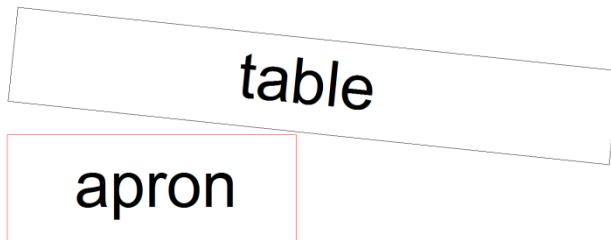
However, I hadn't realize that with the right end of the table over hanging the apron, the left end of the table lifts up from its ways. Not enough movement to see but plenty to cause relatively large random errors in X axis table movement.
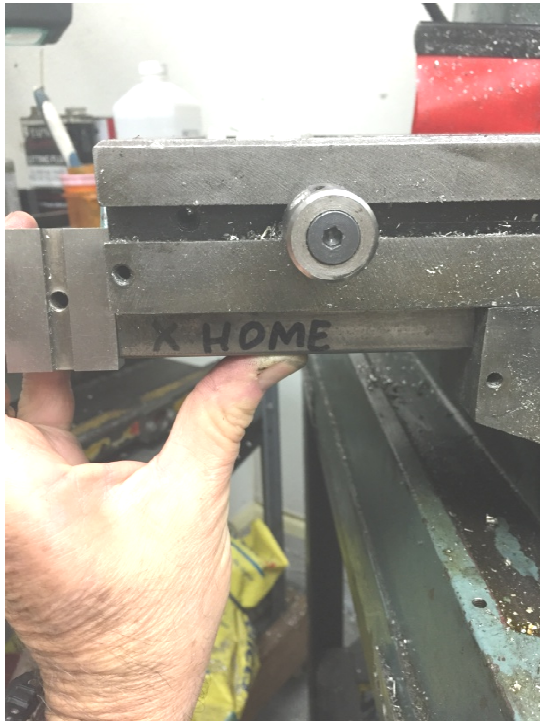
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[1] You are free to distribute this article but not to change it.

| table |
|-------|

apron

The solution I chose was to move the table over so there was a less overhang.

This new Home position needed a reference point. I cut a piece of square tubing, squared and cleaned up the ends to act as my X Home calibration bar.


The X Home calibration bar is held against the table's ways. I'm Home when a block on the end is a snug fit to the flank of the table and the end of the bar.

Normally this is done with one hand holding the bar and block while the other hand is on my jog controls.
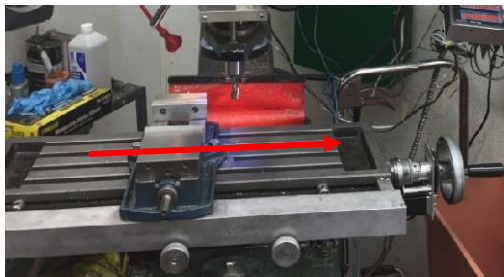

I don't want my X axis backlash error mixing in with my screw mapping so all measurements must be taken after moving in the same direction. I move in a positive X direction.
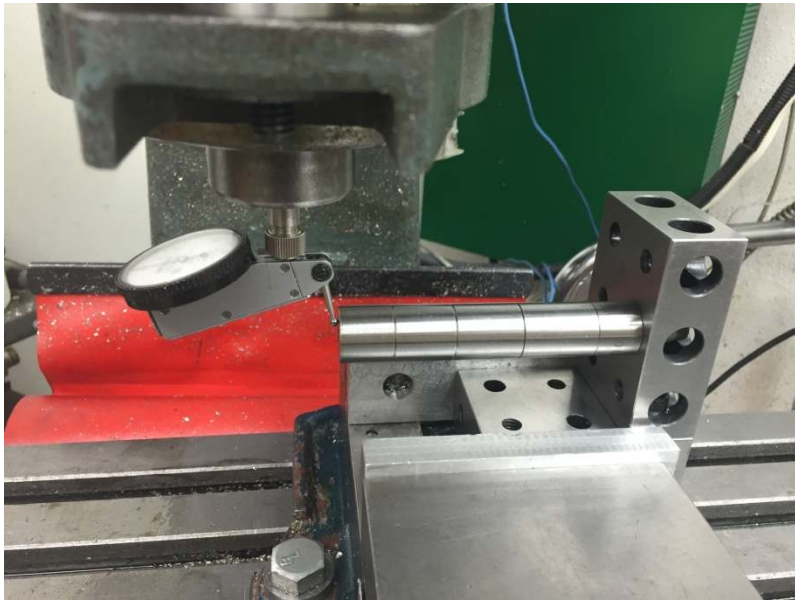
I spent way too much time debugging my spacer set up. The key lessons learned were that I must not bump my Dial Test Indicator (DTI) at all and I must disturb as little of the fixture as possible.

