CS LAB s.c.
ElectronicLaboratory

CSMIO/IP Motion Controllers

Spindle Axis in Mach4

APPLIES TO:

HARDWARE VERSION	FIRMWARE REALEASE (software):
CSMIO/IP-S; CSMIO/IP-A v2 FP4 v2 H7	v3.xxx (Mach4)

Spindle axis feature in Mach4 - general

Before configuring the feature described in this manual, you must meet several basic conditions:

- This feature is intended only for CSMIO/IP-S, CSMIO/IP-A controllers, and a spindle driven by a servo drive operating in the same way and with the same precision as servo drives of other axes (X, Y and Z).

- The servo drive to drive the spindle was previously connected to a CSMIO/IP controller and set in the same way as the servo drives of the other axes. I also mean the configuration of Mach4 and the plugin.

- In the case of a gear between a servo drive and a spindle, it must be a non-slip gear. This means that toothed gears should be used, e.g., a gear with a toothed belt. It is not allowed to use gears built on the basis of a V-belt!

Spindle axis

This feature allows the use of a servo drive set as an OB axis to drive a spindle (the servo drive directly becomes the OB axis).
To run the " Spindle Axis" feature, follow the steps described in the following sections strictly, as any deviation may result in this feature not working properly.

1) Axis Mapping

Go to "Configure/Control.../Axis Mapping". In the displayed window select one of the free "OB" axes, then in the "Master" column select the free "Motor" and turn on the axis by placing a green check mark in the "Enabled" column. In my case, I chose the OB1 and Motor2 axis.

Remember:
The number of the selected "Motor" is in the case of a CSMIO/IP-S controller an output (channel) step/dir number, and in the case of a CSMIO/IP-A controller a number of an encoder input (channel) and an output (channel) of the analog +/-10V.

	Enabled	Master	Slave 1	Slave 2	Slave 3	Slave 4	Slave 5
X (0)	✓	Motor0					
Y (1)	✗						
Z (2)	✓	Motor1					
A (3)	✗						
B (4)	✗						
C (5)	✗						
OB1 (6)	✓	Motor2					
OB2 (7)	✗						
OB3 (8)	✗						
OB4 (9)	✗						
OB5 (10)	✗						
OB6 (11)	✗						

2) „Motor” settings

Go to "Configure/Control.../Motors". In the displayed window check the "check box" for the "Motor" selected in the previous step (the same number of the "Motor"). Then click on the name of the "Motor" on the right, this will display its parameters. In this window, you also need to set parameters "Counts", "Velocity" and "Acceleration".

Attention:
- In the case of rotary axes, which include the "OB" axis used to drive a spindle, the basic unit of these parameters is a degree!

- The parameters listed refer only to the OB axis, not to the OB axis and a spindle.
This means that these parameters do not consider the ratio of a gear between the OB axis and the spindle!

For a better understanding, I will describe the parameters in separate points:

a) „Counts” - the number of pulses per one degree of rotation of the OB axis.
In the case of the CSMIO/IP-S controller, this parameter represents the number of "step" pulses that is needed to rotate a servo motor shaft of the OB axis by 1 degree.
In the case of the CSMIO/IP-A controller, this parameter represents the number of pulses given to an encoder input when rotating a servo drive shaft of the OB axis by one degree.
This parameter is expressed in "Pulses per Degree"

b) „Velocity” - rotational speed that a servo motor of the OB axis can withstand in continuous spindle operation. This speed should not be the maximum speed of a servo motor but slightly underestimated due to the freeness of operation of the PID servo speed regulator. Otherwise, the servo drive may report a PID speed regulator error.
This parameter is expressed as "Degrees per Minute"

c) „Acceleration” - acceleration that a servo motor of the OB axis can withstand during repeated acceleration and braking.
This parameter is expressed in "Degrees per Sec^2".

