Introduction to CNC for a Total Novice

Part of a series by Graham Bland

Setting up the SainSmart 3020-PRO MAX

Contents

Introduction

I just received my SainSmart Genmitsu 3020 PRO MAX. My thanks to SainSmart for sending me one to evaluate. Any comparisons with the 3018-PROVer relate to my existing SainSmart Genmitsu 3018-PROVer and the current specifications on the SainSmart Website.

NOTE: The version I have is a pre-release one. I am fairly sure nothing significant has changed but there may be minor details which have been changed.

If you are already familiar with CNC routers a lot of this may be repetitive for you but it is aimed at a first-time user. You may still find something useful here though.

This is a guide to assembling and setting up the SainSmart 3020 PRO MAX, nothing more but there will be other 'Guides' on useful things such as what you can make with it at a later date.

This is not a review; I am working on one, but that has to include things like using it, and before it is used it should first be set up correctly.

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.

- 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.
- While I do not work for, or am associated with SainSmart in any way they do provide me some ~~toys to play with~~ items to review and update my Introduction to CNC for a Total Novice series of guides. Some I have bought.
- 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!
- 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.
- Take account of the materials you are using and take adequate precautions, fumes, dust and ashes can be harmful.
- 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!

- 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.

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/

Other files in this series

These can be found in the files section of https://www.facebook.com/groups/SainSmart.GenmitsuCNC/, there may be more or less as I am not going to update everything if I add a new one or remove one.

Search for 'Introduction to CNC for a Total Novice –' Or 'Introduction to CNC for the Total Novice –' *Consistency has never been one of my strong points, just search for' Introduction to CNC' or the title you are interested in!!*

Most of them have some 'accompanying files' with them, spreadsheets, databases, Gcode files……. these are uploaded in 2 versions. The first is just a .pdf file containing the guide. The second is all the files including the pdf document together in a Zip file.

Unfortunately Facebook does not allow the uploading of .zip files, however it bases this decision solely based on the file extension so it does allow the file to be uploaded and downloaded if it does not have a .zip extension. To get round this really stupid rule I have renamed all the .zip files to *.zipp so after downloading you will have to edit the file name and rename the file extension back to *.zip In Windows locate the downloaded file in file explorer, highlight the file and right click, select Rename from the options and then change the .zipp extension to .zip Windows will warn you not to do this but just ignore the warning. Then Windows should expand the file contents for you and allow it to be used.

The links below refer to the .zipp file if there are other files, or the .pdf if there aren't any.

Title	Contents	Facebook link
- Getting Started	Introduction to the process and how to check and test your 3018. READ THIS FIRST!	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2352860468358107/
- Making a Spoilboard	Example of how to cut, fix, face and engrave a 3018 Spoilboard with specific instructions for 3018-Pro and PROVer.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2451607738483379/
- Setting up a Laser	Fitting, focusing and starting out with a Blue Diode Laser on your 3018.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2356427294668091
- Tuning Grbl Settings	Exploring and optimizing settings for your 3018 to make it faster and better.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2373672706276883/
- Spindle Speed and Laser Power	The relationship between the Spindle Speed and Laser power of your 3018 and how to set the values.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2531618443815641/
- Bits	Descriptions of what bits are and how to use them on a small router. With Tool Libraries.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2666712616972889
- Setting up an Endurance Laser on a 3018	How to mount and use an Endurance 10W output power Laser on a 3018	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2821169684860514/
- Z-Probes	Setting up and using a Z probe on a Grbl based machine.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2869846236659525/

Title	Contents	Facebook link
- Basic Gcode for Grbl	Introduction to Gcode on Grbl based routers plus non Gcode control commands.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2705472216430262/
- Grbl Pocket Reference	A Fold up pocket guide for Grbl error and alarm codes, Supported Grbl Commands, Settings and States.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2880438818933600/
- Setting up the SainSmart 3020-PRO MAX	Some Assembly hints, setting it up, adjusting some Grbl settings and a number of quick checks to make sure it is working correctly.	This Document

Versions of a lot of these along with more information and resources, yes there are other people who do this sort of thing, some even are photogenic enough to make videos! James Dean Designs on YouTube is a good example. Many resources can be found at https://docs.sainsmart.com

Reviews

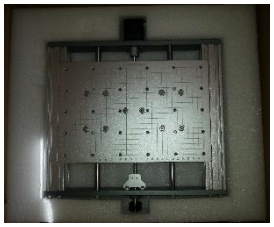
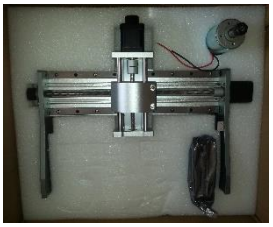
Title	Contents	Facebook link
Review of the Woodpecker CamXtool 3.4 motherboard for the 3018-PRO	A quick review of the new Woodpecker CamXtool 3.4 router controller board.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2286303255013829/
Review of the SainSmart 3018 PROVer	A Review of and my thoughts on the 3018-PROVer.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2404078306569656/
Review of the SainSmart Dust shoe for 3018	I tried out the SainSmart 3018 Dust shoe. I like it, but here are my full thoughts in a review and some usage hints.	https://www.facebook.com/groups/SainSmart.GenmitsuCNC/permalink/2876859215958227/
Review of the SainSmart 3020 PRO MAX	My thoughts on, and initial tests cutting Aluminium of the SainSmart 3020 PRO MAX	Coming Soon.

Unboxing

Carefully cut the packing tape, open the box and take all the parts out of the box! Simple and easy.

Seriously though it is, as normal for SainSmart, well packaged and protected.

Some parts are pre-assembled The Frame and Bed, Gantry, Y and Z axes, all steppers are mounted, there isn't a lot left to do.


Comparison with the PROVer

Some comparisons of the non-obvious details with the SainSmart 3018 PROVer (not all PROVers or PROs are the same). I have used both measurements made by me and specifications from the SainSmart website. All dimensions in mm.

Item/measurement	3020 MAX	3018 PROVer
Frame Side Rails	40mm x 40mm (4 screws)	20mm x 40mm (2 screws)
Front/Back Plates	10mm x 40mm	8mm x 45mm
Y axis Slide Rods	12mm Dia	10mm Dia
Y axis Rod Spacing	150mm	150mm
Y Axis Lead Screw	8mm Dia	8mm
Gantry Upright Thickness	10mm	8mm
Gantry securing Bolts	8 each side	6 each side
X Cross Members	40mm x 20mm (2 screws)	20mm x 20mm (1 screw)
X axis Rails	2 15mm linear Rails	2 8mm Dia rods
X axis rail Spacing	75mm	75mm
X Axis Lead Screw	8mm Dia	8mm Dia
Z axis guide rods	10mm Dia	8mm Dia
Z axis Lead Screw	8mm Dia	8mm Dia
Z Axis Guide rod Spacing	50mm	40mm
Cutting travel X Y Z **	281mm x 195mm x 70mm	290mm x 170mm x 40mm
Steppers*	12V XY:1.5A Z:1.8A	12V 1.3A
Spindle Motor	52mm 48V 300W 12,000 RPM	42mm 24V 75W 10,000RPM
Spindle Collet	ER11	ER11
Power Supply	48V 7.3A	24V 5A

* I have not been able to find the torque figures for the 3020 Max steppers so have not quoted torque for either machine.
** Conservative settings, all 4 limit switches fitted.

While the proof of the pudding is in the eating (an old Yorkshire saying! *When I was a young man I misunderstood the meaning of this saying due to my Mothers Christmas Cake and Christmas Pudding recipes. Both involved large quantities of Brandy as an ingredient*) at first impression it is stronger, more robust, more powerful and more rigid than the PROVer.

Pre Assembly

I am not duplicating the assembly instructions here, they are pretty good, but I will add some checks and hints I suggest you perform before assembling. *Even if you identify as male I still suggest you read and follow the assembly instructions!*

Pre Assembly Checks

After making all of the checks I found my 3020 passed them all, OK I did tighten a couple of screws a little, but the checks don't take long and are a lot easier to perform and correct any problems before the machine is fully assembled. I intend to be using it for a long time so the speed of assembly is not that important to me.

- Check all bolts and screws for tightness. Using threadlock on the screws is your choice, it would be tedious to completely remove each screw, threadlock it and put it back so I am not going to bother. But I will threadlock any bolt or screw if I find to be loose just in case. *NOTE: Even if you threadlock everything it is always worth checking all the screws and bolts for tightness after using it for a short while and periodically as part of normal cleaning and maintenance.*
- Using a square or by measuring the diagonals check that the frame is square.
- Place the frame on a flat surface and check that it sits flat.
- Using a straight edge check that the bed is not warped *(this is a throwback to extruded slotted beds)*.

- Hand wind each of the axes along their full travel. It should take a uniform effort and there should be no feeling of sticking or binding. If there is any problem check the axis involved and make sure the moving parts affected are clean and tidy.

Hints

- The top piece of packaging makes a very handy assembly mat!
- Attach the rubber feet to the bottom of the frame before assembling the bed and gantry, it's much easier.
- According to the manual the rear upright of the gantry should be 13mm from the back of the frame, I find it easier to measure this before attaching the gantry. Using a ruler and square scribe a line 13mm from the back frame with a sharp knife, rub a bit of pencil into it to make it easily visible. It will be much easier to align the gantry to the line rather than messing about with squares and rulers while assembling.
- Before finally tightening the gantry bolts to the frame use a square to check that the bed and the inside of the motor mount is square both in the X axis and Y axis. If not, the gantry can be adjusted to correct this by tilting it forwards or backwards slightly or moving one side up or down slightly.
- If you fit the optional bottom Z axis limit switch, be careful that the routing of the cable keeps it clear of the X axis limit switch.
- When mounting the motor the height in the mount can be adjusted by sliding the motor up and down before tightening. How high to mount the motor will depend on how far the bit you are using sticks out from the spindle and the thickness of your stock including any spoilboard you intend to fit. Make sure that the motor case is not below the top of the mount or above the bottom.
- When tightening the motor securing bolts tighten them both evenly, as you tighten one the mount is compressed and the other bolt may become slack so swap between them while tightening and make sure that both are secure.
- The black piece of sticky labels are wiring identifiers. These loop round the motherboard end of the wires for the Limit switches, steppers etc. to make them easier to identify when plugging them in to the motherboard. Use them or not as you wish.
- Before connecting the cables decide where you want to mount the motherboard, I have mine at the far left of the gantry for 2 reasons. It keeps the USB cable away from the router and my power supply will fit best to the left of the machine and the wires from the power supply are not very long.
- If you plan on swapping the spindle motor with a Laser when 'tidying' the cabling leave the spindle motor wires separate from the 'fixed' Stepper and Z axis limit switch cables.
- Do not use tie wraps to hold the cabling around the X gantry crossmembers apart from at the very ends!
- If, as I am, you are going to sit the power supply place a baffle between the router and the power supply fan intake to prevent any chips and dust from going straight into the power supply. I am using a piece of foam attached to the edge of the power supply with tape.
- **MOST IMPORTANT!** After the assembly is finished and before you turn it on stand next to it and take a Selfie. It is the last time you will ever see it so clean and shiny!

Assembly

The instructions are good (but read my hints above first!).

Install Candle on your PC, if you have problems with installing it look at https://docs.sainsmart.com/article/7c20d7zaw3-how-to-install-candle-grblcontrol-for-windows

Turning it on

A big step but you deserve to enjoy it!

First though check the emergency stop button is released (turn the outside in the direction of the arrows and it should pop out) *If it isn't released the router will be totally unresponsive. I have never accidentally pressed the emergency stop button on a router, but I know a 'friend' who has!*

Double check the voltage selector on the side of the power supply shows the correct voltage for your countries supply!

Connect the USB cable to your PC and the router, open Candle and turn on the power to the router (doesn't have to be in that order).

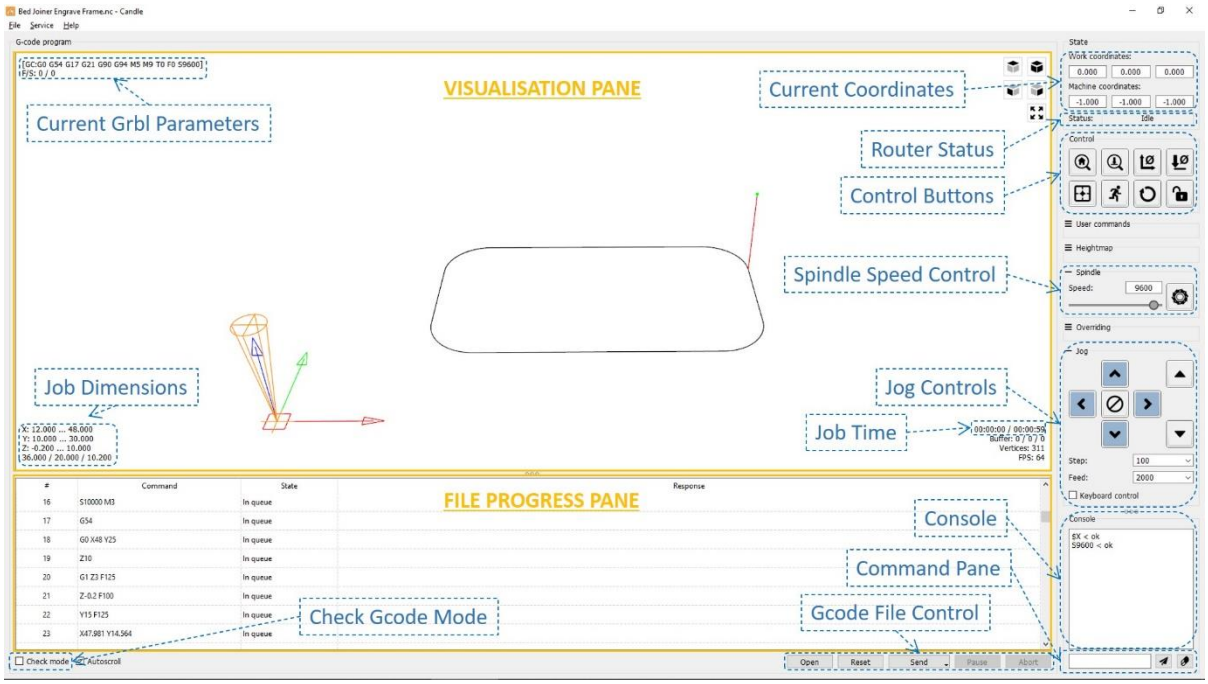
Setting it up

First some simple and quick basic tests, this mainly checks the wiring but even with good quality control manufacturing mistakes can still sometimes happen. I estimate performing these checks will take less than 30 minutes. If they find a problem it will save you hours!

In this guide I am using Candle as the Gcode sender, that is the software on the USB stick that connects to your router and allows you to control it, set it up and send the Gcode files to your router. Others are available.

A 10.5 second introduction to Candle

There are good installation instructions and tutorials available for Candle online, in case you are not familiar with it the Candle screen looks like this:



Starting at the top left and going clockwise:

Current Grbl Parameters	Shows the Gcode settings for things such as mm/inches relative/absolute moves…..
Current Coordinates	Shows the X Y Z coordinates from the Work Origin and the machine position from the Home position.
Router Status	The connection status and router state
Control buttons	Quick buttons for things such as homing, setting work origin, probing reset unlock…..
Spindle speed control	Manual spindle speed and on off button.
Jog Controls	Buttons and values to jog the spindle about.
Job time	Current and estimated time to job completion.
Console	Shows the commands sent to and responses from the router
Command Pane	Enter any manual commands or Gcode here, hit Enter to send.
Gcode File Control	Opens, resets, start sending, pause and abort buttons.
Check Gcode Mode	If this box is checked then the router will parse and validate commands returning any errors but will NOT move any of the axes, start the spindle etc. Useful for verifying a Gcode file, as nothing moves it is quick.
Job Dimensions	Shows the max and min coordinates of the loaded job file and the X Y and Z size

NOTE: you can hide or expand sections by clicking on the icon to the left of their title. The console pane can be resized by dragging the ooo icon up and down so your particular screen may not look identical.

In Candle you should see in the Console pane the start-up message from the router, this will be

< Grbl 1.1f ['$' for help]
[MSG:'$H'|'$X' to unlock]
The Grbl version may vary in the release letter.

and the machine will be in the Alarm state. *(Look it's in a new strange place and has just woken up after a long journey, wouldn't you be alarmed?)*

The Alarm state is normal if the homing cycle is enabled which is the default on the 3020. It means that the machine position has not been determined by homing the machine. Machines without limit switches do not do this and use the position where they were turned on as the Home position. If Candle connects and does not show an alarm state then you need to enable homing (See Homing).

If Candle does not connect to the router check the following:

- The USB cable is correctly seated at both the router and the PC.

- In Candle go to Service / Settings and check the COM port. The drop down list will normally only contain only a few COM ports, try them in turn. *NOTE: The Baud: should be set to 115200 but this is the default setting.*
- If it still won't connect check your Candle and driver installation worked.
- Check the emergency stop button is in the out position and there are 3 red LEDs lit on the back of the motherboard, the Top left shows 48V power is on, the bottom right shows USB power connected and the middle one shows the onboard 12V power circuits are working.

Click the unlock Control Button (the padlock Icon) and you should see a message saying

```
$X < [MSG:Caution: Unlocked]
Ok
```

Testing

It's assembled but let's check it out?

Movement

In the Jog Controls pane check the Step, it's in mm and how far each button press will move the spindle, 5 is good. Set the feed, this is in mm/min, something like 500 is a good test. *Remember if the feed rate is 1mm/min then you will have to sit and watch for 5 minutes as the spindle moves 5 mm!*

Click each of the jog buttons, the left/right arrows should move the spindle to the left/right…. The up button will move the spindle to the back of the bed, the bed will move forwards, and down …..

The right up and down arrows move the spindle up and down in the Z axis.

If there are any problems check the wiring, a common assembly mistake is to swap the stepper motor plugs so when you go left it actually goes back or up.

Spindle motor.

In the Spindle Speed Control pane set the speed to something like 3,000 RPM and then click the circular saw blade icon to the right to start the spindle. It should turn clockwise, if not check the wiring to the motor, a +ve and -ve are probably swapped somewhere. Click again to stop it.

Emergency Stop switch.

Set the spindle turning and then hit the emergency stop switch, the spindle should come to a stop. Make sure afterwards you twist the button in the direction of the arrows to release it.

You will need to hit the reset icon followed by the unlock icon in Candle to reset the router.

Limit switches.

Keep a hand near the emergency stop just in case things go wrong, you will be able to tell by the machine reaching the end of travel on an axis and the nasty grinding noises as it tries to continue if things go wrong!

Click the Home icon (magnifying glass in a circle) in the Control Buttons.

First the spindle should rise to the top of its travel, hit the switch and stop. Then the spindle will move all the way to the right and back of the router (the bed comes forwards) when it reaches the

limit switch it will stop. The Home position has now been set, you should use the home icon each time the router is powered on or reset, this will automatically clear the Alarm state.

IF you see the router return an < error:5 message in response to the home command then please read on to the Tuning the Settings section, change to the suggested values and retry the homing test.

IF you have fitted the bottom Z axis limit switch then test that by using the jog buttons to move the spindle down until it hits the switch, it should stop and send the message:

ALARM:1
[MSG:Reset to continue]

To clear the machine after hitting a limit switch click Reset and Unlock then use Jog to move away from the switch, it will start to move and then see that the switch is still activated and stop, just repeat the Reset, Unlock, Jog sequence until it moves freely. Or use the hand knobs on the axes to move away from the limit switch. Once clear rehome the machine.

Tuning the Settings

Some of the settings in Grbl may not be optimally configured for the 3020 PRO MAX, fair enough I suppose as the board could be used on many different machines. A lot of these settings fall into the ***'Only change if you really know what you are doing'*** category and I am not going to mention those here. *For more information see my Getting Started, GRBL 1.1 Pocket Reference and Tuning Grbl settings guides. See* Other files in this series *section.*

To view your settings in the Command Pane type $$ and hit enter, this will return a list of all the settings in the Console. Each line is in the format of $nnn=val where n is the setting number and val is its value.

I strongly suggest you make a backup copy of these settings before making any changes by using copy and paste on the response to $$ into a text editor and save the file. You can always reset the settings back to the factory settings but these may not be what you want either.

After changing any settings, and they work, it is a good idea to save a copy of the changes as well.

To change the value of a setting in the command pane type $nnn=val where nnn is the setting number and val is the new value. Once changed the setting is permanently stored until it is changed.

Homing

This is controlled by the $22 to $27 values. To enable homing set $22=1, if you don't want to use homing set $22=0. The value of $23 sets the corner to which the machine will go when homing. 0 is the top back right position which is where the limit switches will activate.

The speed and accuracy of the homing cycle is controlled by the following:

- When homing the machine will move until a limit switch is triggered at the Homing Seek Rate ($25)
- It will then back off a bit and re approach the switch at a slower rate, Homing Feed Rate ($24) until it triggers again to get a more accurate position from the slower speed.

- After establishing the final position it will then pull back from the switch until it is not triggered any more, this distance is the Homing pull-off ($27).

Setting	Meaning	Default Value	Suggested value
$22	Homing Cycle Enable	0 (Disabled)	1 (Enabled)
$23	Homing Direction Invert Mask	0	0
$24	Homing feed rate in mm/min. This is the slow rate that the switch will be approached for the second time to get an accurate reading.	25	25
$25	Homing seek rate in mm/min. This is the fast rate that the router will move looking for the triggering of a limit switch.	500	1000
$26	The debounce interval to let the switch settle down after initially making contact in ms	250	50 (250 is very conservative, ¼ Sec, the difference it will make to the homing cycle is small)
$27	The distance the router will back off from the switch to let it deactivate in mm	1.0	1.0

*Homing also uses the machine travel settings to decide how far it can move to find a limit switch the max travel is something like the travel limit * 1.5 so these are not that critical. Setting these is covered in Soft Limits below*

Limits

What the limits do is to stop the machine from following silly instructions, say you tried to carve a piece 600mm wide, the router would obey your instructions and try to move the required 600mm from the origin of the piece. But even if you start at the extreme left the maximum distance it can move without hitting the spindle up against the end of the rails is a lot less. Using Limits will prevent it from making the nasty grinding noises as it hits the physical limit told it to exceed, possibly damaging the router.

There are two types of limits, none, one or both can be used.

Hard Limits

This means the machine limit is detected when a limit switch is activated. Switch triggered and it stops, simple and easy but to only use these you need a limit switch at each end of each axis, 6 in total. The 3020 MAX only comes with 3 (+1 optional). This is enough for homing and these will work as hard limit switches as well even if you have not run a homing cycle and so don't have an accurate machine position.

Soft Limits

These have the same effect as hard limits, as long as a homing cycle has been run the router can calculate if each movement requested will exceed its movement limits, stop and raise an error accordingly.

These need 2 things; A homing cycle must have been run to set a known machine position so it knows how far it can move from that home position on each axis before it has to stop.

The how far it can move before it has to stop is set by the Max Travel values for each axis.

Setting	Meaning	Default Value	Suggested value
$20	Enable (1) or disable (0) Soft Limits.	0	1
$21	Enable (1) or disable (0) Hard Limits.	0	1
$130	Maximum travel in mm on the X axis.	200	281*

Setting	Meaning	Default Value	Suggested value
$131	Maximum travel in mm on the Y axis.	200	195*
$132	Maximum travel in mm on the Z axis.	200	70 or 170**

* All machines are potentially a little different, especially at their limits. The values above may be a little conservative, but should be safe.

** Use the larger size if the optional Z- Limit switch is fitted, this effectively disables soft limits on the Z axis and the hard limit switch will be used.

To determine maximum travel for your router do the following:

- Set $20 to 0 if necessary to disable any existing soft limits
- Home the machine
- Note the Machine position for each axis. At the home position they should all be -1.00 (In the Current Coordinates Pane, X Y Z from left to right)
- Using the Jog function move the spindle on each axis, reduce the jog step as you get close to the edge! Until you get close to the edge. If you go too far you will hear the grinding noises as the stepper motor fails to drive the carriage or bed past it's limits. Note the difference between the initial value and the ending position and that is the maximum travel on that axis.
- Set $130-2 accordingly. (These are always positive numbers so ignore any sign)
- Set $20 to 1 to enable soft limits.

Why are these less than 3020?

- The limit switches are normally mounted quite conservatively, they should stop the travel before it reaches the machines physical limit, trying to go down to very low tolerances is not a good idea.
- I have set the soft limits to be a bit conservative, if you are trying to eke out the last few mm then practically you need a bigger machine. Or make more accurate measurements.

Z-Probes and Heightmaps

The only problem I find with soft limits is when building a height map or using the Z probe. The probing code specifies a 'seek' distance, the maximum distance the Z axis will move down so that the bit makes contact with the probe base. If the probe does not make contact in this distance the probing fails. But if you are using soft limits the 'seek' distance is checked against the soft limits, so if the probe base is close to the top of the bed it is tricky to know where to start the probing, too high and it won't reach the probe base, too low and it will trigger a soft limit.

The 3020 PRO MAX comes with an optional Z- limit switch. I find the best solution when using a Probe is to fit this switch and effectively disable soft limit checking for the Z axis by setting the Z maximum travel to a high figure something like 170mm. This gives the benefits of stopping at maximum travel using the hard limit and not triggering unnecessary soft limits.

Spindle Speed

There are two settings for this, Max Spindle speed and Min Spindle speed, this is how they work.

- If the Gcode Snnn is greater than the Max Spindle speed the Max spindle speed will be used.
- If the Gcode Snnn is less than the Min Spindle speed the Min spindle speed will be used, unless it is zero, that will stop the spindle regardless.

The voltage sent to the motor which determines spindle speed is adjustable in 1024 steps from 0 to 1023 where Max spindle speed is 1023 and 0 is Zero, values in between are calculated. The min spindle speed can be used to prevent the motor from stalling at too low a speed which also means a low torque. The spindle speed of the 3020 is nominally 12,000 RPM

Setting	Meaning	Default Value	Suggested value
$30	Max Spindle RPM.	1000	12000
$31	Min Spindle RPM.	0	0

NOTES:

- The spindle speeds are also used for Laser power when a laser is fitted, make sure your Laser Software has the appropriate values.
- These values should also be set in your other PC software to match.
- Gcode Senders often use these values for things like speed overrides and other calculations so set these values in the Candle Settings to get more accurate predictions.

Maximum movement rates

The router needs to know how fast it can move, like the spindle speed if a movement rate is requested on an axis that is greater than the router can physically move then the maximum rate is used. What this is depends on the stepper motors, leadscrews, weight of the spindle, friction…… But these values are often set very conservatively.

If these rates are set too high then the stepper motors will be unable to keep up and will stall which is known as lost steps, the movement will not be completed and the router will lose track of its position which is a very bad thing.

The benefit of the higher rates is potential speed of cuts as it can move faster, especially on positioning moves. *Determining these is covered in Introduction to CNC for a total Novice – Tuning Grbl Settings (See Other files in this series)*. But remember these are normally limits for No Load movements when the machine is not cutting.

Setting	Meaning	Default Value	Suggested value
$110	X Axis Maximum travel rate mm/min	1000	2000*
$111	Y Axis Maximum travel rate mm/min	1000	2000*
$112	Z Axis Maximum travel rate mm/min	600	800*

*I have not exhaustively tested these values, but these will work, to set them higher will need more testing and experimentation. The Z maximum rate is often set lower, not because it cannot move at the same speed but to minimise the effects of it plunging down too fast!

Acceleration

Nothing can go from stationary to moving in 0 seconds, it has to accelerate up to that speed, how fast it can accelerate depends for a router on a number of factors.

But the acceleration rates (measured in mm/sec/sec or how much the speed per second can be changed each second. It can make a big difference to the time a movement takes, especially short ones.

I think the default values are conservative but it takes a fair amount of testing to be sure that higher values will work. *Determining these is covered in Introduction to CNC for a total Novice – Tuning Grbl Settings (See Other files in this series).*

Setting	Meaning	Default Value	Suggested value
$120	X Axis Acceleration mm/sec/sec	30	30

Setting	Meaning	Default Value	Suggested value
$121	Y Axis Acceleration mm/sec/sec	30	30
$122	Z Axis Acceleration mm/sec/sec	30	30

Testing the Settings

This assumes you have enabled homing, hard and soft limits.

Homing has been covered and does not to be re-tested and we know the axes all move in the correct direction and the limit switches work as expected.

Testing Soft limits

This is checking that the values set for the maximum travel distances are correct.

- Home the machine.
- In the command pane enter G91 G0X-500, an error should be returned and the machine will not move as it exceeds the soft limits.
- Reset and re-home.
- In the command pane enter G91 G0X-val where val is the X axis maximum travel you set in $130 *(LESS 1 mm, if you enter the actual value it will trigger the error)*, the machine should move to that position, stop before it reaches the hard limits of the machine but be close to the limit.
- Repeat the above for the Y and Z axes changing the G0X- for G0Y- and then G0Z- and the maximum travel in $131 and $132 (Less 1mm) you set for the Y and Z axes respectively.

Testing movement

This is not calibrating the axis precisely just checking that everything is OK and nothing is loose or slipping.

- Put a V bit in the collet and tighten *(this is only so you can see the position accurately)*.
- Place a ruler on the bed along the X axis, or use the gridlines on the bed.
- Jog the bit down until it is just above the ruler, adjust the ruler's position or jog the spindle so it is above a convenient measurement point.
- Using the Jog commands jog along the ruler and check that the measured movement matches the jog step value used for the jog command.
- Repeat for the Y axis
- For the Z axis I find it easiest to measure the distance between the top of the motor mount and the Z axis gantry, it is much easier than trying to get a ruler under the bit. Jog up or down a bit and verify the distance changes as expected.

Setting up the Z probe

Before using the Z probe it must be set up in the Gcode sender such as Candle and on the offline controller if you are going to use that.

Simply this involves measuring the thickness of the probe base accurately and setting up the Gcode accordingly. This is covered in detail in "Introduction to CNC for a Total Novice – Z-Probes" see the Other files in this series section to download your copy.

Tramming and levelling

Last test, tram the bed. Tramming (often referred to incorrectly as levelling) is verifying that the spindle Z movement is exactly perpendicular to the bed in both the X and Y axes. Levelling is setting the bed surface to be flat **relative to the movement of the tip of the bit** in the X and Y axes. It does not really check that the Z axis movement is vertical. But to tram a router properly you really need a pair of dial gauges and a mounting for them that holds them at 90 degrees to the Z axis itself. *You can put the spirit level away.* That is too expensive for me and for what I will be doing on this machine I don't really need that level of accuracy; I will be cutting metals but not precision machining.

This method should detect any alignment errors in assembly, it will not detect if the Z axis is exactly perpendicular to the bed. The cast solid bed of the 3020 PRO MAX makes bed warping unlikely, much better than Aluminium extrusions.

For final levelling I will be making a spoilboard for mine, fixing it to the bed and then surfacing it to make sure it is perfectly level relative to the bit. *This will also keep the bed unscratched and nice and shiny, even though I won't be able to see it I will still know!*

I am aiming for good not perfect, mainly tis is to detect any obvious errors. Measurements will be taken by using the router itself.

I am assuming you know paper method of zeroing the Z axis, you can use the Z-Probe if you want *(set it up first)* to make this quicker. I am going to measure the height of the bed at 5 points, one at each corner of the bed and one in the centre, to start with.

It's quite simple:

- Home the machine, then zero the Z axis at that point.
- Use G90 G0 Z0 (type it in the command pane and send it to the router) to set the bit to the zero position in the Z axis and record the MACHINE Z coordinate value from Candle.
- Jog the bit away from the bed to prevent scratching, Jog to the next corner and repeat zeroing the Z axis at that point.
- Repeat for the other 2 corners and the centre of the bed.

Now you should have the machine coordinates of the Z zero position at each corner and the centre. Pick any point and work out the difference at each point. You should end up with something like this (I am using the centre position as the reference 0 point):

Z0: -54.490 ***Diff: -0.144***		Z0: -54.774 ***Diff: 0.140***
	Z0: -54.634	
Z0: -54.491 ***Diff: -0.143***		Z0: -54.884 ***Diff: 0.250***

NOTE: Although Candle and other Gcode senders display the coordinates to 3 decimal places the router is not that accurate! Even if everything else was perfect (and it never is) the minimum distance the router can move in a single step is 0.00125mm.

Personally I think that is pretty brilliant! It is a very good statement about the machine's quality. *The rest is either down to my skills at assembling these routers or pure dumb luck? Your choice.*

In the Y axis the left hand side of the bed is perfectly level, the right hand is sloped up at the front by 0.11mm. In the X axis the right hand is higher by 0.284mm at the back and 0.393mm at the front.

As I said I think that is pretty good, especially as I will be fixing and surfacing a spoilboard which should make the surface completely perpendicular to the tip of the bit.

There are two ways of correcting any errors depending on the axis:

- For the X or Y axes add shims between the bed and the bed supports to lift the bed at the mounting points. These are closer together than the edges of the bed so there will have to be some maths involved or a lot of trial an error You could just measure the points at the centre of the mounting screws on the bed?
- For the X axis only raise or lower the gantry position at one or both sides, there will be a little play in the assembly while the bolts are being tightened.

For the first try I am going to slacken the right-hand side of the gantry mount and try and position it ~0.35mm lower before re tightening the bolts. *(0.35mm is not a lot!)*

To Raise or lower a gantry

- First make a mark (pen, tape or scribe) a reference point at the side of the gantry next to the top of the frame. (I used a piece of masking tape) This just makes it easier to see the position.
- Remove the spindle motor. *You will need to check the adjusted gantry keeps its vertical and this is measured to the inside of the motor mount.*
- Slacken the 4 middle bolts on the gantry support and two on the outside at a Diagonal.
- Slightly slacken the remaining two bolts, so that they keep a bit of friction but can be moved.
- Slide the gantry up or down, (tap it on the top gently with something soft like a rubber mallet to move it down, use a lever to prise it up) while watching the mark to get it at the correct adjusted height and apply some pressure to push it down or hold it up in the new position as you tighten it.
- Double check the distance from the back frame to the gantry uprights and that the gantry is still vertical to the spindle by using a square between the bed and the inside of the motor mount.
- Re-tighten the two diagonal bolts to hold the gantry in place, then tighten the other bolts.

Re measure. After making the adjustments this is my second set of measurements:

Z0: -54.385 ***Diff: 0.131***		Z0: -54.235 ***Diff: -0.019***
	Z0: -54.254	
Z0: -54.425 ***Diff: 0.171***		Z0: -54.325 ***Diff: -0.071***

Slightly more level???? All the slopes at the edges are less than 0.25mm.

I am going to stop here. I don't think I am going to improve on these figures, this was started as a check to make sure something was not grossly out (>1mm) and it wasn't!

Using a Laser

The 3020 PRO Max has a 52mm Motor mount, the 'standard' 33mm square Laser is designed to fit in the groves of a 42mm Motor mount.

Do not worry, your Router comes with a plastic collar which will fit around the laser which can be slid into the 52mm motor mount. Easy.

Connecting the Laser

The Motherboard comes with a 3-pin laser socket vertically mounted. From the outside of the board the connections are Gnd | PWM | 12V *(The markings are on the back of the board).* If your laser has a separate power supply then just connect the Gnd and PWM pins to the appropriate pins on your laser. If takes its power from the Router mainboard then connect the 12V as well, make sure that the correct wire is connected to the correct pins at both ends, the order of these pins can vary depending on the Laser you have. Please see the setting up a Laser guide in the Other files in this series Section.

That's it! Not the end, but time to start using it!