You see two 1-2-3 blocks bolted together and clamped into my vise. My spacers are screwed together and bolted to the face of the vertical block. My DTI 's finger rests on the end of the spacer stack. While the Home calibration bar gets me close, to generate my calibration table and then test it requires more accuracy. Home is defined as the DTI reading 0 when the full stack is present.
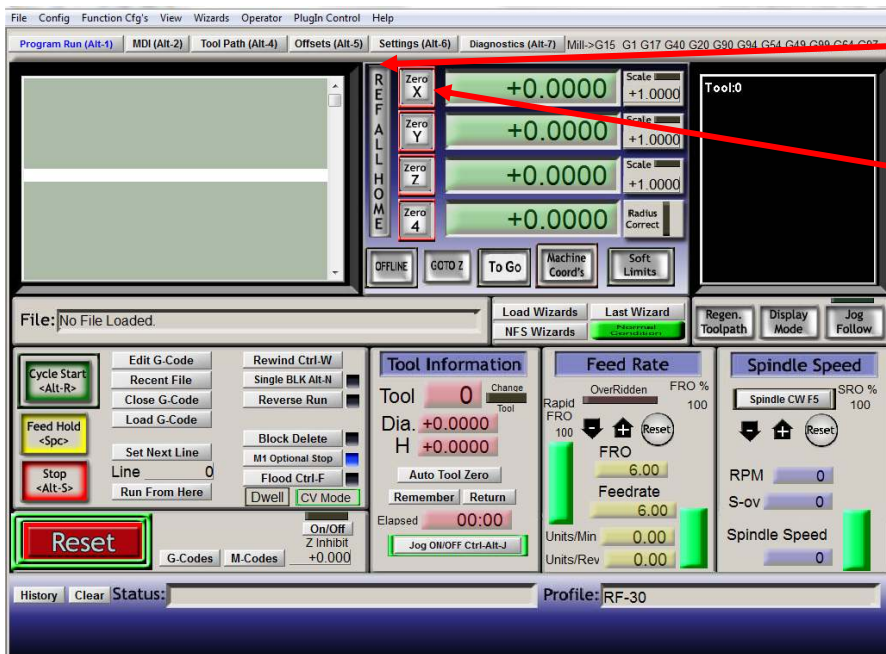

At this position, I press the REF ALL HOME bar to zero X,Y, and Z. Sometimes I must also zero the X DRO output too[2].

