Introduction to CNC for a Total Novice

Part of a series by Graham Bland

Making a Spoilboard

Contents

Changes from V2.0

- Changes made to add the SainSmart Genmitsu 3018-PROVer.
- *Yes I know the first version was for a 'Universal Spoilboard', that was true but only for the Spoilboards then in my universe. A few changes to the model were needed to cope with routers which have an asymmetric cutting area relative to the bed. I am no longer calling the earlier versions Universal!* *But I am not renaming them.*
- Spindle speeds increased to 10,000 to accommodate the increased spindle speed of the PROVer and to make it more realistic for the PRO (if you have a PRO with a max speed set to 1000 this will still be Maximum Speed)
- Extra .nc files for the standard 3018-PROVer as well as the 30180-PRO.
- Positioning for facing and engraving modified to take account of the travel being reduced by limit switches on the PROVer with updated .nc files
- WCS Coordinates changed for easier use.
- Standard slot width increased from 5.5mm to 6mm, experience shows me that 5.5mm can be a bit tight.
- Updated and expanded due to learning and understanding more as I progress.

Introduction

If you are a novice this is for you, if not then there may be bits of interest, if you know what you are doing any comments would be welcome!

A while ago I decided to take the plunge and I purchased a SainSmart Genimitsu 3018-PRO with a 2.5W 450nm Laser module and a full set of bits from SainSmart. I later upgraded to a 5.5W 450nm Laser and added a SainSmart Genimitsu 3018-PROVer with a 5.5W 450nm Laser.

Both use the Grbl System. This refers and applies to both, any specifics for the PRO or PROVer are identified as appropriate. A lot of the principles and examples apply to other models as yours may be different.

But I do hope this series is useful for anyone using any hobbyist CNC router for the first time.

PLEASE, PLEASE IF YOU HAVE ANY COMMENTS, FIND ANY ERRORS OR IF IT JUST DOESN'T WORK ON YOUR MACHINE LET ME KNOW! Graham Bland at the Facebook Page SainSmart Genmitsu CNC Users Group. PM or public post as you prefer.

I am using free to use software here by preference (Apart from Windows of course). *NOTE: I mean free to use for me as a non commercial hobbyist, for example I am using Autodesk Fusion360 and have a free licence as long as I don't try and make any money out of it, that's fine as a full licence would be hundreds of pounds a year and it's a hobby.* Any software which has a free version and a subscription version, well I am referring to the free one unless specified.

I am producing this as a document, mainly because it is an edited series of notes I made, partly because I am tired of watching instructional videos on YouTube which play at Mach 2 and so I am constantly stopping, rewinding and re-watching. *Also I have been told I have a body made for Radio, a voice most suited to the Deaf and I still haven't worked out how to use the video camera on my phone properly.*

Disclaimer

Yeah nowadays it has to be included, and it makes sense as I accept NO liability for anything I may say, write or think.

1. I am a total novice (or was when I started out). **I MAKE NO CLAIM THAT ANYTHING I SAY IS CORRECT!** All this is based on searching the Internet, forum comments.... and my own experiences.
2. The SainSmart Genmitsu 3018-PROVer was provided by SainSmart for me to review.
3. If you have and are using a Laser module, even the lowest powered is powerful enough to destroy your vision completely, and that of any pets, children, spectators etc. **SO EXCLUDE THEM AND USE THE GOGGLES!**
4. These are power tools, sharp pieces of metal designed to cut things while rotating at high speed and throwing small bits away also at high speed. **Keep everybody's fingers out!** A wood chip flying up your nose is nothing to be sneezed at, never mind in one of your eyes.
5. Take account of the materials you are using and take adequate precautions, dust and ashes can be harmful.
6. I work in mm. Why anyone still uses inches for design work is a mystery. *But then I still think of temperatures in Fahrenheit, anything beyond 500m in miles and property plot sizes in acres!*
7. I have been told by lots of people that my sense of humour is at the least a bit strange. I do not apologise for it.
8. Any corrections, clarifications or discussion welcome. You can find me on the Facebook SainSmart Genmitsu CNC Routers Group as Graham Bland. https://www.facebook.com/groups/SainSmart.GenmitsuCNC/

Accompanying files

NOTE: Facebook has a problem, it will not allow compressed (.zip, .gz, ...) to be uploaded to the Files section of any group, but it bases this decision solely on the file extension, not the contents.

It is easy to bypass this by changing the file extension before uploading, I use .zip files, and rename them to .zipp This means that after downloading you will have to reverse this by renaming any xx.zipp file to xx.zip, windows will issue warnings that you are probably going to make the file unusable, just ignore it and rename anyway. Then you can open the .zip file and extract the files as you wish.

So you there will be 2 versions in the files section. One an xx.pdf which is this document, and an xx.zipp including the xx.pdf and everything else.

There are other guides available in my Introduction to CNC for a total novice series, these are all available in the files section of the SainSmart Genmitsu CNC Users Group on Facebook.

Accompanying files are:

Universal Spoilboard.f3d	Archive file of the complete Fusion 360 model.
Universal Spoilboard.dxf	Archive file of the complete Fusion 360 model exported as a dxf file.
Spoilboard-Cut Slots.nc	GCode to cut 4 slots 6mm wide with a centre section of 80mm on one edge of a 6mm thick 300x180mm Spoilboard with 1mm cut-through using a 3.175mm 2 flute router bit.
Spoilboard-CutSlots-Setup.html	Setup sheet from Fusion 360 for the Spoilboard-CutSlots.nc operation.
Spoilboard-Face-PRO.nc	GCode to face by 0.2mm a 300x180mm Spoilboard using a 13mm Facing bit with alignment for a PRO.
Spoilboard-Face-PRO-Setup.html	Setup sheet from Fusion 360 for the Spoilboard-Face-PRO.nc operation.
Spoilboard-Engrave-PRO.nc	GCode to engrave an XY grid on a faced Spoilboard mounted on a PRO to allow easy alignment of the stock, using a 20degree VBit.
Spoilboard-Engrave-PRO-Setup.html	Setup sheet from Fusion 360 for the Spoilboard-Engrave-PRO.nc operation.
Spoilboard-Face-PROVer.nc	GCode to face by 0.2mm a 300x180mm Spoilboard using a 25mm Facing bit with alignment for a PROVer.
Spoilboard-Face-PROVer-Setup.html	Setup sheet from Fusion 360 for the Spoilboard-Face-PROVer.nc operation.
Spoilboard-Engrave-PROVer.nc	GCode to engrave an XY grid on a faced Spoilboard mounted on a PROVer to allow easy alignment of the stock, using a 20degree VBit.
Spoilboard-Engrave-PROVer-Setup.html	Setup sheet from Fusion 360 for the Spoilboard-Engrave-PROVer.nc operation.

What this covers (supposedly)

The advantages of using a Spoilboard and how to make one using pre-cut material and the same router as it is to be used on to machine it.

- Making a simple slotted Spoilboard from MDF on the router
- Fastening down using the Blue Tape technique
- Facing the Spoilboard.
- Engraving the Spoilboard
- Notes on the Fusion360 model

My Fusion 360 model uses parametric modelling (basically instead of using dimensions and fixed values use parameters which can easily be changed and to which the model automatically adjusts) so it can be simply adjusted to make pretty much any Spoilboard, just change a couple of parameters and the model will automatically adjust, the only thing you will need to do is to regenerate the tool paths and export the GCode.

