XoomSpeed PathPilot/Fusion 360 integrated probing

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About this document

This document describes the installation and operation of XoomSpeed's integrated probing routines for Fusion 360 and PathPilot. Fusion 360 provides 19 different probing functions. These subroutines implement 17 of them – the exceptions being the ones that deal with axis rotation. If you try to use the axis rotation probing routines, you will get an error from the post processor and no code will be generated.

For detailed information of the individual probing routines, please consult the Fusion 360 documentation.

Licence

The code in this download is free and I am happy to donate it to the machining community and hope that you enjoy using it.

I do hope that you will realise that there's a non-trivial amount of effort involved in creating something like this, so if you would like to make a donation to support the ongoing support and development, then by all means send such donations via PayPal to david.loomes@ntlworld.com. I'm not suggesting any minimum – or maximum – amount, rather I'd like you to decide what it's worth to you.

Whatever you decide, please do post your experiences either to the 'Tormach Operators' group on Facebook or to the 'XoomSpeed' page on the same platform. Whilst I obviously don't guarantee to incorporate every suggestion, I don't believe I have a monopoly on good ideas, so am always interested to hear what you think.

Download contents

The files included in the download are as follows.

- **ProbeTesting.f3d** A Fusion 360 model that includes examples of all the probing routines supported by this download. This is intended to be 3d printed to produce a model on which you can test your probe. There's one setup in the 'Manufacturing' tab and if you post that, you should be able to run all the probing routines. To do it, start by setting your G54 origin to the top surface of the model and the bottom left corner. When the code runs, each operation will update part of G55 and at the end, you should be able to check that G55 coordinates are very close to G54. G54 will be unchanged.
- **PPWithProbing.cps** A Fusion 360 post processor. This is based on the most recent (at Feb '19) PathPilot post processor with additions to support the probing functions.
- **Subroutines*.ngc** G-code subroutines that perform the probing.

Installing the probing functions

The ngc files are installed simply by copying them to the 'subroutines' folder in PathPilot. Place the ngc files on a USB memory stick and use the 'Files' tab in PathPilot to copy them from the USB to the subroutines folder. There's no further installation required and they should survive any future PathPilot updates.

The Fusion Post is just as easy. Place it on your computer's hard disk in the same folder as all your other POSTs and it will automatically appear on your post list. Fusion360 will generally remember the last POST you used, so you should only have to do this once.

To use the probing functions within Fusion 360, you'll have to define a probe tool in your tool library. This should be of type 'Probe', should be marked as 'non-live' so the spindle stays off (!) and should have the tool diameter set to the nominal tip diameter e.g. 3mm. It's not necessary to set the exact diameter here as this value is used only to get the probe to the correct clearance distance before starting to probe and not to calculate the exact location of any probe results. Since PathPilot insists that the probe should be tool 99 to use the built in probing routines, your Fusion 360 library entry should also be set to tool 99 on the 'Post Processor' tab of the tool properties.

In PathPilot, you probably already have the probe defined as tool 99. The important thing here is that whilst Fusion 360 only requires the nominal diameter of the probe tip, in the PathPilot tool table, you need to enter the accurate, effective diameter of the probe. There are various ways of determining this, but I tend to favour probing both sides of a piece of known thickness metal – a parallel perhaps – and adjusting the tool table's tool diameter entry until the probe's measurement of the parallel's thickness matches what you get with a micrometer. This value will generally be slightly smaller than the nominal tip diameter because the shaft of the probe will inevitably flex a little before the probe trips. Don't be surprised if this turns out to be as much as 0.002" smaller than the nominal size.

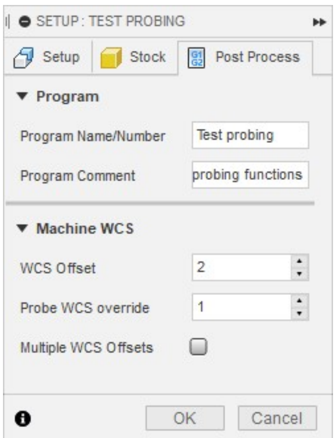
That's all there is to it. Once you've done that, you're ready to go.

Fusion 360's probing routines

Parameters from your manufacturing Setup

Post Process tab

This is where the 'magic' takes place. To get the probing routines to work, you have to specify two separate WCSs instead of the usual one.



In the above example, the WCS offset is set to 2, so all the machining operations will be output using G55. The probe WCS override is set to 1, so all the probing operations will take place using G54. It is possible to use the same WCS for both functions, but that would be missing the point.

To run the final program, the operator should set up G54's origin as he or she would normally do were the program running in G54. The difference is that there's generally no need to be as accurate as normal as the G54 origin only has to be accurate enough to allow the probing routines to find the intended features given the values of **clearance** and **over travel**. The probing routines will then adjust G55 to be as accurate as possible and the machining operations run in the corrected G55.

The thing that's very different from normal, manual probing is that the WCS origin is not moved to the location found by the probe. Instead the G55 origin will be adjusted so that in G55, the probed feature has the coordinates it should have had in G54 if only G54 had been perfectly setup. If, for example, you probe in x for a feature that should be at x=10 and you actually find it at x=10.01, then the probing function will move G55's origin to be 0.01 to the right of G54's origin. That means that if you now switch to G55, the feature will be exactly at x=10. This is quite a lot different to the way probes are used manually and it opens up a lot of different approaches to aligning the WCS prior to machining.

This then is the main reason behind integrated probing. It allows the 1st WCS (G54 origin in this case) to be set pretty roughly and then the automated probing routines adjust the 2nd WCS (G55) to make up for the inaccuracy. This is particularly useful when making multiple parts held for example in a vise. Instead of the operator having to probe each part manually, the G54 origin is set once at the start and automatic probing takes care of any inaccuracies in loading each piece of stock into the vise.

There are other, more exotic uses for automated probing, but this is probably the most common.

Parameters common to each probing operation

All of Fusion's probing functions share the following parameters and there's little, if any, variation in the way they're interpreted in use.

Height Tab

- **Clearance Height**. This is the height to which Fusion 360 rapid (G0) moves before and after the rest of the probing operation runs. Like every other operation in Fusion, it should be well above any fixtures you may be using.
- **Retract Height**. When Fusion 360 calls the probing sub routines, the probe will rapid down to this height. At the end, the probing routines will rapid back to this height. All movements below this height are protected by the action of the probe and will stop and abort if unexpected contact is made. How low you make this above the work is a matter of confidence. Once you're used to it, I find 10mm above the top of the stock isn't a bad setting. To start with, using 50mm is probably wise.
- **Bottom Height**. The height at which the probing moves will be made.

Geometry Tab

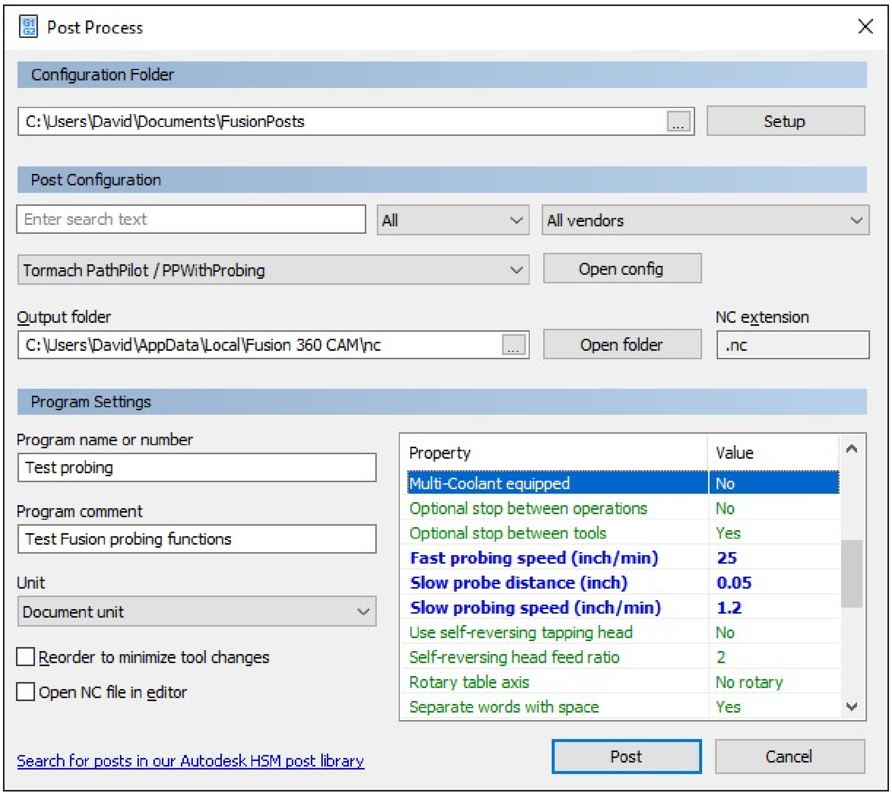
- **Clearance**. The distance away from the surface(s) being probed where the probing operation (G38.2) starts. For the z-axis probe, this is obviously the height above the surface whereas in all the other cases it's the lateral distance away from a wall.
- **Over travel**. The distance past the expected contact point that the probing operation is permitted to travel without detecting the intended contact. If the move reaches this point without making contact, then the program will abort with an error message printed to the status screen.

