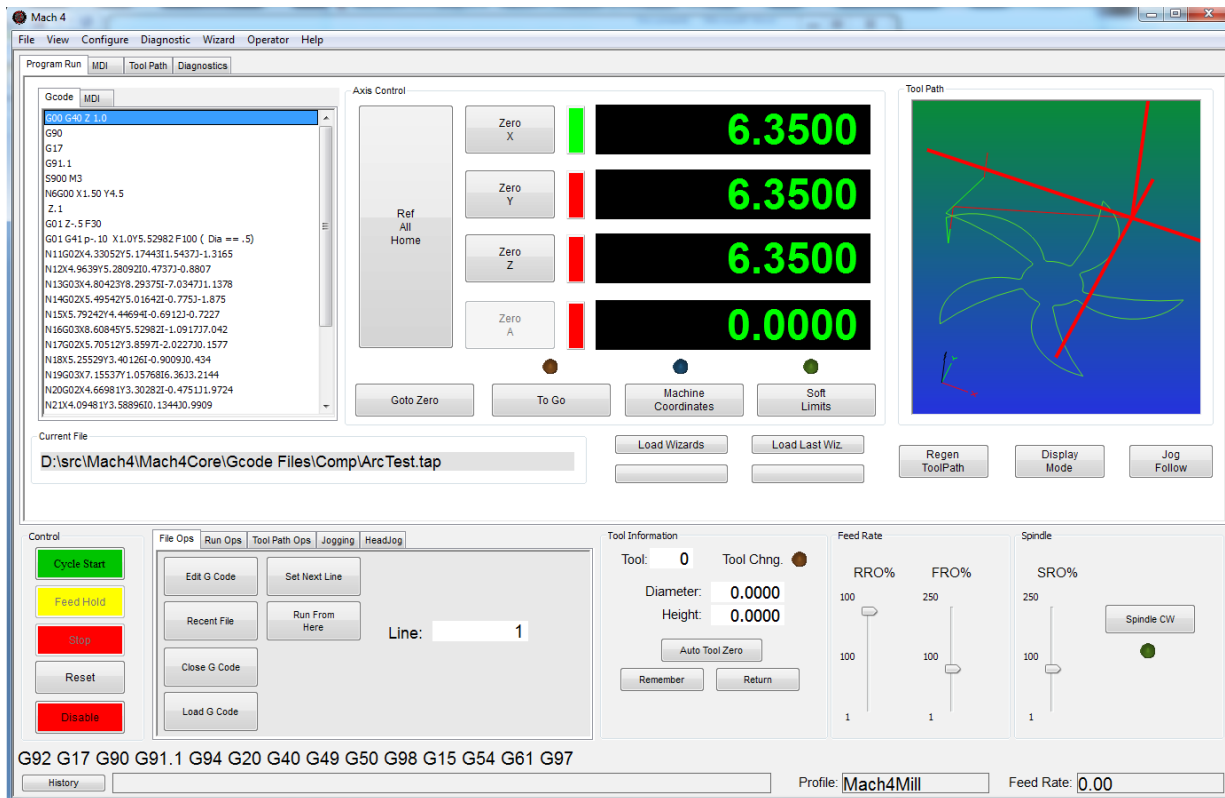


# Mach4 CNC Controller

## Software Installation and Configuration Guide

### Version 1.0



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## Chapter 1 Introduction to CNC Systems

This chapter introduces you to terminology used in the rest of this manual and explains the purpose of the different components in a computer numerically controlled (CNC) system. CNC machines are in many industries and becoming more popular in manufacturing lines. The traditional machine types are Mills, Routers, Lathes and Plasma cutters. The non traditional things that can be done with a CNC system can be but not limited it laser measurement, pick and place, quilting, assembly, laser cutting, rapid prototype, painting and so on. Because of the popularity of CNC's in non traditional CNC industries Mach4 has been made to be extremely configurable and expandable. The ability to add and remove modules will be covered in this manual but the screen and scripting customization will be covered in there respective manuals.

### ***Before You Begin....***

Any machine tool is potentially dangerous. Computer controlled machines are potentially more dangerous than manual ones because, for example, a computer is quite prepared to rotate an 8" unbalanced cast iron four-jaw chuck at 3000 rpm, to plunge a panel-fielding router cutter deep into a piece of oak, or to mill away the clamps holding your work to the table. Because we do not know the details of your machine or local conditions we can accept no responsibility for the performance of any machine or any damage or injury caused by its use. It is your responsibility to ensure that you understand the implications of what you design and build and to comply with any legislation and codes of practice applicable to your country or state. If you are in any doubt, be sure to seek guidance from a professionally qualified expert rather than risk injury to yourself or to others.

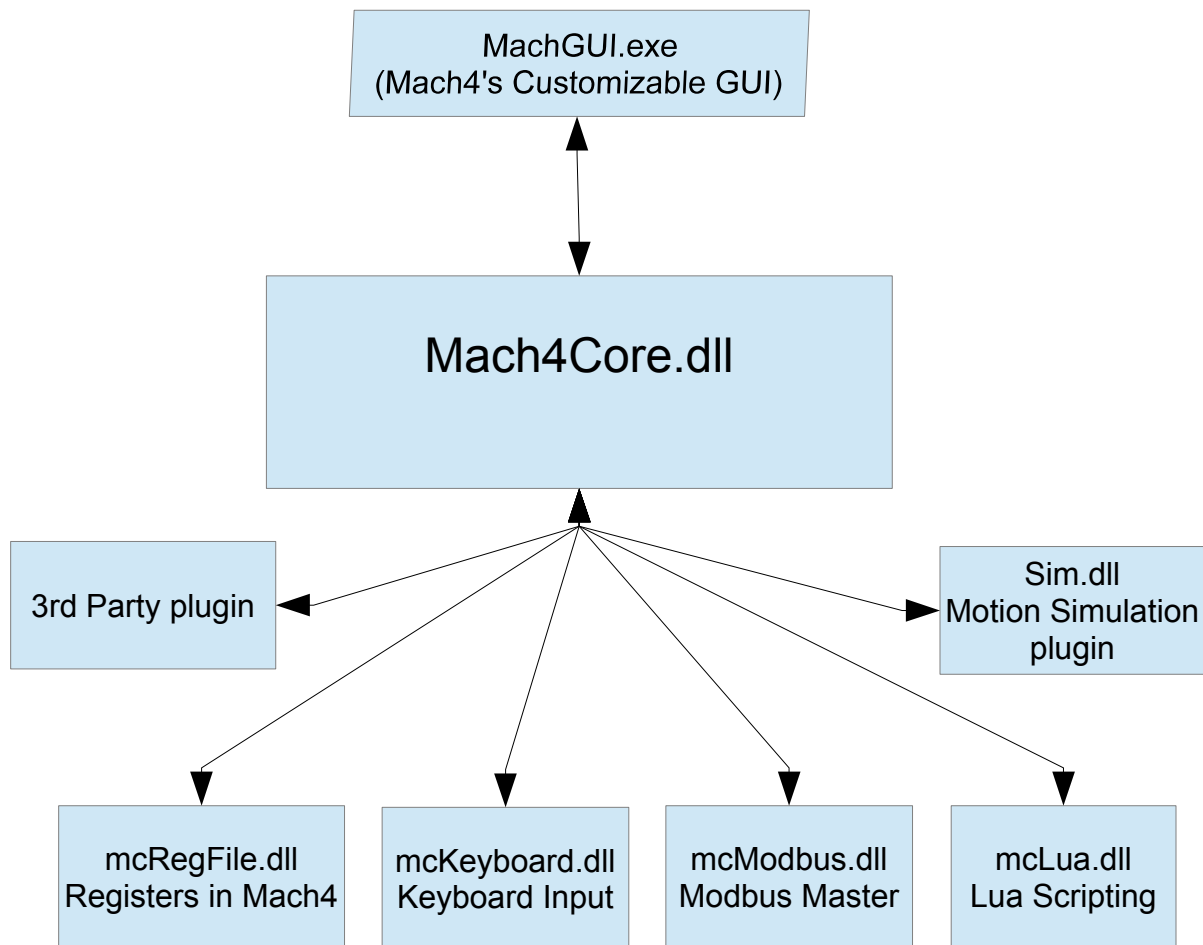
### ***Introduction***

This document tells how to install and setup Mach4 motion control software. The foundation of Mach4 is the core called Mach4Core, Mach4Core can be setup in many configurations for the following machine configurations general automation, Mill, Router, Lathe, Plasma, Pick and Place, etc... A separate documents explain how to operate Mach4 with the specific machine types. The user interface has no relation to the core or motion and/or IO devices used.

**YOU WILL NEED TO READ THIS DOCUMENTATION!** Mach4 is a very complex software package that cannot be simply made "to work" without proper configuration. The install and play with the settings approach may work for other software packages but this is not the case with Mach4. The time spent reading the manual will save many hours of aggravation and will result in a better running machine. This manual will give the steps in a logical order that must be followed.

## ***Mach4 Layout***

Mach4 is built on a central core called Mach4Core.dll and is what connects all the parts of Mach4 together. The following diagram (see Drawing 1) shows how all the components are connected:



*Drawing 1: Mach4Layout*

All IO, Motion and addon devices are plugins allowing them to be setup and configured in Mach4. The plugins supplied by Newfangled Solutions in the installer are added as appendixes to the end of this

document. Any plugins that are not being used should be removed from the system to lower the overhead of Mach4 on the computer. Development partners of Newfangled Solutions have access to Mach4's SDK allowing them to manufacture plugins for other devices and/or functions. The setup, configuration, and any diagnostics will not be covered in this manual for their devices.

## **Chapter 2 Installing Mach4 Software**

If Mach4's installer is not on the machine, a copy can be found at [www.machsupport.com](http://www.machsupport.com) in the downloads section of the web page. The machine tool does not need to be connected to the web to install Mach4.

If the machine is setup by an OEM or manufacture as a complete system, many if not all of the steps in the following chapter may have already been done for you. The machine settings are all saved in the profile directory with its own named directory. The named directories can be added and removed from the profiles dialog but it is useful to know where the settings are. The named directory for each machine contains all the machine settings in it's machine.ini file. The machine.ini file is backed up every time mach4 is started so the user can roll back settings if there was an error made during software configuration. The other directories in the named profile directory contain the macros, tool table, fixture table, ini backups, screw maps and so on. If a new computer is being setup to replace the an existing PC with Mach4 a simple copy of the profile named directory can be done to move over all the machine settings.

### ***Installation***

Mach4 is distributed by Newfangled Solutions over the internet. The software is available as a single installer from the web-page with a download size of about 17MB. After install Mach4 will be in demo mode with a limitation of how long Gcode will execute. The time the software can be run in demo is about 20 min and then it will randomly stop in the middle of a run. Newfangled Solutions recommends that Mach4 is setup and tested before purchasing a license. Pricing and options are available at [www.machsupport.com](http://www.machsupport.com) .

### ***Downloading***

Download the installation package from [www.machsupport.com](http://www.machsupport.com) . Click on the download link and save the self-installing file on the desktop or in a convenient folder. Mach4 needs to be install as administrator, this can be done by right clicking on the self-installing file and telling it to “Run as Administrator”. If installing in a remote location the installation file can be saved and moved to a

machine that has no web access. The file will require a CD or USB drive to have adequate storage volume.

## ***Installing***

This section will guide the process of installing Mach4 software. If Mach4 has been previously installed on the machine, Mach4 can be installed on top of a previous installation. There is no need to uninstall before reinstalling.

### **If a machine is connected:**

The machine that is connected to the computer should be set in a condition that will not allow motion or IO to be triggered. If the machine can be disconnected please disconnect. If the machine can't be disconnected please press the E-stop button to put the machine into an E-stop condition.

## ***Run the installer***

Running the installer should be done as Administrator to allow Mach4 to be installed correctly. The package will be installed by default in the C:/Mach4 directory. It is recommended that you keep the installation directory as C:/Mach4 so the support staff can better assist you with your future support needs. The basic install will load the appropriate files needed for each machine type (Lathe, Mill and Plasma).

## ***Setting up the Profile***

To test the installation double click on the Mach4 Icon that was placed on the desktop by the Mach4 installer. The icon will launch the MachGUI.exe executable and allow the selection of a profile. It is recommended that a new profile is setup for the machine that is being configured. A new profile can be generated by pressing the "Create Profile" button (see Figure 1),but this will create a blank profile. If a similar setup is available the "Copy Profile" button (see Figure 1) can be used to copy all the profile settings and create the profile.

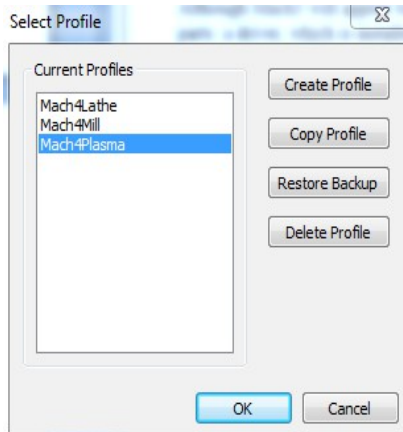


Figure 1

A "Copy Profile" is very powerful as it will copy all the machine settings such as the tool data, fixture data, ini backups, Macros, and all machine settings. This can be used later to make a test profile to allow changes to be made without harming the running machine profile. The profile can be removed after testing is finished with the "Delete Profile" button. The profile settings can also be restored to a previous session if a bad setting has been made. The "Restore Backup" button (see Figure 1) will launch the Restore Backup dialog (see Figure 2). The machine.ini can be selected by looking at the Date and Time of the last known running configuration.

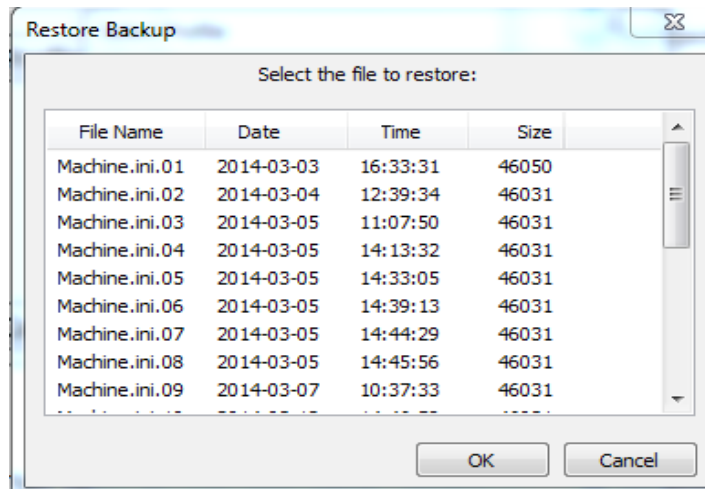


Figure 2

## Create Shortcut to Profile



A shortcut can be created to allow the an immediate launch of the software with a selected profile. By adding the following " /p Mach4Mill" to the end of the target string (see Figure 3) allows MachGUI.exe to load and immediately load the "Mach4Mill" profile.

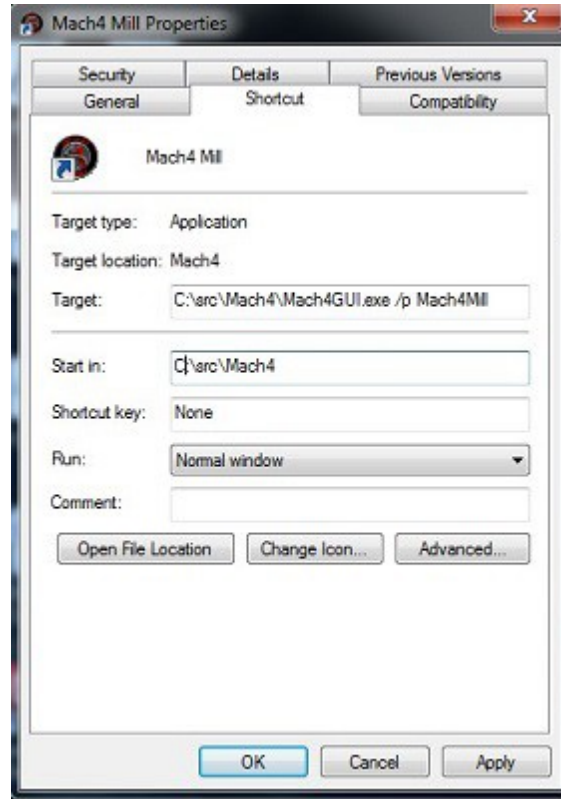


Figure 3

Any other profile can be loaded by changing the profile name after the /p in the target string.

## Chapter 3 Setting up the software

### *Step by step setting up of the machine*

In this section the machine specific settings will be done to transform the software into a functioning machine controller. The first step was to create a new profile to save the machine settings. This was done as part of the installation process to protect the machine settings. If this was not done please review the "Setting up the Profile" section of this manual.

By the end of this chapter a typical machine should be setup and capable of motion and IO (inputs and outputs). In order to setup the machine the first step is to install all the plugins that you need for the machine. Examples of plugins that may be needed could be Parallel Port and Modbus.

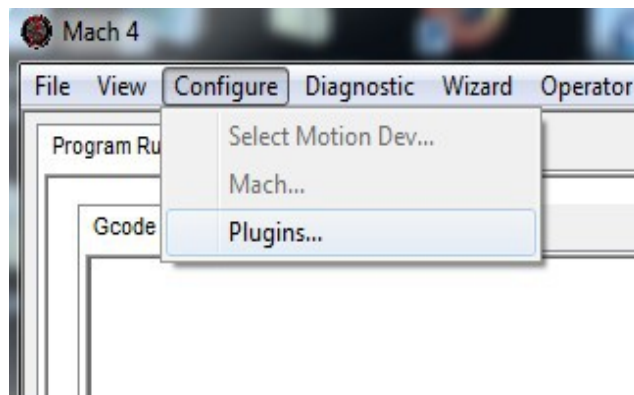
Note: If the software is locked the configuration settings may not be available. If the software is locked non of the configuration dialogs will be available.

## ***Plugins and their function***

The plugins in Mach4 are the building blocks of the system. The plugins all use the Mach4core.dll as a base but have the power to add functionality to the system. Plugins can perform the following functions Scripting, Motion, IO, File conversions, File loading, Motion Generation and countless other functions. The ability to add such functionality is fundamental in the setup of the machine. The most important plugin is the motion control plugin. A careful selection of plugins needs to be done to add the appropriate functionality for the machine to be configured.

## ***Adding and removing Plugins***

To add a plugin from a plugin archive file m4plugw for windows, m4plugl for linux, and m4plugm for mac. To load a plugin archive navigate to the "Configure Plugin" Dialog (see Figure 5) by navigating Configure/Plugins (see Figure 4)



*Figure 4*

A plugin must be enabled to allow the plugin to function. The software must be restarted after enabling or disabling to allow the plugin function to change its state. To remove a plugin highlight the row of the plugin and press the "Remove" button (see Figure 5).

## ***Configuring Plugins***

The configuration of the plugins can be done from the "Configure Plugins" dialog (see Figure 5). Not all plugins can be configured as they have no settings that can be customized. For the plugins that can be

configured a "configure" plugin button is available to the right of the plugin description. When the configure button is pressed it will launch the configuration dialog supplied by the Plugin author. The configuration of the device must be done before the devices IO can be accessed or used by Mach4. The configuration of the plugins incorporated in the installer will be covered in appendixes to this document.

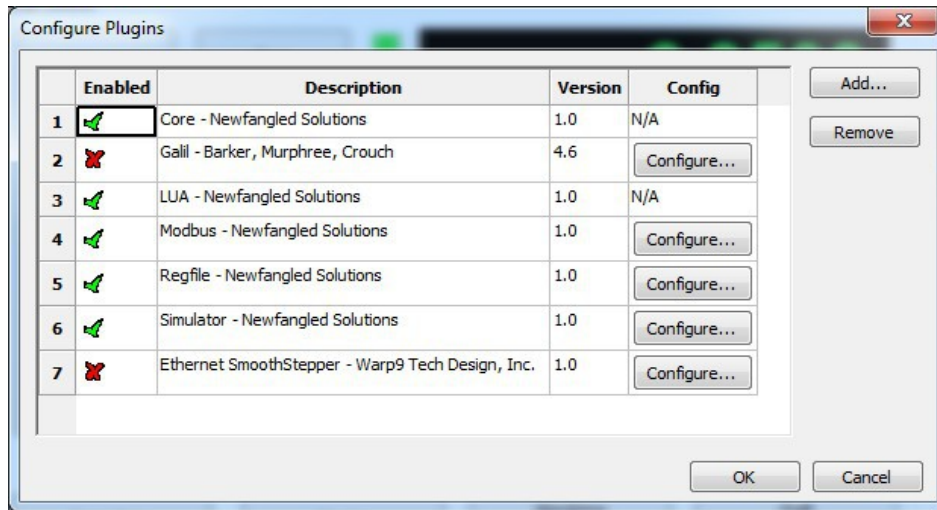


Figure 5

## Select Motion device

The first device that needs to be setup is the motion device. To select the device go to "Configure/Select Motion Dev." (see Figure 4). The "Select Motion Device " dialog (see Figure 6) allows the appropriate motion device to be selected. The selected motion device tells the core what device can drive the motors and the high speed IO. The all other motion devices are set to be deactivated and will not allow the IO or motion to be controlled. The system must be restarted after motion device has been selected to allow the motion device plugin to do its startup initialization. After the restart the motion device needs to be configured. To configure the motion device please use the Motion device supplied manual and continue setting up the software once it is complete.

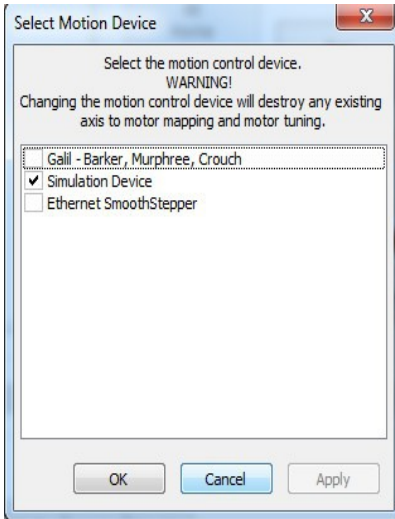


Figure 6

## ***Other Plugins***

The rest of the IO devices can be setup at this time if the settings are known. Some plugins that are not fundamental to the machine can be setup at a later time. It is the responsibility of the installer to determine what is needed to get the machine running. An example of a plugin that would need to be setup and configured would be if a PLC was installed to enable the servo amps and machine. In this case no testing can be done without Modbus communication to the PLC. To many machine configurations can be done for this manual to take them into account so careful planning on the part of the installer is the only way to get a system setup.

## **Chapter 4 Machine Settings**

### ***Default Modal State***

The default state of the software is set at start-up or when the reset button is pressed. The following options can be set and should only be set once. If the CV mode or some other setting needs to be changed in a Gcode or for a short period of time, MDI should be used. The configuration dialogs are only used for setting the start up state

All configuration settings can be found in the "Mach Configuration" dialog (see Figure 7). The following is a description of the settings that can be changed in the dialog (see Table 1).

Setting	Description
Units Mode	Inch G20 / G21 Millimeters, The default units the machine is setup in such as
Traverse Mode	Rapid G00 / Feed G01
Motion Mode	Exact Stop G61 / Constant Velocity G64
Look Ahead Lines	Number of lines the interpreter can chain together to get to the programmed Feedrate
Distance Mode	Absolute G90 / Incremental G91, Distance mode used by default
Arc Center Mode	Absolute G90.1 / Incremental G91.1, Distance mode for the IJK circle centers. R type centers are not effected.
Feed Mode	Feed Per Rev G95 / Feed Per Min G94, feed mode used by linear and arc feed moved. Feed per rev must have true spindle RPM to be used.
Active Plane	XY Plane G17 / XZ Plane G18 / YZ Plane G19, The plane selection used for Drill cycles, Arcs and cutter comp
Cycle Retract	Initial Z G98 / Rapid Plane G99, Selects the can cycle position for the moves in the working axis. The working axis is perpendicular to the current active plane.
Spindle Mode	Constant RPM G97 / Constance surface Speed G96, Selects the default spindle speed mode.
Initialization Codes	The init codes are run when the program starts and also when the reset is pressed
Coolant Delay	Time to wait for the Coolant to turn on
Mist Delay	Time to wait for the Mist to turn on
Jog Increments	Increments used for Incjog register
Gcode File Extensions	The Gcode extensions for files to be executed. This sets the open able extensions of the file open dialog.
Include Comments in Message	Enabling the selection will add all comments in the Gcode file to the messages log.
Deref Axis In E-stop	Enabling sets the axis homing to be false when in E-stop is active
Cycle Stop is Controlled Stop	Enabling will set the axis to do a controlled deceleration when a Cycle Stop is commanded. A very slight delay will be seen as the axis comes to a stop.

*Table 1: General Settings*

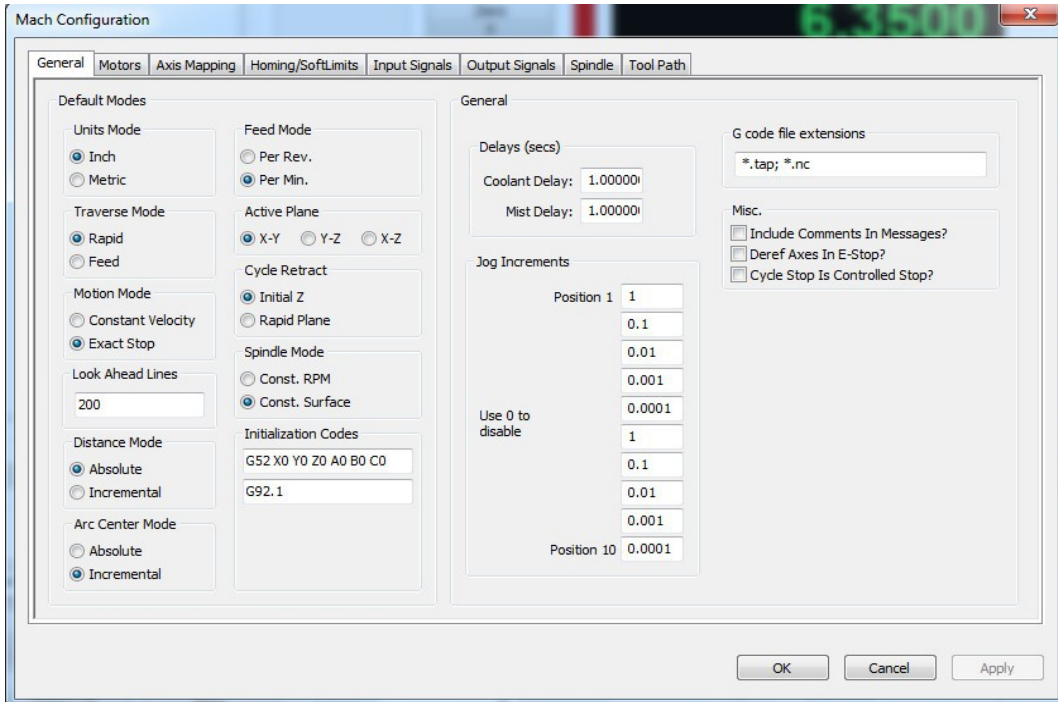


Figure 7

## Motor Tuning

Motor tuning is one of the most important settings in configuring a machine. The settings available in the motor tuning dialog (see Figure 8) will allow the motor to be setup for the appropriate Counts per Unit, Max Velocity, Acceleration, Backlash, Direction Reversal and delay for enable signal. A detailed description of each of the settings will be given in the following section.

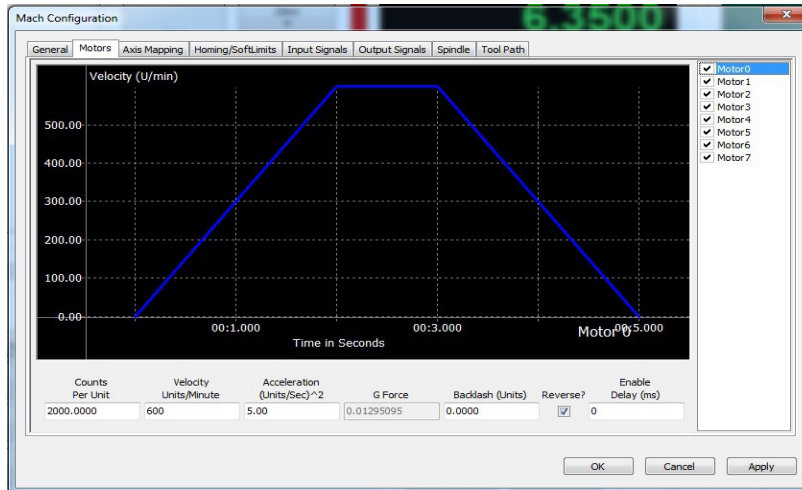


Figure 8

## Counts Per Unit

The Counts Per Unit is used to convert the users units (Inches, Millimeters, Degrees,etc...) into encoder counts or step pulses depending on the type of system. The counts per unit is a value that can be found with mathematics. The value should never be “tuned” or “adjusted” because it is a mathematical relationship with the drives, screw pitch, reduction ratio and so on. The following examples will show how this value can be calculated:

Example 1: CNC Router with rack and pinion drive

Stepper Motor with 2000 Steps per Rev

Belt Reduction (Small Pulley 15 teeth(Input Gear), Large Pulley is 40 teeth(Output Gear))

Pitch Ratio of the Pinion gear is .765 “

$$\frac{\left(\frac{\text{OutputGear}}{\text{InputGear}}\right) * \text{CountPerRev}}{\text{PitchDia}} = \text{Counts per Inch}$$

$$\frac{\left(\frac{15}{40}\right) * 2000}{.765} = 6971.67756 \text{ Counts Per Inch}$$

Example 2: CNC Lathe with a lead screw

Lead of screw .25 inch Per Rev

Belt Reduction 15 tooth (Input Gear), 30 tooth (Output Gear)

Servo drive with 5000 encoder counts per rev

$$\frac{\left(\frac{\text{OutputGear}}{\text{InputGear}}\right) * \text{EncoderCountperRev}}{\text{ScrewPitch}} = \text{CountsPerInch}$$

$$\frac{\left(\frac{15}{30}\right) * 5000}{.25} = 40,000 \text{ Counts Per Inch}$$

As a rule of thumb an inch machine should have the steps per unit greater than 5000 (200 for MM). A value of 5000 will give a resolution of .0002 inches. A greater number of steps per unit will give better performance as well as finer resolution. The only issue with a very high count per unit is that the max velocity can become limited. The motion controller may only be able to deal with a limited number of counts or steps per sec. Please check your motion controllers documentation to see get the max frequency of the motors. If you would like to predict the max frequency this can also be done with mathematics.

$$\frac{\text{MaxVelocity} * \text{CountsPerUnit}}{60} = \text{OutputFrequency}$$

In the next examples we will consider the max velocity to be 200 Inches per minute

$$40,000 \text{ counts per unit} \quad \frac{200 * 40,000}{60} = 133,333.333 \text{ Hz} = 133.33 \text{ kHz}$$

$$6971.67756 \text{ counts per unit} \quad \frac{200 * 6971.67756}{60} = 23,238.93 \text{ Hz} = 32.24 \text{ kHz}$$

## Velocity

The Velocity in the dialog is the maximum rate in units per min. This is also the velocity that will be used for rapid moves when running Gcode.

Setting a Stepper:

On a stepper machine to set the max velocity a series of test need to be made. The Steps per Unit must be set before the axis can be tested. Set a value of a max velocity that seems to be reasonable and test with a jog at 100% jog rate. If the axis is able to move without missing steps (most times you will hear a “buzzing” or “squealing” sound when steps are missed, repeat this process until the upper limit is



found. Once the max velocity is found the max velocity should then be set to 20% - 30% less. To insure that there are no missed steps during motion.

#### Setting a Servo:

To set the max velocity of a servo machine a small series of tests can be preformed or it can be done mathematically with some calculations. When testing the max rate of a servo and the max velocity is exceeded the servo may fault from being out of position (digital servo) or will not get to max velocity and make an abrupt stop. If ether one of the following happen the velocity must be lowered until the behavior is fixed. Once the motor is fixed the velocity should be lowered by 5% to insure that the best performance can be obtained.

### ***Acceleration***

The max acceleration sets how quickly the motor can get to speed. The higher the acceleration the faster the cutting can be done. The higher the acceleration the quicker an axis can reverse and go around corners. Cycle times can be lowered by running higher accelerations and lowering the max velocity. The acceleration should not be raised to the point that it causes motor stalling, vibration in the frame, or other unwanted vibration.

### ***Backlash***

Backlash is used to take out mechanical wind up in the drive system. The misconception is that backlash can be used to fix "slop" in a screw/ ball-nut or slop in a rack and pinion. This can be used to help fix the machine but is not the proper way to correct the problem. The only way to truly fix the issue is to fix the mechanical issue. The backlash should never exceed .005 inches or .1 mm .

### ***Reverse***

The reverse section is used to reverse the motion of the motor.

### ***Enable Delay***

Enable delay will allow a the enable signals to turn on with a delay. The delay can be used to stage the enabling of the amps. This can be used to lower the inrush current by enabling the amps one by one.

## Axis Mapping

The axis mapping dialog (see Figure 9) is used to set what motors are used for an axis as well as the homing order and max limits for the axis. The motors can be assigned to an axis with a maximum of 6 motors per axis. The axis will use the lowest max velocity and the lowest acceleration. This is done to allow slave motors to not have the same motor settings as the other motors associated to the axis. The steps per unit also do not need to be the same for each motor that is part of the axis.

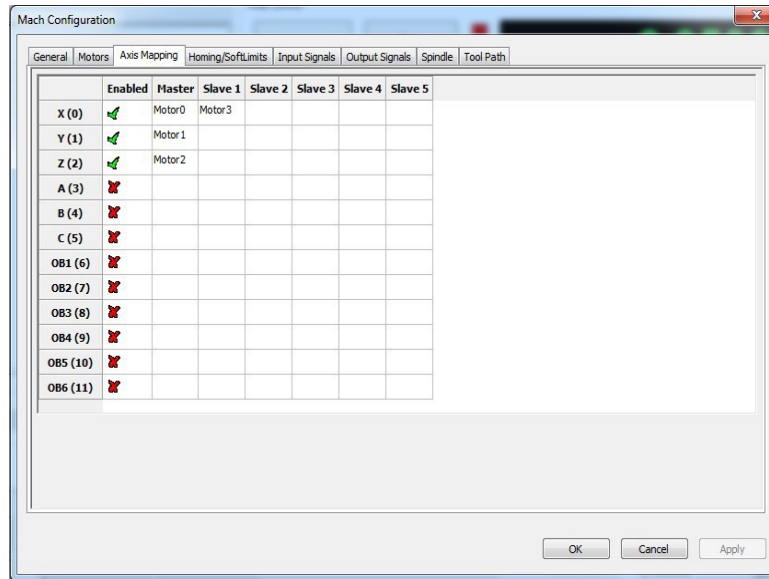


Figure 9

## Homing and Limits

Setting the homing and limits will set what the machine will do when the machine enters a home state or reaches a limit. The act of homing is fundamental in the operation of CNC's and automated equipment. Homing the machine will set the machine zero position of the motors. This will be the base from which all work / fixture offsets are calculated from. All the settings for the homing of the axis are done in the Homing and Limits dialog (see Figure 10).

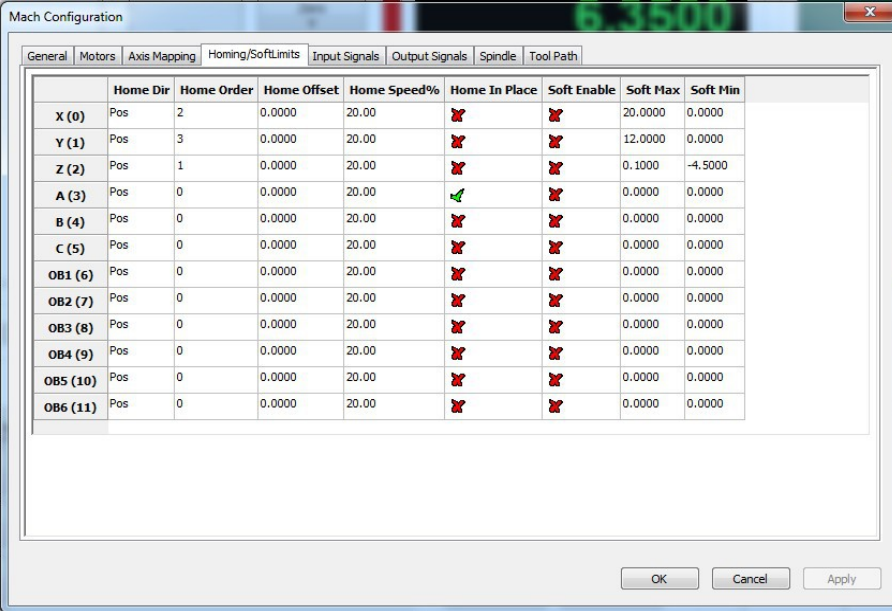
## Home Direction

This sets the direction to home the axis (see Figure 10). Pos for homing in the positive direction Neg for homing in the negative direction.

## Home Order

The sequence the axis home in can be controlled by setting the “Home Order” (see Figure 10). The first axis to home will be axis with the number 0 and then subsequent axis will home with the next greatest home order value. For example if you would like to home the Z axis first then the X and Y at the same time the values would be as follows:

X=2  
Y=2  
Z=1



	Home Dir	Home Order	Home Offset	Home Speed%	Home In Place	Soft Enable	Soft Max	Soft Min
X (0)	Pos	2	0.0000	20.00	✘	✘	20.0000	0.0000
Y (1)	Pos	3	0.0000	20.00	✘	✘	12.0000	0.0000
Z (2)	Pos	1	0.0000	20.00	✘	✘	0.1000	-4.5000
A (3)	Pos	0	0.0000	20.00	✔	✘	0.0000	0.0000
B (4)	Pos	0	0.0000	20.00	✘	✘	0.0000	0.0000
C (5)	Pos	0	0.0000	20.00	✘	✘	0.0000	0.0000
OB1 (6)	Pos	0	0.0000	20.00	✘	✘	0.0000	0.0000
OB2 (7)	Pos	0	0.0000	20.00	✘	✘	0.0000	0.0000
OB3 (8)	Pos	0	0.0000	20.00	✘	✘	0.0000	0.0000
OB4 (9)	Pos	0	0.0000	20.00	✘	✘	0.0000	0.0000
OB5 (10)	Pos	0	0.0000	20.00	✘	✘	0.0000	0.0000
OB6 (11)	Pos	0	0.0000	20.00	✘	✘	0.0000	0.0000

Figure 10

## Home Offset

The home offset allows for a shift from the home switch position(see Figure 10). This can be used to shift the home position if the home switch is not located at the end of travel.

## Home Speed

The home speed is the rate the machine moves to detect the home switch (see Figure 10). The home switch will set the machine zero position with the addition of any home offset. The Home Speed is set as a percentage of the max velocity of the axis. Example :

MaxVel = 200 Units Per Min

HomeSpeed = 20%

$$\text{MaxVel} * \left( \frac{\text{HomeSpeed}}{100} \right) = 40 \text{ Units Per Min}$$

$$200 * \left( \frac{20}{100} \right) = 40 \text{ Units Per Min}$$

## **Home In Place**

The Home in Place selection tells the axis to set the machine zero where it is when a home axis is requested (see Figure 10). This feature is used on machines that have no home switches or an axis that has no home switch. On a machine with no home switches the axis can be moved to the end of the travel and lined up with an indicator mark. With the machine at the home position the home can be triggered for that axis setting the machine position. This will allow the softlimits to be used and fixture offsets.

## **Soft Enable**

The state of the Soft Enable tells the core if the axis should be checked against the upper and lower soft limits (see Figure 10). With the soft limits active the axis will decelerate to the Max or Min limit if it is jogging and will prevent any incremental jogs past the limits. When running Gcode any moves panned past the limits will not be done and the machine will be put into a stop condition and a soft limit error will be displayed.

## **Soft Max / Soft Min**

The max and min settings are the most positive and negative machine positions for the axis (see Figure 10). The most simplistic way to get to get the values is to use the machine position DRO's. The process is to home the machine, jog each axis to the most positive position in each axis and enter as the positive soft limit. Then repeat the process in the negative direction and set the min soft limit.

## **Signals in General**

The signals are used to represent the internal state of items needed by the controller or items needed to trigger IO for special functions. The signals can be triggered by Inputs, Outputs, Plugins, or Lua. When a signal changes state, a state change event is propagated throughout the system and will be seen by all plugins, and Lua event scripts. Later in the customization of Mach4 the utilization of Mach4's signals will

be seen. In the section the setup of triggering IO with signals will be shown. When setting up an IO point the device's plugin must be first setup. A device could be a motion controller, bussed IO (modbus), Input device (keyboard), Special Functions in plugins, etc.. The "Device" is the first selection and displays all the registered IO devices to the system (see Figure 11)

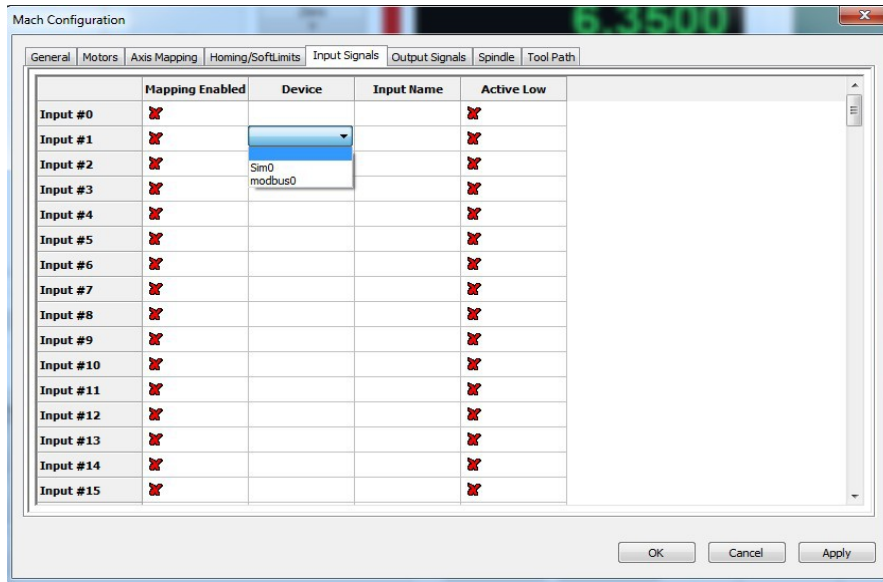


Figure 11

Once the device is selected the appropriate Inputs / Outputs will be displayed in the I/O Name's column. A drop down list will appear allowing the selection of the desired IO (see Figure 12). With the Device and IO name selected the signal will now be tied to that IO. The Input signal will change state when the Input assigned to it changes state, and Outputs are triggered by their associated Output signals. The high / low state can be inverted by selecting the Active low state.

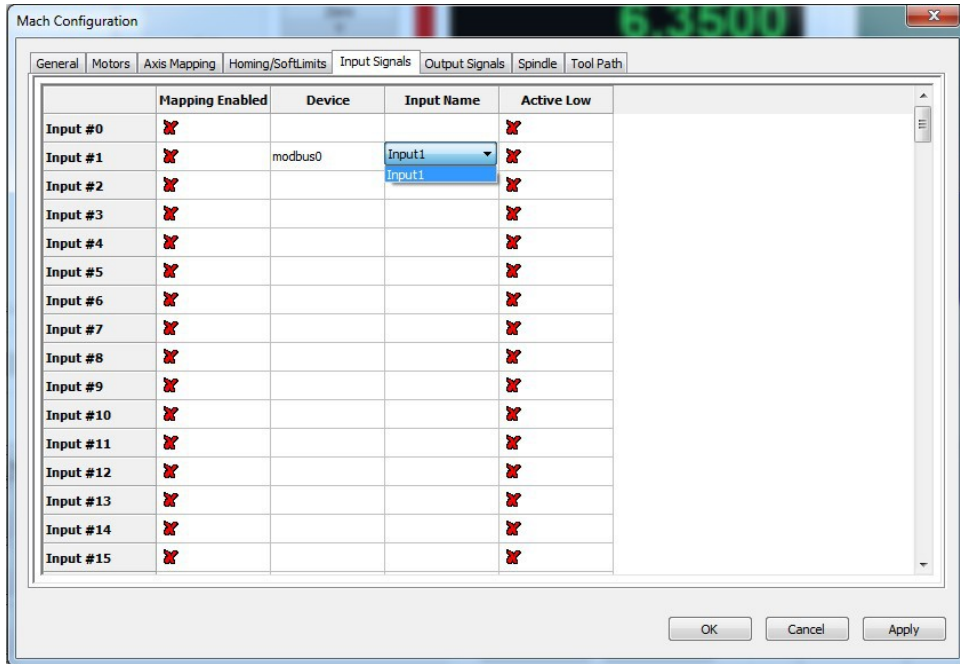


Figure 12

## Input Signals

The input signals are used to connect Inputs from devices to Input Signals in the core. Some of the most important signals are the Homing and Limit inputs. The Homing and Limits are set per motor NOT per axis. The axis use motors to show what motors drive the axis and to display the state of the limits and homes. As an example if Motor 1 and Motor 5 where used on the X axis and the + Limit was hit the X axis would show positive limit as being active. The inputs of the motors are or'ed to the axis states. Below is a complete list of the Input signals (See Table 2).

Input Signal	Description
Input #0 To Input #63	User inputs that can be mapped to any function
Motor 0 Home To Motor 31 Home	The home input of the motor with the associated number
Motor 0 ++ To Motor 31 ++	Positive limit for the motor
Motor 0 – To Motor 31 --	Negative limit for the motor
Digitize	Probe input for G31 commands
Index	Once per rev input for getting the RPM of the spindle
Limit Override	Override the limits to allow jogging when on a limit switch
E-Stop	Used to tell the core that the system is in E-stop. This input is NOT to issue an E-stop but to tell that the one has occurred with the proper e-stop hardware (Master control relay disabled for example).
THC On	THC (Torch Height Control) is enabled allowing the head to be jogged up and down while Gcode motion is active to keep a proper gap from the plate to the tip.
THC Up	Move the Torch tip Up when THC is active , Disabled it THC On is off
THC Down	Move the Torch tip Down when THC is active, Disabled it THC On is off
Timing	More then one input per rev to get spindle speed (legacy input and may not be in all motion devices).
Jog Axis +/-	Jog X+, Jog X-,Jog Y+... Command axis to jog in the +/- direction
Spindle At Speed	Input to tell the the spindle is at the commanded Speed. This will take the place of the spindle speed up delay if enabled.
Spindle At Zero	Input to tell the spindle has reached zero Speed. This will take the place of the Spindle deceleration time if enabled.

Table 2: Input Signals

## Output Signals

The output signals are used to tie the device outputs to the output signals. The output signals can be used to drive outputs directly for things such as Spindle outputs, Coolant, indicator lights on panels and so on.

Output Signal	Description
X ++	Activated when one of the motors that makes up the X axis has a positive limit switch pressed.
X --	Activated when one of the motors that makes up the X axis has a negative limit switch pressed.
X Home	Activated when one of the motors that makes up the X axis has a Home switch pressed.
Y ++	Activated when one of the motors that makes up the Y axis has a positive limit switch pressed.
Y --	Activated when one of the motors that makes up the Y axis has a negative limit switch pressed.
Y Home	Activated when one of the motors that makes up the Y axis has a Home switch pressed.
Z ++	Activated when one of the motors that makes up the Z axis has a positive limit switch pressed.
Z --	Activated when one of the motors that makes up the Z axis has a negative limit switch pressed.
Z Home	Activated when one of the motors that makes up the Z axis has a Home switch pressed.
A ++	Activated when one of the motors that makes up the A axis has a positive limit switch pressed.
A --	Activated when one of the motors that makes up the A axis has a negative limit switch pressed.
A Home	Activated when one of the motors that makes up the A axis has a Home switch pressed.
B ++	Activated when one of the motors that makes up the B axis has a positive limit switch pressed.
B --	Activated when one of the motors that makes up the B axis has a negative limit switch pressed.
B Home	Activated when one of the motors that makes up the B axis has a Home switch pressed.
C ++	Activated when one of the motors that makes up the C axis has a positive limit switch pressed.
C --	Activated when one of the motors that makes up the C axis has a negative limit switch pressed.
C Home	Activated when one of the motors that makes up the C axis has a Home switch pressed.
Enable #0 →	Enable will be active when the machine is enabled. The enables can be turned



Output Signal	Description
Enable #31	on with a delay set under the motor tuning dialog. If the axis that uses the motor is not enabled the motor will not get an enable signal
Output #0 → Output #63	Output #0 → #63 are used for OEM and user output signals
Gcode Running	Output is active when running Gcode, used for indicator lights to show a file is running
Feed Hold	Output is active when in a Feed Hold state
Block Delete	Output is active when Block delete is active
Single Block	Output is active when Single Block is active
Reverse Run	Output is active when Reverse Run is active (reverse run is to run a file backwards)
Opt Stop	Output is active when optional stop is active (stop on M01's in Gcode file)
Machine Enabled	Output is active when the machine is in an enabled state
Tool Change	Output is active when a tool change is active or waiting for a Cycle start when in manual toolchange
Dist To Go	Output active when selectable DRO is set to display Distance To Go (distance from end point of the current move)
Machine coord	Output active when selectable DRO is set to display Machine Position (position from the home switch)
Softlimits On	Output active when the softlimits are active
Jog Inc	Output active when the cores user Jog mode is set to Incremental jog mode
Jog Cont	Output active when the cores user Jog mode is set to continuous jog mode
Jog Enabled	Output active when the cores user Jog mode is enabled
Jog MPG	Output active when the cores user Jog mode is set to Manual Pulse Generator (MPG) jog mode
X Homed	Output active when a home cycle has been completed for the X axis
Y Homed	Output active when a home cycle has been completed for the Y axis
Z Homed	Output active when a home cycle has been completed for the Z axis
A Homed	Output active when a home cycle has been completed for the A axis
B Homed	Output active when a home cycle has been completed for the B axis
C Homed	Output active when a home cycle has been completed for the C axis
Dwell	Output active when a Dwell is active (G4 command in Gcode)
Toolpath Mouse Down	Output toggles when the toolpath is set to report the mouse position and Core is set to report clicks. See Lua Script manual to set the core into Toolpath capture mode
Limit Override	Output active when the Limit override is active
Charge Pump #1	Output when the Charge Pump #1 should be active
Charge Pump #2	Output when the Charge Pump #2 should be active
Current Hi/Low	Output active when motion is about to be done to set drive to be in high current mode
Spindle On	Output active when the spindle is on
Spindle Fwd	Output active when the spindle is running in forward direction

Output Signal	Description
Spindle Rev	Output active when the spindle is running in the reverse direction
Coolant On	Output active when the Coolant is set to be on
Mist On	Output active when the Mist is set to be on
Digitize Trigger	Output active with the digitize input is active

*Table 3: Output Settings*

## **Spindle**

The Spindle dialog allows the configuration and setup of up to 20 spindle ranges. The spindle ranges can be gears and or belt settings to allow for a change in the range of speeds available.

Output Signal	Description
MinRPM	The minimum RPM the spindle in the selected range
MaxRPM	The maximum RPM the spindle in the selected range
Accel Time	The time to accerate the spindle in the slected range. If the “Spindle At Speed” signal is enabled the Accel Time is not need and should be set to zero. Any value in the Accel Time field will be done after the Spindle At Speed signal has been toggled.
Decel Time	The time to decelerate the spindle in the slected range. If the “Spindle At Zero” signal is enabled the Decel Time is not need and should be set to zero. Any value in the Decel Time field will be done after the Spindle At Zero signal has been toggled.
Feedback Ratio	By default the Feedback ratio is 1, a value of one is used in an application where the feed back device is mounted on the spindle. If the feedback device is mounted on the motor or some other part of th gear train the feedback ratio can be used to get the correct speed.
Reversed	Reversed selection allows the spindle motor to reverse the direction based on the reversed check box. This selection is used when a gear or ratio causes a reverse in the spindle direction. It is common for knee type mills to reverse direction from high to low range.

## **Max Motor RPM**

The maximum RPM of the spindle motor. The reason for the maximum RPM is to allow for proper scalling of the motors RPM on all ranges. The motor RPM is used by motion devices, plugins, VFD's, Lua etc for planning the proper motor RPM to get the requested spindle RPM.

## **Motor as Spindle**

With this selection a stepper motor, servo motor, or VFD that can be setup as a motor in the motion device. The motor will be treated as an out of band axis and will use the motors acceleration settings.

## ***Tool Path Settings***

The toolpath has some parameters that can be changed to allow better visualization of the toolpath. The colors of the toolpath can be changed to allow for a better “looking” toolpath. But more importantly is the ability to change the color of the toolpath to aid color blind users.

## ***Machine Limits***

The machine limits can be shown in the toolpath, showing where the machine can traverse to by displaying dotted lines.

## ***Extended Functionality***

To get more extended functionality and or customization, Plugins and or scripts will need to be added and configured. The Customization and scripting manual covers topics such as on screen buttons to trigger outputs, Tool changers, Buttons to move the machine to a specific location, hardware buttons for operator interfaces, etc. Some of the plugins are covered in the appendixes for your convenience . If the plugin of interest is not covered in the appendix please visit [www.machsupport.com](http://www.machsupport.com) and look under Mach4 plugins for more information.