What is a Spoilboard/ Baseboard / Wasteboard

A bit of sacrificial material mounted on top of the bed, levelled and underneath the stock. Baseboard, Wasteboard and Spoilboard are just synonyms. Here I will use Spoilboard.

Why use one?

There are a number of reasons, in summary they are:

- Protecting the machine and the bits.
- Providing a totally level surface.
- Making alignment of your stock easier.

Protection

If you are trying to cut completely through the stock without a Spoilboard of some sort you are going to start cutting the nice shiny Aluminium Bed. And if you are using a bit to cut through wood it is suddenly going to make contact with a piece of Aluminium which is a lot harder and probably won't like it. It will get blunted and possibly break to say nothing of what it will do to the bed!

Using a laser to cut a paper stencil means the ideal material will be resistant to laser cutting so it doesn't start to burn and so set the paper on fire.

I bet your parents told you to always use protection!

Level surface

It is very important that the bit or laser is absolutely parallel to the surface of the stock. Imagine if you are engraving using a V bit with a 0.75mm depth of cut and the right hand side of your stock is 1mm lower than the left. This would mean that if you started on the left by the time you got to the right the bit would not even be touching the surface!

Using a Spoilboard mounted permanently and securely means you can use a bit to slightly trim or face the surface. This means even if the level of the bed is slightly out of alignment with the spindle or laser the top of the Spoilboard will not be, as long as it is securely mounted of course.

Stock Alignment

Not only will the bed of your machine not be totally level the edges and the lines of the slots will be slightly out of alignment with the spindle motion as well, not a lot but a little.

Fitting a Spoilboard means you can then engrave it with totally accurate lines.

Options

Get the setup exact in the first place

This would avoid the surfacing and engraving operations, but it would take a very long time!

If the bed is 1mm out left to right the angle is 0.3 degrees so put away the spirit level, and it has to be level relative to the spindle motion..... Also this doesn't address the 'I need to cut totally through the stock' problem or it happening unintentionally.

Strips

Attach pre-cut strips of the correct size to the flat bits on the top of the bed leaving the slots exposed. This will work quite well; it would just need levelling and optionally engraving.

No Slots

A board possibly with holes drilled and a captive nut mounted to allow the use of clamps secured into the holes or just use painters tape and superglue or double sided tape to secure the stock. This will also work quite well, some examples I have seen with holes and captive nuts look amazing, but it would be lot of effort.

Slotted board

A solid board but with slots cut at each edge to allow the clamps to be placed in the slots. This works very well and is the best idea because I thought of it *(maybe)*.

The slotted board solution is the one I will describe here but the methods of facing and engraving apply to all solutions.

Size, especially depth of the Spoilboard, is important!

The 3018's don't have a massive amount of vertical movement; only about 44mm, out of the box the PROVer has a bit less. So using a 30mm thick Spoilboard would work but could be very limiting. On the other hand something 1mm thick may not be enough, it needs to be thick enough to absorb the damage you foresee inflicting on it. You can compensate for the thickness of a Spoilboard by changing how high you mount the Laser or spindle in the mount of course.

Also the composition is important, when using a router bits a soft base board is good, if you try steel for example it will last longer but you will break a lot of bits if you try to cut into it, never mind trying to face it.

In laser cutting one of the main considerations is the ease of burning. On my first attempts I was using a bit of old scrap pine underneath paper and cardboard, but as soon as the laser cut through the paper sometimes the wood would start to char and set fire to the paper! Not good.

It's really all that simple. (*Coughing fit!*)

Making a Spoilboard

Well I have experimented, I am not going to describe the results of all my mistakes, but let's just say this is the fruits of those experiments.

In summary what do I need from a Spoilboard:

- Cheap, I do expect to have to replace it fairly often.
- Firm enough to allow things to be clamped down or attached to it in other ways.
- Soft enough so that when it is cut it won't affect the operation much.
- It can be made from pre cut stock using my router (3018-PRO and 3018-PROVer).
- Ideally not very toxic when cut or burnt with a laser.

- Thick enough to take the abuse but thin enough to give a decent Z axis movement.
- Allows me to use the clamps flexibly to secure the stock and allow other methods as well.

Well you can't have everything! So I decided on MDF, fits all the criteria apart from the toxicity bit but I'm not going to cut it a lot and can open the windows when using a laser.

I selected a small sheet of 6mm thick MDF and had my local hardware store cut it up into 300 x 180mm rectangles for me.

How to make it

I use Fusion 360 from Autodesk as my main CAD/CAM software, a steep learning curve but IMHO worth going through, and it is free for hobbyists. There are some notes on Fusion 360 model at the end.

I have provided GCode files for the 3018-PRO and the 3018-PROVer so there is no real need to install Fusion 360 and look at the model (*as long as the GCode files work for you*).

So this is a design for a Universal Spoilboard, any number of slots on the base, any size..... Well, nearly universal! I first created this for the 3018-PRO and one of the assumptions was that the spindle movement was equal to the bed size (with a bit of a margin to keep it from hitting the edges) and that the cutting area was symmetrically aligned over the bed. Because of physical differences in the 3018 PROVer and the way the limit switches are fitted the cutting area of the PROVer is reduced and is not symmetrically aligned with the bed. But I still want a Spoilboard covering the whole bed and want it flat over all its surface, hence the use of a larger surfacing bit for the PROVer to help it reach the edges of the Spoilboard, not totally successfully. It's still the same model for both the PRO and PROVer but the facing and engraving operations have different parameter values, different tool paths and so GCodes.

What you will need for a 3018

If you are using the Fusion 360 model you can change anything you want, but if you are using these instructions and the included .nc files this is what they are set up for.

- A 3018 CNC Router, *Doh!*
- 3.175mm (1/8") flat end router bit (*or similar*) to cut the slots.
- 20˚ engraving/V bit (o*r other*) to engrave the lines.
- Surfacing bit to give a flat and level finish. *NOTE: The only bits I could find in these sizes have a 6mm or ¼" shank so you would also need a 6mm or ¼" (a 7mm will take a ¼" shank, a 6mm is a very tight fit) collet. I could not find a decent sized surfacing bit with a 3.175mm shank!*
    - For the PRO a 13mm (1/2") diameter surfacing bit.
    - For the PROVer a 25mm (1") diameter surfacing bit.
- Two 300x180x6mm sheets of Spoilboard material (MDF).
- A roll of Blue painters tape.
- Superglue (CYA).

Is your bed level?

Not the one where you sleep! Even if you have assembled it very carefully the alignment of the spindle and the bed may be a bit out. If you are carving deep lines a lack of alignment will be less visible, but as a sensitive guy who does delicate work 0.1mm can make the difference between a decent line and no line!

I am not going to try and disassemble it and shim it until everything is exactly in alignment, it would take a lot of effort to align it exactly even if that is possible on these machines, and the only alignment that really matters is that the bed, or surface of the Spoilboard, is level relative to the movement of the spindle motor or Laser focus!

How to check your alignment

Quite simple, mount the spindle motor, put a bit in and open Candle. Use the Jog commands to position the bit to just touching near the front left corner of the bed. Jog up 5mm and then over to the back right, set the step to 1mm and jog down while watching carefully to make sure you are not going through the bed on the next step, if in doubt reduce the step to .1mm or less. If it takes 5x1mm steps to get the end of the bit touching the bed then it's pretty flat! Repeat for the other corners.

If it's out by more than 1mm then you may have a problem with the assembly. Mine was 0.2mm out using this method.

Step 1 - Cutting the slots

This is the same for both the PRO and PROVer

Accompanying files – Spoilboard-Cut Slots.nc (*see associated setup file Spoilboard-CutSlots-Setup.html.*)

Slot size	6mm x 110mm
WCS	Middle Top Front (with Spoilboard rotated 90 degrees. *Just read on a bit)*
Bit	3.175mm (1/8") flat end bit
Cut through	1mm below stock bottom (7mm total)
Depth of cut	1mm
Speed	10,000RPM (as fast as your machine will go!)
Cutting Feed rate	500mm/min
Stepover	3mm (amount the bit centre is moved between each cut)

I realised that if I just stuck a piece of Spoilboard material on the bed, without a Spoilboard, and tried to machine it then I would be running up against the machine limits with the associated nasty grinding noises or tripping limit switches on the PROVer and would be outside the cutting limits of the machine.

So I decided to make it by cutting the slots in both ends separately, meaning the stock can be rotated by 90˚ before cutting the slots on one edge, then rotating 180˚ to cut the slots on the other edge, so fitting within the machines limitations.

I also realised that I needed to cut completely through the stock *(that was one of the reasons I am making a Spoilboard)*. So I decided to make 2 at once, aligned on top of each other, to allow me to

cut through without hitting the bed, then rotate, repeat to cut the slots at the other end, then turn over and repeat ending up with 2 pieces of stock with the slots cut out.

Next time I will cut the new Spoilboard on top of the old Spoilboard which will absorb any cut through so I will only need to make one at a time.

In my case the 300x180 MDF I had turned out to be 302x181.5mm, close enough but not exact! In my first attempts the slots at each end were not aligned with each other. *Any mis-sizing of the stock is amplified by the original start from a corner then turn it round, then over....* So for the WCS Origin of this operation I have changed to the middle point of the front stock edge.

The alignment when rotating and turning over the stock should be as good as you can make it, the Spoilboard slots are narrower than the slots in the bed so there is room for error, but let's make it the best we can, if nothing else it's useful practice.

Measure your stock along the shorter dimension and make a pencil mark in the middle. Do this at both ends and draw a line between the marks, if you are making 2 then line up the boards on top of each other and using a square draw a line down the edges, then draw the line between the marks on the other piece.

Take the two pieces of MDF, pencil marks on the outside and aligned with each other.

Mount them on the bed, the short edge should be at least 20mm away from the front edge of the bed to allow the bit to enter the cuts from the outside, this means the other end will stick out through the back of the router but that's fine.

To align your first Spoilboard(s) lightly clamp the stock down, Jog the bit to align with the pencil line on the X axis then Jog away in the Y axis about 100mm and adjust the alignment of the stock so the alignment of the bit on the pencil line is the same.

Jog back close to the origin and double check the alignment. Once happy tighten the clamps to secure the stock. *Then recheck!*

The Work Coordinate System (WCS) origin for this .nc file is Front Middle at the Top of the stock, so position the bit to the centre of the pencil mark on the X or axis as in the photo print out and lightly glue a bit positioning aid in place to make it easier. Zero the XY and Z axes.

NOTE: You don't have to position the origin of the Z axis at the same point as the XY axes, so after setting the XY jog into the centre of the stock a bit as it is easier and more accurate to set the Z origin over the stock rather than at its edge!

HINT: As this is going to take 4 operations make some pencil marks on the bed once the 1st cut is aligned, this should make lining up the next cuts easier.

NOTE: It is always a good idea to jog up a few mm after zeroing the Z axis to make sure the bit is above the stock when it is first moved, if you are using a Z-Probe effectively this will be automatic, Fusion 360 normally moves the XY axes BEFORE raising the Z axis.

Hit Start, Run, Send whatever!

After the first set of slots has been cut:

- Unclamp
- Rotate by 180 degrees keeping the boards aligned.
- Put them back in exactly the same position and alignment and re-clamp OR just re-clamp and then reset the alignment and XY axes Origin. The Z Axis origin should be unchanged.
- Cut the next set of slots.
- Unclamp and turn the stock over still keeping the two pieces of MDF aligned with each other.
- Repeat the above to cut the slots on the second piece. (It's not really necessary to do this now, but you might as well while everything is set up)

You should end up with something that looks like this.

As this is being cut on a bed which is not yet levelled it is possible that the slots are not quite cut through in places. If this is a case trim off any remnants out the slots using a sharp knife. Also there will be bits of fluff or an edge around the slots, don't worry about the top, the facing operation will take care of the ones on the top, but the bottom should be fairly flat, again trim the edges of the bottoms if needed with a sharp knife or sandpaper.

Step 2 – Mounting the Board

This is the same for the PRO and PROVer.

Facing, which is the next step after this, is taking a small bit off the top of the stock to make it level, or reduce the thickness when needed. In this case the aim is to level it by taking the minimum amount off the top.

But first it needs to be fixed to the bed, semi-permanently, I don't want it to move but at some time it will need changing as it gets gouged up, I may be able to re-face it a few times but sooner or later I am going to need to fit a new one.

- It can't be clamped down as the facing operation will need to cover the entire surface and it would shift once it was unclamped.
- Glue would work, but it would have to be strong enough to keep it fixed yet weak enough to allow it to be replaced, preferably without using power tools or explosives!
- Double sided tape is an option, but the same limitations for glue apply, and a lot of double sided tape is designed for holding paper or has a foam inner which would give a bit of flex. *NOTE: I have seen double sided CNC tape advertised, but not in the UK and the shipping costs are far too high for me to try it out.*
- Velcro? Definitely not, too much flex.
- *Nails – Just getting silly!*

So *(not my idea)* I am going to use masking tape on the bed and Spoilboard and then superglue the pieces of tape together.

The Blue Tape technique

Well not just any masking tape of course, the normal (cheaper) paper stuff would let the glue soak through, but Blue (*other colours are available*) Painters tape which has a more robust and impervious surface. Yes it's more expensive than the cheap paper masking tape, but I don't need a lot so a roll should last for a while.

Also this technique can be used to fasten your stock to the top of the Spoilboard, useful if you find it difficult to use clamps on some pieces or don't want to leave tabs on a cut out.

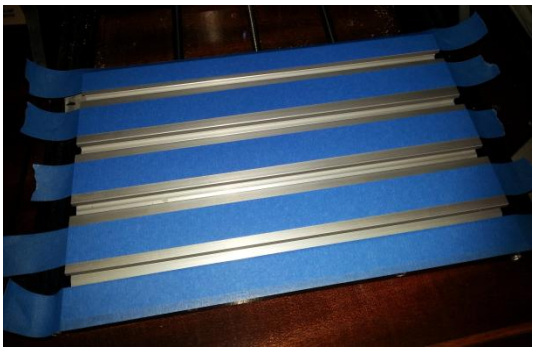
This will work on any Spoilboard method you have selected, just adapt the placing of the tape accordingly.

First very lightly sand the bottom of the Spoilboard and/or stock to remove any bits and pieces and leave a level surface, any ridges round the slots should fit into the bed slots and should not be a problem.

Clean both the bed and the bottom of the Spoilboard or the top of an attached Spoilboard and the bottom of the stock. I have seen people recommend acetone or nail polish remover to clean metal surfaces, I don't have any so I used a very, very slightly clean damp cloth on the bottom of the Spoilboard to remove any dust and a no residue window cleaner on the bed.

Let everything dry!

I am using 3M Blue painters tape *(other brands are available and I make no comparison, this is the first one I bought)* 24mm wide.



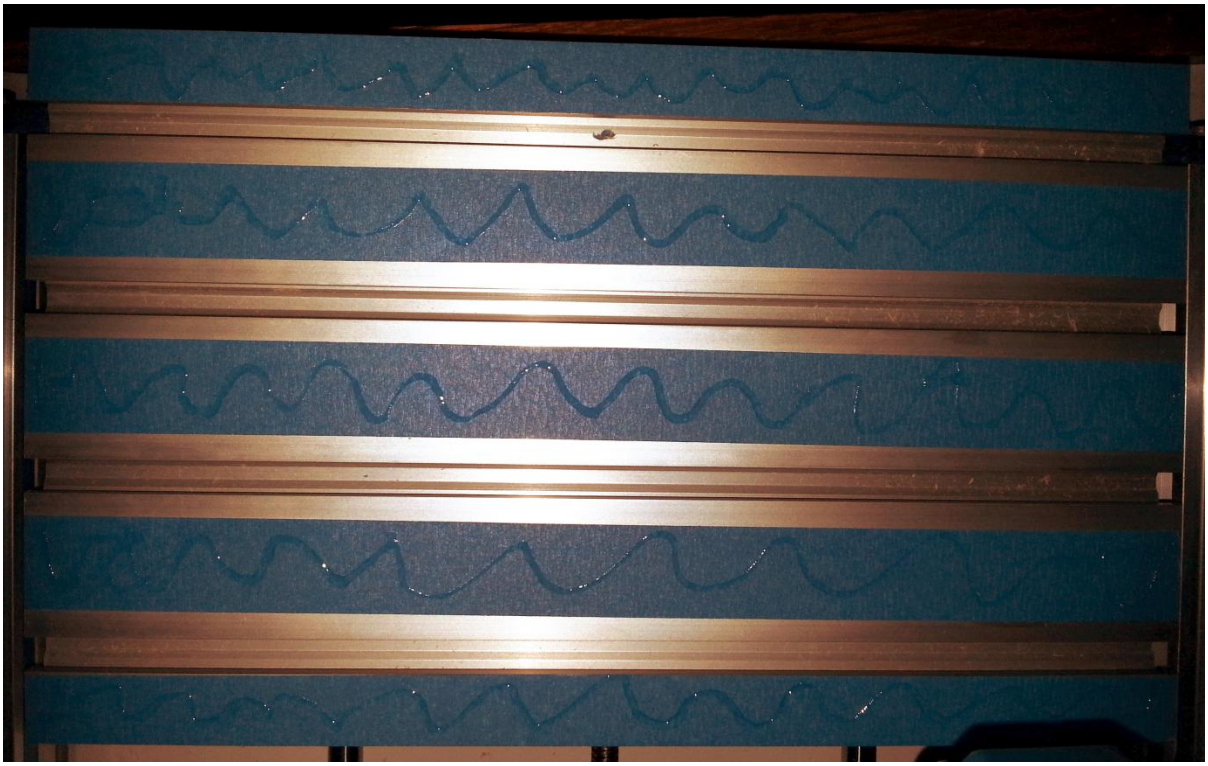
Place one set of tape strips on the bed, a matching set on the bottom of the Spoilboard. The pattern doesn't really matter as long as each bit is going to be stuck down. However it is important that the patterns match. Keeping the edges and the tape itself clear of the slots is easier.

Make sure there are no air bubbles or wrinkles in the tapes and burnish them down as hard as you can to give good adhesion. Then wrap the tape up/down round the edges or trim it with a sharp knife cutting down from the taped side to avoid lifting the edges of the tape and putting bits of MDF under it.

Put a wiggly line of superglue (CYA) down the centre of each tape on the bed. I used Loctite Precision, again other brands are available, I used this because it was what I already had.

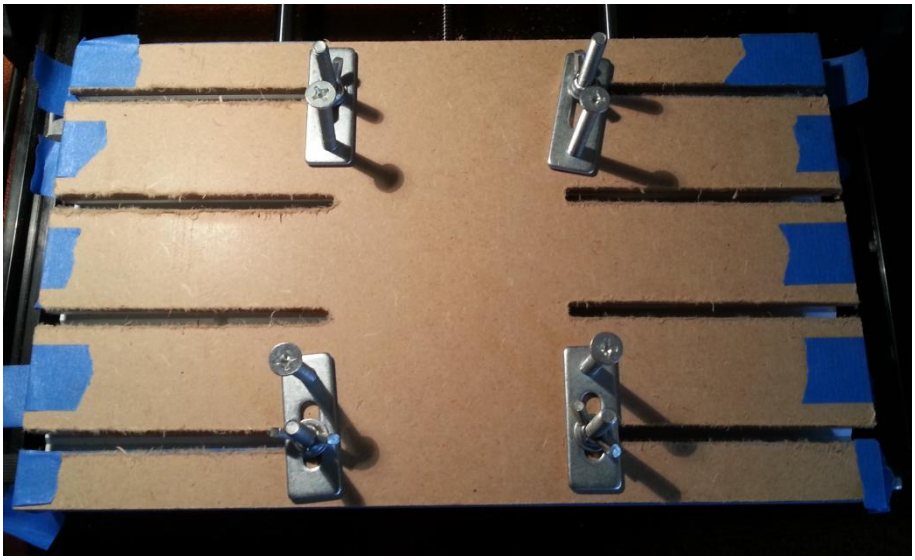
It is important not to use too much, or too little glue! *Don't you love all the helpful advice like this?*

Seriously you don't want too much so that the glue will flow off the edges of the tape, but you need enough so it will spread out a bit and give a good bond between the tapes as you press the Spoilboard down.



I will say this only Once! As that is all the chances you are going to get without stripping it off and starting again. Very carefully line up the Spoilboard, tape side down, with the bed without letting them touch. Then press them together evenly and firmly.

I know Superglue is supposed to set instantly but I then used the clamps to compress the Spoilboard and bed together and left it for a while.



Remove the clamps and make sure it is secure to the bed, if you left them on then trim off the edges of the tape using a sharp knife is you so desire.

If you misaligned the Spoilboard with the bed, and it doesn't have to be exact, the key thing is that the slots are over the top of the slots in the bed and about in the centre. If not then you will have to remove it and start again with the cleaning and tape. To remove it I use a paint scraper along the middle of the tape and pry it apart, or more likely off the bed or Spoilboard. Then peel off or scrape off any remaining tape.

So a Spoilboard is affixed. But it is not yet level and doesn't have any XY reference lines on it.

Step 3 – Facing

There are some differences between the PRO and the PROVer which have to be taken into account, because of the mounting of the limit switches on the PROVer and other differences the effective cutting area, where you can position the centre of the bit, is smaller and is not aligned with the centre of the bed.

Facing is a milling operation where you make the surface level and smooth and is also used to reduce the height of the stock to the size of the component. (I use a lot of rough scrap wood!)

To do this properly you need a large diameter, 25mm (1") is the largest I have tried, facing (flat bottomed) bit. You can do this with a small flat bottomed bit but you will need to make many more passes across the surface and the finish is not going to be as good.

I use a 25mm bit on the PROVer to try and reach the edges of the Spoilboard from the cutting area. For the PRO I use a 13mm facing bit which reaches the edges easily. The ones I have are inexpensive facing bits, but they have a 6mm shank and so will not fit into the standard 3mm collet in the tool holder. So I bought a set of collets which includes a 6mm one and a 7mm one. I am based in the UK, but they should give you an idea of what to look for.

https://www.sainsmart.com/products/sainsmart-er11-spring-collet-set-1-0mm-7-0mm

The collet set is worthwhile for me, I can now use different diameter drills and other bits that don't have a 3.175mm shank. NOTE:Getting the collet out of the ER11 end nut can be tricky, especially at first when they are a bit stiff, it's one of those 'and with your third hand' sort of things. So I have also bought 7 spare ER11 end nuts from Ebay at less than £1 each although free delivery from China can take a while! Makes it much easier.

The 25mm dia bit is a very tight fit in the 6mm collet I have, so I used the 7mm one instead. The bit probably has a ¼" shank just labelled as 6mm. Or I just bought the wrong one! *Should I get a 6.5mm (or ¼") collet as well? Probably but the 7mm collet needs a bit of tightening but it does hold the bit!*

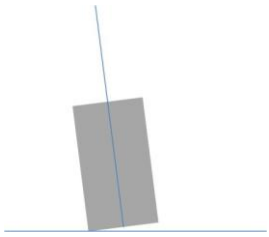
My bits came from Ebay/Amazon. *Other sellers are available!*

Anyway I want to use it to here level the top of the Spoilboard in relation to the movement of the bit. There will be, hopefully small, deviations from perfectly level in the gantry assembly, the exact alignment of the guide rods on all axes, mounting of the bed etc. Even the consistency of the thickness of the Spoilboard itself, the tape, amount of glue.... can have an effect.

Checking the Alignment of the Gantry

The one thing facing cannot compensate for is if the Z axis is not vertical.

Imagine the (very exaggerated) example below where the rectangle represents the bit.



In a small diameter bit the effect will probably not be noticeable, the larger the diameter the more this effect can be seen. After you start a facing operation if it is out of alignment you will be able to see the effect as a series of steps/lines, left on the surface by the edge of the bit. This effect can occur in both the X and Y axis, from my experience it is more likely to be caused on these machines by the Gantry not being quite vertical giving lines as the bit moves along the X axis.

(Adjusting the router to minimise this is known in the CNC world as Tramming, I assume as the steps form lines that look like tram lines but that's just a guess, for all I know the effect could have been first noticed and corrected by Ms A. Tram?)

There are 2 possible causes for this, possibly the alignment is a little out, the second is that the router is not entirely rigid so moving a bit across the surface will cause it to 'dig in' a little at the leading edge The first can be checked and corrected, the second not so much.

The only way to cure this is to re-align the Z axis by adjusting the assembly and alignment of the router. To Tram a router exactly requires patience and more importantly dial gauges mounted in a jig; these will probably cost more than you paid for your router!

But rough checks are in order before you start. Use a square placed on the Spoilboard and sighting along it like so, then moving it around and re-sighting.

It's not going to be absolutely exact on these machines; this is a rough but easy check! If it is obviously out then fix it before you continue. This is also a good time to check the tightness of all the screws and that all the axes move freely.

I am taking advantage here that the bit sticks out over the edges which is fine, the .nc files have been set up so the bit won't touch anything it shouldn't.

3018-PRO

Accompanying files – Spoilboard-Face-PRO.nc *This will work on ANY Spoilboard method you have used for a 3018-PRO.* Also see Spoilboard-Face-PRO-Setup.html for details.

WCS Origin	Top, 5mm inside front and left edges.
Bit	13mm flat facing bit
Depth of cut	0.2mm
Passes	1
Speed	10,000RPM
Cutting Feed rate	500mm/min
Stepover	5mm (amount the bit centre is moved between each cut)

Mark a point 5mm in from the front left corner on the X and Y axes. Carefully set the WCS origin on the point, I say carefully as you will be close to the machine limits, and Zero the XY axes. Set the Z axis to just touching the top of the stock and zero the Z axis.

3018-PROVer

Accompanying files – Spoilboard-Face-PROVer.nc *This will work on ANY Spoilboard method you have used for a 3018-PROVer.* Also see Spoilboard-Face-PROVer-Setup.html for details.

WCS Origin	Machine Home position at Front Left, Z Top of the stock.
Bit	25mm flat facing bit
Depth of cut	0.2mm
Passes	1
Speed	10,000RPM
Cutting Feed rate	200mm/min
Stepover	10mm (amount the bit centre is moved between each cut)

It is nearly impossible to set the work coordinates origin close to the edge of the Spoilboard using a standard PROVer. Because of the mounting of the limit switches and the X axis coupler it just won't go there! So another position has to be found. The best idea I have come up with is to use the homing cycle position, set that as the XY axes origin then set the Z axis origin.

So a quick note on homing positions. Where the spindle ends up on your 3018-PROVer after a homing cycle depends on two of the router Grbl settings: $23 sets which corner you want the homing cycle to use and $27 which is the distance the machine will pull back once a limit switch has been reached during the homing cycle.

The default setting for $23 is 3 which means that the spindle should end up in the top left front corner which matches the WCS coordinate system I am using. The default Homing pull off value ($27) is 1mm, in order to get the maximum travel to allow the bit to reach the edges of the Spoilboard I have set my pull off down to 0.5mm.

Make sure your $23 setting is 3 and your $27 value is set to 0.5 before proceeding! You can change them back later if you desire, *(you did save their current values, didn't you?)*.

To set the WCS origin run a homing cycle and the spindle should be at the top left front. Without jogging anywhere set the XY axis origin. Jog into the centre a little to make it easier and place the Z-Probe base under the bit making sure that a flute of the bit will touch the Probe base, attach the clip to the shank and use the Z-Probe button to set the Z axis origin *(Or any other method of setting the Z axis origin to the top of the stock of course)*.

It is always a good idea to jog up a few mm after zeroing the Z axis to make sure the bit is above the stock when it is first moved. Fusion 360 often moves the XY axes <u>BEFORE</u> raising the Z axis.

Then run.

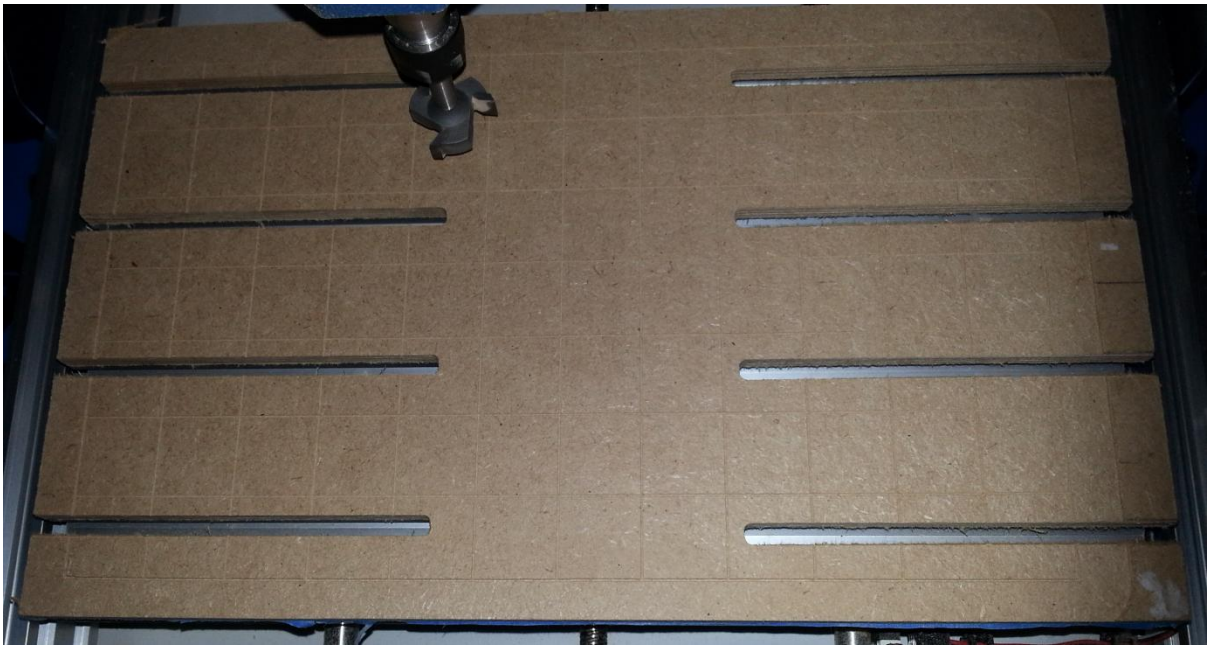
From this example (on the PRO) you can see that the bed is a bit higher on the left than on the right, maybe my initial measurement as being 0.2mm out was close but slightly optimistic!

The .nc file will take 0.2mm off the top of the Spoilboard, but if after the first pass any part of the surface has not been levelled just repeat the run after zeroing the Z axis again. If you want to take off less than the 0.2mm on a cut, position the bit to the top of the stock, then jog up for example 0.1mm and reset the Z axis origin, remember that setting the Z axis origin can be done anywhere it does not have to be in the same location as the XY axis origin so if there is a low spot you can set it there.

If at any time your Spoilboard has been chewed up and scarred then you can always resurface it, just be careful that there will be enough thickness left for it to still do its job though.

Finishing off facing on the 3018-PROVer

When the facing is complete on the PROVer you are going to end up with something like this:



Well without the faint grid lines, *OK I forgot to take a photo at the correct stage*.

But what is important is the left hand corners and the right hand edge of the Spoilboard. Even using as large of a bit as I feel comfortable with it has not reached the right hand edge or corners.

The only problem here is that I don't want high points sticking up which may affect mounting any stock. So manually trim off the bits sticking up on the corners and the edge so they are not proud of the levelled surface. Chisel, plane, whatever! I actually used a paint scraper which had a fairly sharp edge. The MDF will separate in layers quite easily. It is better for to trim the edges off to below the levelled surface rather than be above it.

Step 4 – Engraving

Again the same differences between the PRO and the PROVer have to be taken into account as for facing.

The engraving step is completely optional, what it does is engrave a series of parallel lines, one set exactly aligned with the X axis movement and one set exactly aligned with the Y axis. I find these very useful for aligning the stock with the axes. The distance between the lines is not designed as a useful measurement.

3018-PRO

Accompanying files – Spoilboard-Engrave-PRO.nc *This will work on ANY Spoilboard method you have used.* Also see Spoilboard-Engrave-PRO-Setup.html for details.

WCS Origin	Use the same as the facing operation.
Bit	20˚ V/Engraving bit
Depth of cut	0.2mm
Passes	1
Speed	10,000RPM
Cutting Feed rate	500mm/min
Stepover	N/A

The 20 degree engraving bit came with my machine and will make fine lines. The spacing of the grid lines I didn't consider to be important as I am not going to use them as a ruler, just for alignment. But the grid starts at 5mm from each edge, with 14 vertical lines and 9 horizontal ones (including the edges). *This leaves the distance between each vertical line as 22.3076923mm apart and the horizontal ones 21.25mm apart. I did say they were just for alignment!*

Jog to and set the origin of the axes in the same way as for the facing operation.

3018-PROVer

Accompanying files – Spoilboard-Engrave-PROVer.nc *This will work on ANY Spoilboard method you have used for the PROVer.* Also see Spoilboard-Engrave-PROVer-Setup.html for details.

WCS Origin	Use the same as the facing operation.
Bit	20˚ V/Engraving bit
Depth of cut	0.2mm
Passes	1
Speed	10,000RPM
Cutting Feed rate	500mm/min
Stepover	N/A

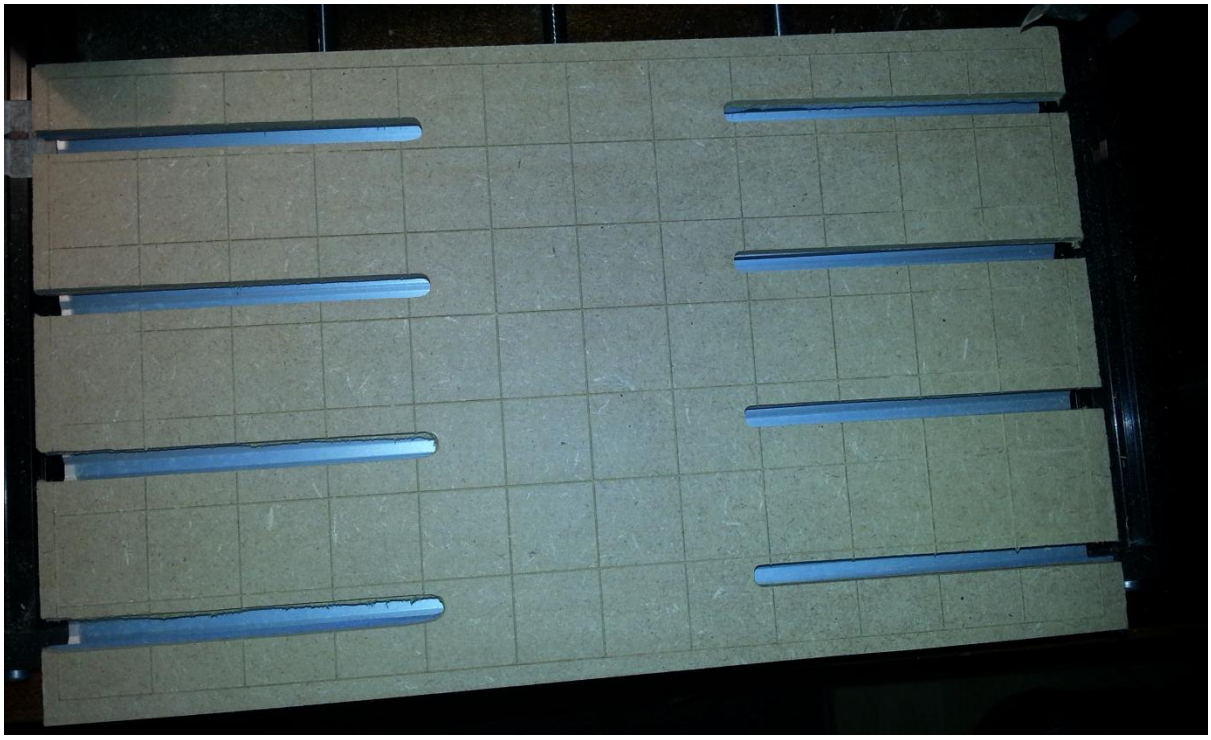
The 20 degree engraving bit came with my machine and will make fine lines. The spacing of the grid lines I didn't consider to be important as I am not going to use them as a ruler, just for alignment. But the grid starts at the Front Left homing position (after pulloff), with 12 vertical lines and 8 horizontal ones (including the edges). *This leaves the distance between each vertical line as 21.7083333mm apart and the horizontal ones 22.42857142857143mm apart. I did say they were just for alignment!*

Set the axes origins in the same way as the facing operation.

It is always a good idea to jog up a few mm after zeroing the Z axis to make sure the bit is above the stock when it is first moved. Fusion 360 often moves the XY axes <u>BEFORE</u> raising the Z axis.

Then Run.

Voiala *(or something like that) Picture is from a PRO*



Level, smooth as an infant's posterior with perfect alignment lines!

The only problem is that now I don't want to mess it up!

Step 5 – Finishing

Again not necessary but think about how you are going to mount your stock, clamps or tape, and if you are going to be using any liquids such as lubricant or coolant.

MDF and most woods do not react well to getting wet; they tend to swell which destroys the level surface.

Peeling tape off MDF will bring a little, not a lot but a little, of the surface with it.

So if you are planning to use a lot of tape rather than clamps or any fluid then seriously think about sealing the Spoilboard surface before you use it.

Varnish, paint, lacquer, whatever, a couple of coats perhaps or just one would probably be enough. Paint messages on it, paint it in pink and green stripes, paint the individual squares in different colours *(But do not go over the lines or the bears will get you!)*

Notes on the Fusion 360 Model

This is NOT a Fusion 360 tutorial. If you are looking for one the best I have found is here: http://www.toptechboy.com/3d-cad-design-tutorials/fusion-360-tutorial/

If you are just going to use the concepts or the GCode files you don't need this, but if you are using Fusion 360 then here is an explanation of the steps I used in my model (OK a sort of Fusion 360 tutorial).

I do have to introduce one concept regarding the model here though.

Parametric Modelling

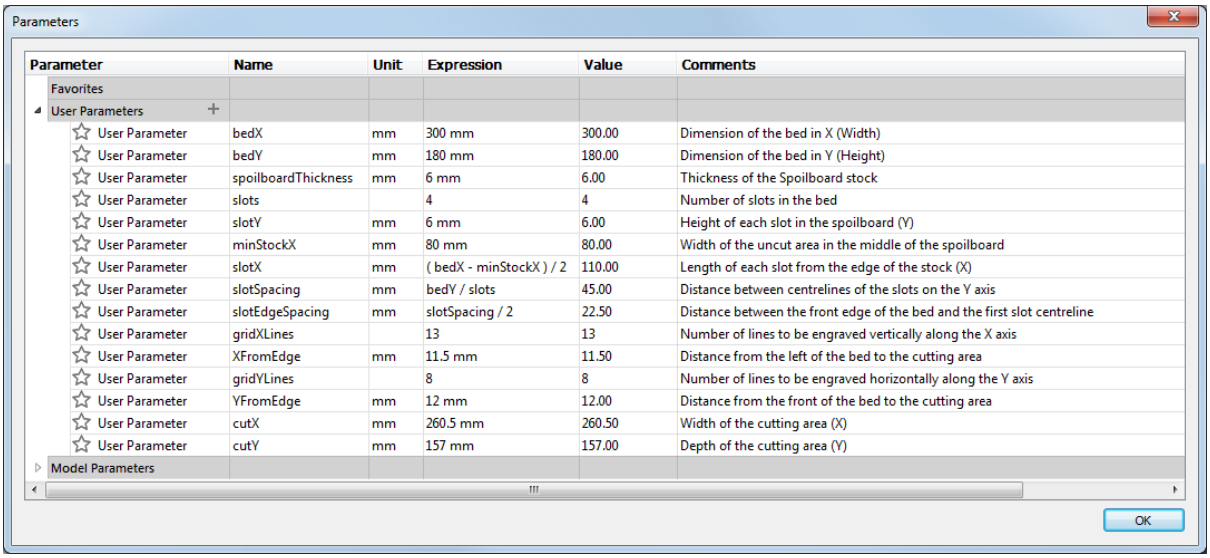
This is what drives this project and makes it a Universal Spoilboard by using parameters for dimensions, angles etc. instead of fixed values. If you use parameters such as *bedX*, *bedY* and *spoilboardThickness* rather than 300, 180 and 6 then you can edit the parameters and the model automatically updates, no need to re-dimension, move things around and .....

This Fusion360 model, the same one, can just as easily create a Spoilboard 20 x 60 x 15mm with 5 slots on the base as it can a 300 x 180 x 6mm with 4 slots on the bed (Within limits), just by changing the values of *bedX*, *bedY*, *spoilbardThickness* and *slots*. The length of the slots is derived from *minStockX* which is the bit to leave as solid in the centre and *bedX.*

Parameters are also used to determine the grid pattern which is engraved on the faced surface.

So, first I created the parameters, some of these are derived from other parameters to make the modelling process easier. You can enter the formula directly as dimensions or parameters in the model, but I found this approach easier.

These are the parameters I used for the PROVer:



Parameter	Name	Unit	Expression	Value	Comments
Favorites					
User Parameters					
User Parameter	bedX	mm	300 mm	300.00	Dimension of the bed in X (Width)
User Parameter	bedY	mm	180 mm	180.00	Dimension of the bed in Y (Height)
User Parameter	spoilboardThickness	mm	6 mm	6.00	Thickness of the Spoilboard stock
User Parameter	slots		4	4	Number of slots in the bed
User Parameter	slotY	mm	6 mm	6.00	Height of each slot in the spoilboard (Y)
User Parameter	minStockX	mm	80 mm	80.00	Width of the uncut area in the middle of the spoilboard
User Parameter	slotX	mm	(bedX - minStockX) / 2	110.00	Length of each slot from the edge of the stock (X)
User Parameter	slotSpacing	mm	bedY / slots	45.00	Distance between centrelines of the slots on the Y axis
User Parameter	slotEdgeSpacing	mm	slotSpacing / 2	22.50	Distance between the front edge of the bed and the first slot centreline
User Parameter	gridXLines		13	13	Number of lines to be engraved vertically along the X axis
User Parameter	XFromEdge	mm	11.5 mm	11.50	Distance from the left of the bed to the cutting area
User Parameter	gridYLines		8	8	Number of lines to be engraved horizontally along the Y axis
User Parameter	YFromEdge	mm	12 mm	12.00	Distance from the front of the bed to the cutting area
User Parameter	cutX	mm	260.5 mm	260.50	Width of the cutting area (X)
User Parameter	cutY	mm	157 mm	157.00	Depth of the cutting area (Y)
Model Parameters					

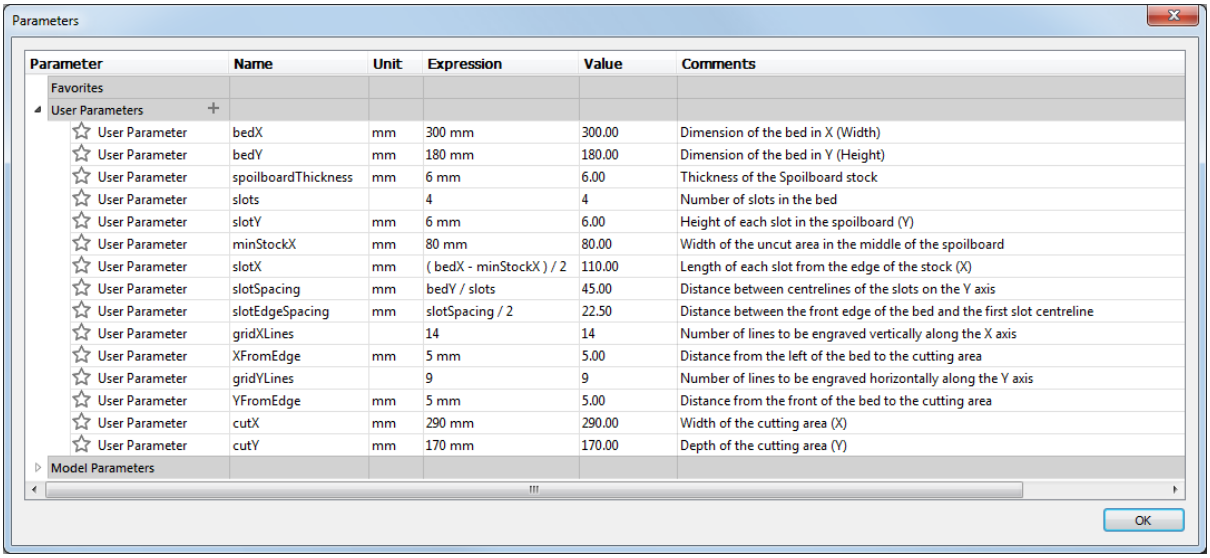
NOTES:

- The XFromEdge, YFromEdge, cutX and cutY parameters are set for my PROVer to maximise the size of the faced area and the alignment grid. These are pretty close to the limits for MY

PROVer, yours may be slightly different, if the cutting area for your machine is smaller even by 1-2mm then you may hit limit switches. If so then adjust these values accordingly.

- I have set the pullback after homing to 0.5mm from the default 1.0mm. This gives me an extra 1mm of travel on each of the axes. Not a lot, but every little helps!

These are the parameters I used for the PRO:



Parameter	Name	Unit	Expression	Value	Comments
Favorites					
User Parameters					
User Parameter	bedX	mm	300 mm	300.00	Dimension of the bed in X (Width)
User Parameter	bedY	mm	180 mm	180.00	Dimension of the bed in Y (Height)
User Parameter	spoilboardThickness	mm	6 mm	6.00	Thickness of the Spoilboard stock
User Parameter	slots		4	4	Number of slots in the bed
User Parameter	slotY	mm	6 mm	6.00	Height of each slot in the spoilboard (Y)
User Parameter	minStockX	mm	80 mm	80.00	Width of the uncut area in the middle of the spoilboard
User Parameter	slotX	mm	(bedX - minStockX) / 2	110.00	Length of each slot from the edge of the stock (X)
User Parameter	slotSpacing	mm	bedY / slots	45.00	Distance between centrelines of the slots on the Y axis
User Parameter	slotEdgeSpacing	mm	slotSpacing / 2	22.50	Distance between the front edge of the bed and the first slot centreline
User Parameter	gridXLines		14	14	Number of lines to be engraved vertically along the X axis
User Parameter	XFromEdge	mm	5 mm	5.00	Distance from the left of the bed to the cutting area
User Parameter	gridYLines		9	9	Number of lines to be engraved horizontally along the Y axis
User Parameter	YFromEdge	mm	5 mm	5.00	Distance from the front of the bed to the cutting area
User Parameter	cutX	mm	290 mm	290.00	Width of the cutting area (X)
User Parameter	cutY	mm	170 mm	170.00	Depth of the cutting area (Y)
Model Parameters					

Pretty much the same but adjusted to move the cutting area into the centre and closer to the edges of the Spoilboard.

To view or change the parameters in Design select Modify/Change Parameters.

NOTE: *All are lengths in units of mm APART from slots, gridYLines and gridXLines, which are 'No Units' as they are just numbers.*

Creating the Model

I am only modelling one end of the Spoilboard as this is all that is needed. To machine the slots the stock will be rotated 90 degrees and I will cut the slots out of one end, then remove, rotate 180 degrees and then cut the slots out of the other end. This is necessary to make it using the router it will be used on as it would otherwise be difficult to cut the slots out as the machine would be bouncing off its limits.

Manufacture

I am going to need 3 separate setups and .nc files here. All are milling operations. The reason for 3 setups is that the stock definition and bits will be different.

NOTE: Parametric modelling only fully applies to the modelling, not the manufacture! If you change the model you will have to edit the machining operations, maybe reselect the geometry and re-generate the toolpaths!!!!!

I had a lot of problems creating the facing operation as I was using the 2D Facing operation. This is very basic and it works as such. But I couldn't control the entry of the bit, it always came in from the

outside of the cut. This is bad as I have a 300 x 180 Spoilboard on a machine with motion limits are 300 x 180 so starting with the bit outside those limits is impossible!

With a lot of help from the Fusion 360 forum I realised that the 3D milling operation of parallel, and others, are quite happy to operate on a flat surface and are a LOT more flexible. It allows you to set a tool boundary relative to the stock size, it won't move the tool centre outside of this boundary which is just what I wanted.

I also set the Horizontal and vertical lead-in radii to zero, Fusion 360 by default enters the tool on a curve from outside, a zero radius means it just goes straight down.

It took me a while to realise that. The error messages in Fusion 360 are as helpful as a wall chart in another room is to a blind person playing scrabble without tiles marked in Braille. But they can give an occasional hint.

Acknowledgements

I would like to thank:

- All those involved (too many to list) in creating Grbl, releasing it as a free to use Open source project and supporting and improving it.
- Denvi for creating, improving and supporting Candle as a free to use Open source project.
- Arkypita for creating, improving and supporting LaserGRBL as a free to use Open source project.
- SainSmart Customer support for all their help and standing behind their product.
- All members of the SainSmart Genmitsu CNC Users Group on Facebook, both for answering my stupid questions, showing inspiring examples and asking questions that made me think.
- .....

This is not intended as a definitive manual but it may help with some of the principles and techniques involved. If nothing else writing this down has clarified my understanding.

Any comments, proofreading, other ideas or discussions welcomed.

Especially if this does not work for you for any reason! If it didn't please let me know what and why and I will update it.

Regards

Graham Bland.