Tool Tab

- **Lead-in feed rate**. This is the feed rate used to get from the retract height down to the bottom height and then to a distance **clearance** from the feature being probed. All moves at this feed rate are protected by the probe (G38.3). If any of these moves stops because the probe made contact, then the program will abort with a message to the status screen. This feed rate should be set slow enough that if the probe hits something unexpected, the table has time to stop before the probe tip breaks.

Additional parameters in the POST

There are 3 parameters the probing routines need beyond those provided by Fusion 360 and these have been added to the Fusion 360 POST properties that you can see just before the code is output. You can see them highlighted in blue in the following picture. These values are always entered in inches and inches/minute irrespective of the units chosen for output to the mill. Any conversion required will be added automatically.



- **Fast probing speed**. The first part of every probe is always done at this speed. It can be chosen to give a probing error of 0.010" or more. With the Tormach passive probe converted to wireless operation, values of 20"/minute or even higher are perfectly acceptable.

- **Slow probing speed**. After the fast probing, the probing routines perform a second, much slower probe to determine the exact position of the feature being probed. Here we are looking for a speed that allows the ultimate probe accuracy to be realised. For the Tormach passive probe, 1"/minute is ideal. If you use the XoomSpeed wireless conversion for the passive probe, the slow probing speed should not be higher than 1"/minute or you may find that the wireless link latency starts to affect the accuracy of the probe results. At a rate of 1"/minute there's no noticeable difference between the wired and wireless cases.
- **Slow probing distance**. After the fast probe, the system moves the probe away by this distance before performing the slow probe. 0.040" or even less is typical.

Typical probing operation

To help get an understanding of how all the above parameters interact, here's a description of all the moves that make up a complete probe operation. I've chosen to describe the 'x-channel' operation that probes across the width of a channel oriented parallel to the y-axis and finds the x-coordinate of the centre of the channel. The other probing operations are made up from the same building blocks.

1. Fusion outputs G0 commands to move the probe to the **clearance height** above where it expects to find the centre of the channel.
2. The Fusion generated code then calls the g-code subroutine f360_probing-x-channel
3. The subroutine rapids down to the **retract height**.
4. G38.3 is used to move the probe at the **lead-in feed rate** down to the **bottom height** and then across in the +ve x direction until the edge of the probe is **clearance** away from the expected position of the channel wall. The nominal probe diameter from Fusion's tool library is used to calculate this position. Any probe contact during this move results in the motion stopping and the program terminating with a message left on the status screen.
5. G38.2 is then used at **Fast probing speed** to find the wall. The maximum travel allowed is **clearance** + **over travel**. If the wall is not found, then the program terminates.
6. Assuming the wall was found successfully, the probe then rapids away from the wall a distance of **Slow probe distance**.
7. The wall is G38.2 probed again, this time at a speed of **Slow probing speed**. The maximum allowed length of this move is 2 * **Slow probe distance**.
8. The exact position of the wall is calculated using the x-coordinate at the probe contact point and the accurate probe tip diameter from PathPilot's tool table.
9. Now that the first wall has been located, the probe rapids back to the centre of the channel. This move is over ground that has previously been checked by the probe and is known to be empty, so it's safe to use G0.
10. Steps 4 through 9 are repeated in the –ve x direction to determine the position of the other wall.
11. Finally the probe rapids back up to the retract height and the probing subroutine exits back to the code generated by Fusion360.