> **NOTE**: *Before proceeding with this document. It is required to consult the "Mach4 Integration Manual" for the current motion controller in order to perform the preliminary integration with Mach4 (i.e. ESTOP, Limit switch setup, etc.).*

> **NOTE**: *It is advised to read this document thoroughly before attempting rigid tapping in Mach4. Improper parameter configuration, and hardware/software setup may damage tap heads and possibly result in personal injury.*

Contents

Rigid Tapping in Mach4

Rigid tapping mode in Mach4 is started with the "G84.2 Z__ R__ F__" command, and stopped with the "G80" command. While in Rigid tapping mode, specifying motion coordinates will cause the machine to move to each coordinate position and execute a rigid tap cycle upon reaching specified destination(drill and retract).

Electronic gearing is used with VSI Motion Controllers such as the "7763 DSPMCv3", "7866 HiCON Integra" and "7766 HiCON Integra". Electronic gearing allows directly controlling the Z axis motion based on the actual spindle RPM. This allows the Z axis to slow down when the Spindle RPM decreases as a result of friction incurred when tapping through materials.
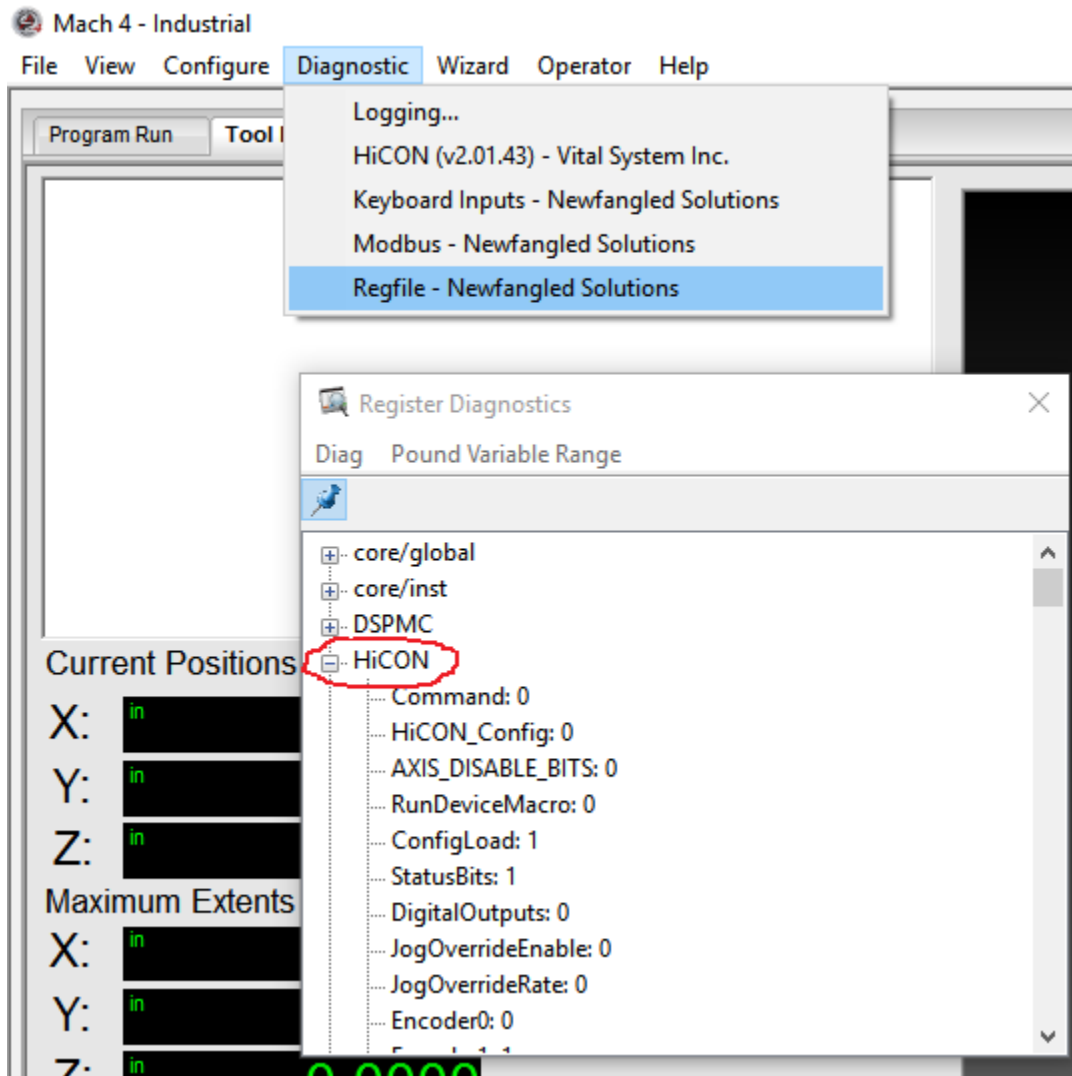
Parameters:

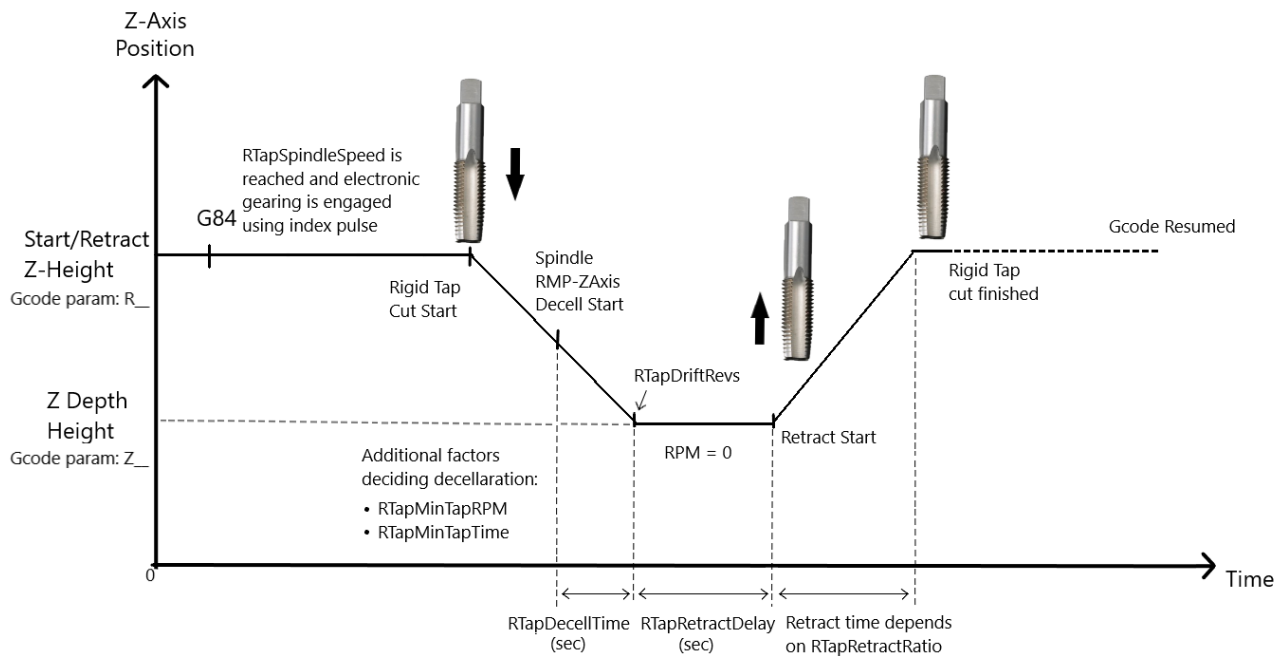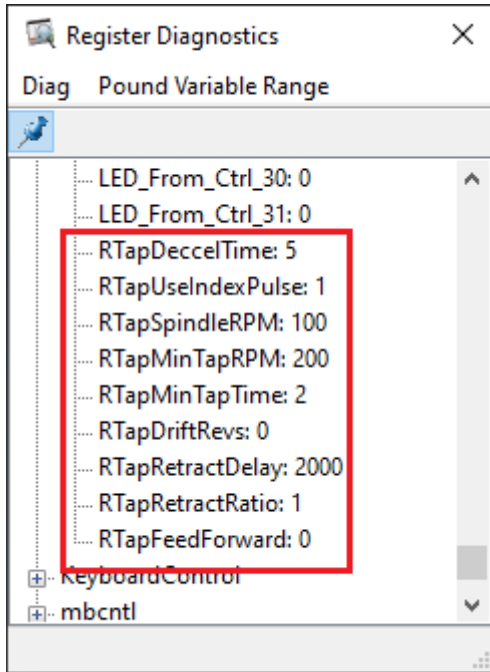| G84.2	GCode command to start rigid tapping mode
Z__	Parameter to specify the end depth position of the tap cycle before retracting the cutting head. *Example: "Z-4" specifies that the Z axis will keep drilling until it reaches a position of -4 (inches or mm).*