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[2] I'm still trying to understand why this second step is occasionally needed.
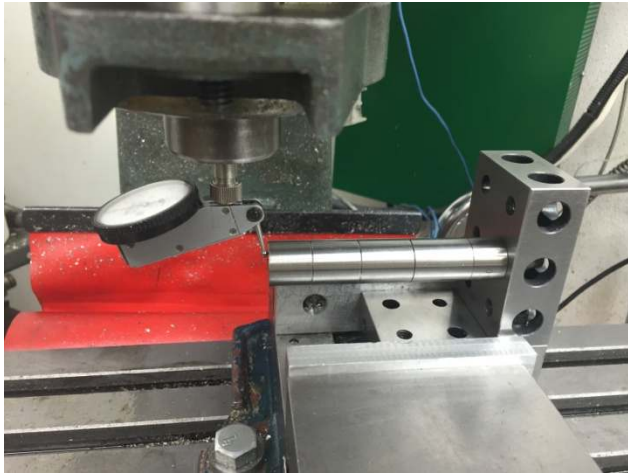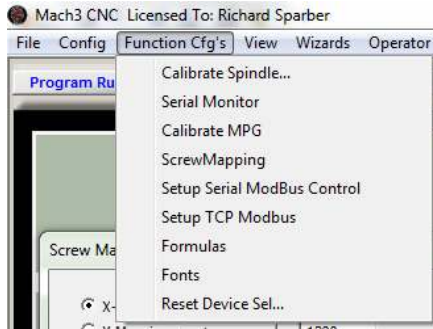
The best way I found to avoid bumping the DTI was to move the table along the Y axis until the finger of the DTI was far from the spacer stack. I could then unscrew spacers safely. Then I move back along the Y axis and over on the X axis until the DTI again reads zero.
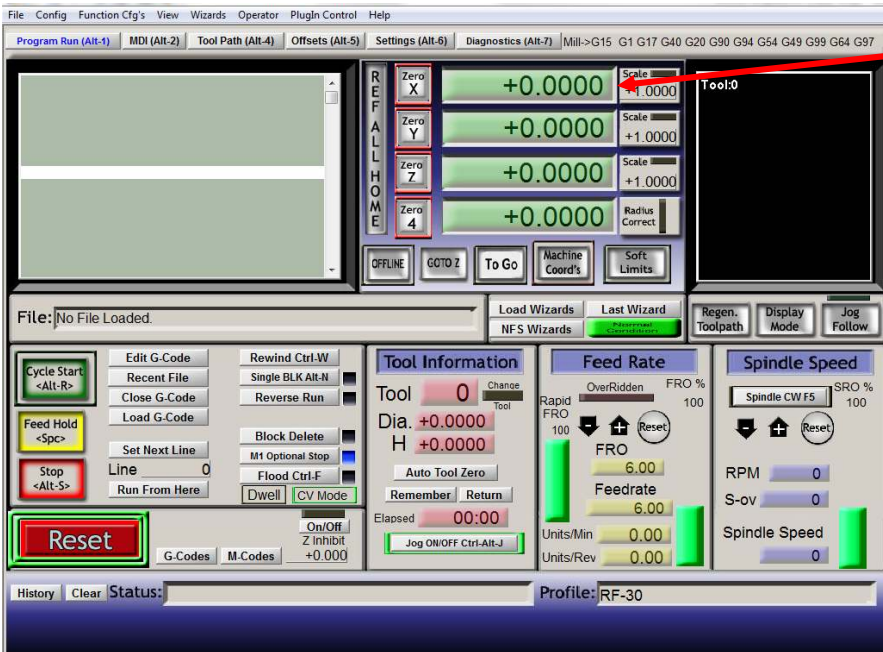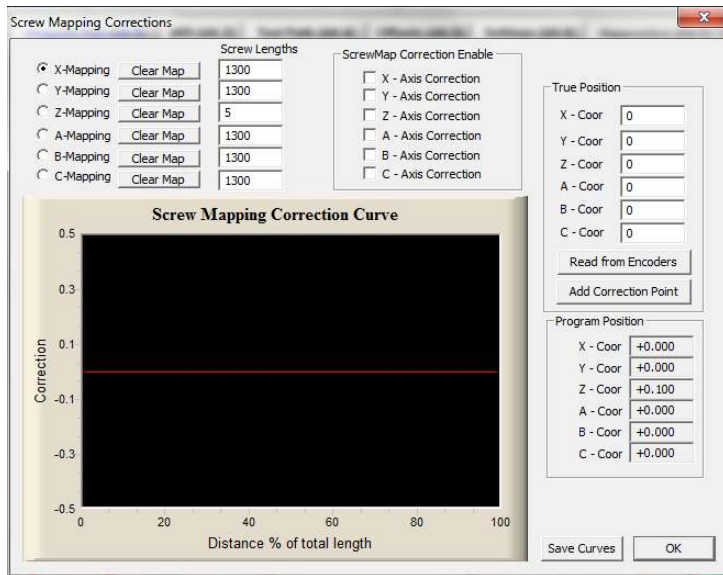

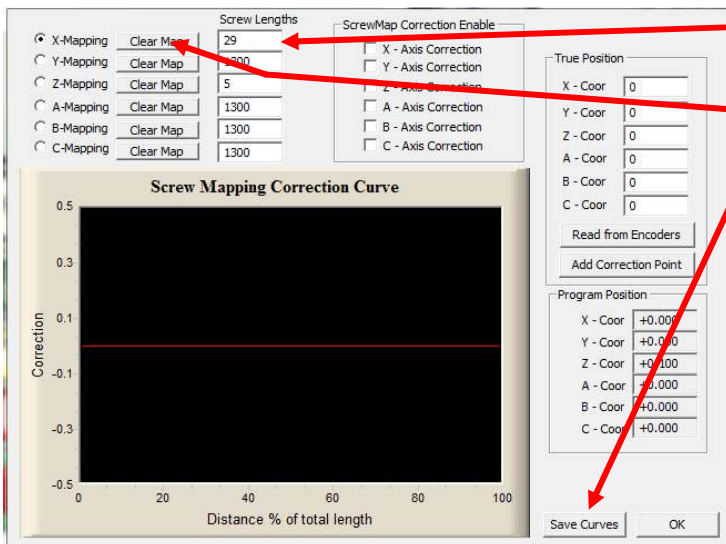When the DTI reads zero, I record the X DRO value.

An X Axis Calibration Run

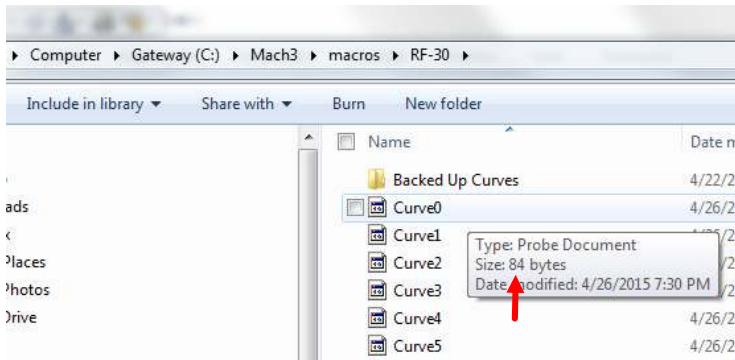Open the ScrewMapping entry from the Function Cfg's menu.

The default data set is X-Mapping which is what we want. Set the screw length. If your system is set up for inches, then the screw length is inches but must be at least 5.


My X axis screw is about 29 inches.

Press Clear Map
and then Save Curves in order to clear the file that holds the X axis mapping data.

Once in a while, this clearing operation does not work so I always go to the file to verify it has been zeroed. Assuming you have done a "normal" install of Mach3, go to C:\Mach3\XX\macros where XX is the name you gave to your set up.

Mine is RF-30. Then hover your cursor over the file Curve0. Here you see it has a size of 84 which means it has not been cleared. A value of 36 means the file is clear.
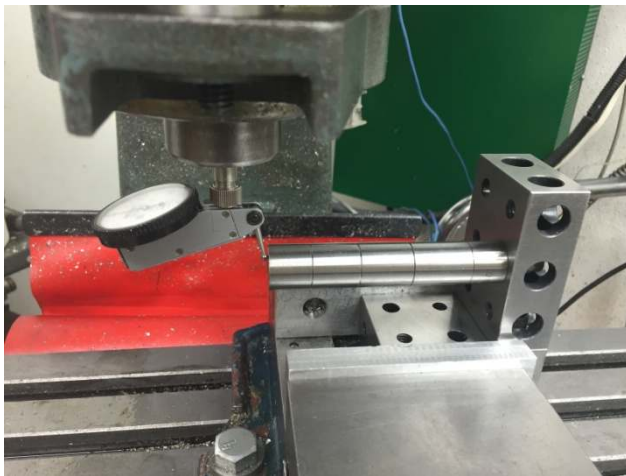
After moving the DTI away from the spacer stack along the Y axis, remove one spacer. I removed a 0.700 inch spacer. Then the DTI it moved back in line with the spacer stack and I jog in a positive direction until the DTI again reads zero. The value in the X DRO is then recorded. Mine was 0.7011 inches. This means Mach3 thinks it moved 1.1 thou more than it actually did. Using equation (1) from the Z axis memo updated for the X axis,

$$\textbf{True Position X Corr} = \textbf{2} \times \textbf{X DRO} - \textbf{Actual} \qquad (1')$$

