Mach3 USB Motion Board (NPN) Installation Manual

(Model: LF77-AKZ250-USB3-NPN)

Doc Ver：1.0.5

Features:

- ✧ USB Full-speed connection.
- ✧ Up to 5 axes, 500kHz pulsing engine, which is suitable for the servo or stepping motor.
- ✧ 2 real-time Manual Pulse Generation (MPG) input ports for 2 MPG at the same time. When the MACH3 MPG is set in the multi-step mode, it has the same real-time performance as the CNC machining center, smoothly. The control board has no delay and the mechanical system performance is fully utilized.
- ✧ 16 general-purpose input, with particular indicators, the input signal states can clearly shows.
- ✧ 8 general-purpose output, It can be configured as: spindle clockwise / CCW / Mist / Flood / VB script programming control.
- ✧ PWM signal spindle control or Step/Dir signal spindle control.
- ✧ 2 analog input ports for adjusting the machining speed / jog speed / spindle speed.
- ✧ Status indicator LED can be useful to show the USB connection, and working statuts by flashing.
- ✧ 5 high-speed optocouplers (Dual Channel) with 10MHz, 26 general optocouplers for isolating all of the input/output signals, this high-cost design can be provided high performance and stable system.
- ✧ Fully supporting all Mach3 versions, including the Mach3 R3.043.066 version. Supporting Windows series, including Windows XP-Windows10(32bit/64bit).

- ✧ No need to install any USB drivers, it can be used after plugging in the computer.
- ✧ Easy firmware update.

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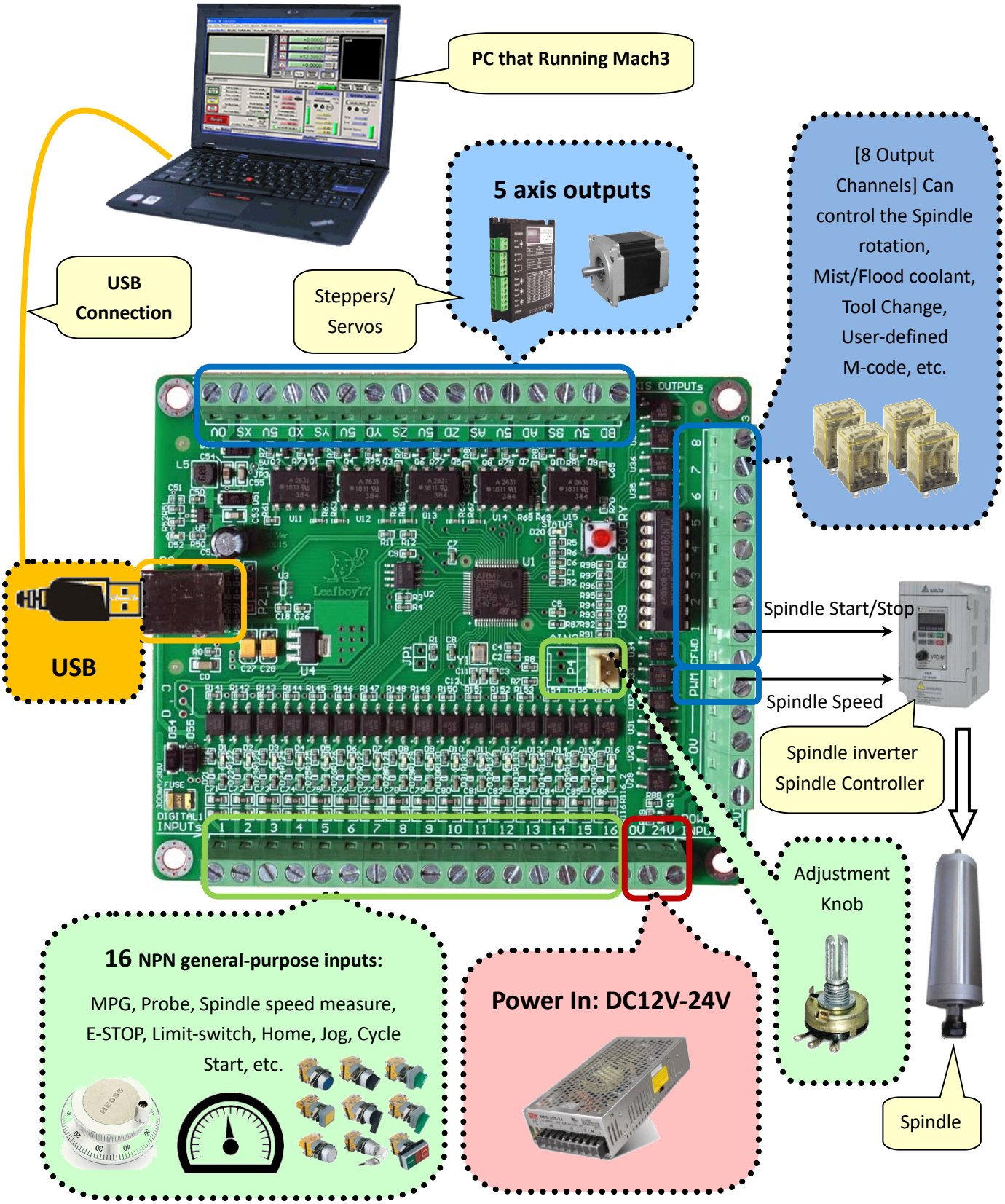
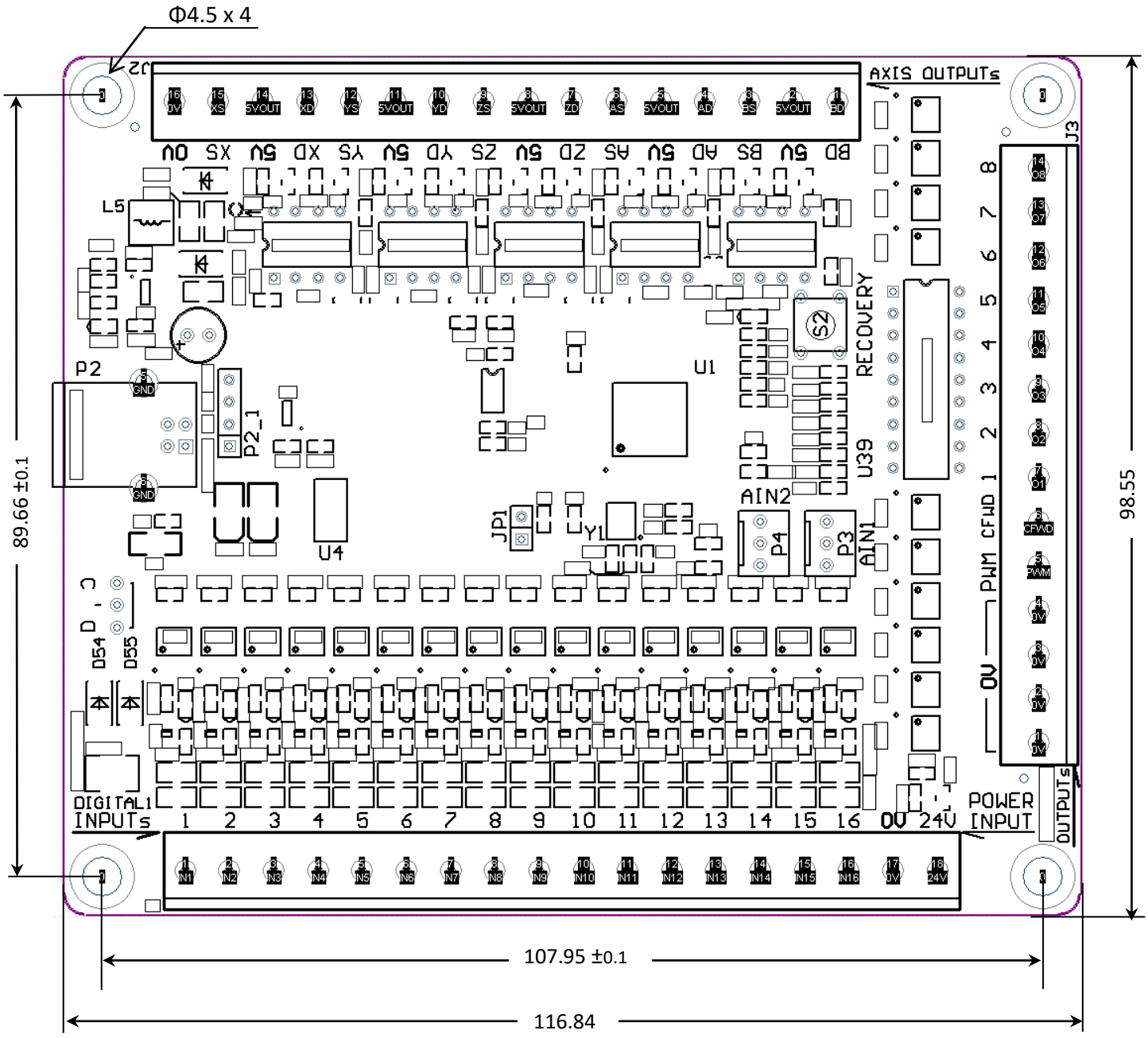
Revisions List

Date/Version	Info
2019-9-27 Ver1.0	Init
2019-10-12 Ver1.0.1	Added warning description: "CFWD" terminal cannot be used when the output controls both inductive loads (such as relays, solenoid valves) and other devices (such as inverter control).
2019-10-12 Ver1.0.2	Modify: Restore factory firmware steps Modify: Hard reset operation steps
2019-10-21 Ver1.03	Power Input: DC12V-24V
2019-11-28 Ver1.0.4	Modify parameters: PWM output maximum current 10mA Change photo: Photo of the external Adjustment Knob
2021-4-27 Ver1.0.5	Added: MPG Enable Button wiring and description

Basic connection diagram (Overview)



Mechanical dimensions diagram

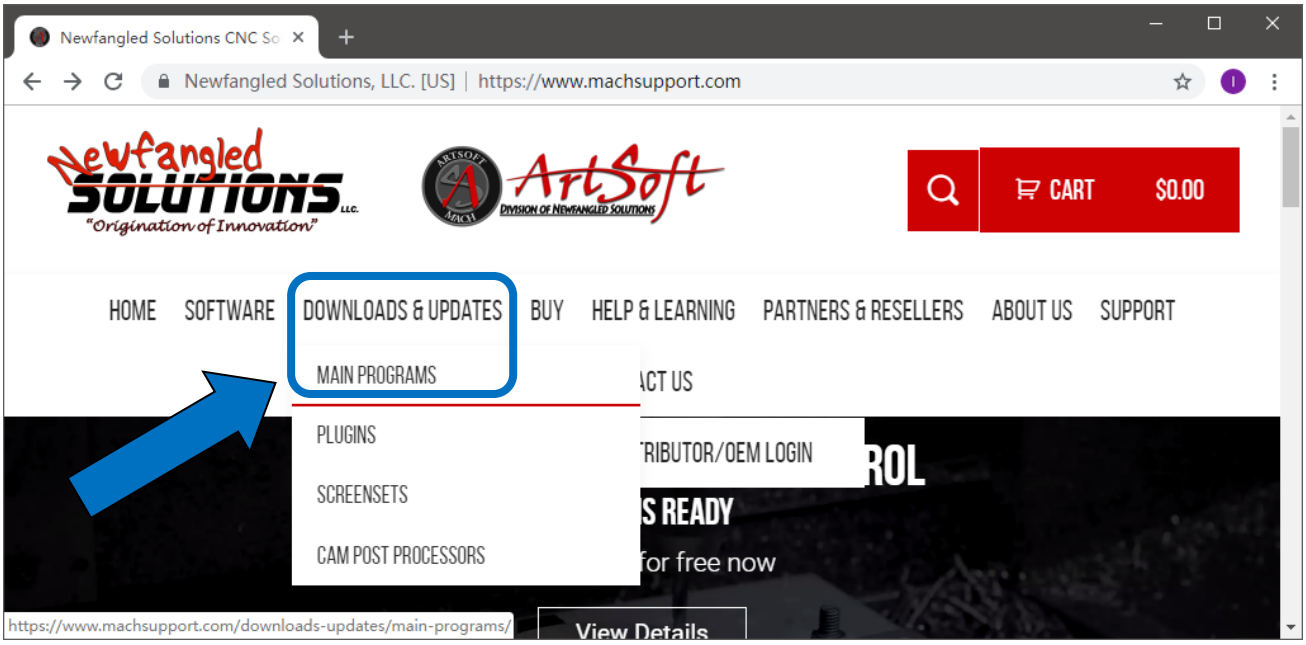


1. Prepare

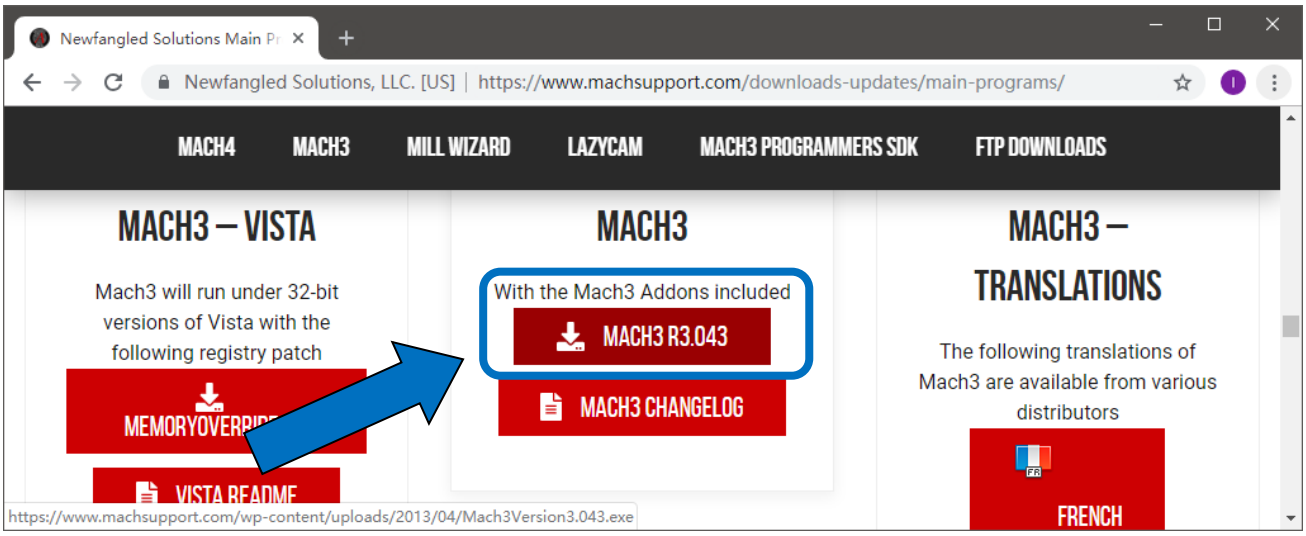
1.1 Mach3 download and install

The latest version of Mach3 official website download URL：https://www.machsupport.com/

After entering the official website, click DOWNLOADS & UPDATES => MAIN PROGRAMS as shown in the blue circle below

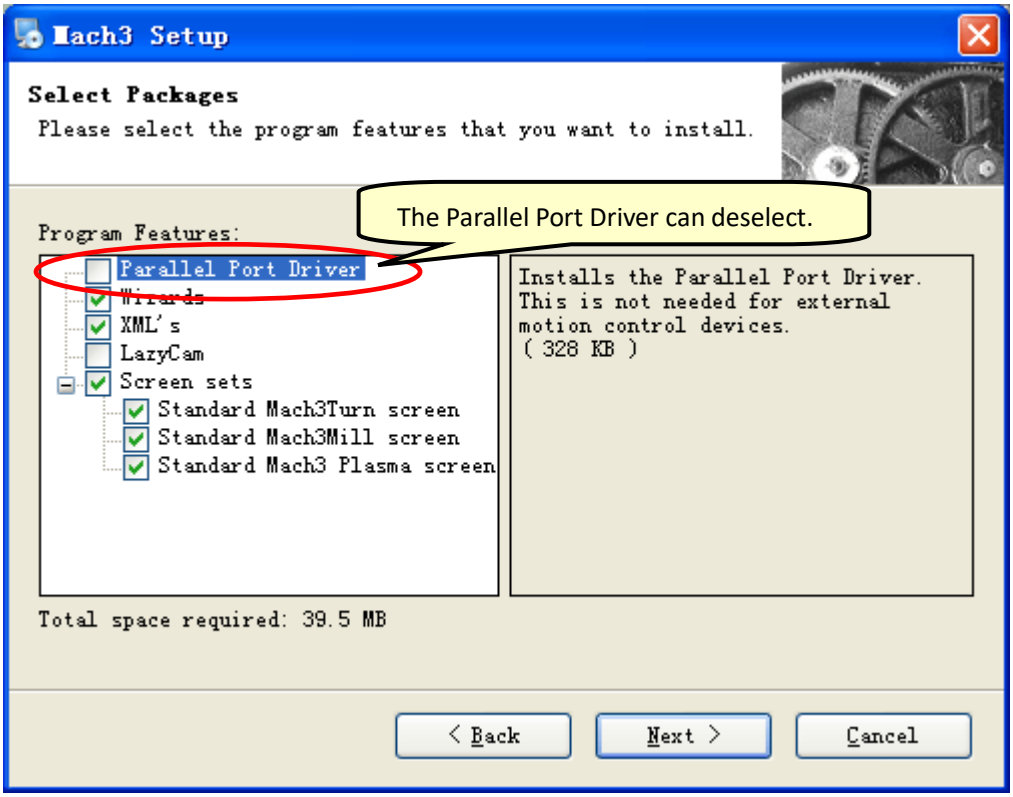


After entering the download page, find MACH3 and download it, as shown in the blue circle below.



After the download is complete, install Mach3

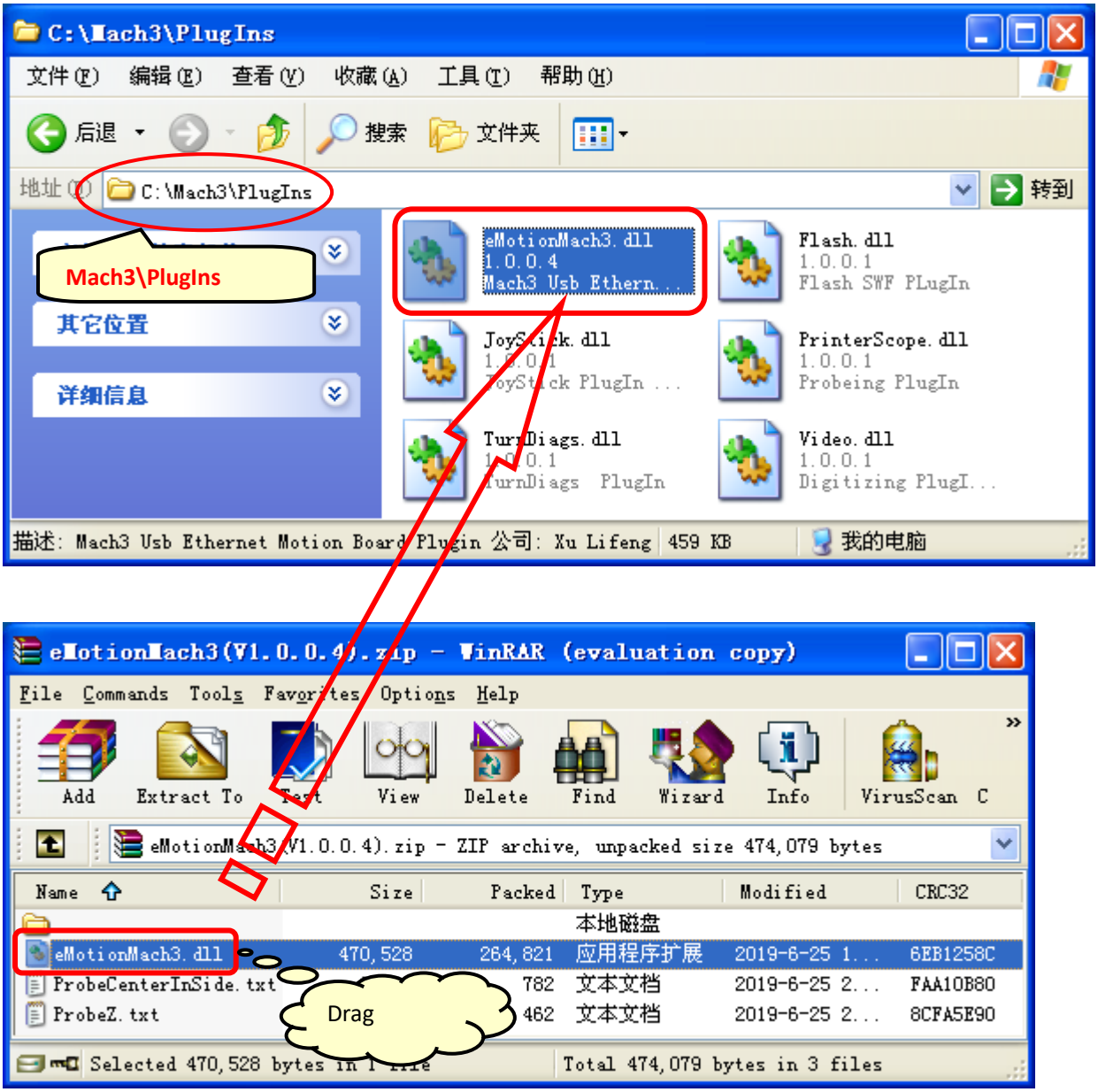
Note:
The Parallel Port Driver does not require.



1.2 Download and install the Mach3 plugin

In order to enable MACH3 to recognize and drive this motion control board, you need to install a mach3 plugin.

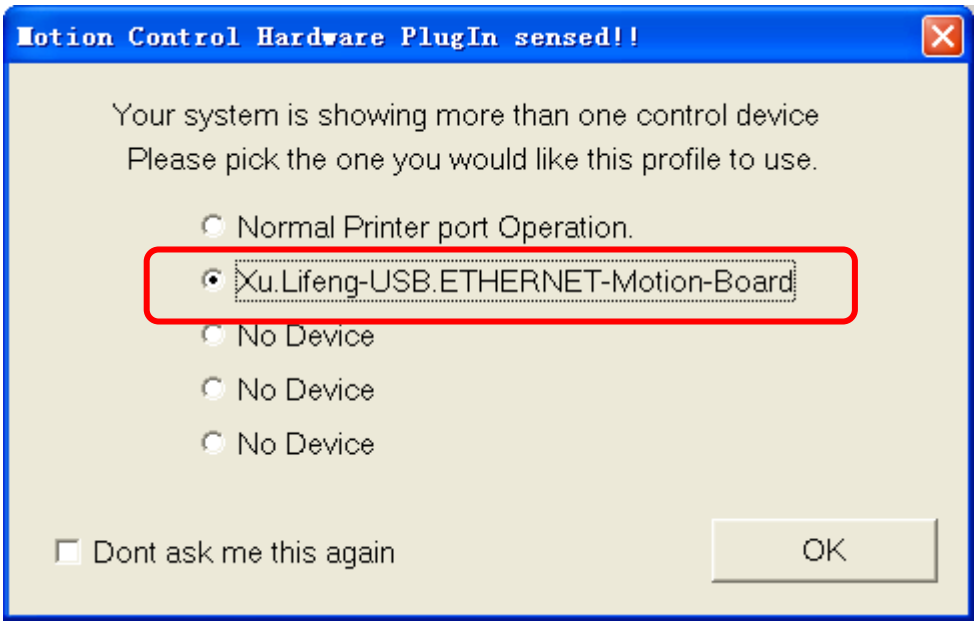
Copy or drag **eMotionMach3.dll** (Unzip the eMotionMach3.zip) into **Mach3\PlugIns** folder.
For example, if your Mach3 software is installed in C:\Mach3, place eMotionMach3.dll into C:\Mach3\PlugIns



Mach3 Plugin eMotionMach3.zip
Please go to the following URL to download the latest version.
http://leafboy77.com/

After completing the Mach3 plugin installation, start the Mach3 software.

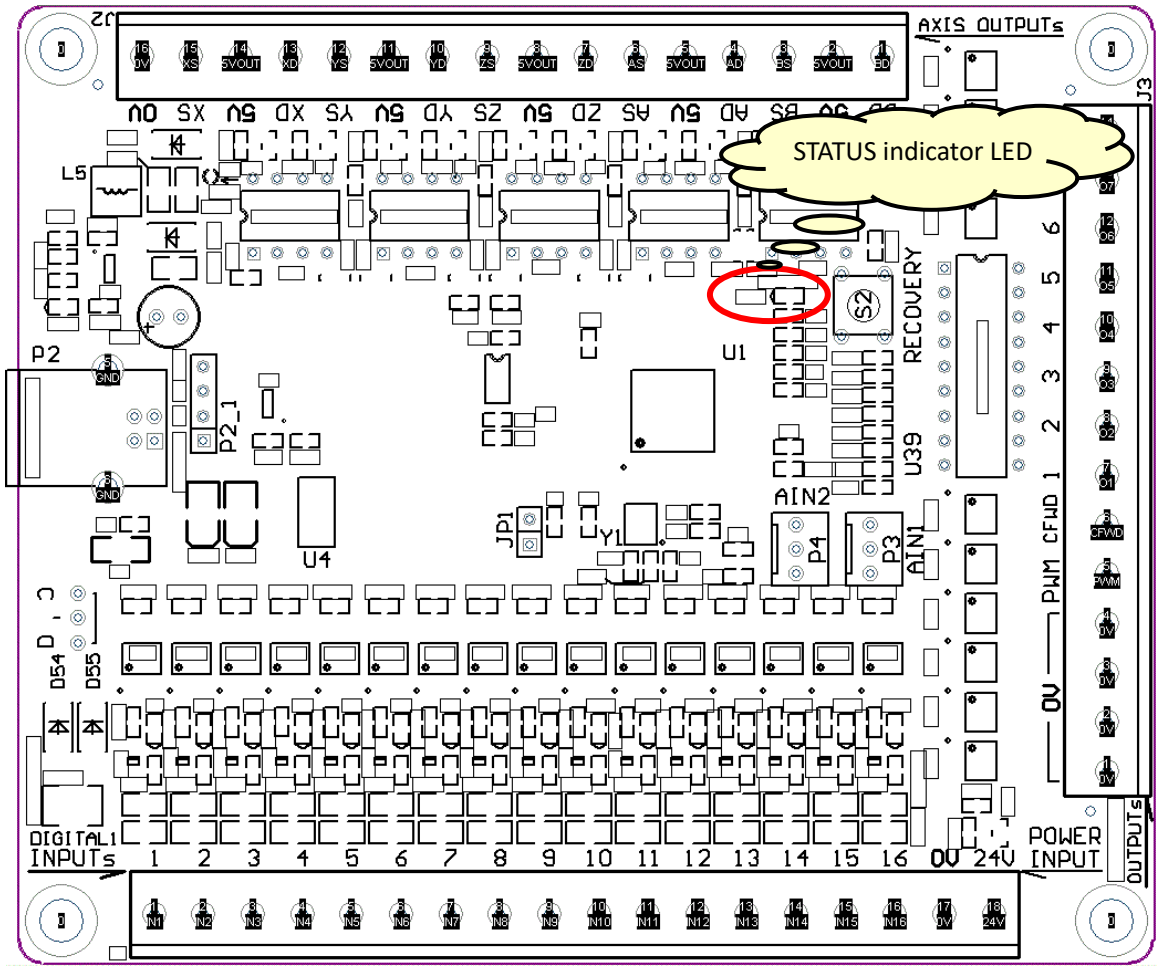
A dialogue of “Motion Control Hardware PlugIn sensed!!” is shown.
Please choose the option “USB.Ethernet-Motion-board“.
You can also check ”Don't ask me this again”.



1.3 Status indicator(LED) of motion control board, External power supply

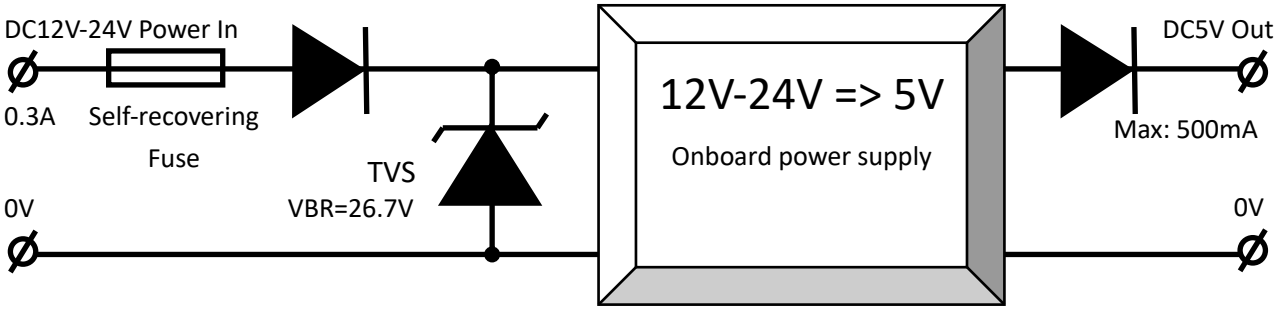
1.3.1 The motion board has a status indicator LED that indicates the current status by different blinking modes.

LED flashing mode	Status
Always bright	Standby (POWER ON)
Slow flashing	Connection (has already established a connection with MACH3 via USB)
Fast flashing	5-axis operation (eg running G code, jog, but not pulse spindle)
Slow flashing, gradually flashing quickly, turn off after 5 seconds	After pressing the RECOVERY button for 5 seconds, the Motion Board soft reset.



1.3.2 External power supply

1.3.2.1 Schematic



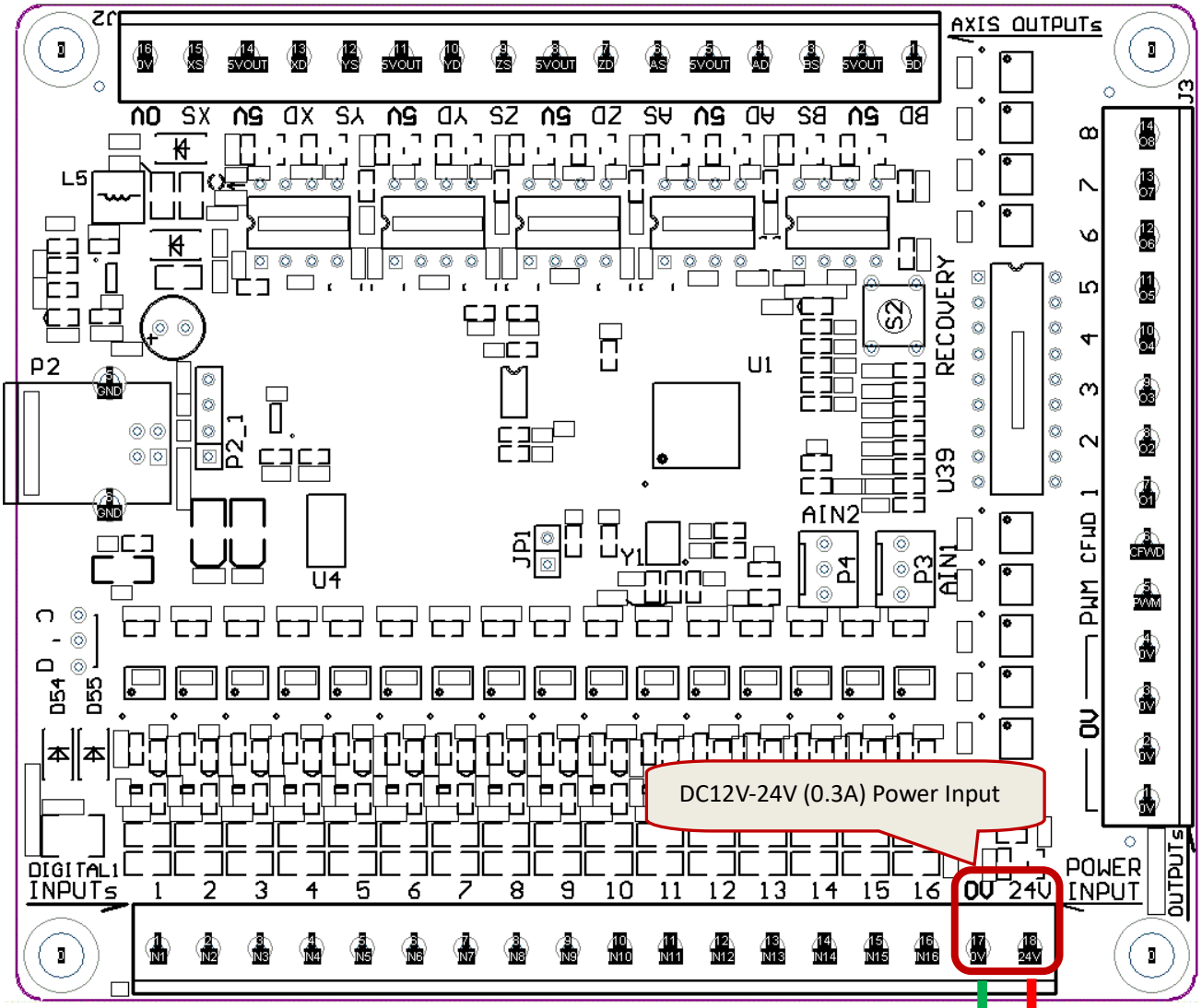
1.3.2.2 Wiring

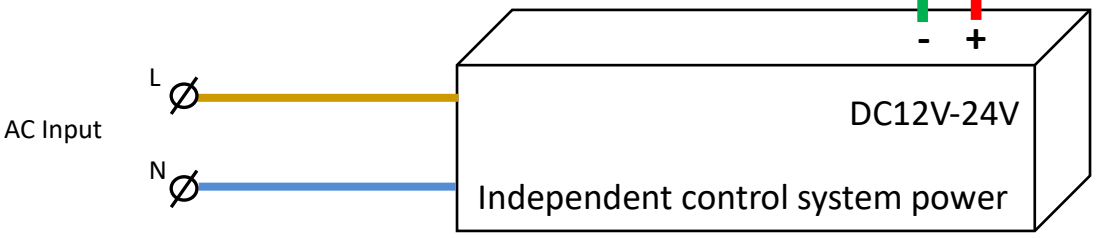
Motion control board, requiring DC12V-24V (0.3A) power supply

Warning: The control panel input voltage (peak) cannot exceed 26V.

The board requires an independent power supply (control system power supply) that can be shared with sensors, handwheels, and the like.

Because the motor has a back EMF, the control board cannot share a power supply with the motor to ensure safety and reliability.





2. Motion control board and PC connection

Note:
First: complete the Mach3 plugin installation, start Mach3 and select the external motion control board

2.1 USB

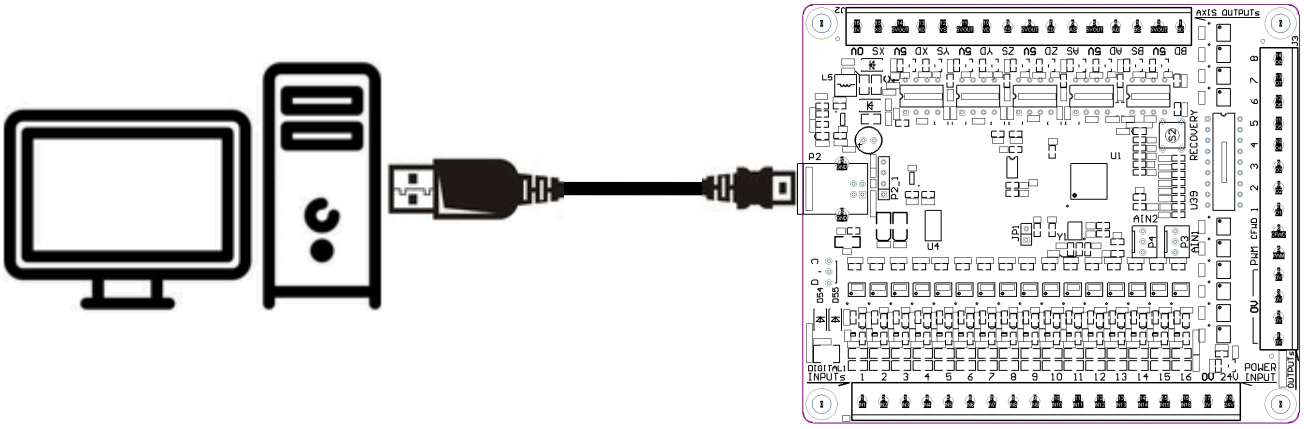
Magnet ring installed in the USB cable at both ends

Attention:

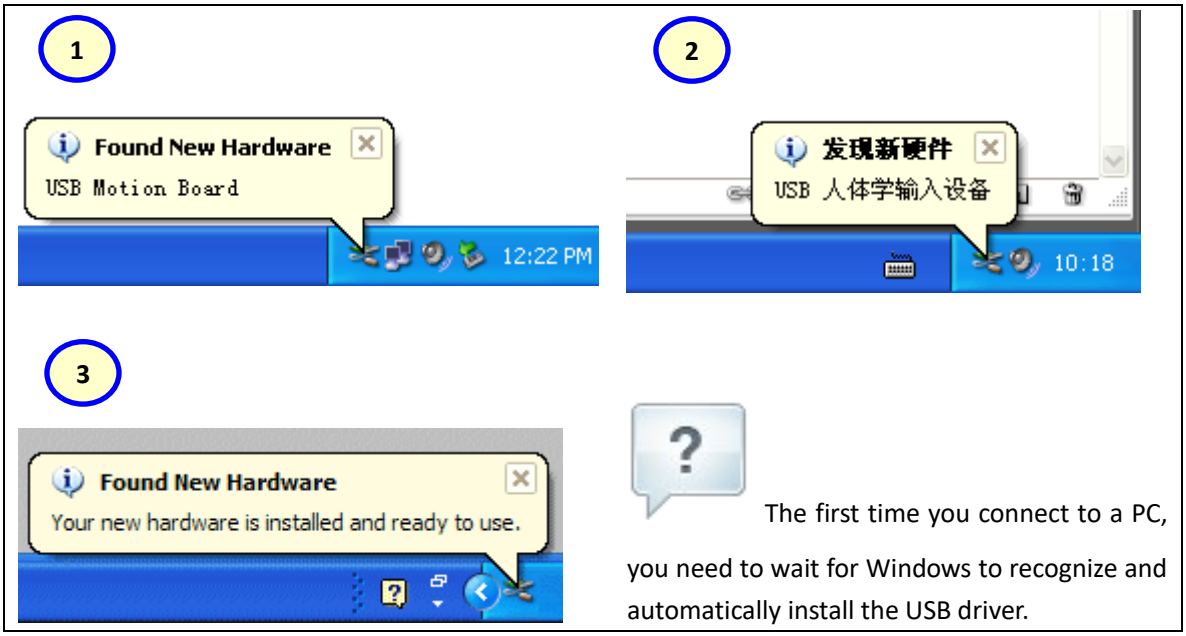
Please use the USB cable supplied with this product.

If you choose the USB cable yourself, please make sure to use a quality cable.

The motion control board is connected to the PC using a USB cable and is powered on (DC12V-24V)



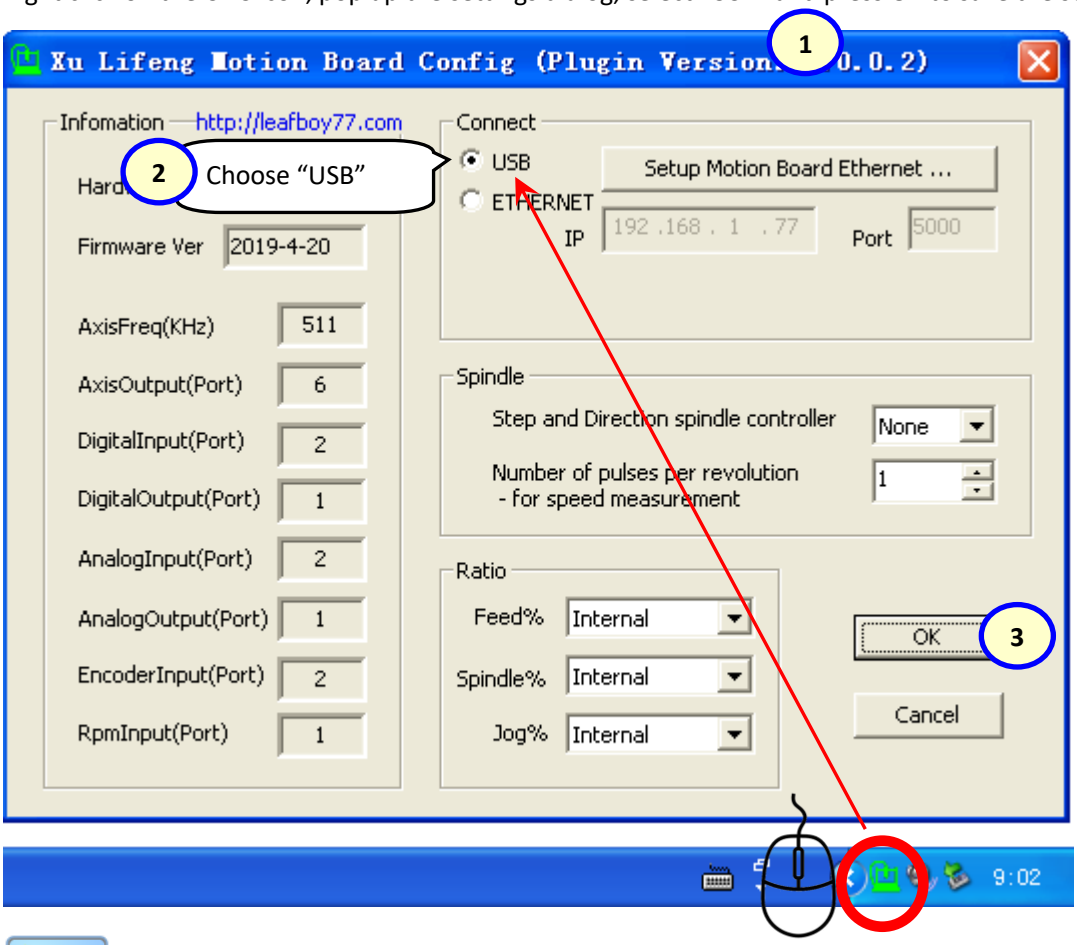
This motion board does not need install any USB driver， Windows XP - Windows 10 can directly identify



The first time you connect to a PC, you need to wait for Windows to recognize and automatically install the USB driver.

Start Mach3 and select external motion control board.

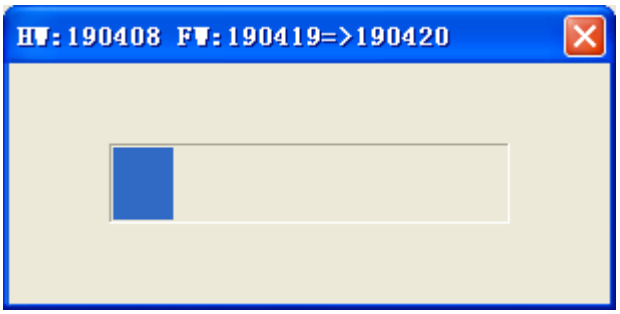
Right click on the CNC icon, pop up the settings dialog, select "USB" and press OK to save the settings.



When the Mach3 is successfully connected to the motion control board (USB), the STATUS-LED indicator flashes slowly.

3. Firmware upgrade, Restore factory firmware, Restore factory settings

The chip firmware of this motion control board supports upgrades, and users can continuously get the latest feature support. The firmware is stored in the Mach3 plugin (the latest version of the Mach3 plugin, please download it from http://leafboy77.com). When Mach3 is launched and connected to the motion control board, the firmware version is checked and automatically upgraded.

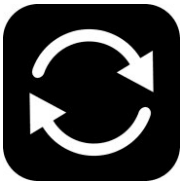


Normally, the upgrade can be completed successfully. If the upgrade fails in a special situation and the board fails to start, the motion board provides the function of **restoring the factory firmware**. The steps are as follows:

i. Unplug the USB plug from the Motion Control Board
ii. Press and hold the RECOVERY button of the Motion Control Board
iii. Plug in the USB plug to the Motion Control Board (and make sure the other end of the USB cable is plugged into the PC)
iv. Release the RECOVERY button
v. The STATUS LED is always on (standby status), indicating that the recovery operation is complete (It takes about a few seconds)

SOFT RESET Motion Control Board, the steps are as follows:

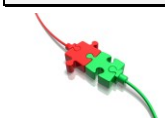
i. The USB plug is plugged into the Motion Control Board (and the other end of the USB cable is plugged into the PC), and the STATUS-LED is on.
ii. Press and hold the RECOVERY button for more than 5 seconds, STATUS-LED flashes slowly => fast flashing => off
iii. Release the RECOVERY button, the STATUS-LED is always on (standby), SOFT RESET completed.



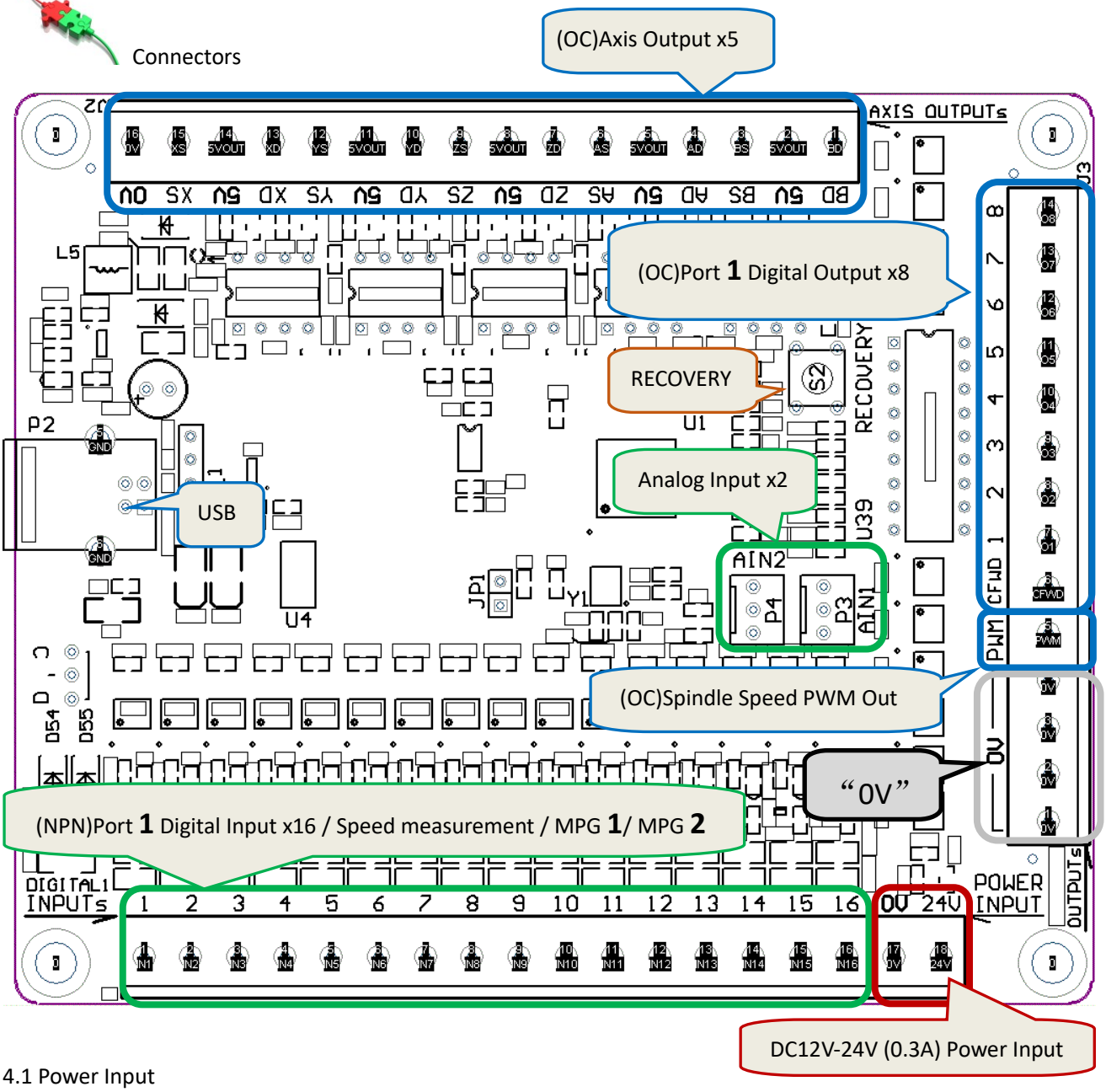
HARD RESET Motion Control Board, the steps are as follows:

i. Unplug the USB plug from the Motion Control Board.
ii. Plug in the USB plug to the Motion Control Board (and make sure the other end of the USB cable is plugged into the PC)

4. Electrical characteristics and wiring table



Connectors



4.1 Power Input

Connector	FUNCTIONS	ELECTRICAL	Description
0V	power input negative	0V	Common ground: (axis/digital input/digital output/PWM)
24V	power input positive	DC12V-24V / 0.3A	Independent power supply required (separate from motor)

4.2 Power Output

The Motion board has a 5V output power supply for the interface of the 6 stepper drives and the PNP-5V MPG 2.

Connector	FUNCTIONS	ELECTRICAL	Description
5V	power output positive	DC5V / 500mA	All 5V Connectors, a total output of 500mA

4.3 (NPN) Port 1 Digital Input x16 / Speed measurement /MPG 1/MPG 2

Connector	FUNCTIONS	ELECTRICAL	Description
1	Digital Input Pin 1 Speed measurement	NPN Optocoupler isolation x16 Interface voltage = power input (12V-24V) Min trigger current: 3mA Max operating current (12V): 5mA Max operating current (24V): 9mA	Port 1 Digital Input Speed measurement MPG 1 Input MPG 2 Input
2	Digital Input Pin 2		
3	Digital Input Pin 3		
4	Digital Input Pin 4		
5	Digital Input Pin 5		
6	Digital Input Pin 6 MPG 2 Input A		
7	Digital Input Pin 7 MPG2 Input B		
8	Digital Input Pin 8		
9	Digital Input Pin 9		
10	Digital Input Pin 10		
11	Digital Input Pin 11		
12	Digital Input Pin 12		
13	Digital Input Pin 13		
14	Digital Input Pin 14		
15	Digital Input Pin 15 MPG 1 Input A		
16	Digital Input Pin 16 MPG 1 Input B		

4.4 Analog Input x2

Analog input for external potentiometer control speed, electrical characteristics are **non-isolated**

Connector	FUNCTIONS	ELECTRICAL	Description
AIN1	Analog Input Port 1	**Non-isolated x2** Input voltage: 0V-3.3V Input current: <0.1mA	For external speed control: Spindle speed / jog speed / Feed
AIN2	Analog Input Port 2		

4.6 Axis Output x5

Connector	FUNCTIONS	ELECTRICAL	Description
XD (Xdir)	Xaxis Direction signal	High speed optocoupler isolation x10 Max: 24V / 13mA OC=Open collector output	Used to connect: Stepper drive server Driver
XS (Xstep)	Xaxis Step signal		
YD (Ydir)	Yaxis Direction signal		
YS (Ystep)	Yaxis Step signal		
ZD (Zdir)	Zaxis Direction signal		
ZS (Zstep)	Zaxis Step signal		
AD (Adir)	Aaxis Direction signal		
AS (Astep)	Aaxis Step signal		
BD (Bdir)	Baxis Direction signal		
BS (Bstep)	Baxis Step signal		

4.7 (OC) Port 1 Digital Output x8

Connector	FUNCTIONS	ELECTRICAL	Description
1	Digital Output Pin 1	Optocoupler isolation x8 Max: 24V / 500mA OC=Open collector output	Digital output pin for driving inductive loads (eg relay / solenoid valve) In order to prevent the back EMF from breaking through the driver chip (ULN2803), the CFWD terminal must be connected to the (loaded) power supply positive terminal. Or need an external independent freewheeling diode
2	Digital Output Pin 2		
3	Digital Output Pin 3		
4	Digital Output Pin 4		
5	Digital Output Pin 5		
6	Digital Output Pin 6		
7	Digital Output Pin 7		
8	Digital Output Pin 8		
CFWD	Common freewheeling diode	Connected (loaded) power supply positive	The CFWD terminal must be connected when driving an inductive load (or need an external freewheeling diode)

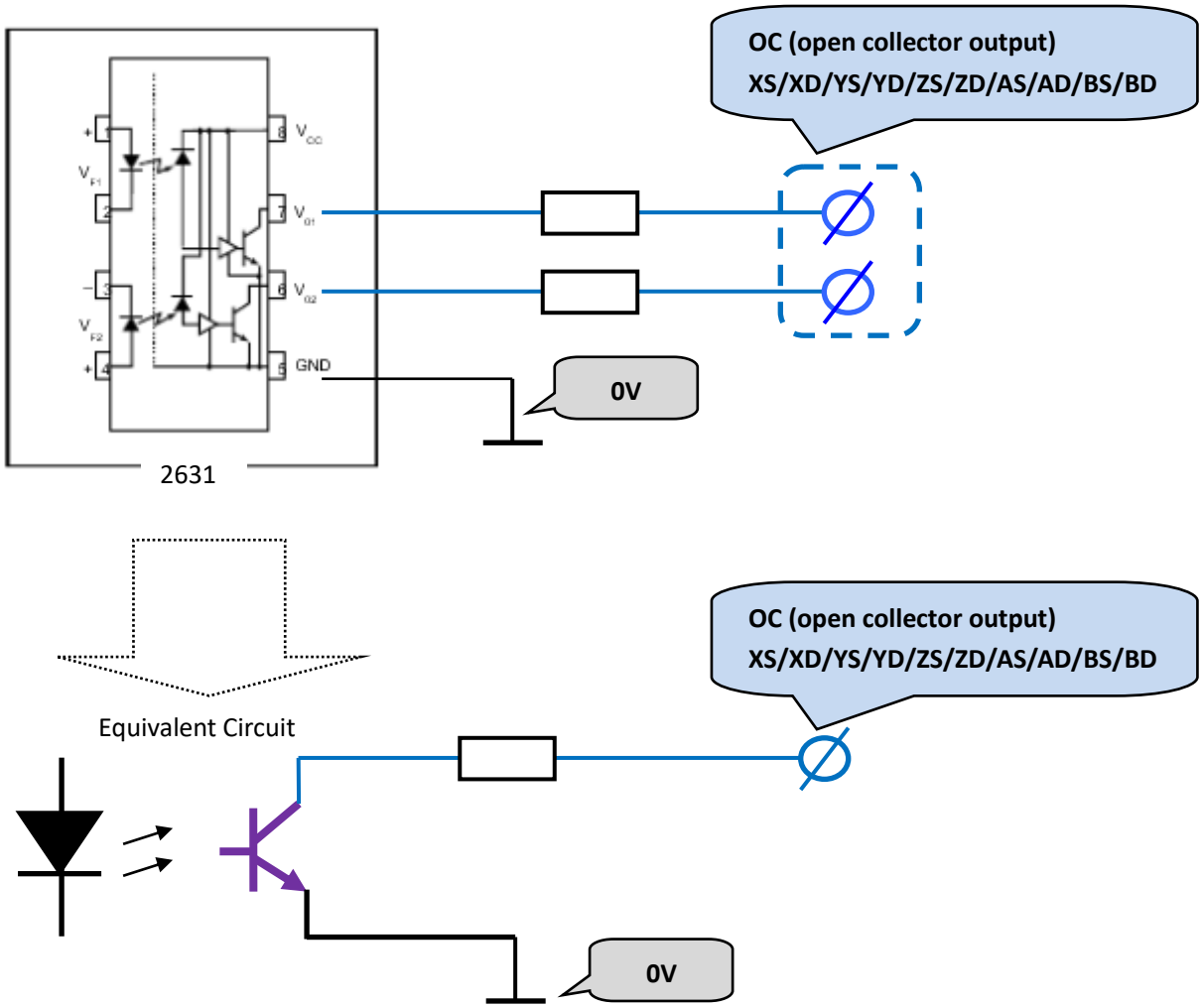
4.8 (OC) Spindle Speed control signal (PWM) output

Connector	FUNCTIONS	ELECTRICAL	Description
PWM	Spindle Speed signal output (PWM = Pulse-Width Modulation)	Optocoupler isolation x1 Max: 24V / 10mA OC=Open collector output	Spindle pulse width speed regulation, can also be used for inverter 0-10V speed regulation

5. Wiring and configuration with stepper (or servo) drives

5.1 5-axis outputs interface schematic

6 axis output of the control board (10 channels): open collector output, high speed optocoupler isolation



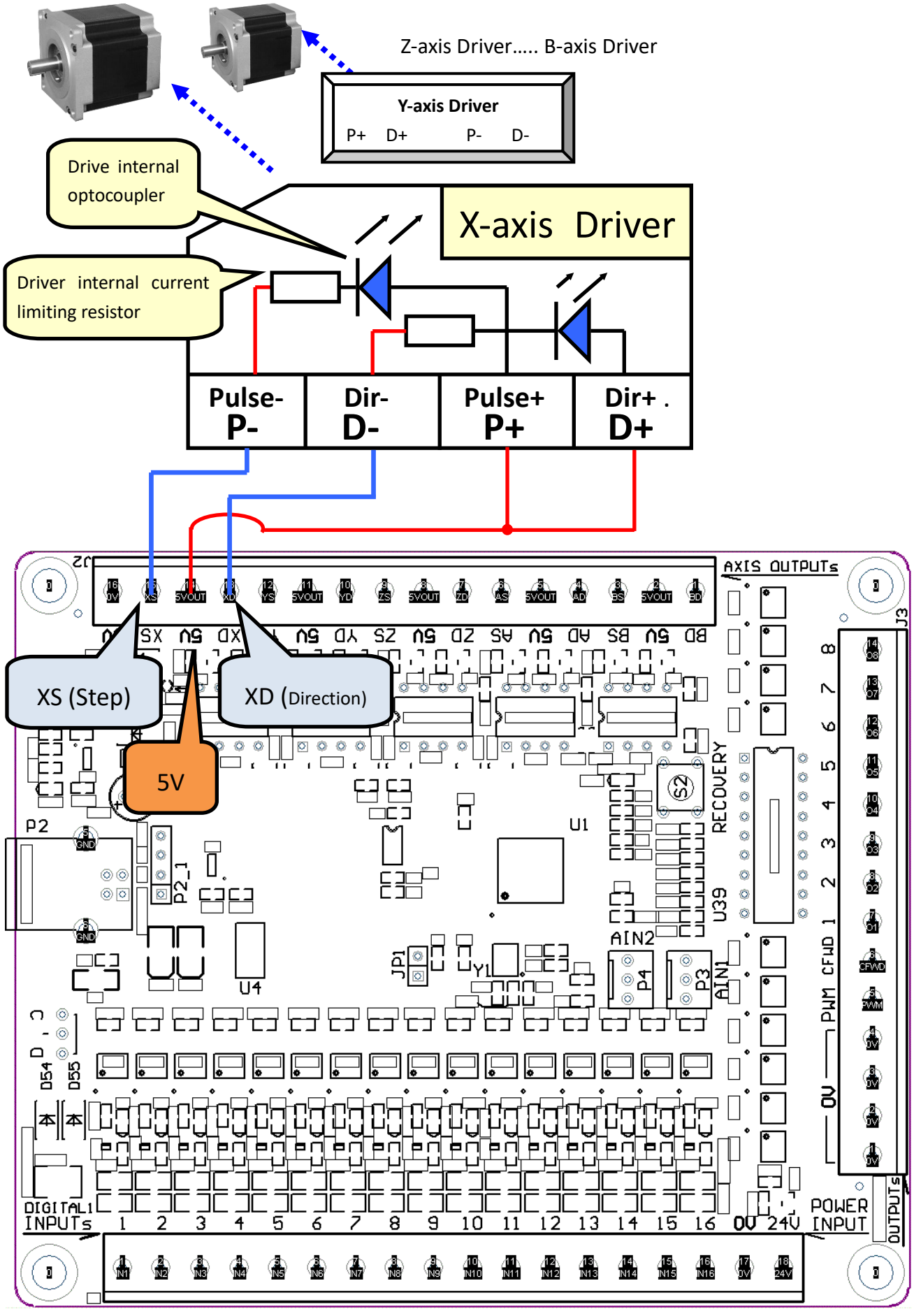
5.2 Stepper/Servo Driver Wiring Diagram

The interface of the stepper/servo drive uses the following two power supply methods:

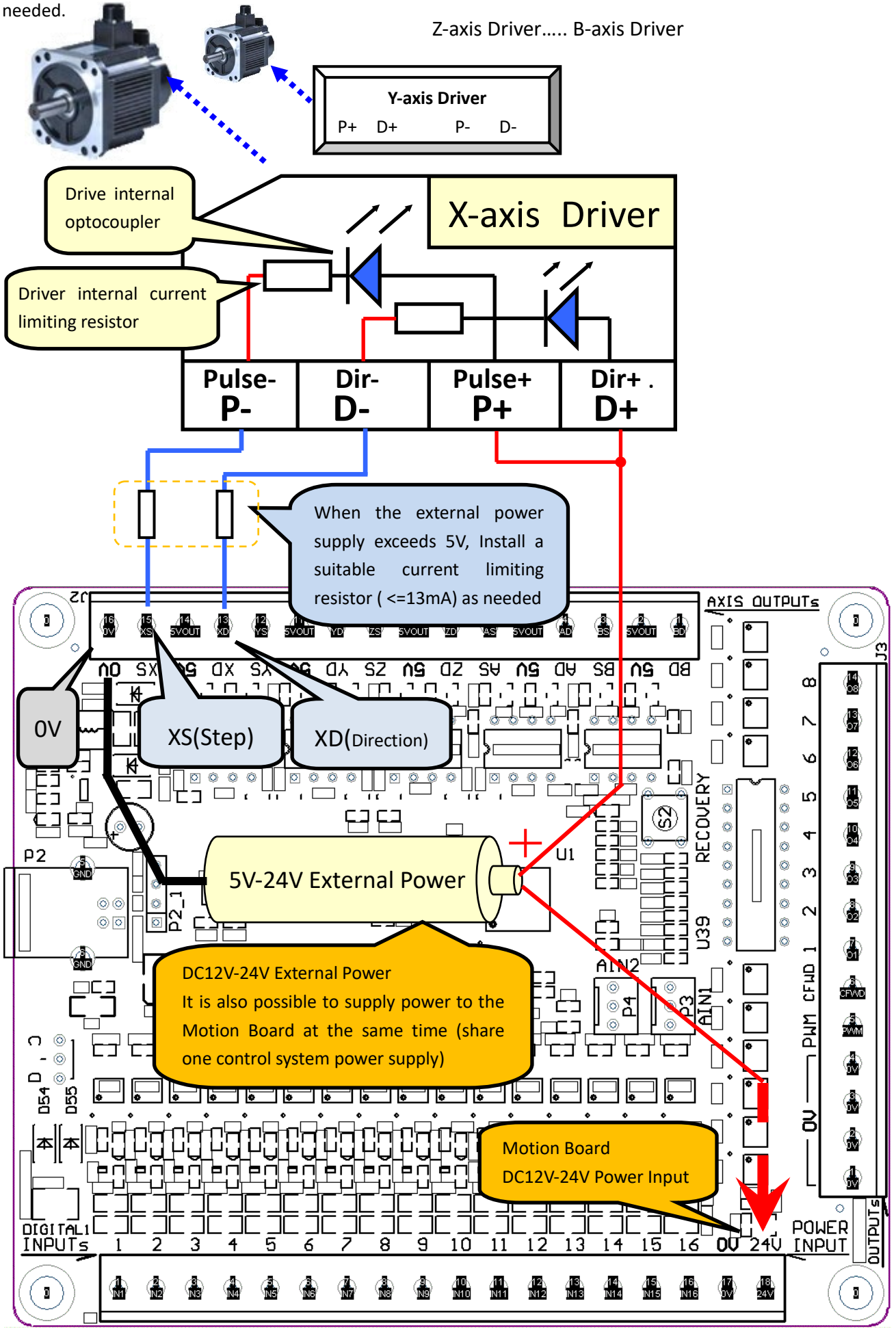
- Internal power supply 5V (suitable for stepper drive)
- External power supply 5V-24V (suitable for servo drive)

Note:
External power supply 12V-24V, this power supply can also supply power to the control board at the same time (share one control system power supply)

5.2.1 Use the 5V power supply inside the motion control board, suitable for stepper drivers, please install suitable current limiting resistors as needed.

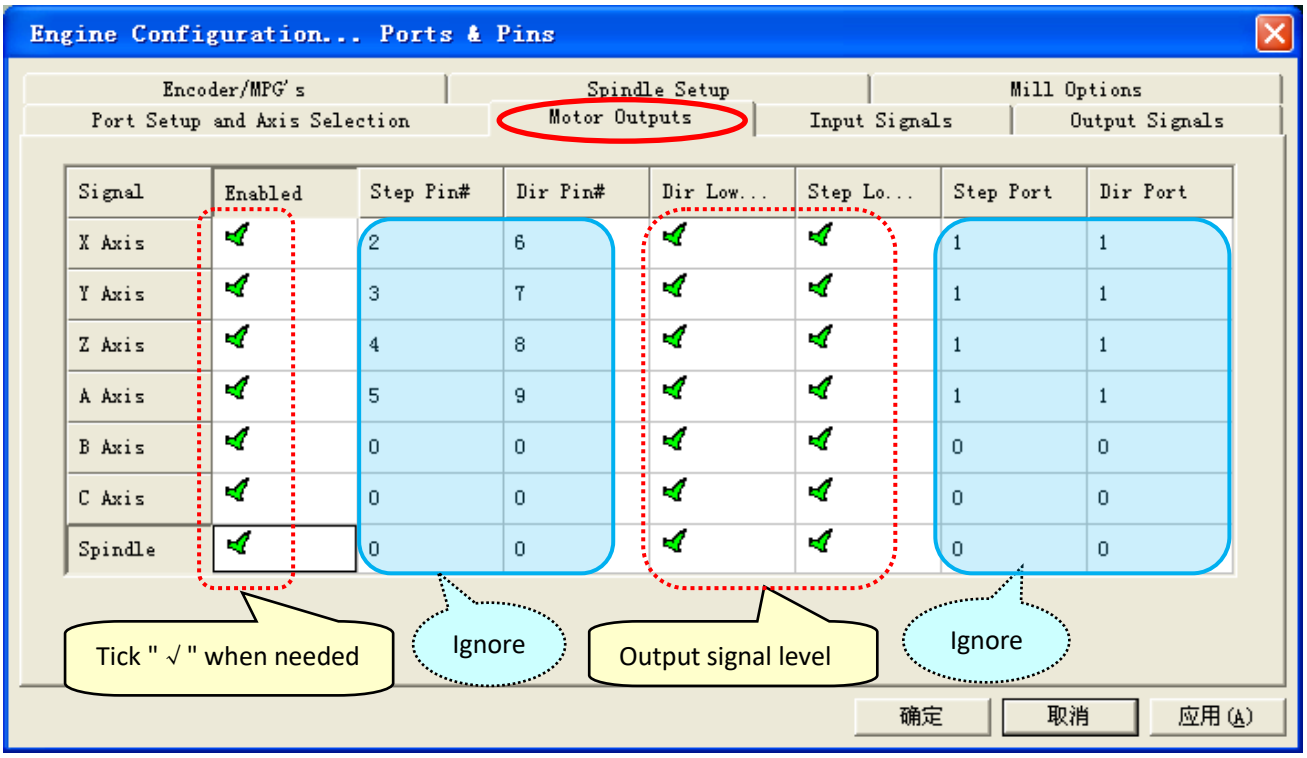


5.2.2Use 5V-24V external power supply, suitable for servo drive, please install suitable current limiting resistor as needed.

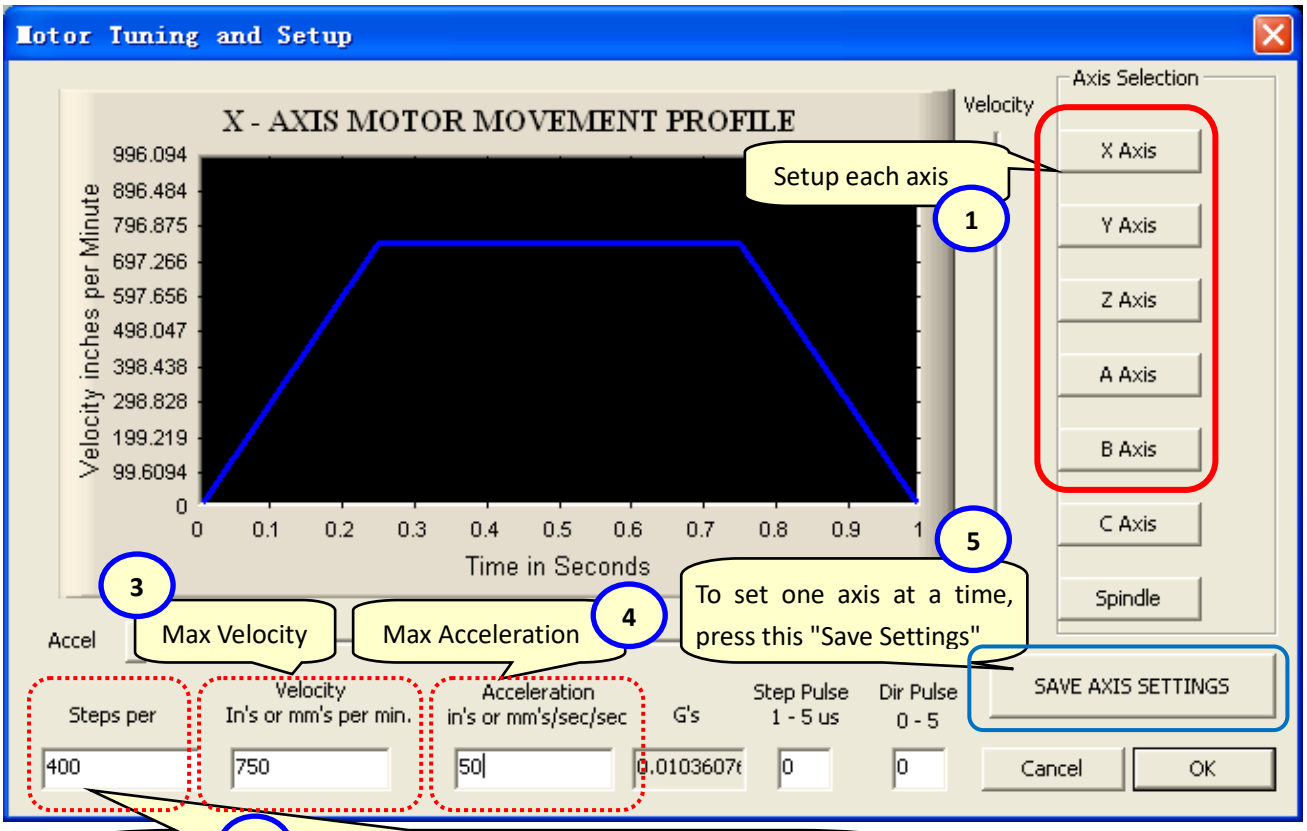


5.3 Motor parameter configuration

5.3.1 Mach3's X,Y,Z,A,B,C axis configuration, as shown below: (Config => Ports and Pins => Motor Outputs)

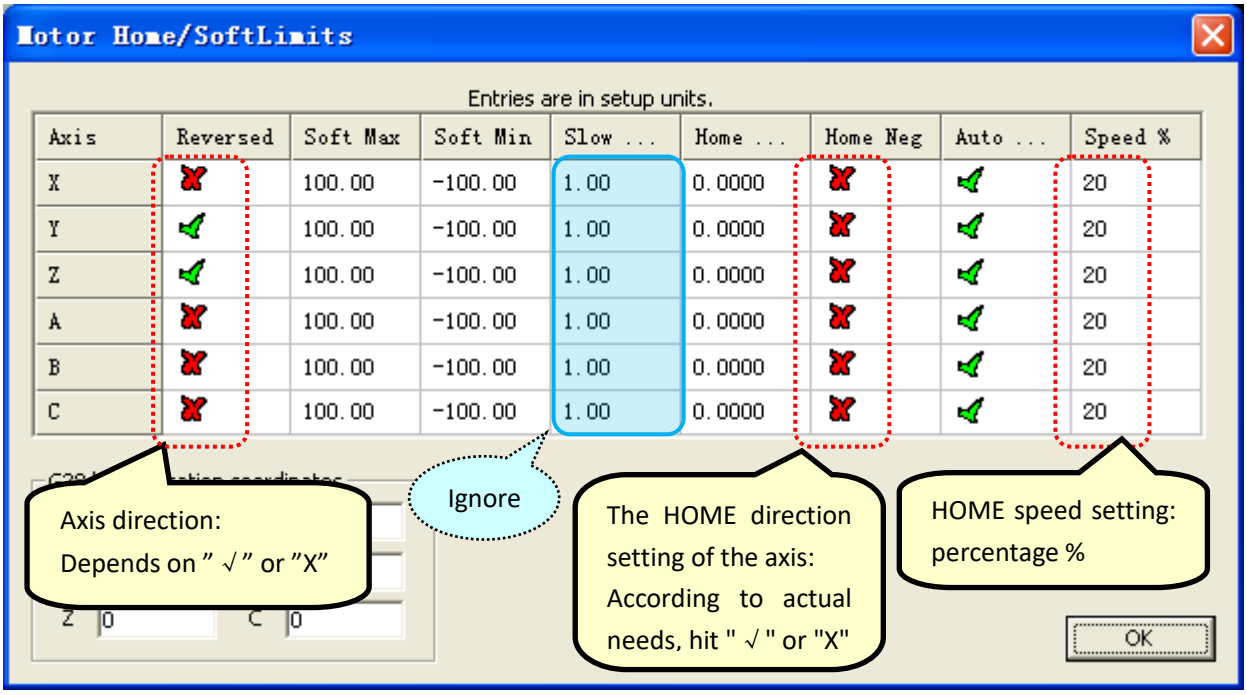


5.3.2 Mach3 tuning setup as shown below: (Config => Motor Tuning)



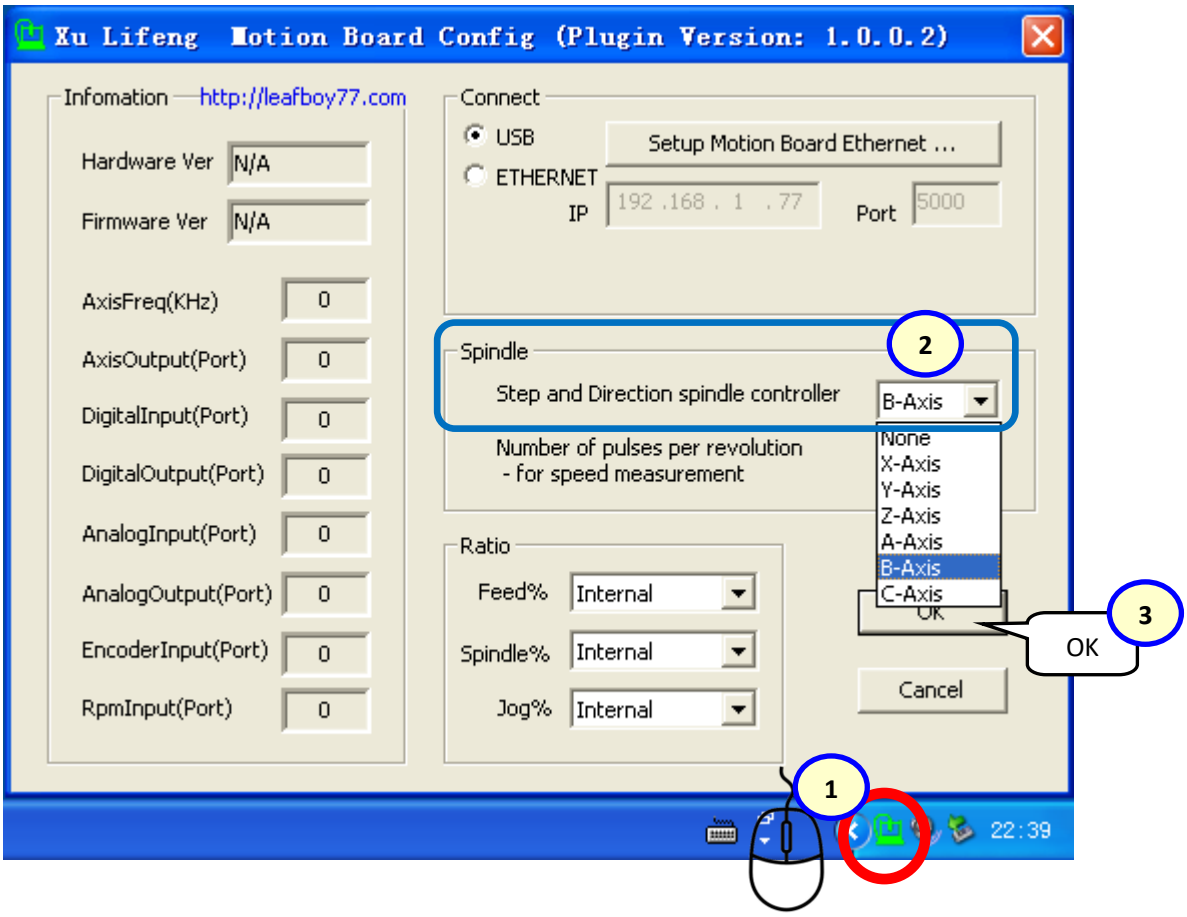
5.3.3 Mach3's **axis running direction** is recommended as shown below:

Mach3 Main menu => Config => Homing/Limits



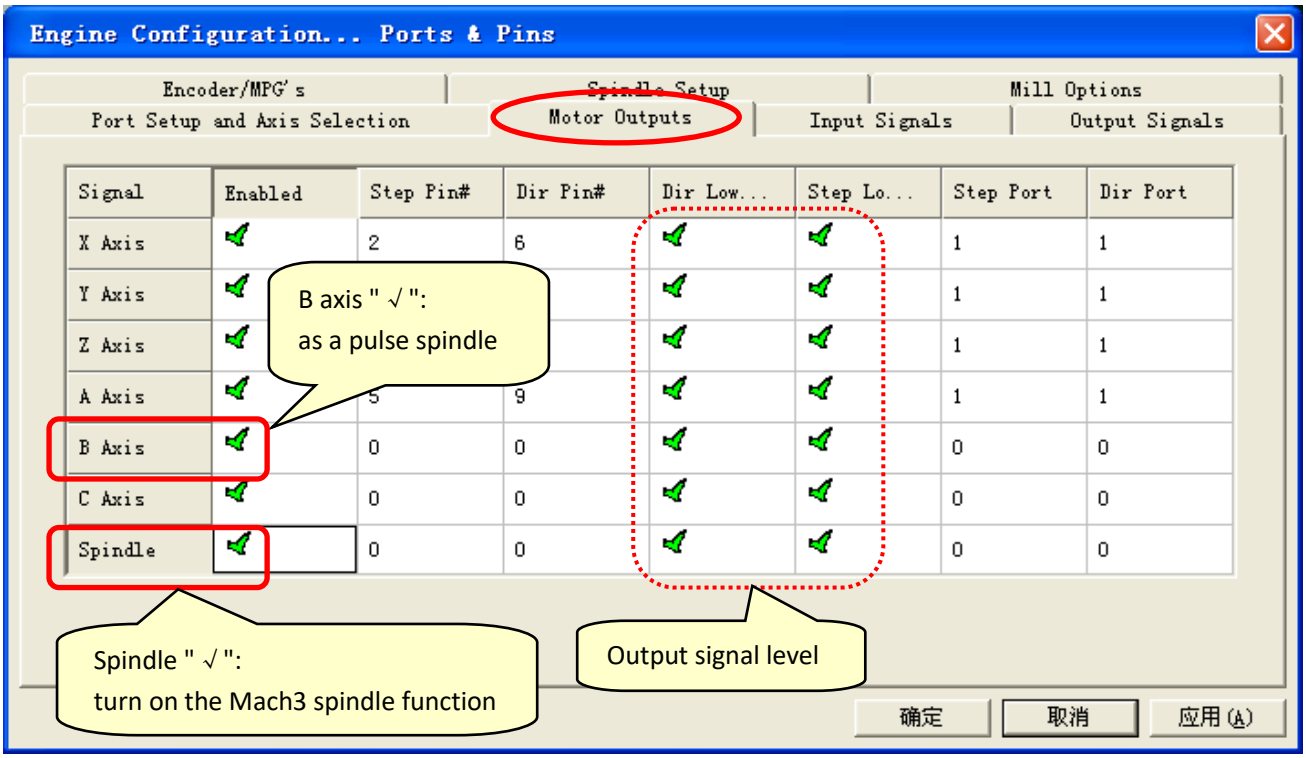
5.4 Pulse Spindle Configuration

You can set any one axis of the motion control board as the pulse spindle output, and specify the B axis as an example: Right click on the CNC icon, pop up the settings dialog, select "B-Axis", press OK to save the settings.(Turn off the pulse spindle function Select "None")



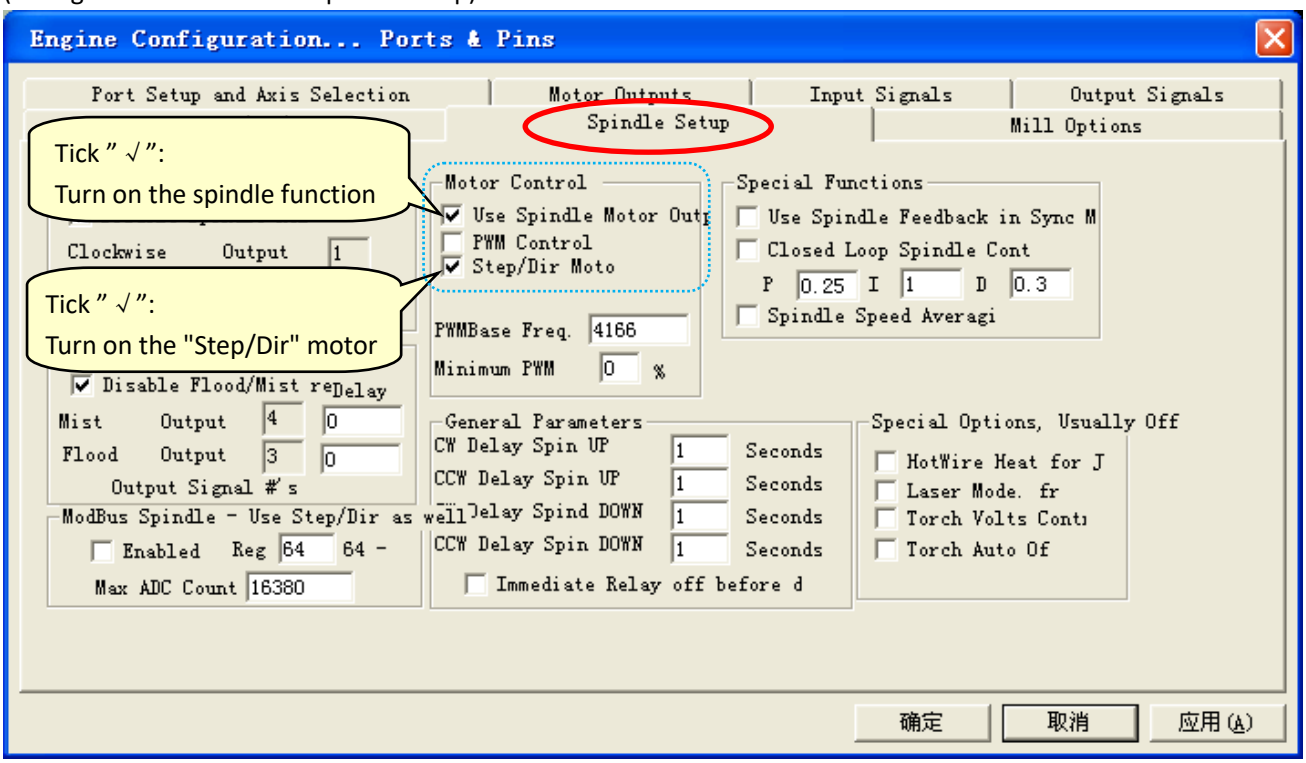
Confirm that the B axis is turned on (as a pulse spindle), and confirm that the spindle function (Spindle) is turned on, as shown in the figure below:

(Config => Ports and Pins=>Motor Outputs)

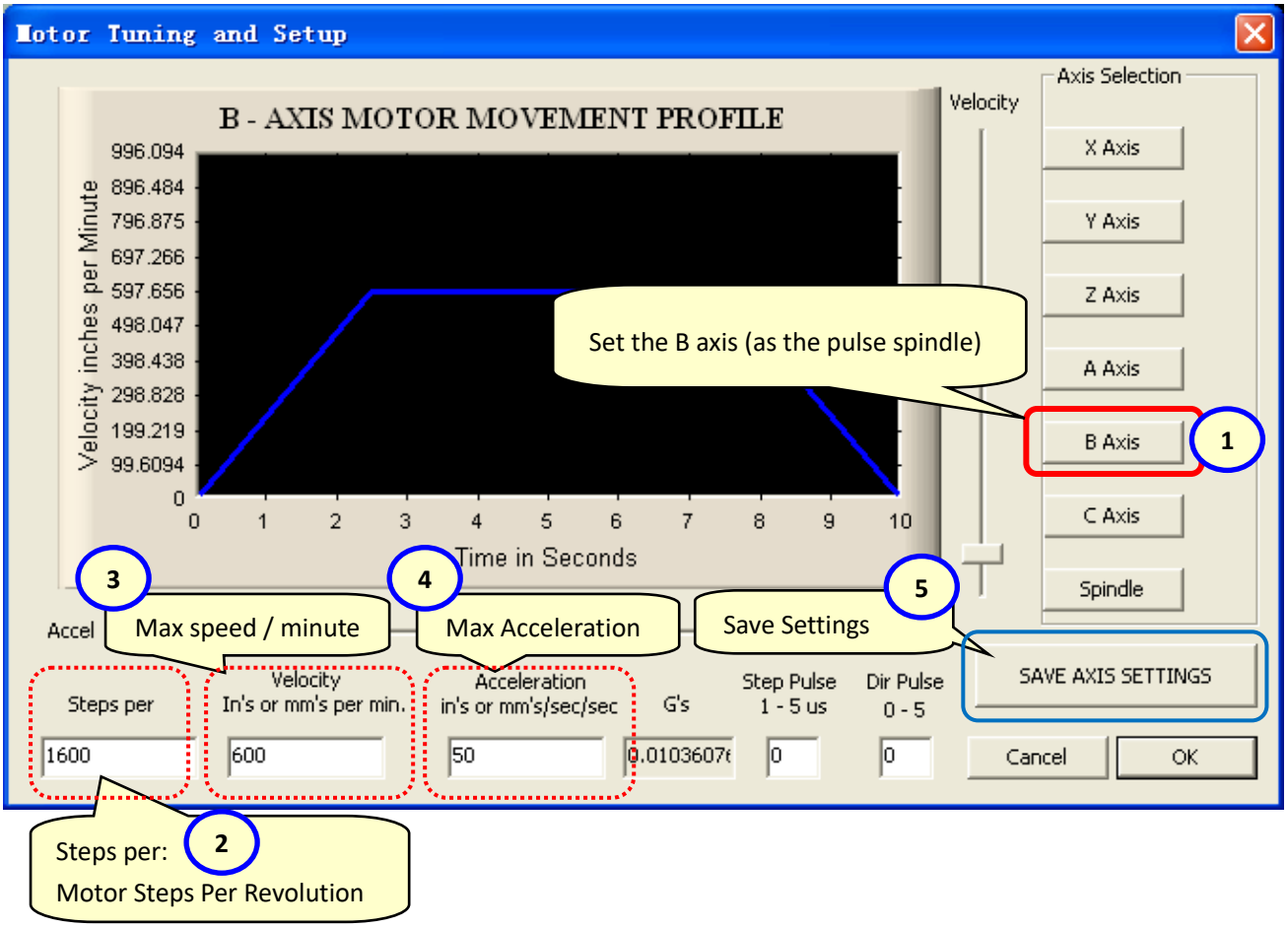


The spindle is set to: pulse / direction motor

(Config => Ports and Pins=>Spindle Setup)

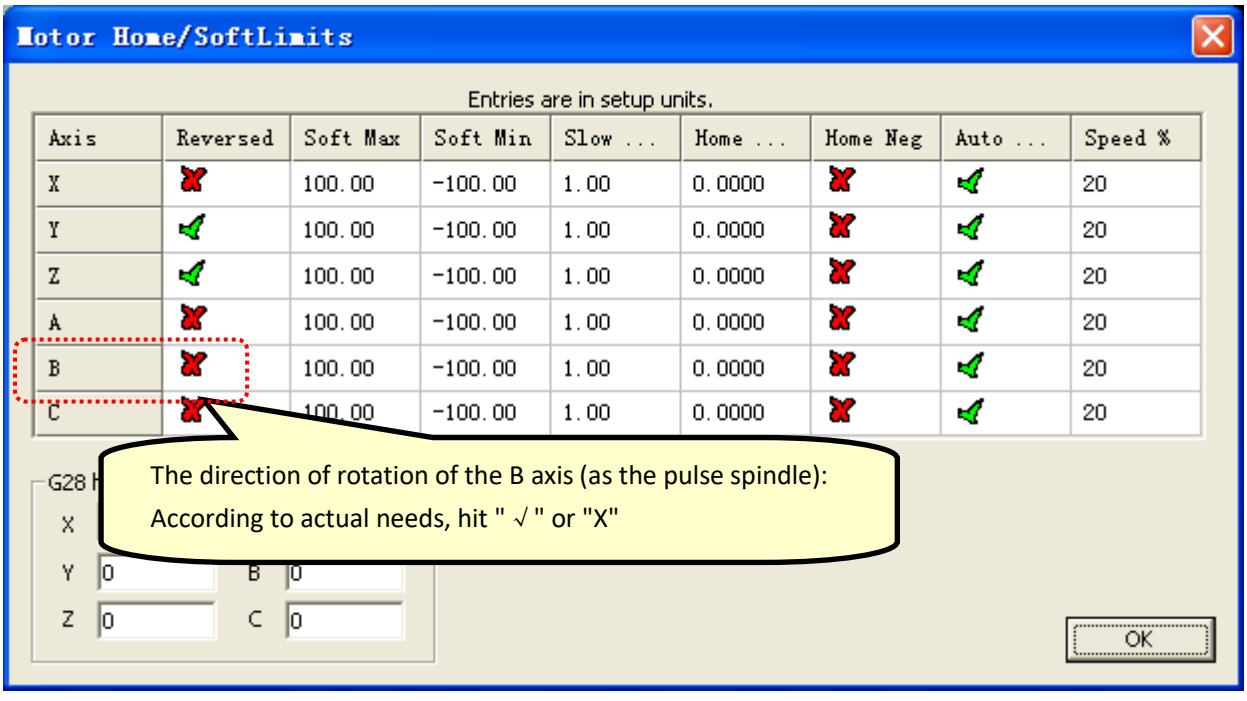


Motor operating parameter setting of B axis (as pulse spindle), as shown below: (Config => Motor Tuning)



The direction of rotation of the pulse spindle is recommended as shown in the following figure:

Mach3 main menu => Config => Homing/Limits

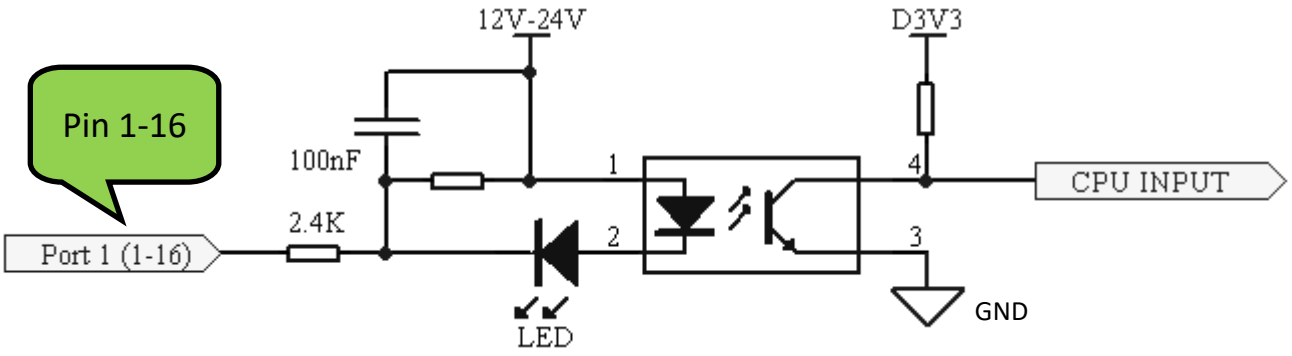


6. Digital input

6.1 NPN input interface characteristics, wiring and configuration

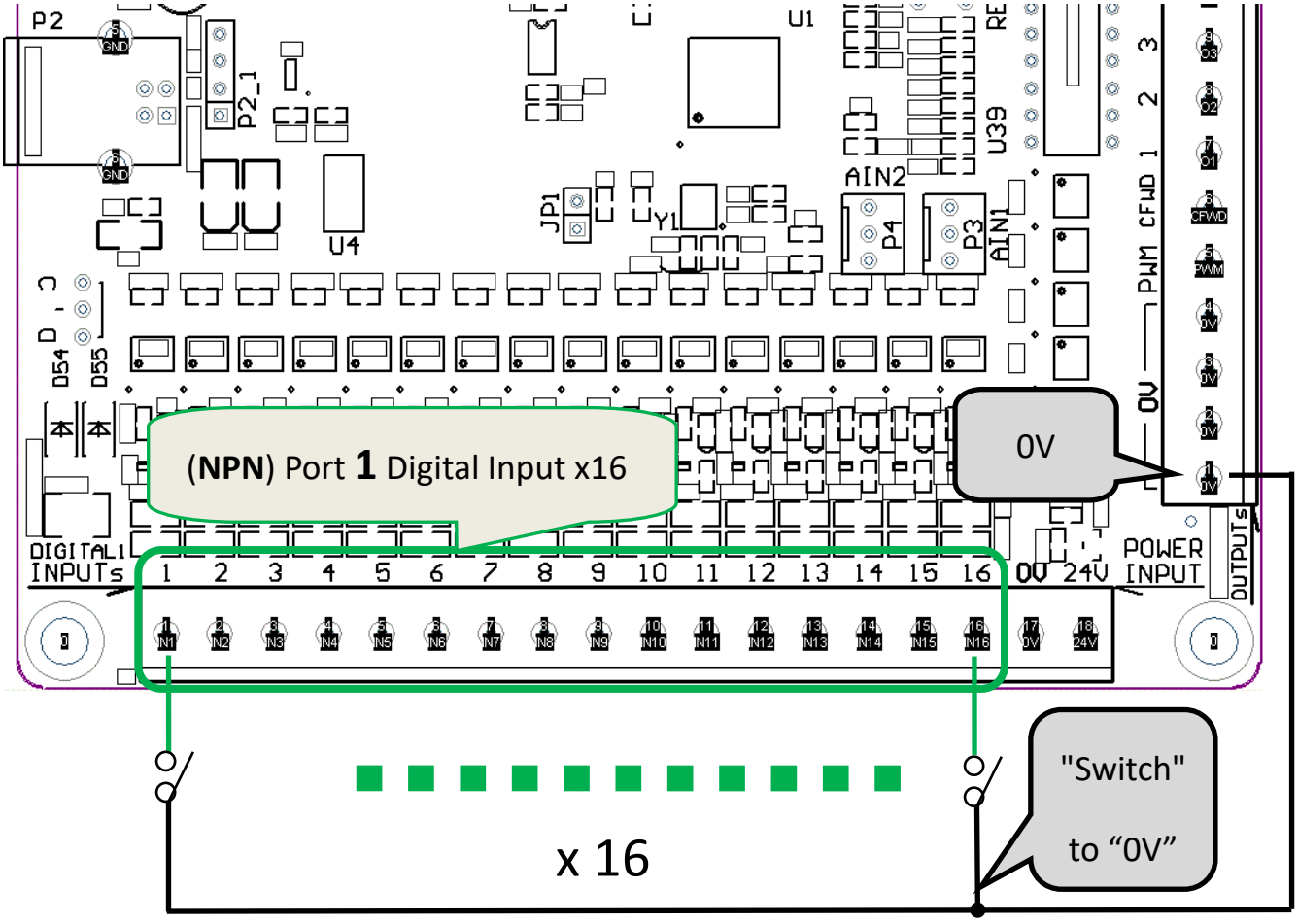
6.1.1 Interface schematic

Port **1** Digital Input: **NPN** Input x16, optocoupler isolation

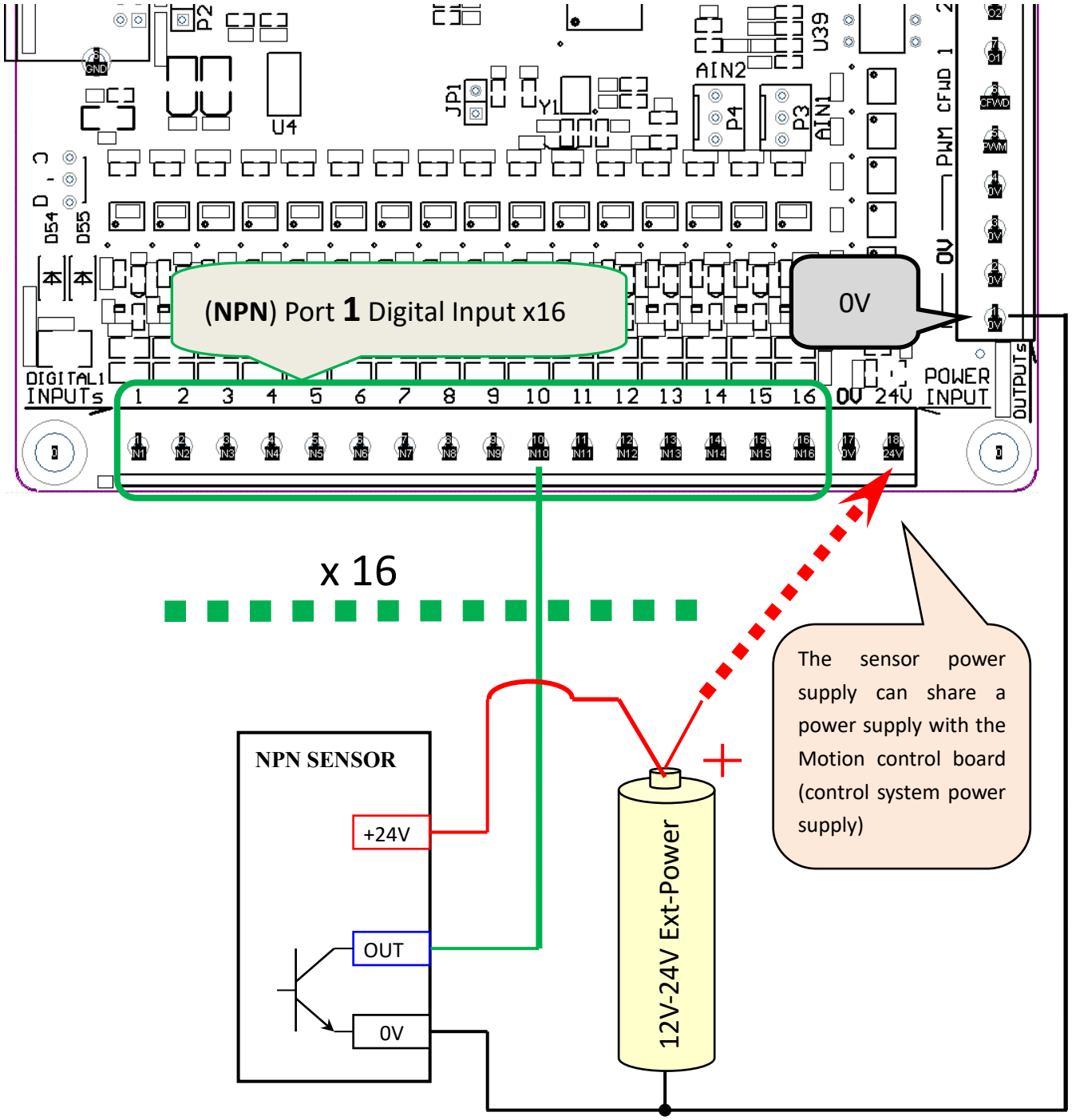


6.1.2 Wiring

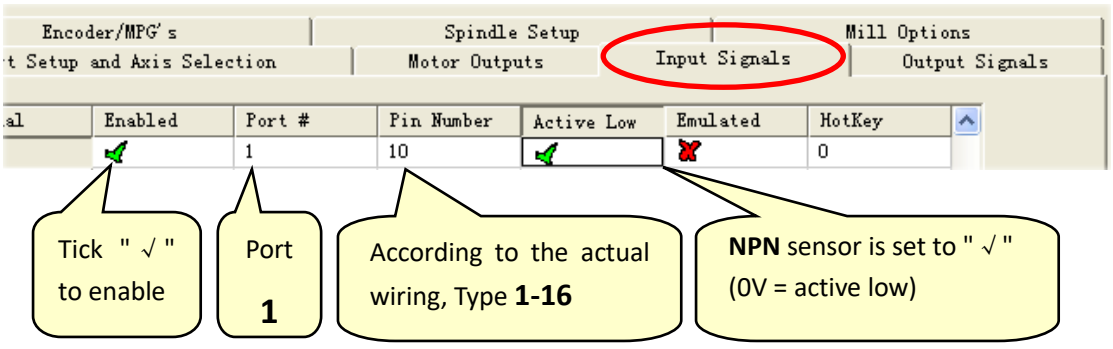
6.1.2.1 **Button, mechanical switch** wiring



6.1.2.2 **NPN sensor** wiring

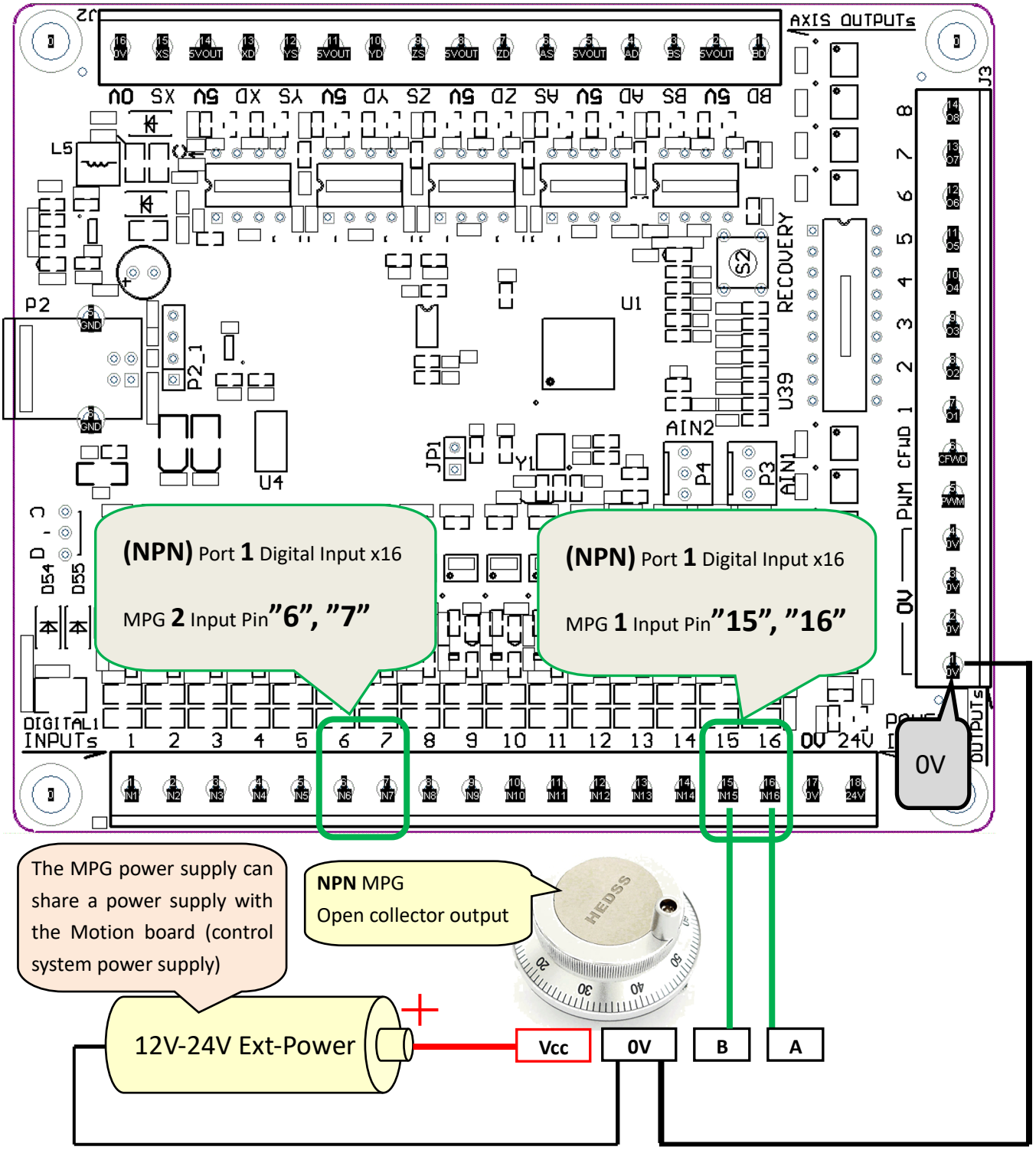


6.1.3 Mach3 input signal configuration (Config => Ports and Pins=>Input Signals)



6.2 **NPN** MPG(Manual Pulse Generation) wiring

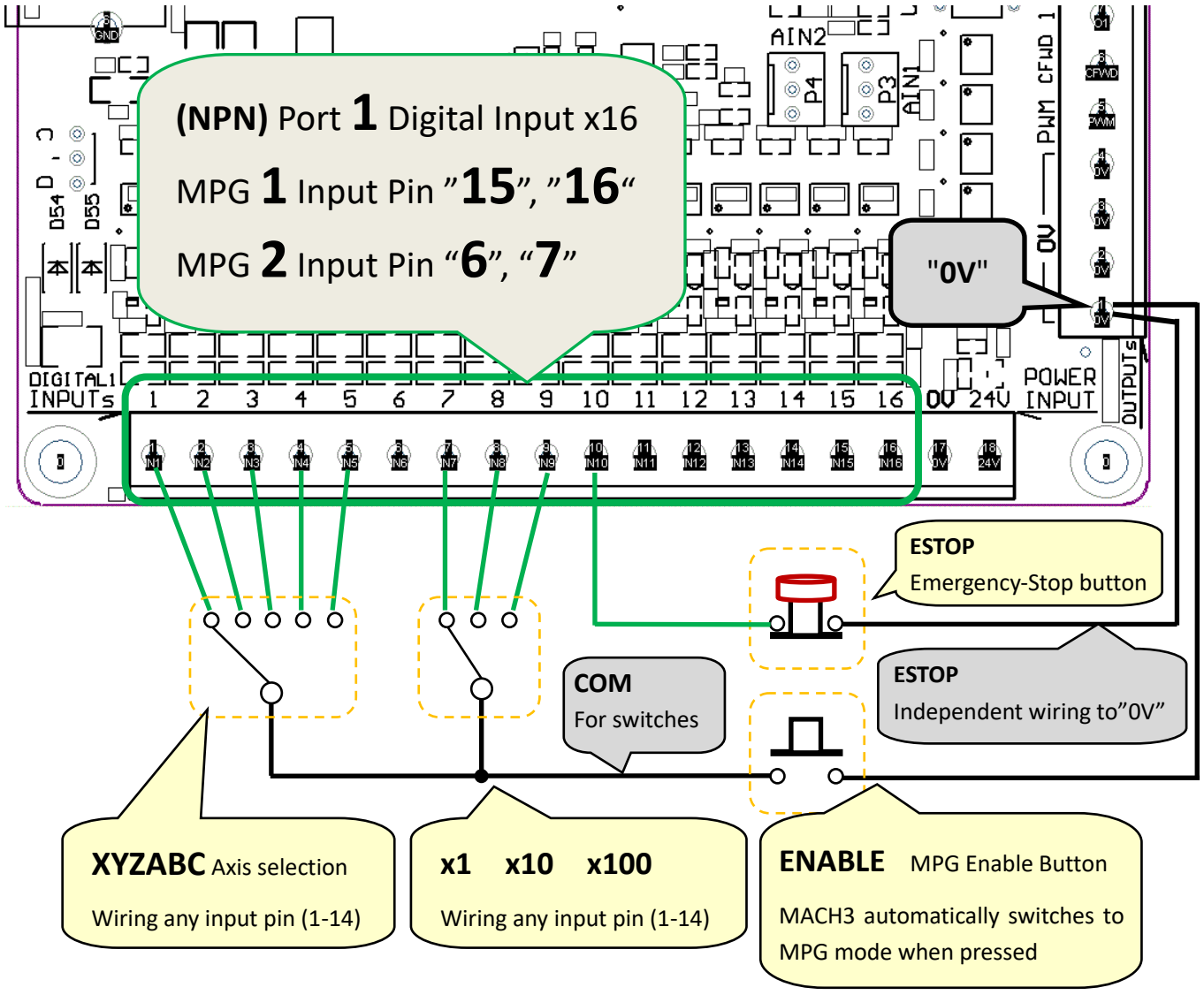
Output type of NPN MPG: **Open collector output (OC)**



Usually the MPG rotates clockwise, the coordinates increase; counterclockwise rotation, the coordinates decrease.

If the direction of rotation of the electronic handwheel is opposite to the direction of the MACH3 coordinate, exchange the wiring of the electronic handwheels "A" and "B".

6.3 Wiring of MPG switch



"Switch" and "Emergency Stop button" are connected to any input pin and then configured in Mach3.

When the "Enable Button" is pressed, the Jog Mode of Mach3 automatically switches to MPG mode, and automatically switches back to the original mode when the button is released.

The "Enable Button" automatically switches the JOG mode. The control board plug-in v1.3.1.2 (or later) version is required. See "Download and install the Mach3 plugin" to download the latest version.

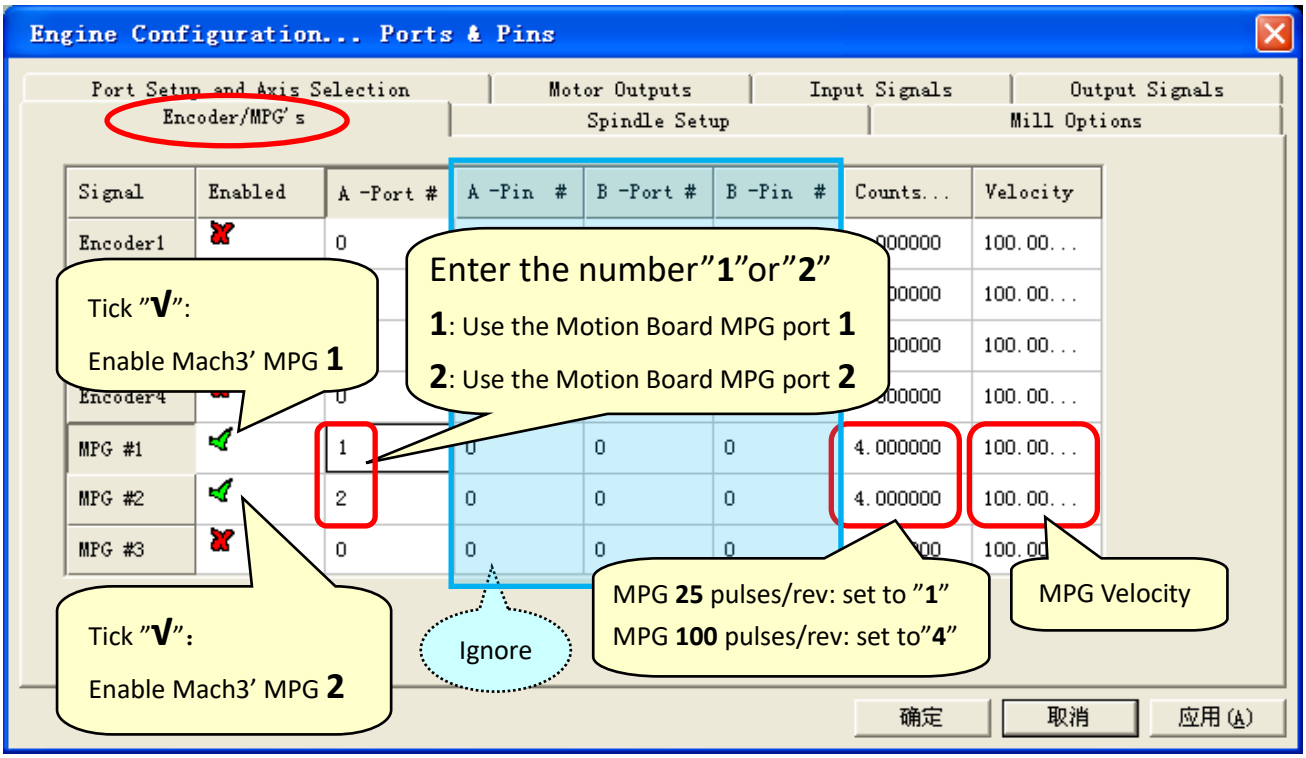
If the "Enable Button" is not needed, please short-circuit it (the common terminal "**COM**" of the switches is directly connected to the "**0V**" terminal of the control board).

Attention:

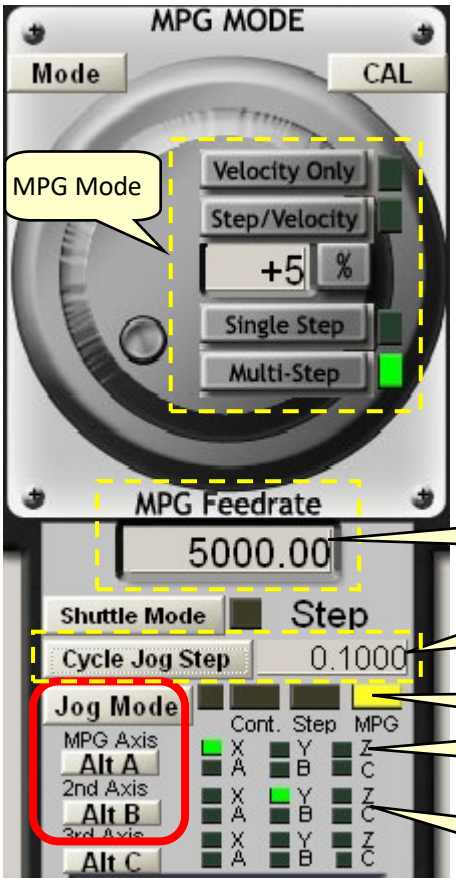
"Emergency-Stop button" It is recommended to use the "normally closed" contact. If a fault occurs in the disconnection of the wiring, an emergency stop will be triggered.

6.4 Configuration of the MPG

6.4.1 Mach3 MPG configuration, as shown below: (Config => Ports and Pins => Encoder/MPG's)

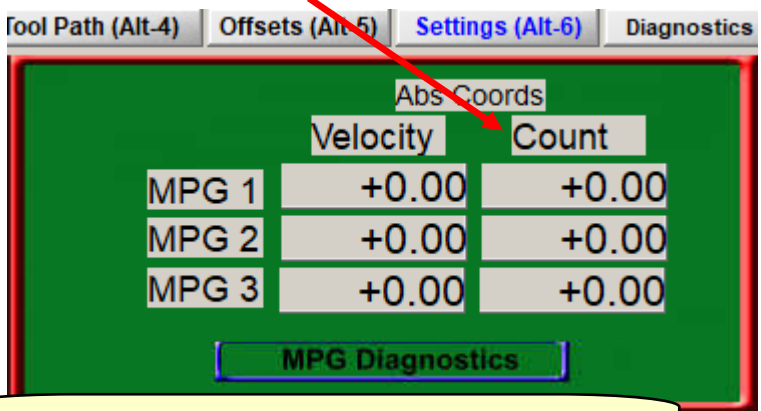


In Mach3, press the keyboard "TAB" and set it as shown below.



Multi-Step mode, MPG signal is processed in real time by motion control board

Mach3's MPG Count does not change at this time.



MPG Velocity: mouse click, type number, press **Enter**

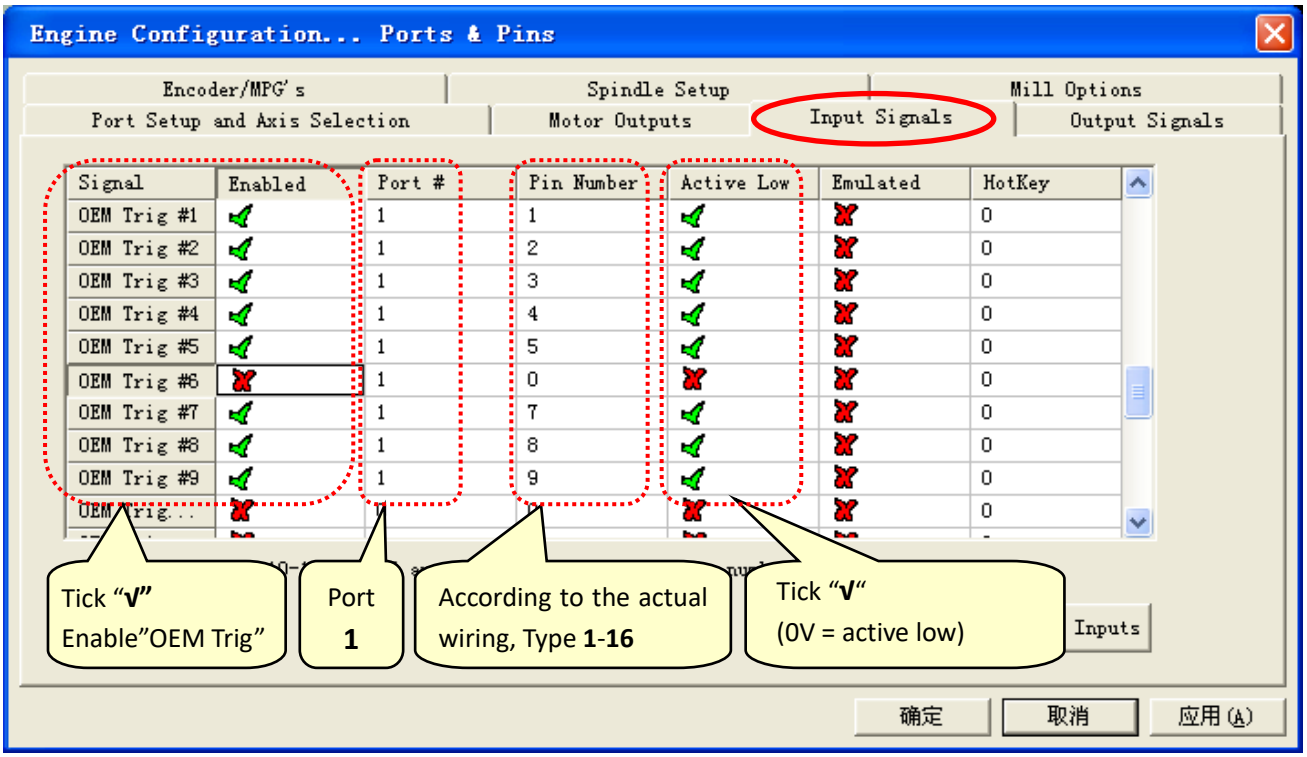
Jog Step: setup by click "Cycle Jog Step" button, or key in

Click "Jog Mode" button, set the jog to "MPG" mode

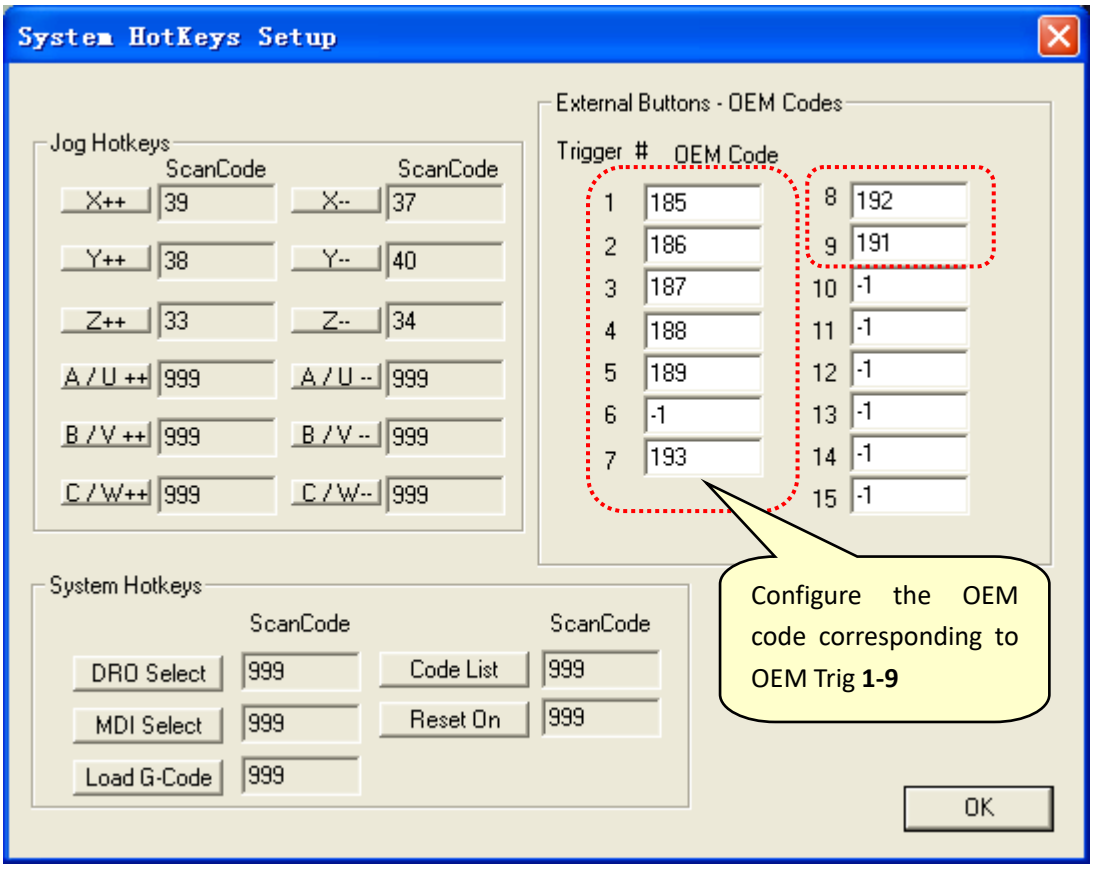
Click "Alt-A" button, select the axis(XYZABC) controlled by MPG **1**

Click "Alt-B" button, select the axis(XYZABC) controlled by MPG **2**

6.4.2 Mach3 electronic MPG switch configuration, as shown below: (Config => Ports and Pins=>Input Signals)



Configure the functions performed by "OEM Trig" as shown below： (Config => System Hotkeys)

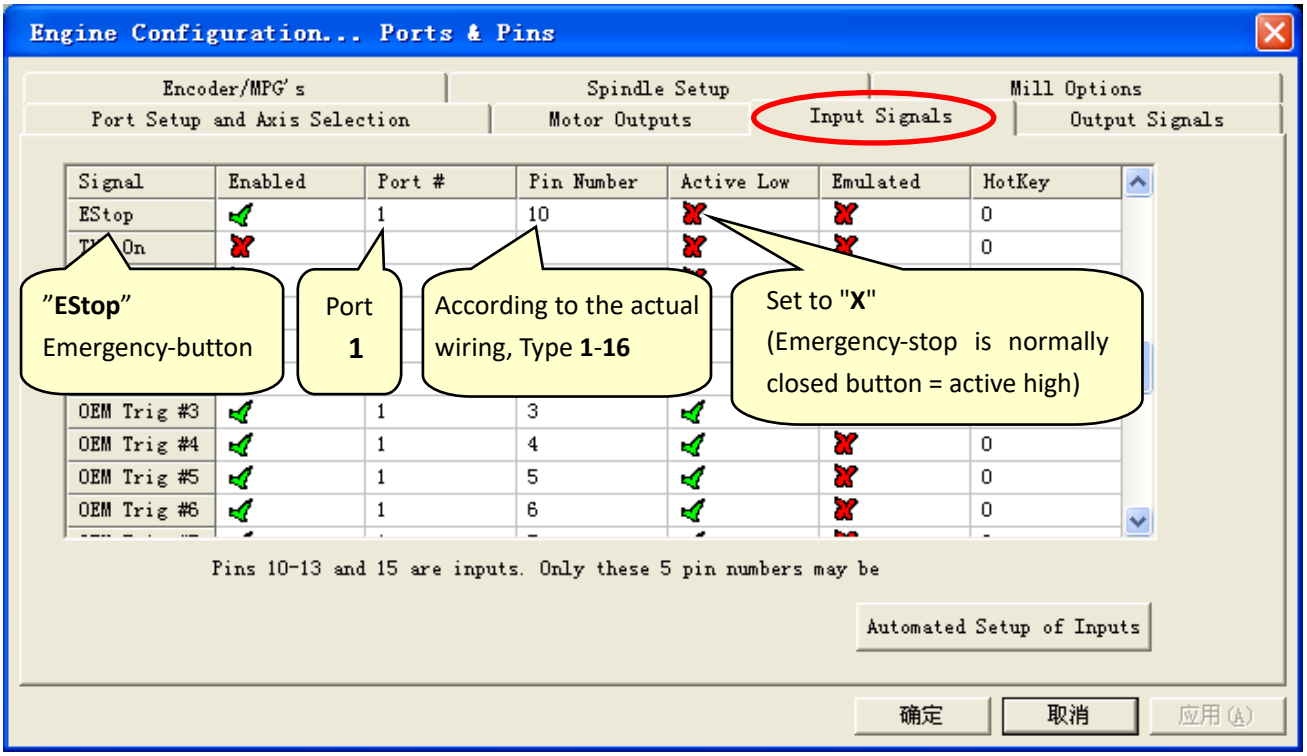


Mach3 axis selection for MPG / Jog step select OEM Buttons code table

Function	OEMCode
Select X for MPG 1	185
Select Y for MPG 1	186
Select Z for MPG 1	187
Select A for MPG 1	188
Select B for MPG 1	189
Select C for MPG 1	190
Select Jog Increment 1	191
Select Jog Increment 2	192
Select Jog Increment 3	193

Complete OEM Buttons code table, please search online

6.4.3 Mach3's **emergency-stop button** configuration, as shown below: (Config => Ports and Pins => Input Signals)

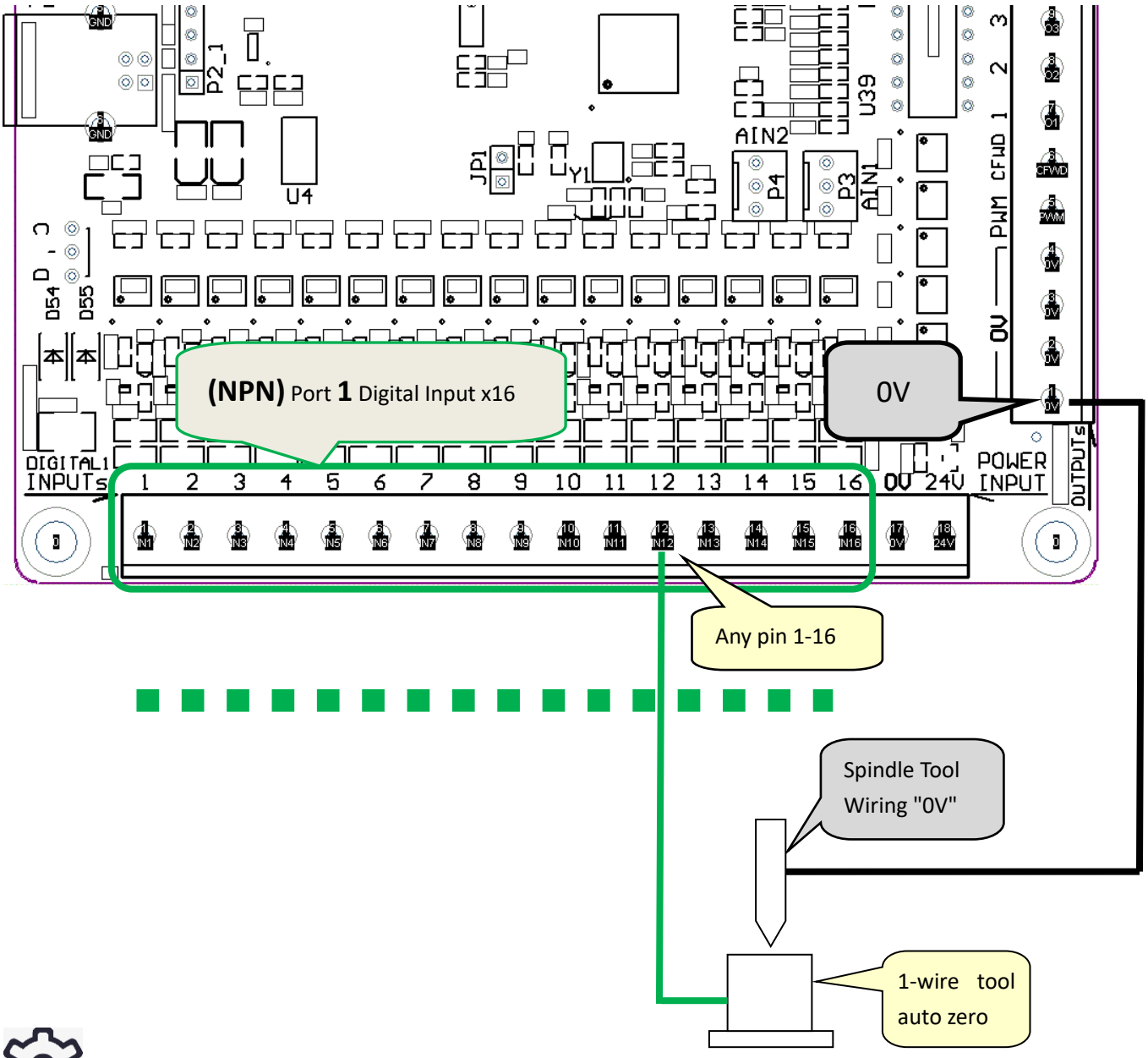


Attention:

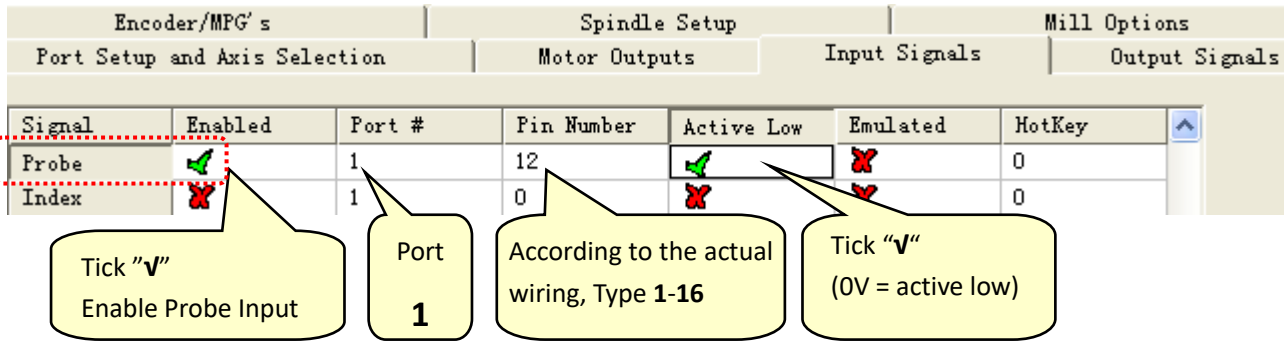
"Emergency-stop button" It is recommended to use the "normally closed" contact. If a fault occurs in the disconnection of the wiring, an emergency stop will be triggered.

6.5 Probe (Auto Tool Zero) wiring and configuration

6.5.1 Wiring: Use digital input port **1**, any pin(1-16), as the Probe input signal



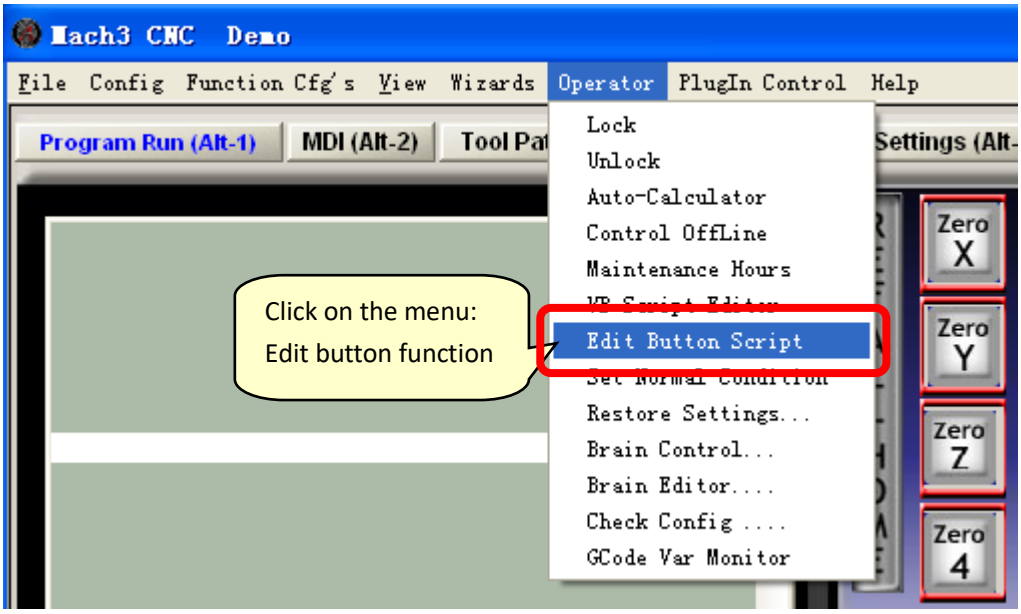
6.5.2 Mach3 Probe input signal configuration, as shown below: (Config => Ports and Pins=>Input Signals)



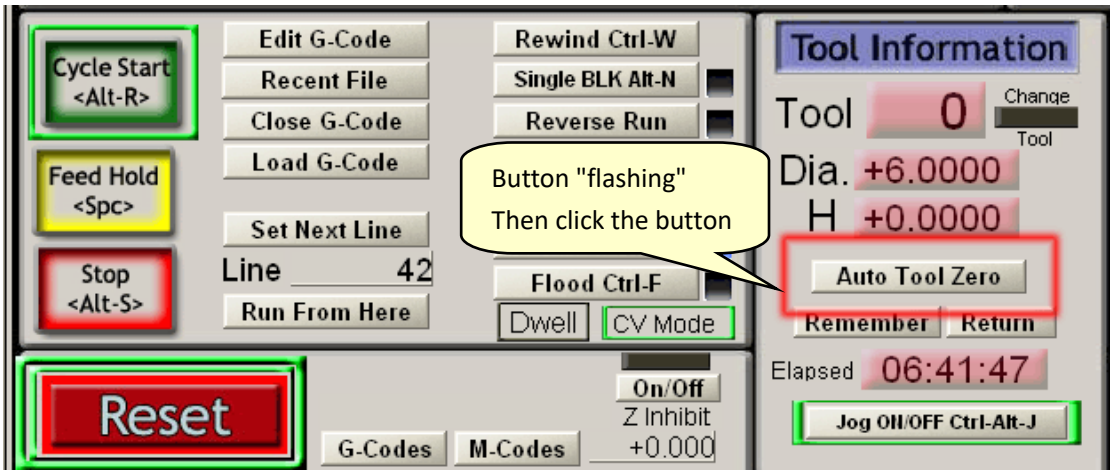
6.5.3 Mach3's "auto tool zero" button, loading VB code

Mach3 can customize the function of some existing buttons on the screen, such as the "Auto Tool Zero" button, set the VB script.

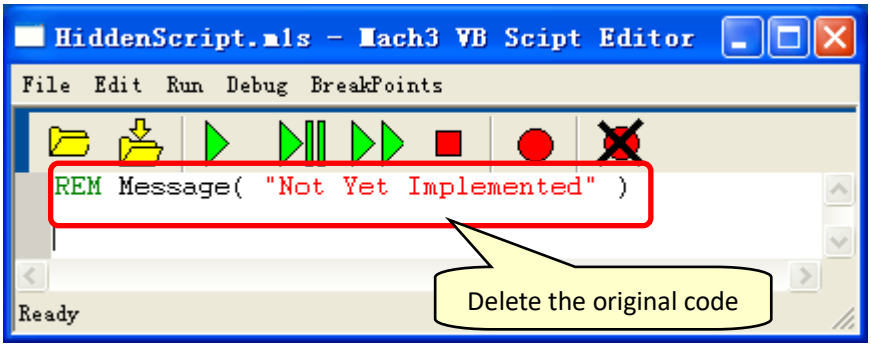
6.5.3.1 Mach3 menu (Operator => Edit Button Script)



6.5.3.2 Click the "**Auto Tool Zero**" button in the **flashing**

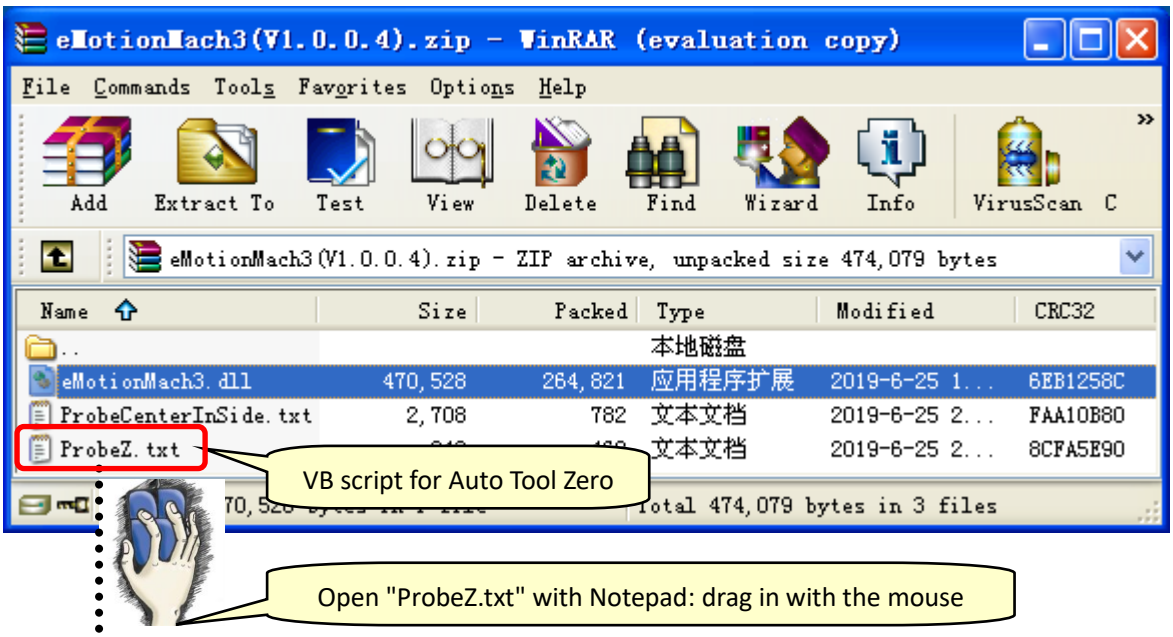


6.5.3.3 Pop up the VB editor and delete the code

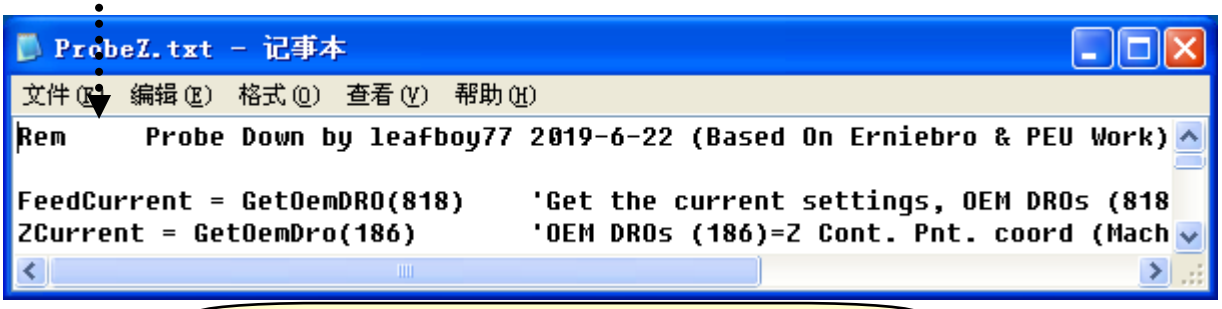


6.5.3.4 Enter the VB script in the VB editor

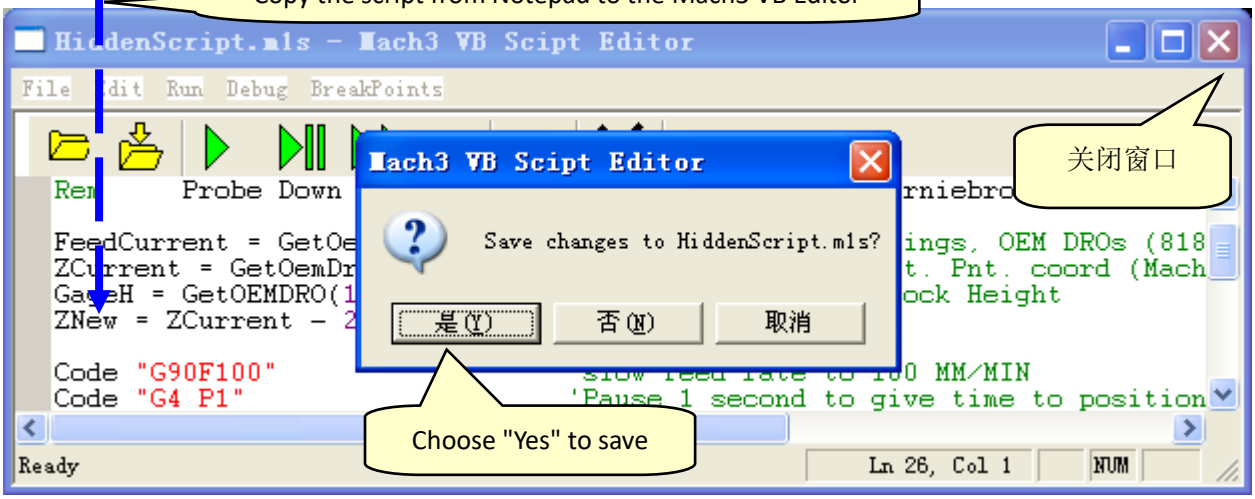
The VB "Auto Tool Zero" demonstration script "**ProbeZ.txt**" is provided in **eMotionMach3.zip** attached to the motion control card. Please open it with Notepad.



Open "ProbeZ.txt" with Notepad: drag in with the mouse



Copy the script from Notepad to the Mach3 VB Editor



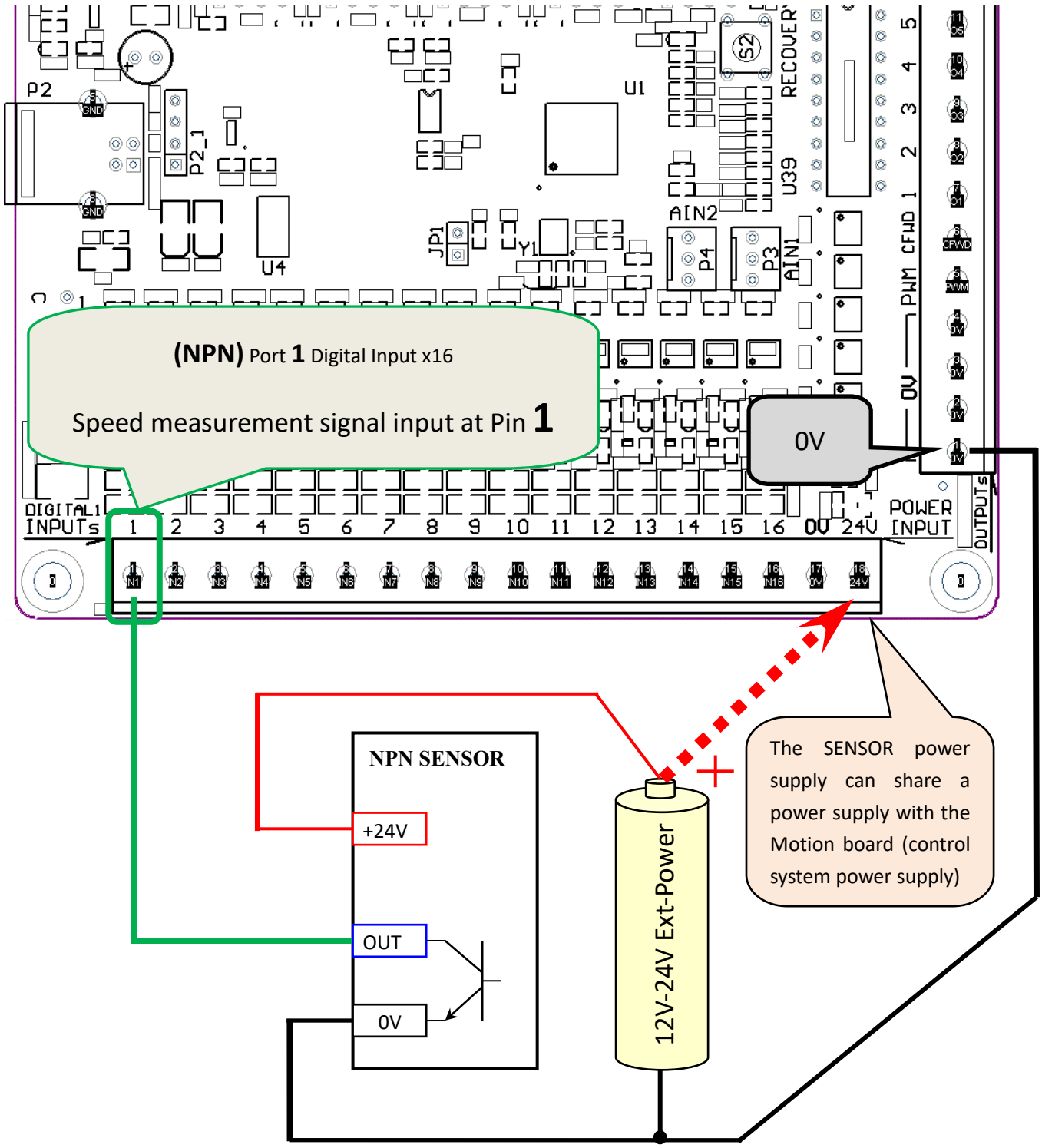
6.5.3.5. Test: Click the "**Auto Tool Zero**" button Auto Tool Zero to test the tool zero action.

The VB "Auto Tool Zero" demonstration script "ProbeZ.txt", can be changed according to actual needs.

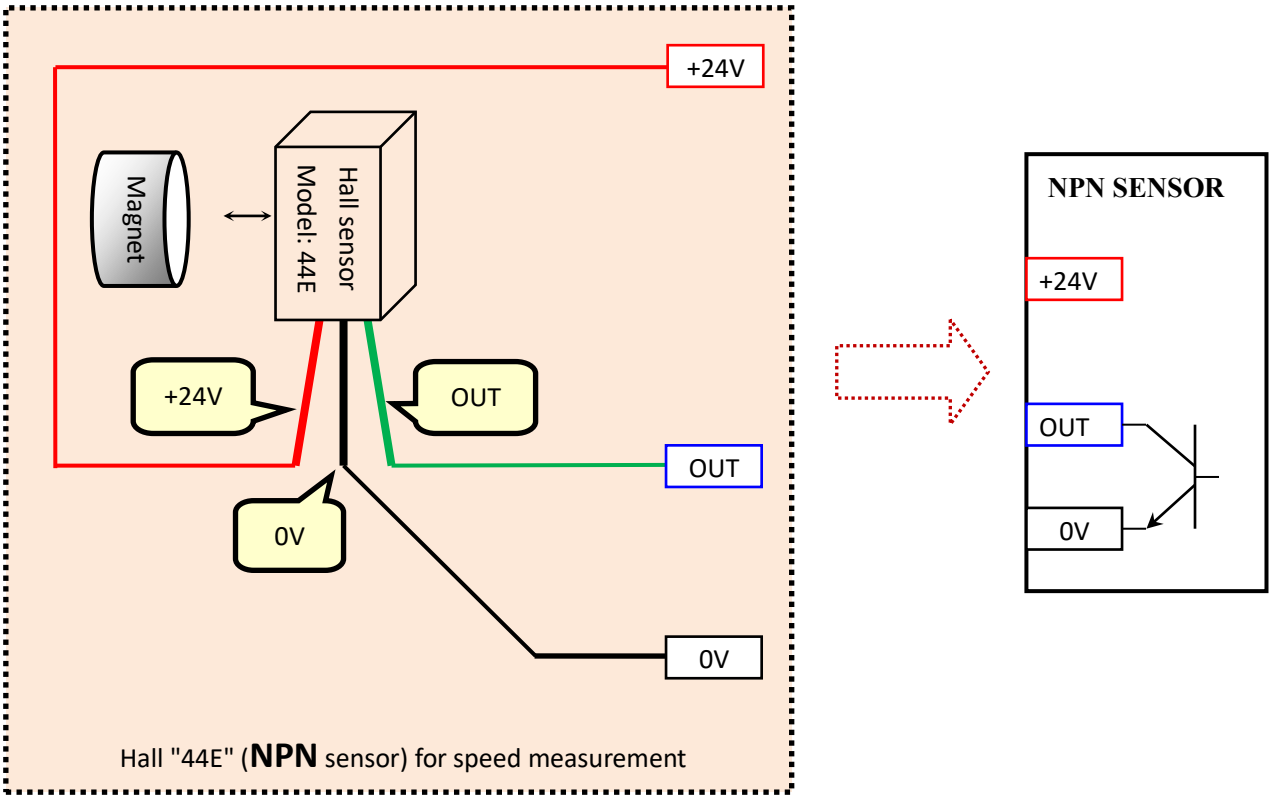
6.6 Wiring and configuration of spindle speed measurement signal input

6.6.1 Wiring: Speed measurement signal input fixed wiring at Pin **1** of digital input port **1**.

6.8.1.1 External power supply, wiring of **NPN** sensor speed signal:

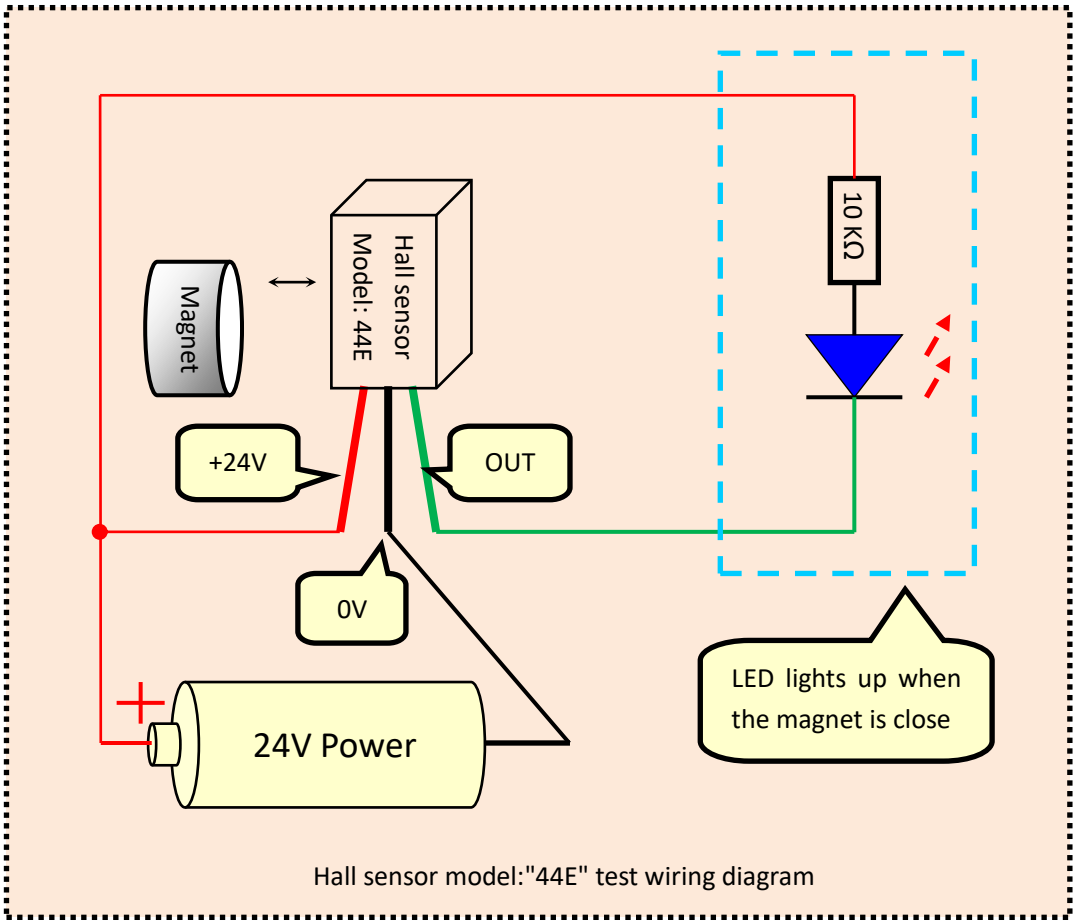


6.8.1.2 The equivalent circuit of the Hall device "44E" and the **NPN** sensor:



Hall "44E" (**NPN** sensor) for speed measurement

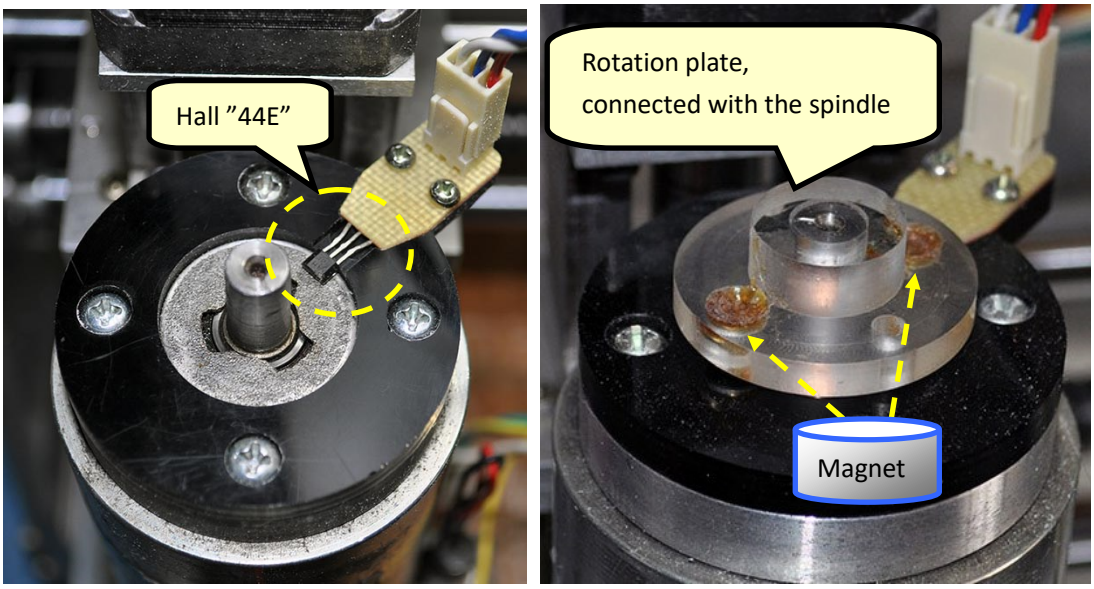
6.6.1.3 Example: Hall sensor model "44E" test wiring diagram



Hall sensor model:"44E" test wiring diagram

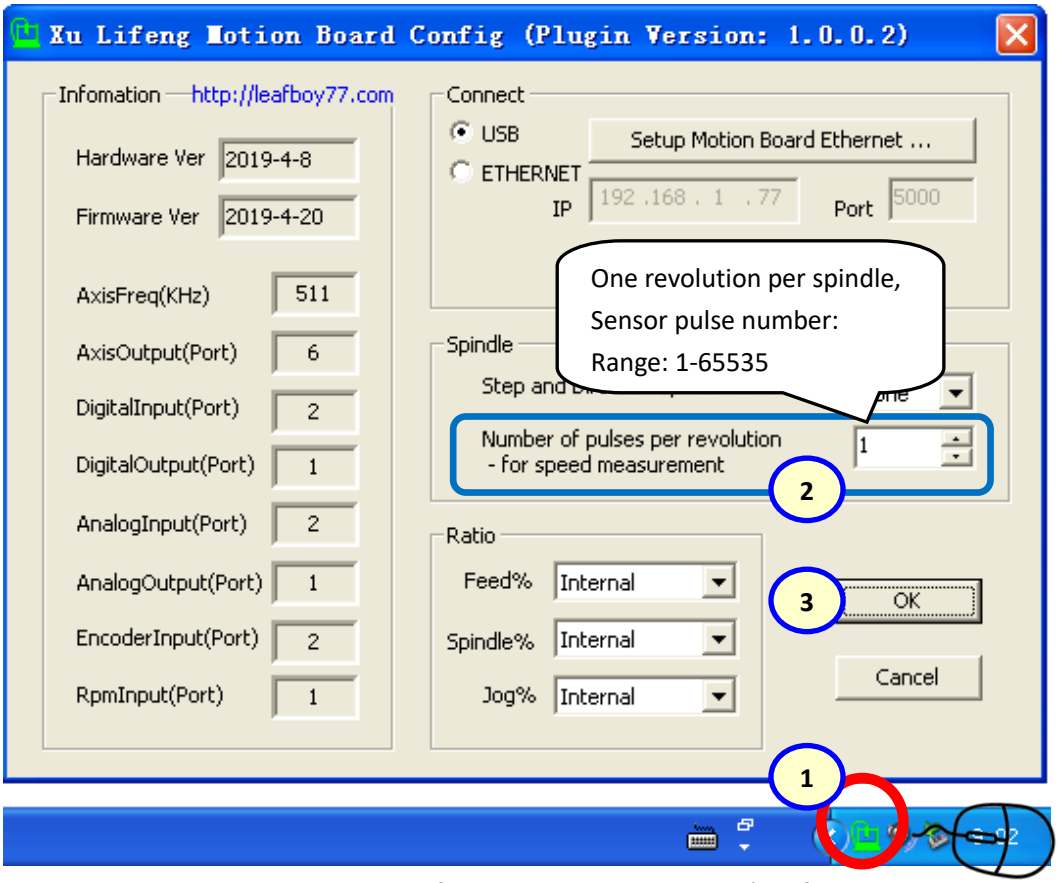
Hall sensor / Rotation plate installation diagram

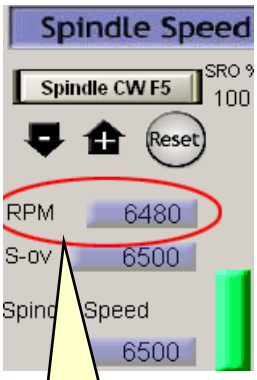
Note: The magnet has a SN pole and should be adjusted during installation.



6.6.2 Mach3 measurement speed configuration

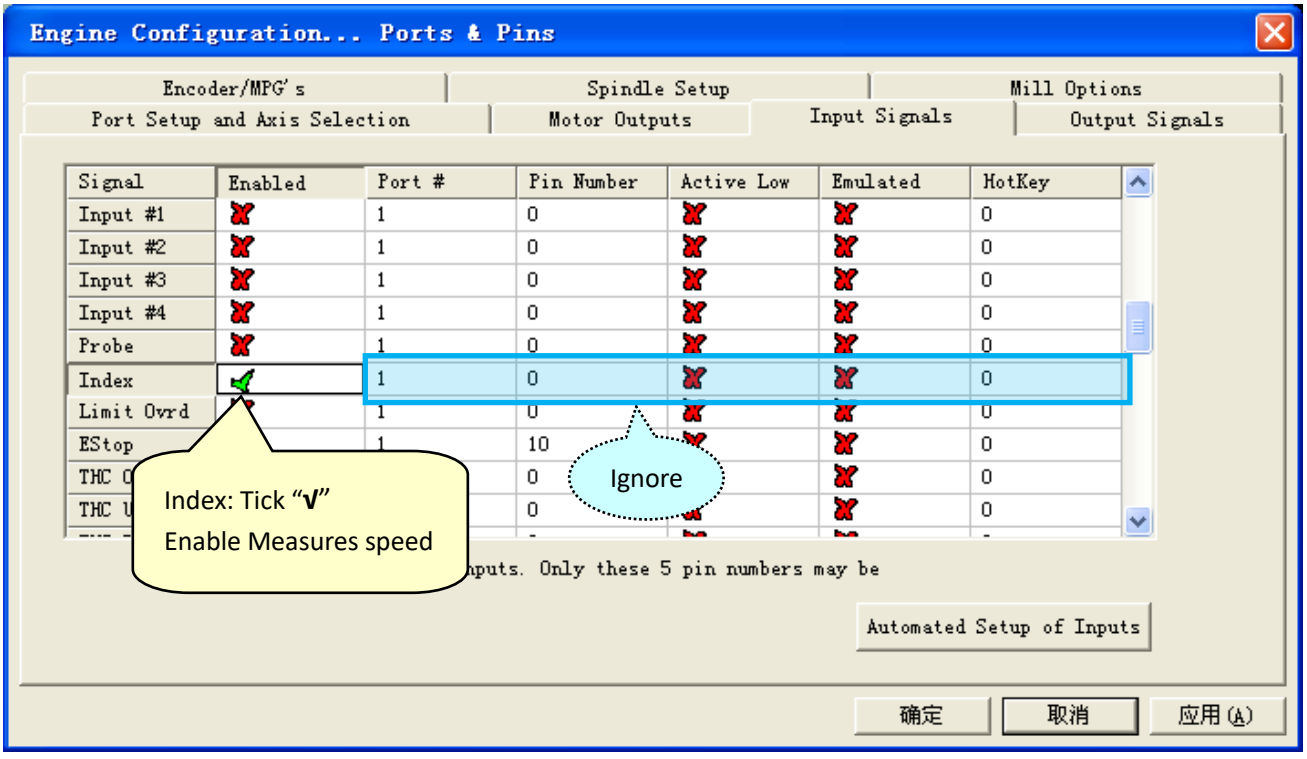
Start Mach3 and select the external motion board, right click on the CNC icon, type the "Number of Pulses" in the settings dialog box, press OK to save the settings.





RPM:
The measured speed will be displayed in Mach3

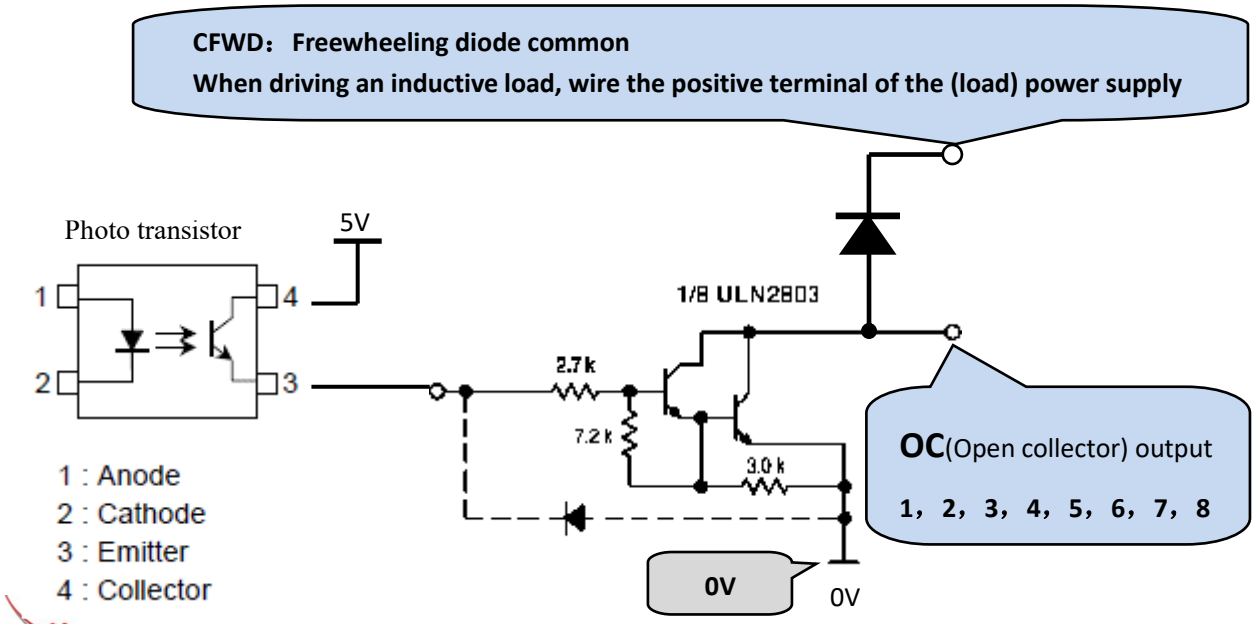
Mach3 measures the speed signal configuration as shown below: (Config => Ports and Pins=>Input Signals)



7. Digital output

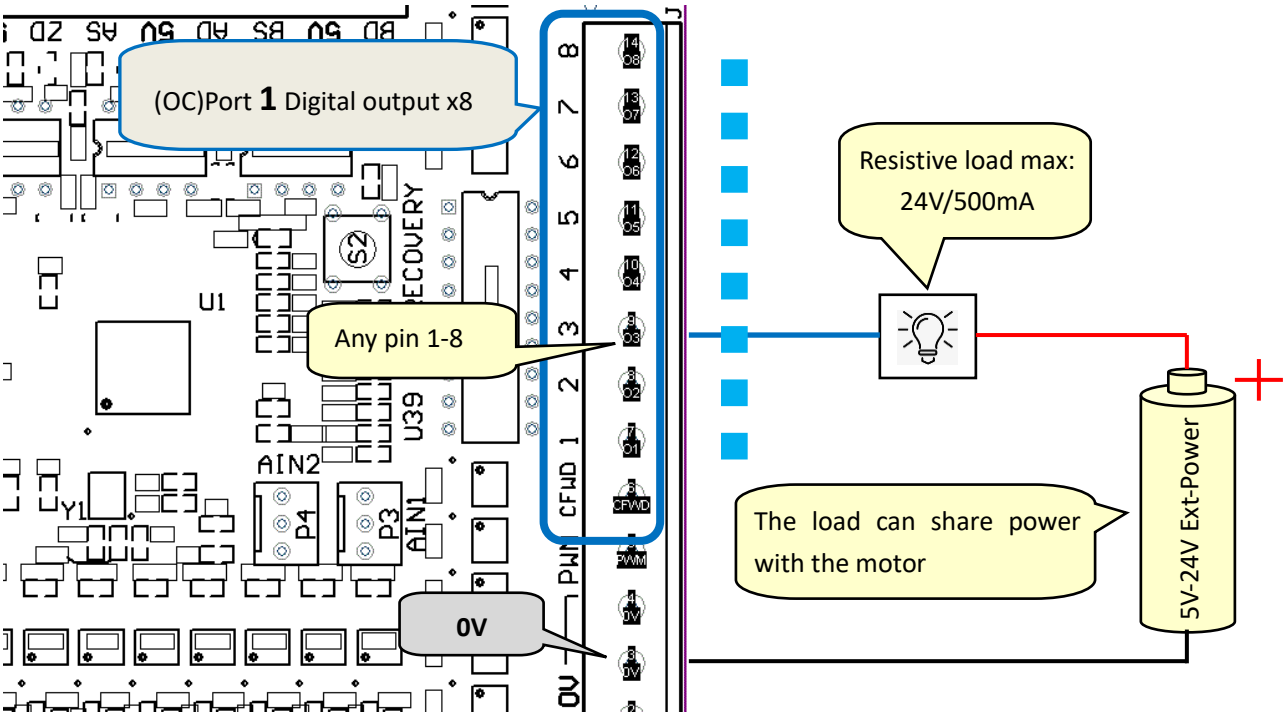
7.1 Interface characteristics of general digital output

Port **1** Digital Output: **OC**(Open collector) output x8, optocoupler isolation.

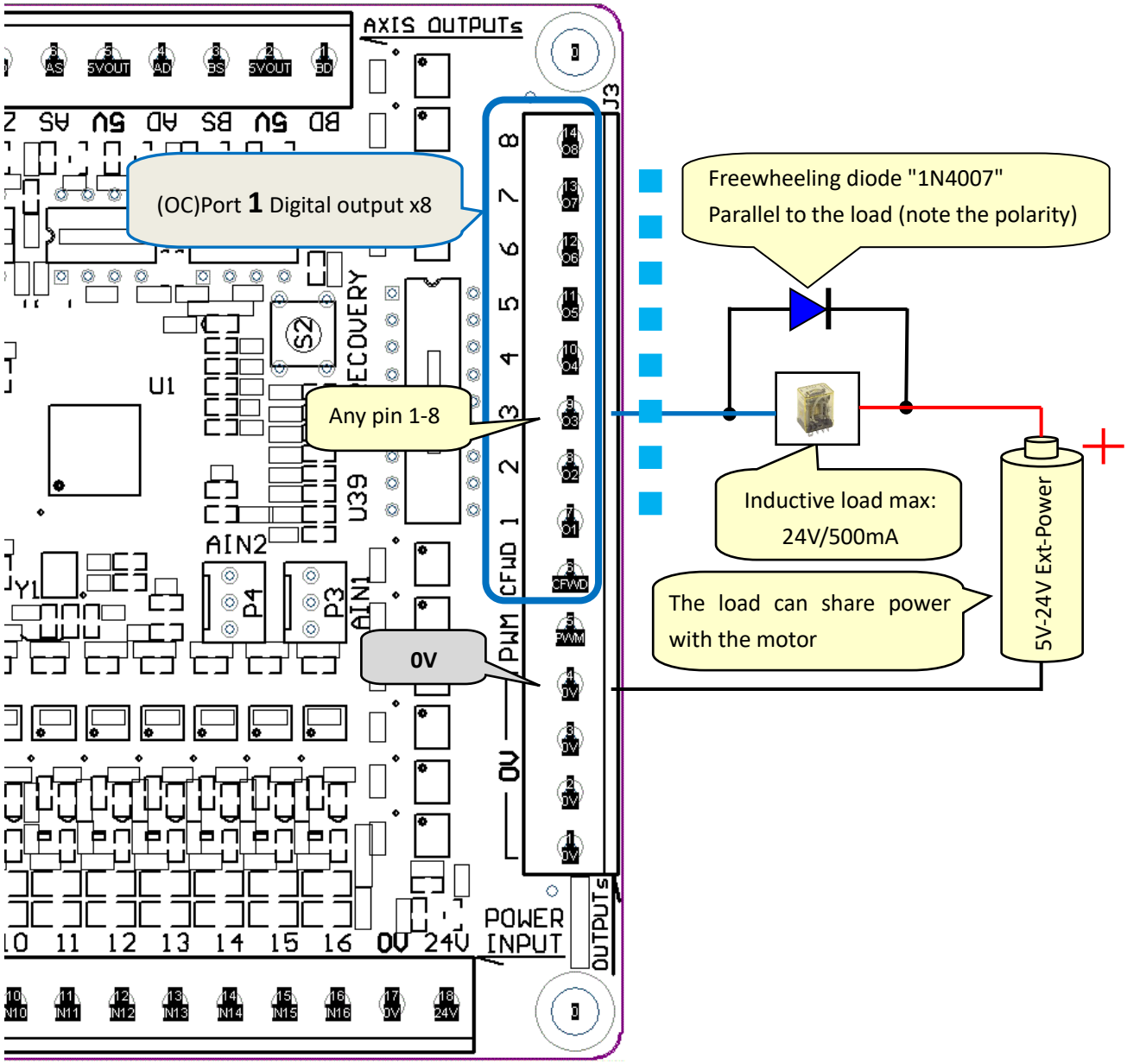


7.2 Wiring diagram

7.2.1 Driving **resistive load**

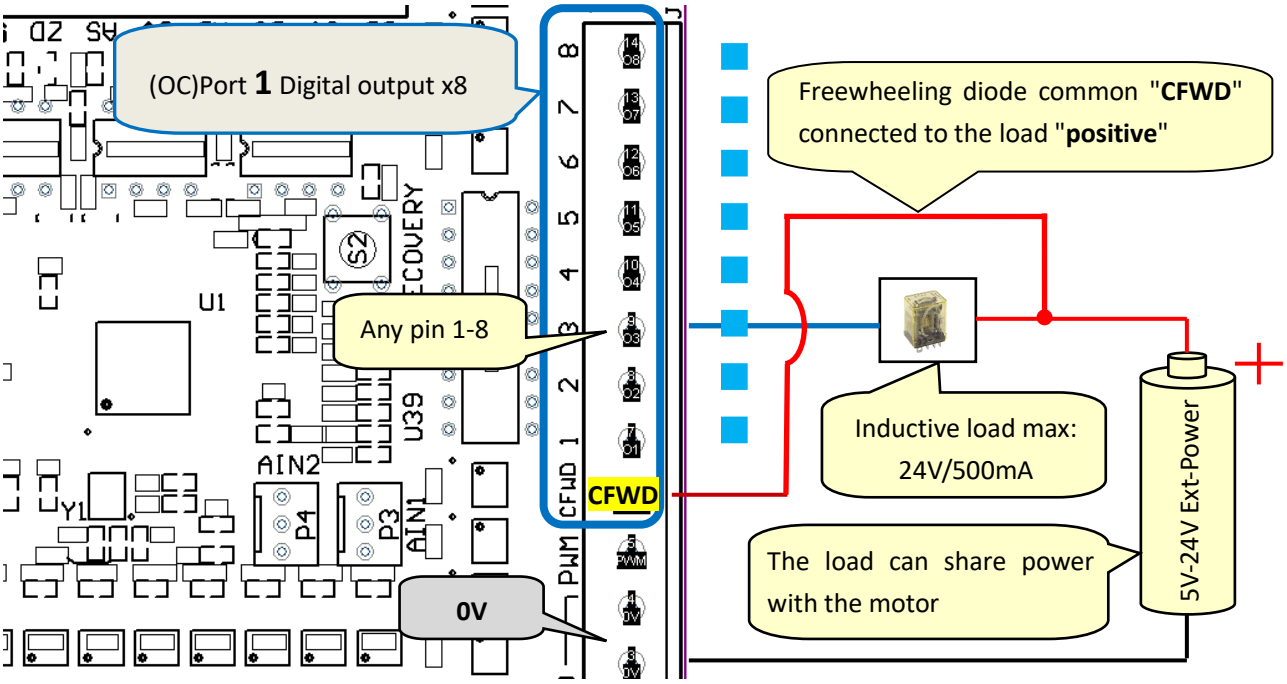


7.2.2 Driving **inductive loads** (such as relays, solenoid valves): installing **an external freewheeling diode**



7.2.3 Driving **inductive loads** (such as relays, solenoid valves): use the internal freewheeling diode common terminal "**CFWD**" on the motion board

With the "CFWD" terminal, all loads can only be connected to the same external power supply.
With the "CFWD" terminal, the "inverter" cannot be connected because there is an additional separate power supply inside the "inverter" interface.



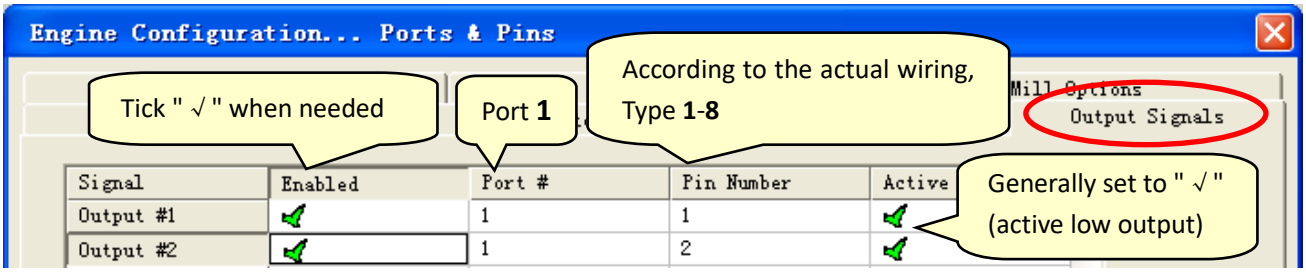
Note: There are 2 or more external power supplies for the loads. You cannot use "CFWD". An external freewheeling diode must be installed.
See: 7.2.2 Driving **inductive loads**: installing **an external freewheeling diode**

For example, the two output terminals of the Motion-board are connected to the inverter and the relay,

In this case, an external freewheeling diode must be installed for the relay (or inductive load).

Reasons for explanation: There is one independent power supply inside the inverter interface, and the relay also has one external power supply. There are two power supplies in total.
When the power is turned off, or when the power is suddenly turned off, the voltage drop speeds of the two power supplies are different, which may cause the inverter to trigger the operation by mistake, which may cause danger! (For example, changing a Tool). Install an external freewheeling diode (you **cannot use "CFWD"**) to avoid malfunction caused by the interaction of the two power supplies.

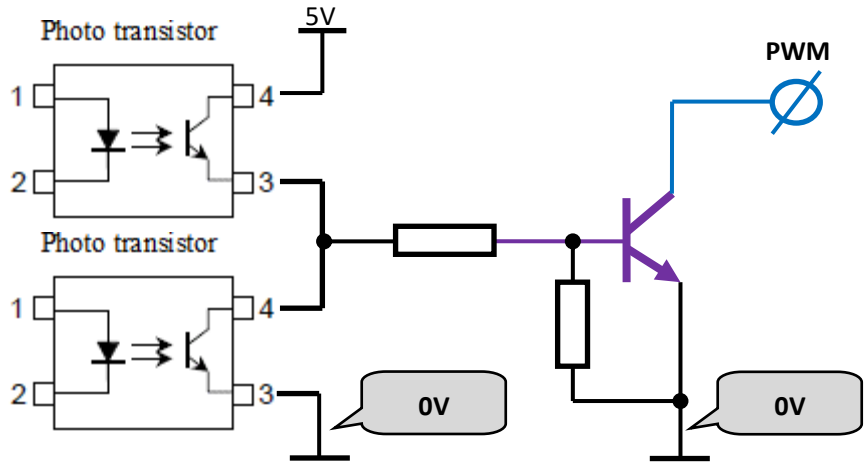
⚙7.3 Mach3 output signal configuration, as shown below: (Config => Ports and Pins => Output Signals)



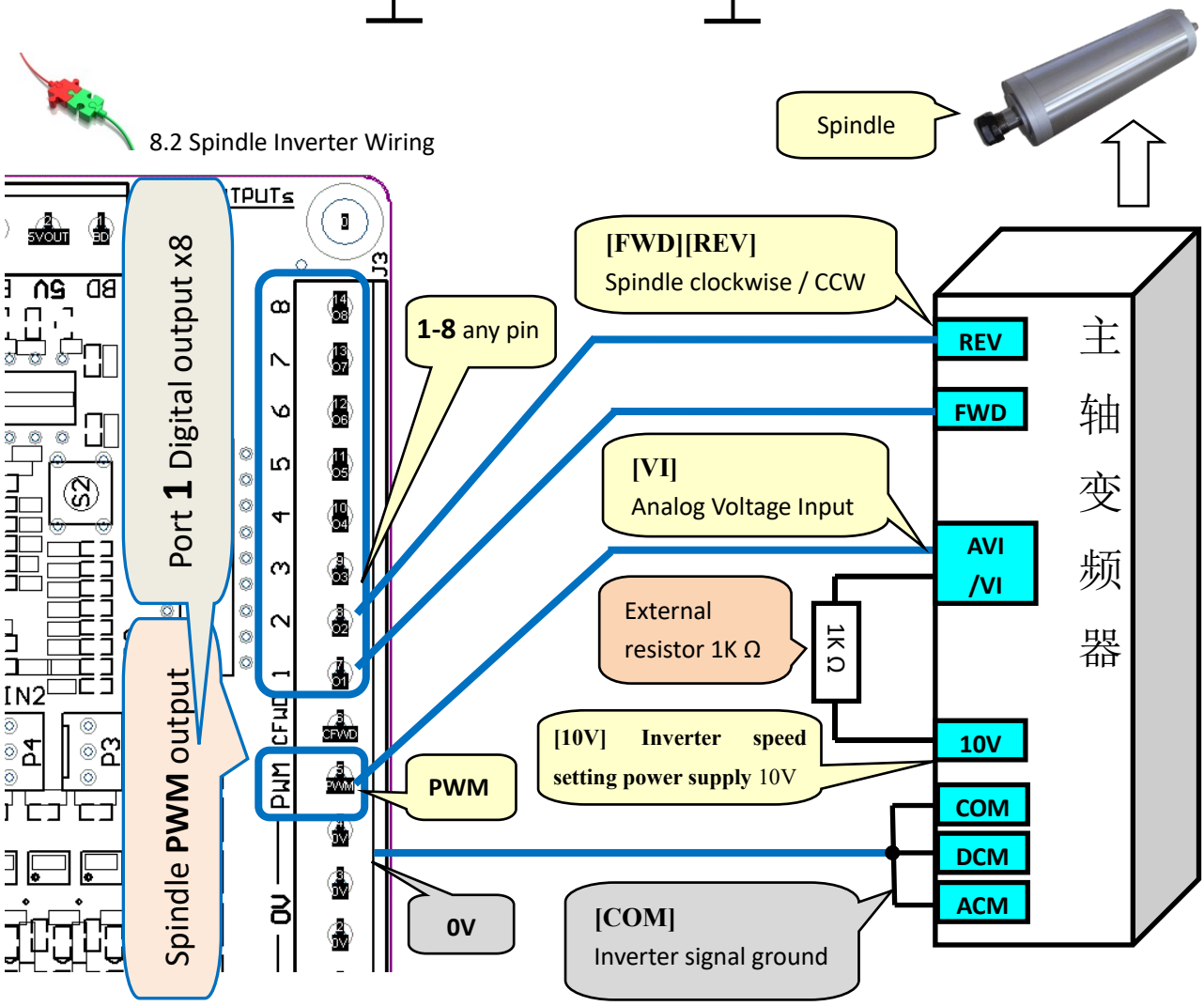
8. Spindle speed control analog output

8.1 Interface Characteristics of PWM Output

PWM Analog (Pulse Width Modulation) output: **OC**(Open collector) output x1, optocoupler isolation.



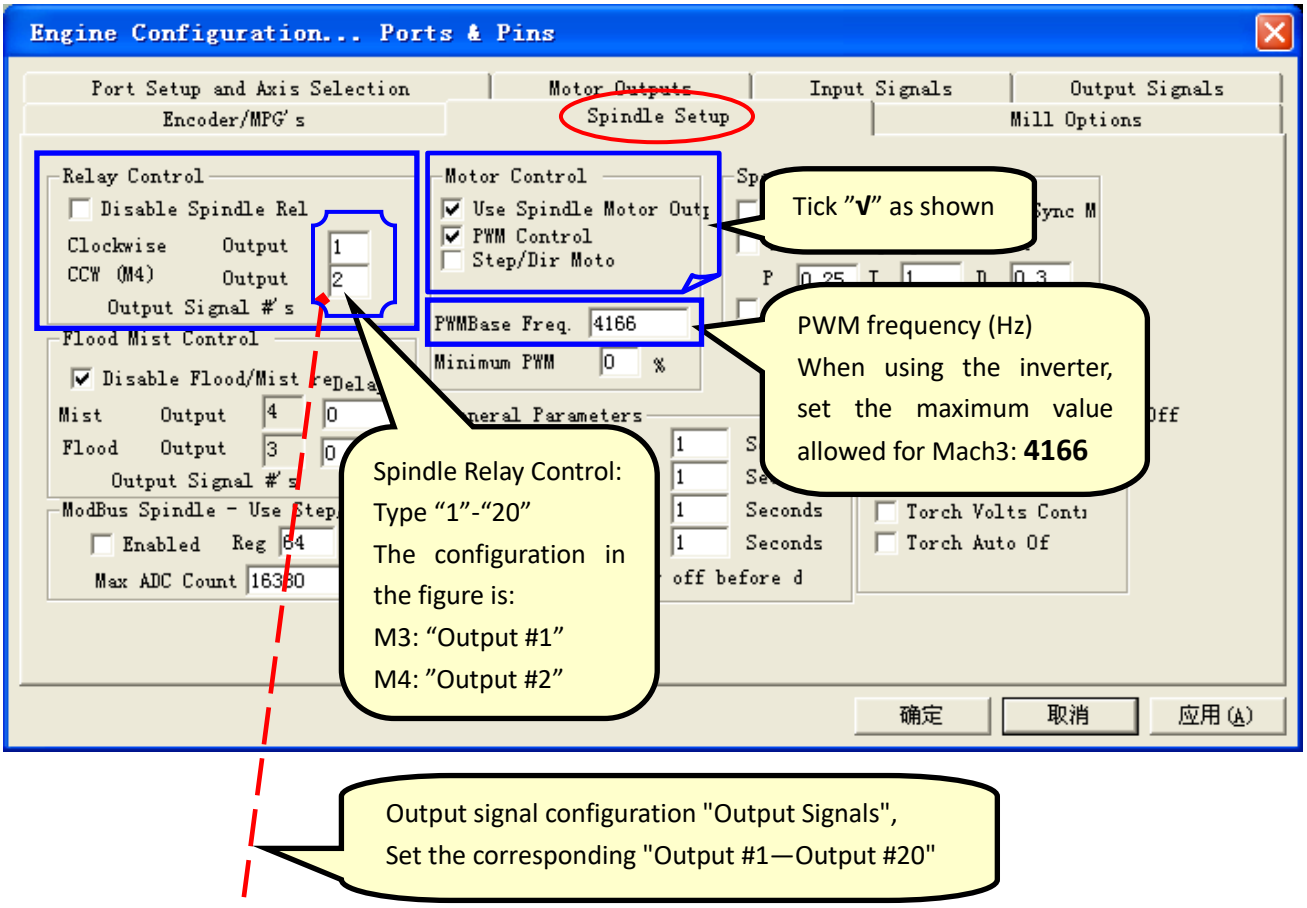
8.2 Spindle Inverter Wiring



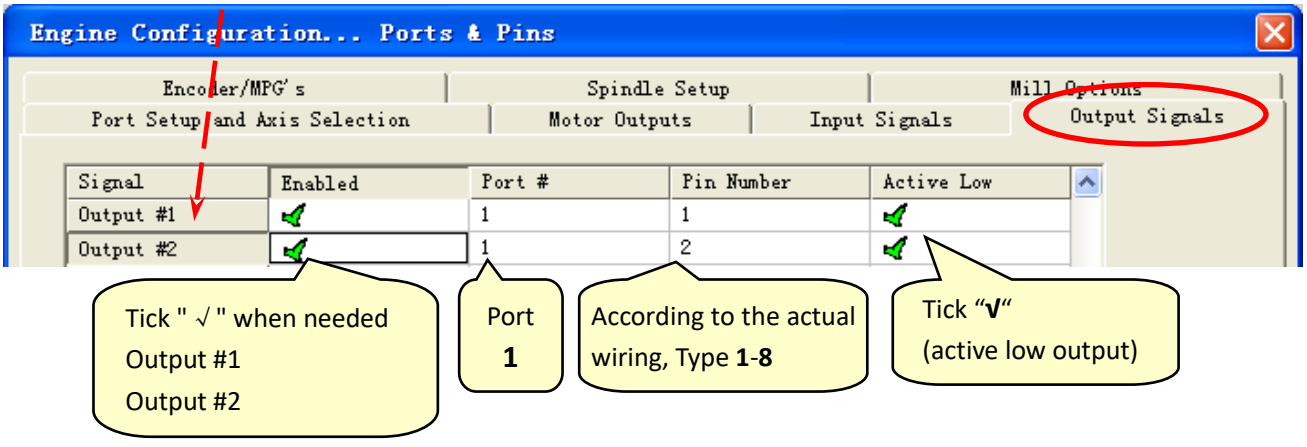
8.3 Configuration

8.3.1 Mach3's Spindle configuration, as shown below: (Config => Ports and Pins=> Spindle Setup)

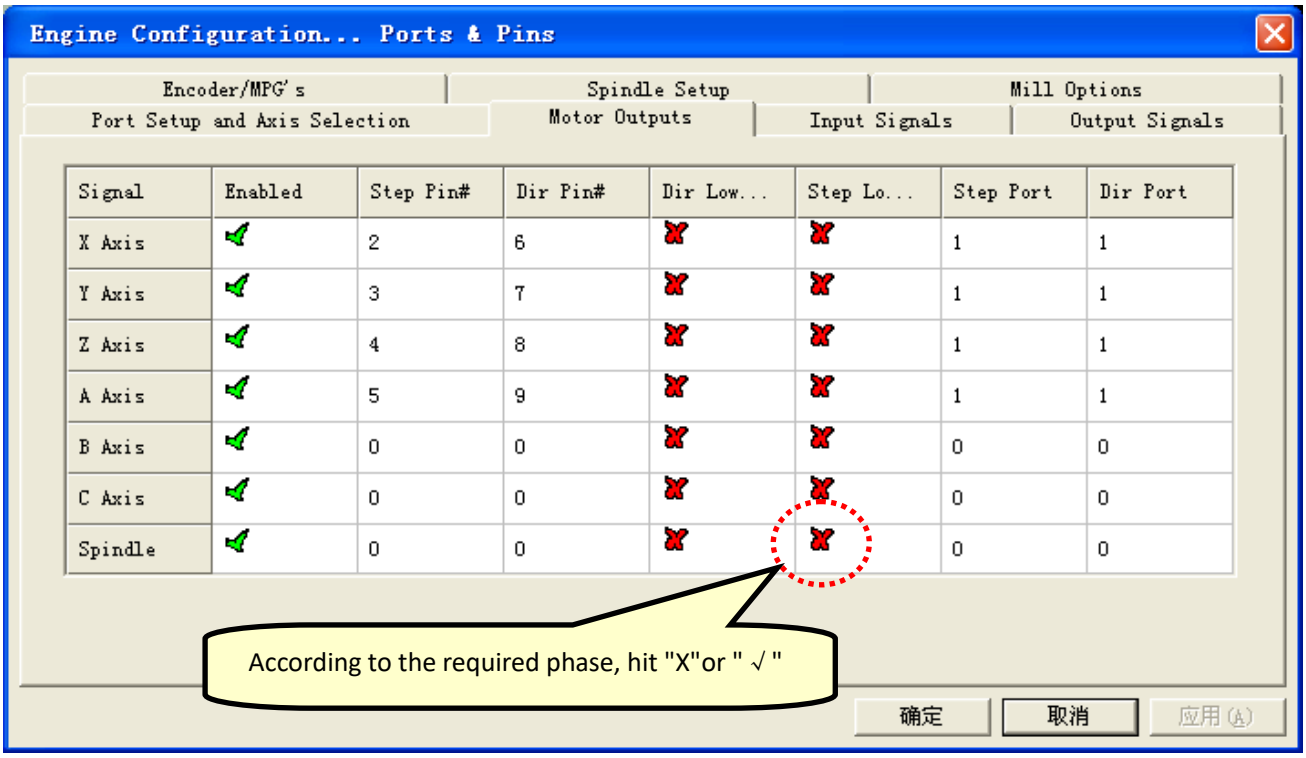
Tick “Use Spindle Motor Output” and ”PWM Control”, type the required frequency in "PWMBase Freq.", the unit is Hz.



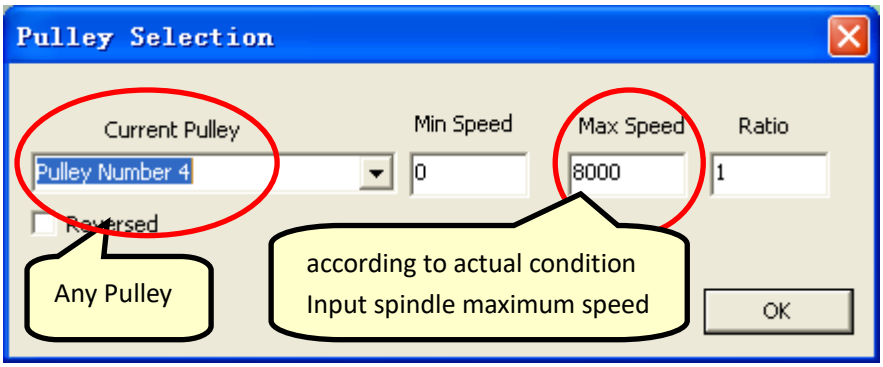
8.3.2 Spindle relay configuration, as shown below: (Config => Ports and Pins=>Output Signals)



8.3.3 The **phase configuration of the spindle speed control signal PWM** is shown in the figure below: (Config => Ports and Pins => Motor Outputs)



8.3.4 Mach3 menu ”Config => Spindle Pulleys..”, ”Pulley Selection”

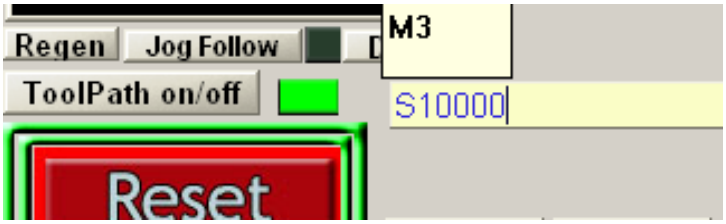


8.3.5 For other configurations of the spindle, please refer to “**Mach3Mill_Install_Config.pdf”**

8.3.6 Spindle test

In Diagnostics (Alt-7) or MDI(Alt-2):

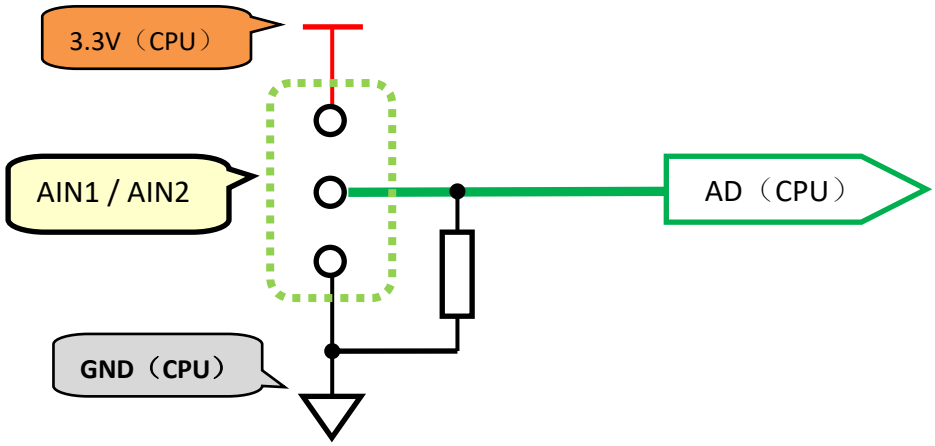
- Keyboard input “M3”.
- Keyboard input “S10000”, spindle starts to rotate. (When testing, it is recommended to use half of the maximum speed to avoid the phase setting error and the spindle does not rotate. After the spindle is running, adjust the speed. Adjust the spindle phase setting when the spindle speed is opposite to the set speed)
- Keyboard input “M5”, the spindle will stop rotating.



9. External Adjustment Knob

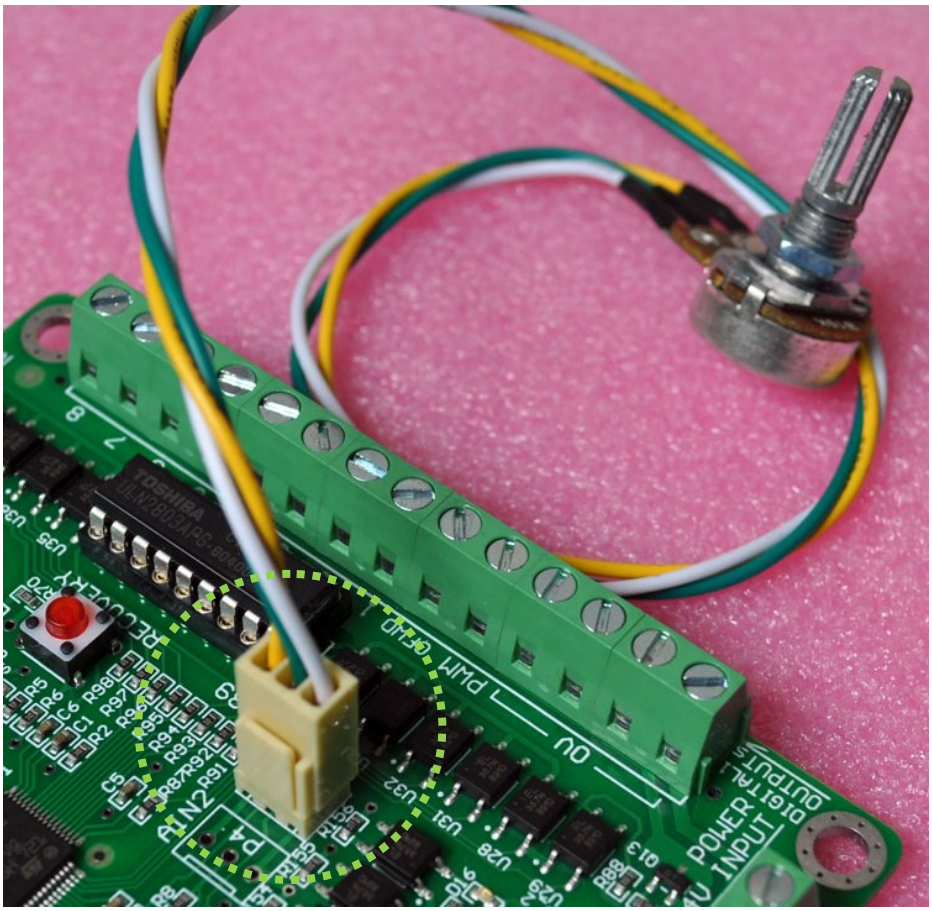
9.1 Interface characteristics of analog input

AIN1、AIN2 analog input port: 0 - 3.3V, **non-isolated**



9.2 Wiring diagram

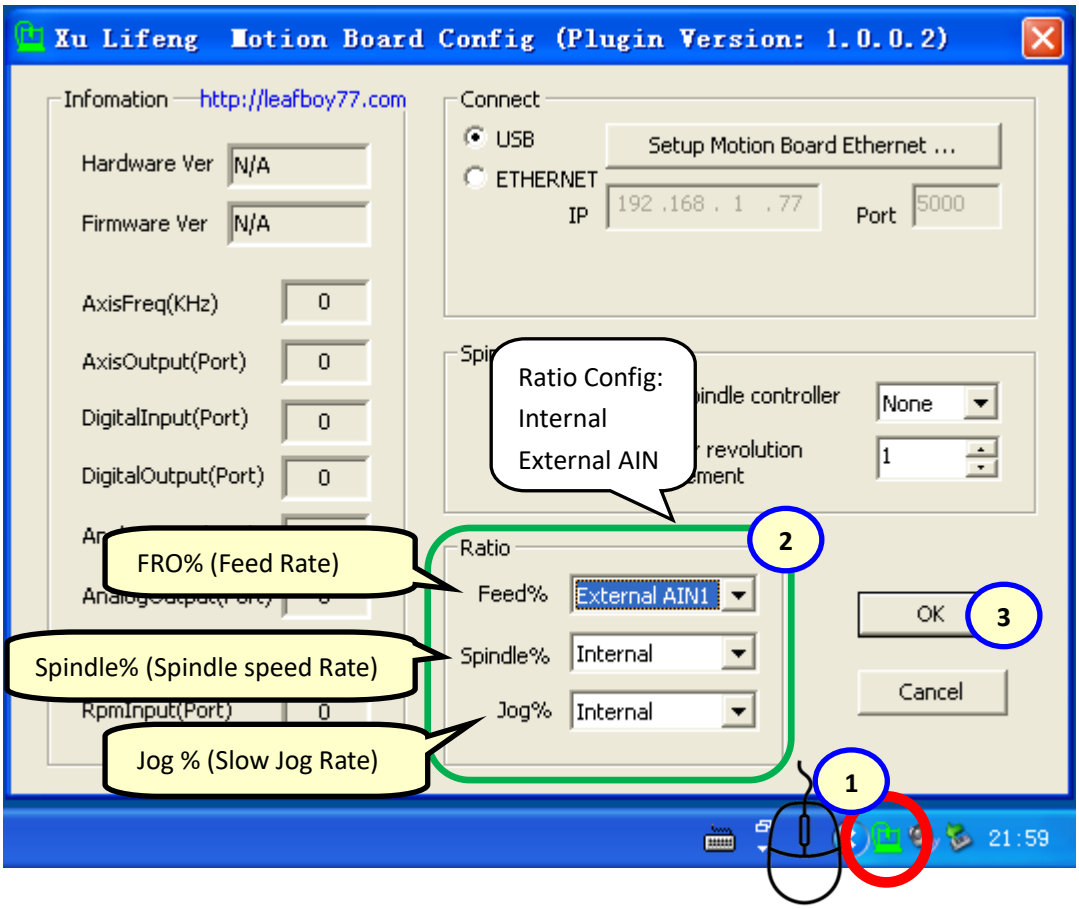
Connecting the adjustment-knob with the AIN1 of Motion board

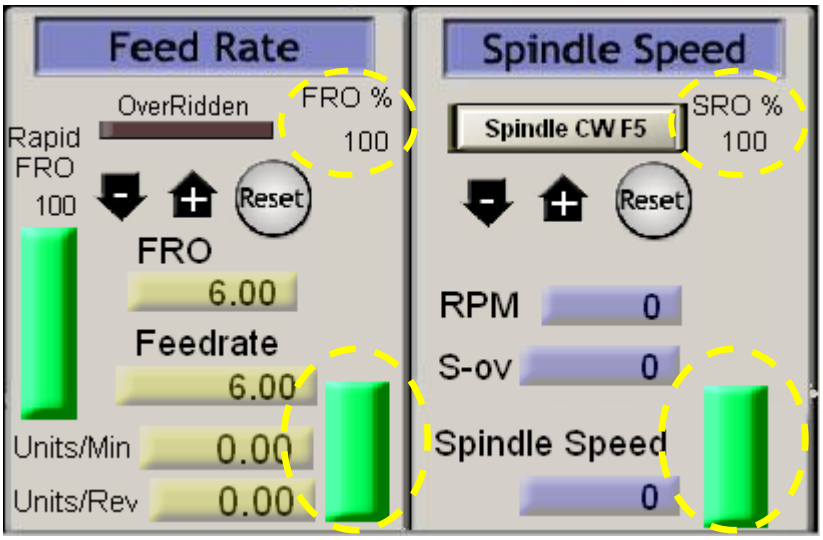
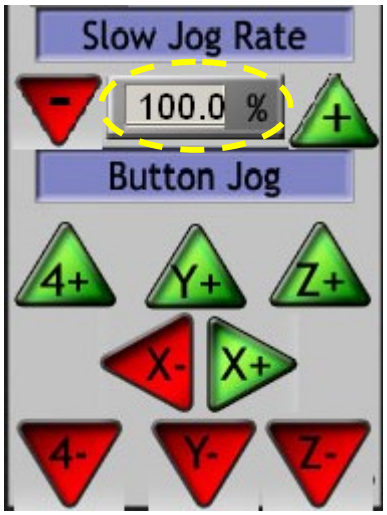


9.3 Configuration

Start Mach3 and select the external motion board. Right click on the CNC machine icon, setting dialog will be shown. You can select one of the functions which is able to controlled by the external knob.

Please select “External AIN1” in your particular setting.



Then, click “OK” to exit.

Now, you can try to turn the knob to adjust your selected function.