R__	Parameter to specify the retract height position at the end of the tap cycle. *Example: "R1" specifies that the Z axis will retract until it reaches a position of 1 (inch or mm).*
F__	Parameter to specify the Z feedrate when performing a tap cycle. The usage of this parameter varies depending on if G94 or G95 was executed prior to the G84.2 command to start rigid tapping mode.
S__	Command to specify the spindle RPM.
M3	Command to turn ON the Spindle.
M5	Command to turn OFF the spindle.

G94	GCode command that indicates the "F" parameter is specified in terms of **units/min.** With this setting the "Threads/Unit" value is calculated by:
	
	   • *Threads/Unit = SpindleRPM / F-ParameterValue*
	   • *ThreadPitch = 1 / (Threads/Unit)*
	
	Example:
	  - **G94**
	  - **S200 M3**
	  - **G84.2 Z-4 R1 F20**
	
	The aforementioned code snippet turns on the spindle and sets it to a target RPM of 200, then starts Rigid tap mode where the Z axis will drill until a position of -4, and will retract to a position of 1, while the Z axis will move at a rate of 5 units/min.
	
	Threads/Unit = 200 / 20
	Threads/Unit = 10

G95	GCode command that indicates the "F" parameter is specified in terms of **units/rev**. With this setting, the "F" parameter directly specifies the Thread pitch value.
	
	Example:
	  - **G95**
	  - **S200 M3**
	  - **G84.2 Z-3 R2 F0.1**
	
	The aforementioned code snippet turns on the spindle with a target RPM of 200, then starts Rigid tap mode where the tap cycles will thread holes with 0.1 pitch, and the Z axis will drill until a position of -3, and will retract to a position of 2,
	
	Z-Feedrate = SpindleRPM / (1 / ThreadPitch)
	Z-Feedrate = 200 / (1 / 0.1)

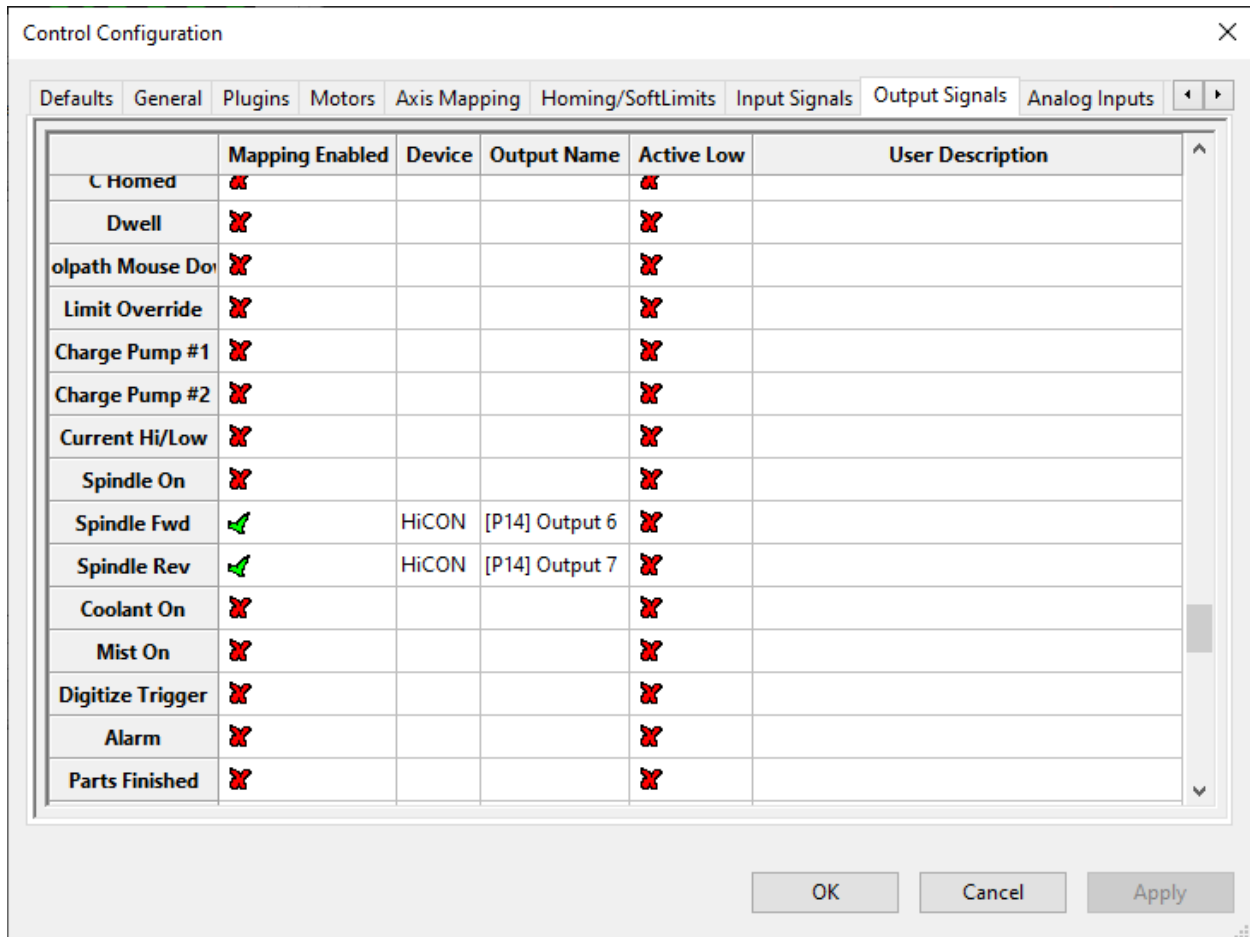|	
	Z-Feedrate = 20 units/min
G80	GCode command to end rigid tap mode.

Rigid Tap Parameters

The Rigid Tap configuration parameters can be accessed from the "Register Diagnostic" window in Mach4. The parameters themselves can be found by scrolling down under either "HiCON" or "DSPMC". Double-clicking each parameter allows the value to be modified.

Register Diagnostics

Diag   Pound Variable Range

---- LED_From_Ctrl_30: 0
---- LED_From_Ctrl_31: 0
---- RTapDeccelTime: 5
---- RTapUseIndexPulse: 1
---- RTapSpindleRPM: 100
---- RTapMinTapRPM: 200
---- RTapMinTapTime: 2
---- RTapDriftRevs: 0
---- RTapRetractDelay: 2000
---- RTapRetractRatio: 1
---- RTapFeedForward: 0
KeyboardControl
mbcntl

Z-Axis
Position

RTapSpindleSpeed is
reached and electronic
gearing is engaged
using index pulse

G84

Start/Retract
Z-Height
Gcode param: R__

Rigid Tap
Cut Start

Spindle
RMP-ZAxis
Decell Start

Gcode Resumed

RTapDriftRevs

Z Depth
Height
Gcode param: Z__

Retract Start

Rigid Tap
cut finished

Additional factors
deciding decellaration:
 • RTapMinTapRPM
 • RTapMinTapTime

RPM = 0

0

Time

RTapDecellTime
(sec)

RTapRetractDelay
(sec)

Retract time depends
on RTapRetractRatio

Register Name	Description
RTapDeccelTime	The amount of time (in seconds) that it takes for the Max Spindle RPM to decelerate to the Min Tap RPM. In practice the time given to decelerate will be scaled by the ratio of currentRPM/maxRPM. A slow moving spindle will need less time to decelerate.
RTapUseIndexPulse	MUST BE ENABLED. this setting will allow the Z axis to wait for the index pulse trigger (from the spindle encoder) before initiating the tap cycle. This allows for consistent threading orientation on all tap cycles.
RTapSpindleRPM	The RPM of the spindle while searching for its initial start position using the Index pulse. Note that once the start position has been found, the RPM will change to the value configured by the 'S' command in GCode.
RTapMinTapRPM	The minimum RPM that the spindle will decelerate to. This stabilizes the spindle as it approaches the target depth of the tapping cycle which allows the spindle to come to a complete halt when the target depth is reached.
RTapMinTapTime	The amount of time (in seconds) that the spindle will maintain the "Min Tap RPM" before completely turning off the spindle. Minimizing the RPM by the end of the tap cycle allows the spindle to take less time decelerating, which helps prevent "overshooting" the depth.
RTapDriftRevs	The estimated number of extra revolutions that the spindle will make upon setting the RPM from 'MinTapRPM' to Zero. This provides another method to correct for Overshoot.
RTapRetractDelay	The amount of time (in milliseconds) to delay before retracting the spindle after drilling.
RTapRetractRatio	This value is a multiplier for the RPM of the spindle when retracting. For example, if a spindle RPM of 500 is used for the tapping cycle and a "Retract Ratio" of 1.75 is set, then the spindle will retract at an RPM of 875.
RTapFeedForward	LEGACY SETTING. NOT RECOMMENDED FOR USE. It may still preferable to perform feed forward tuning on servo drives. *Set this to zero to disable it*. This parameter is used to minimize the following error between the spindle and Z motion by applying a feed forward multiplier. It is recommended to use small values (ex. 0.1), then gradually increase the value to the desired performance.

Mach4 Output Mapping

Make sure to perform dry run for rigid tapping. If the Z-Axis is moving in opposite direction opposed to the intended please flip the "Spindle Fwd" and "Spindle Rev" mapping.

If the user desires a clock wise / anticlockwise spin, user must set the spindle reverse option inside Mach control ->Spindle tab. Please do not flip the mapping/wiring to reverse the default direction.

Example GCode Program

The short program below demonstrates a simple sequence that utilizes rigid tapping.

G00X0Y0Z2	Rapid move to position X at 0, Y at 0, and Z at 2
G95	Use inches/rev (F-Parameter specified thread pitch)
S200 M3	Start spindle with 200RPM
G84.2 Z-3 R2 F0.1	Start rigid tap mode. Each tap cycle will thread a hole with 0.1 pitch, and keep drilling until Z reaches a position of -3, and retract until Z reaches a position of 2.
X1.5	Move X position to 1.5 and start tap cycle upon reaching target position
X2.5	Move X position to 2.5 and start tap cycle upon reaching target position
X3.75Y1	Move X position to 3.75 and Y position to 1 and start tapping cycle upon reaching the target position
G80	End rigid tap mode.

```
G00X0Y0Z2
G95
S200 M3
G84.2 Z-3 R2 F0.1
X1.5
X2.5
X3.75Y1
G80
M5
```