$$\textbf{True Position X Corr} = \textbf{2} \times \textbf{0.7011} - \textbf{0.7000}$$
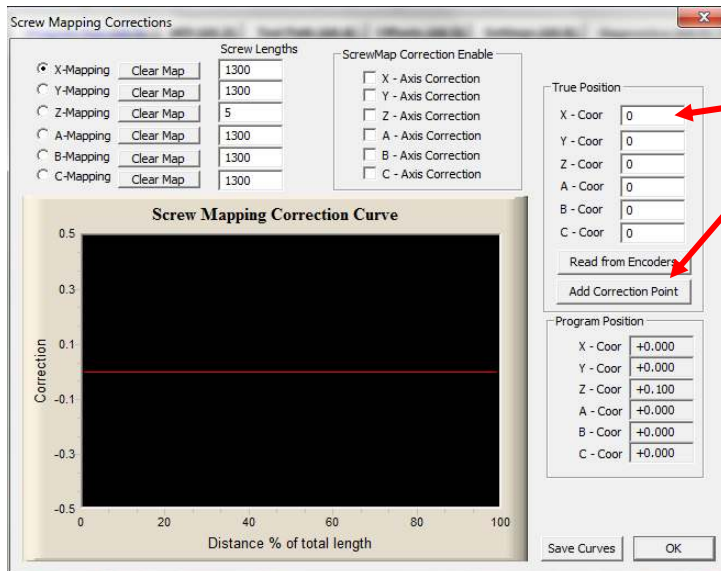
Rounded to three places to the right of the decimal, I get 0.702. It is entered at True Position X-Coor.

Then press Add Correction Point.

Warning: Do not press Add Correction Point when at Home. It will trash the file and require you to clear it out and start over.

Warning: Do not press either X axis jog key on the keyboard while in this window. At best it may crash Mach3 and require a program restart. At worst you will have to power cycle the PC and then reinstall Mach3.

Warning: If you enter two calibration points at almost the same X value, you may cause the problem explained in the Z axis article. The only way to recover from this error is to clear out all data and start over.
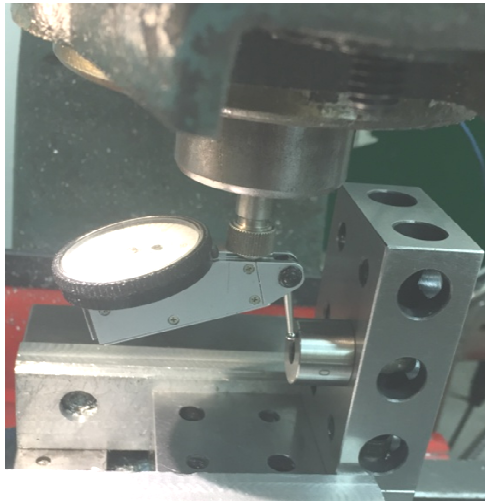
When you are done entering calibration points, press the Save Curves button and then OK.
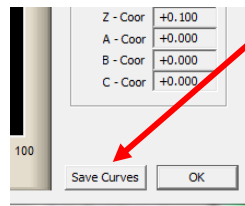
You can go back to the Curve0 file and check the number of data points recorded. Each data point uses 16 bytes so

$$number\ of\ data\ points = \frac{bytes\ displayed - 36}{16} \qquad (2)$$

For example, if the file contained 100 bytes, then $\frac{100-36}{16} = 4\ data\ points$.
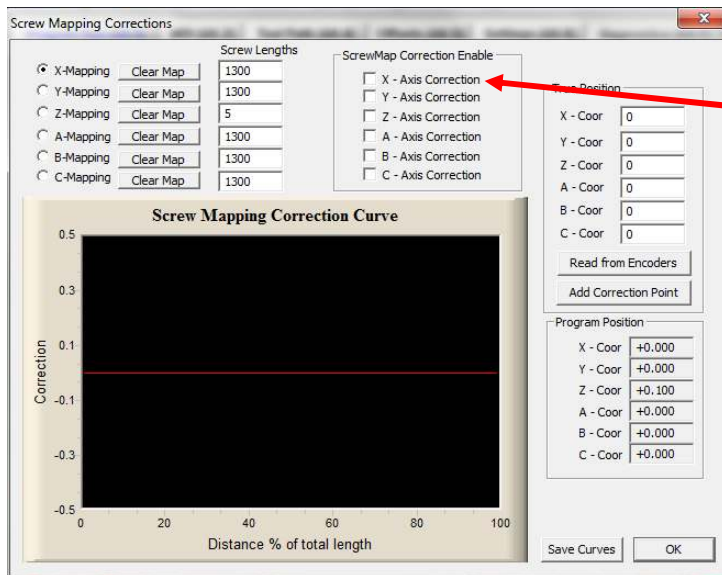
Using The Screw Mapping Data

Before enabling Screw Mapping, move back to Home. Be careful to move to Home in the same direction as used when collecting mapping data. Arrive at Home before enabling Screw Mapping.
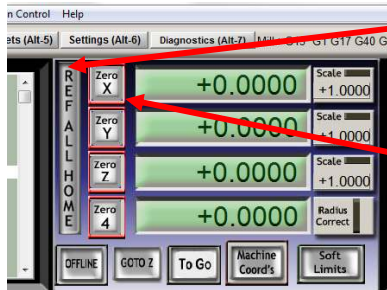
If needed, press REF ALL HOME to zero the Machine Coordinates.

Press Zero X if the X DRO is not zero. You are now at Home and ready to use the Screw Mapping data.

Go back to the Screw Mapping Corrections window and click on ScrewMap Correction Enable, X-Axis Correction. Then press OK.

Warning: When Screw Mapping is active, you cannot move to X axis values less than zero. Attempting to move past zero in a negative direction will cause you to move in a positive direction and possibly lose position.

Shop Data

Spacer Block	X DRO value	calculated value	error (spacer block - X DRO) in thou	X DRO/Spacer
none	set to 0	warning: do not enter any value	n/a	
0.7000	0.7011	0.702	-1.1	1.0016
1.5000	1.5021	1.504	-2.1	1.0014
2.4000	2.4032	2.406	-3.2	1.0013
3.4000	3.4042	3.408	-4.2	1.0012
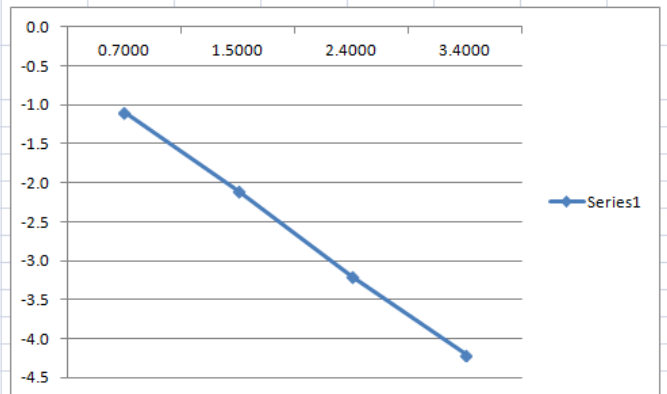
This data was taken around the center of my table where my vise sits. The graph is almost a straight line which implies that a small change in Steps Per [inch] could be used in place of screw mapping. But look at the last column in the spreadsheet (X DRO/Spacer). You can see my calculated gain which varies in the fourth place. If the gain was constant, it could be fixed with a simple Steps Per [inch] change.

Calibration Enabled

Spacer Block	DTI value in thou	spacer + DTI value	spacer+DTI value/Spacer
none	set to 0		
0.7000	-0.2	0.6998	0.9997
1.5000	-0.2	1.4998	0.9999
2.4000	-0.3	2.3997	0.9999
3.4000	-0.5	3.3995	0.9999
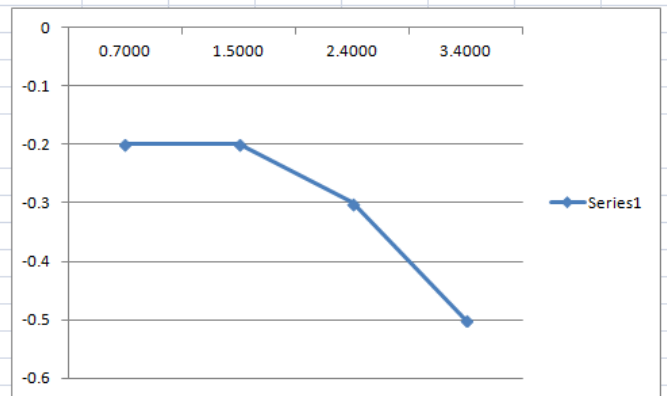
Here is what happens when Screw Mapping is enabled. The gain value is 0.9997 at one data point but the rest are at 0.9999. In absolute terms, the worst case error went from -4.2 thou down to -0.5 thou, an improvement by a factor of 8.4.

The error is not centered around zero which implies there was a shift in Home. If the error was centered, we would see ± 0.25 thou.

Do understand that all of these tests were run with the machine off. Different forces come into play during the cutting of metal. But if the static behavior is off, the dynamic behavior can't be any better. When I have calibrated my Y axis, I can begin XYZ dynamic behavior testing.

More Shop Data

I was contacted by Dan Asper who was able to follow my procedure.
Dan has a ball screw on his X axis. He also had access to a laser measuring instrument which was accurate to better than ± 0.00001 inches.

His data showed an X axis DRO error offset of -0.0009 inches. Subtracting this constant error from the error at each point, we see the variation in error which cannot be handled by a simple adjustment in steps per inch during motor tuning.
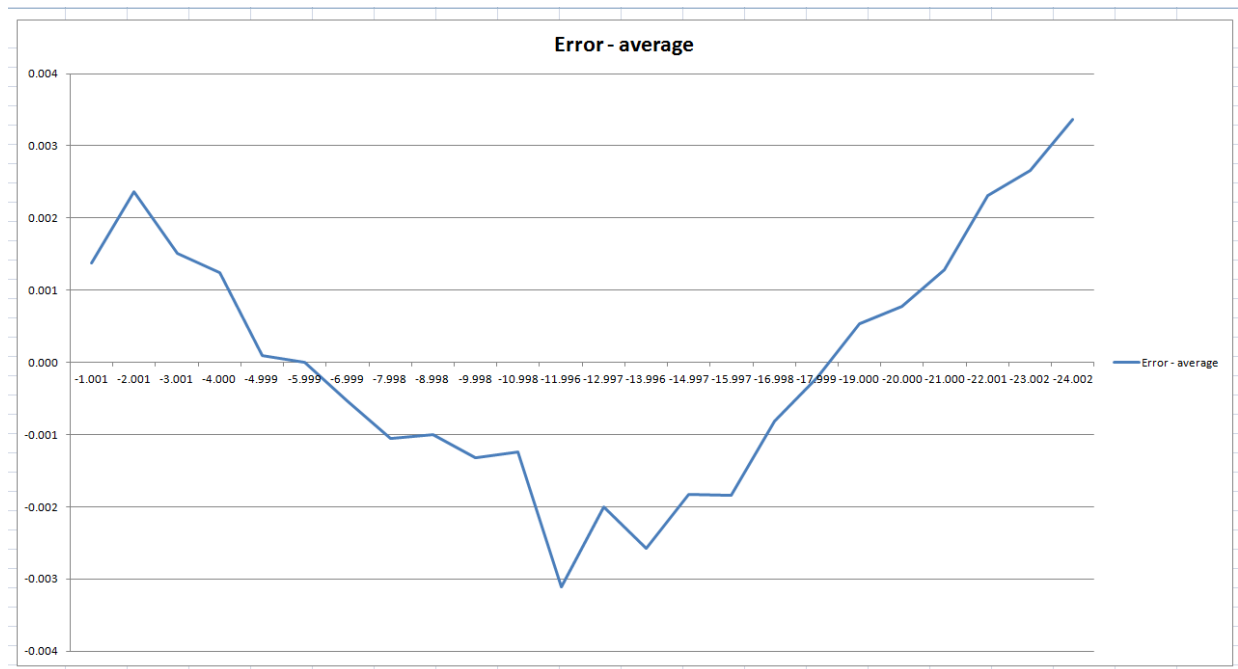
The error varies by ±0.003 inches.

After calibration this error was brought down by almost a factor of ten to ± 0.0004 inches. Nicely done Dan!

Acknowledgments

Thanks to Dan Asper for sending me his experience with Mach3 screw mapping.

I welcome your comments and questions.

If you wish to be contacted each time I publish an article, email me with just "Article Alias" in the subject line.

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