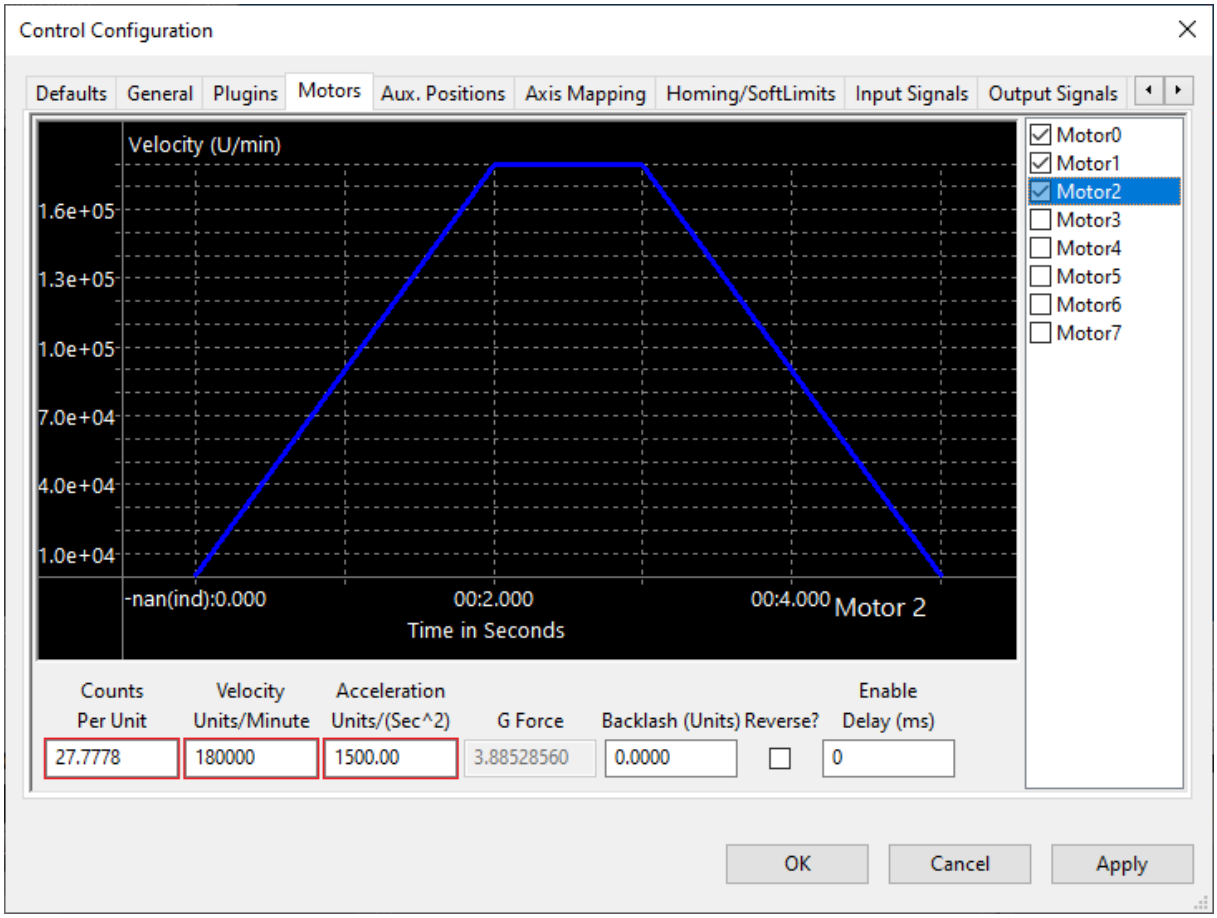
In order to understand exactly what the above-mentioned parameters mean; I will use an example of the machine on which I carried out the tests. Since it is a desktop machine, its spindle is driven by a stepper drive (it does not matter, I could just as well use a servo drive). The stepper driver has been set in such a way that it requires 10,000 pulses for the input of the "step" signal so that the stepper motor performs one full rotation. I assumed that the permissible speed of the stepper motor will be 500RM, and it will be able to accelerate the spindles to the permissible speed in 2 seconds without any problems. Based on this information, we can calculate the value of all required parameters:

Counts = 10000 pulses: 360 degrees
Counts = 27.7(7) Pulses per Degree

Velocity = 500 revolutions per minute * 360 degrees
Velocity = 180000 Degrees per Minute

Acceleration = Velocity: 60 seconds: 2 seconds
Acceleration = 180000 Degrees per Minute: 60 seconds: 2 seconds
Acceleration = 1500 Degrees per Sec^2

After calculating the values of the parameters, we rewrite them to the "Motors" window, in my case it looks like this:



3) „Spindle” settings

Go to „Configure/Control…/Spindle”. In the displayed windows you should set three (3) parameters. For a better understanding I will describe them in separate points.

a) „Step/Dir Spindle Axis” – From the drop-down list, select the "OB" axis with the same number that you selected in point 1. In my case, this is the "OB1" axis. This parameter tells the Mach4 software which OB axis will be used to drive the spindle.

b) „Max Spindle Motor RPM” - corresponds to the "Velocity " parameter which is described in point 2b. The only difference is that the "Velocity" parameter is expressed in degrees per minute, and the parameter "Max Spindle Motor RPM" is expressed in revolutions per minute. In my case, the value of the parameter "Max Spindle Motor RPM" is 500 revolutions per minute.

c) „MaxRPM” - the maximum spindle speed resulting from the ratio of the gear between the OB axle and the spindle in each gear. This absolutely cannot be a value resulting from us wishing to limit the rotational speed of the spindle in each gear.
This parameter is expressed in revolutions per minute.

The ratio of the gear between the OB axis and the spindle is calculated by dividing the number of teeth of a pinion mounted on a servo motor shaft of the OB axis by the number of teeth of a pinion mounted on the spindle shaft.

$$i = \frac{Z1}{Z2}$$

Z1 – the number of teeth of the pinion mounted on a servo motor shaft of the OB axis.
Z2 – the number of teeth of the pinion mounted on a spindle shaft.
i – the ratio of the gear between the spindle motor and the spindle.

In my case, the pinion mounted on the shaft of a stepper motor has 18 teeth, and the pinion mounted on the spindle shaft has 40 teeth. Using the above formula, we get:

i = 18 teeth: 40 teeth
i = 0,45

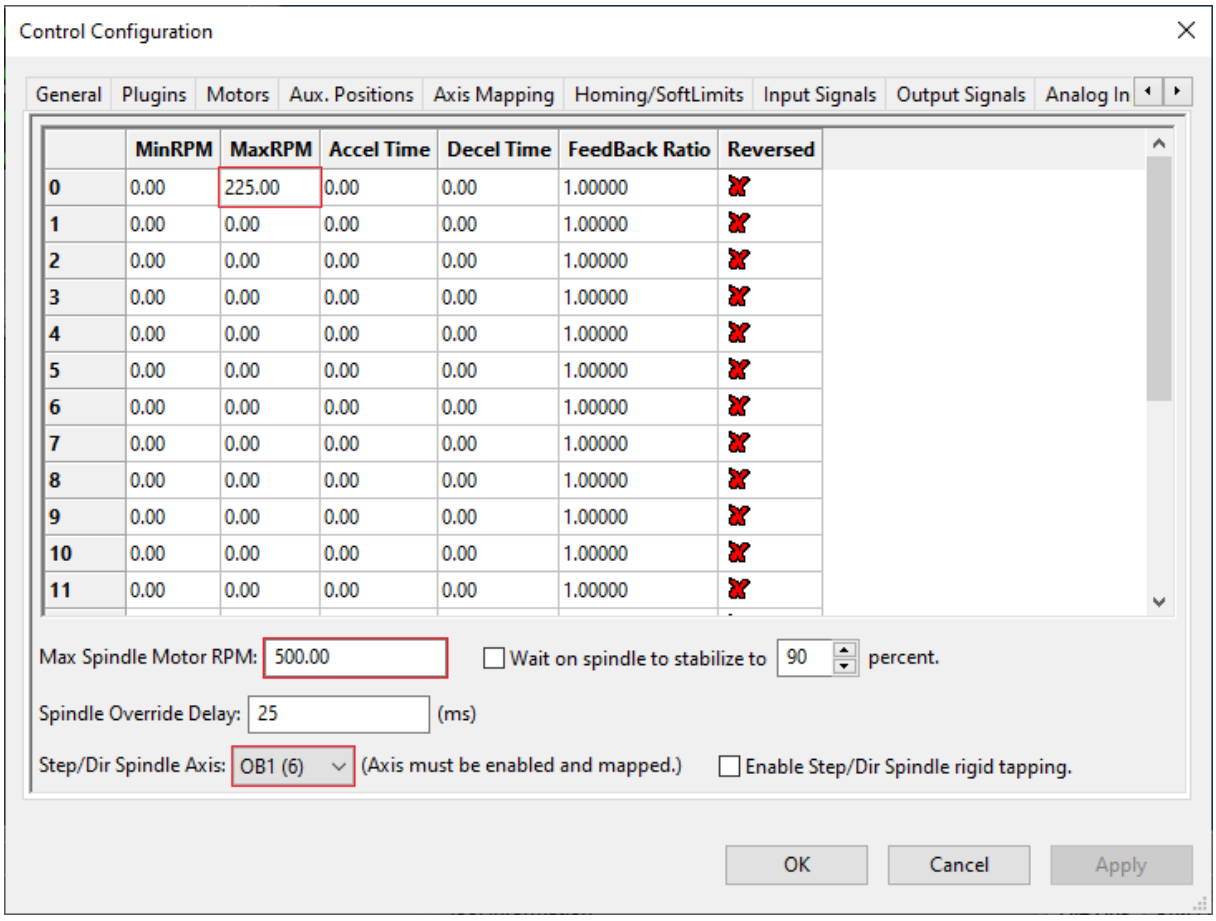
Now, we can already calculate the value of the "MaxRPM" parameter, to do this, multiply the value of the "Max Spindle Motor RPM" parameter by the value of the gear ratio.

$$MaxRPM = Max\ Spindle\ Motor\ RPM * i$$

In my case, the value of the parameter "Max Spindle Motor RPM" is 500 revolutions per minute, and the value of the gear ratio is 0.45. Using the above formula, we get:

MaxRPM = 500 revolutions per minute * 0,45
MaxRPM = 225 revolutions per minute

After rewriting the parameters to the "Spindle" window, in my case it looks like this:



	MinRPM	MaxRPM	Accel Time	Decel Time	FeedBack Ratio	Reversed
0	0.00	225.00	0.00	0.00	1.00000	
1	0.00	0.00	0.00	0.00	1.00000	
2	0.00	0.00	0.00	0.00	1.00000	
3	0.00	0.00	0.00	0.00	1.00000	
4	0.00	0.00	0.00	0.00	1.00000	
5	0.00	0.00	0.00	0.00	1.00000	
6	0.00	0.00	0.00	0.00	1.00000	
7	0.00	0.00	0.00	0.00	1.00000	
8	0.00	0.00	0.00	0.00	1.00000	
9	0.00	0.00	0.00	0.00	1.00000	
10	0.00	0.00	0.00	0.00	1.00000	
11	0.00	0.00	0.00	0.00	1.00000	

If your machine has a spindle gearbox equipped with more gears, the actions described in subsection "c" must be repeated for each of them.

4) Spindle work test.

Exit the settings, put Mach4 in the "Enable" state (the button in the lower left corner of the screen), enter the command "M3 S100" in the MDI line and press the "Cycle Start Gcode" button. At this point, the spindle should begin to rotate at a speed of 100 revolutions in a clockwise direction. If this has happened, it means that you have reached the end of the configuration of the "Spindle Axis" feature and you can start running the "Spindle Positioning (M19)" function.

If the spindle rotates counterclockwise, you need to go to the "Motor" tab and use the "Reverse" option: