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RCNC
Brushless Motor Controller

Manual - Version 1.21

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⚠ **CAUTION**

READ ENTIRE MANUAL BEFORE USING THIS
DEVICE

BY USING THIS DEVICE YOU ACCEPT THE NOTICE
OF LIABILITY AND WARRANTY DISCLAIMER IN
THE LEGAL SECTION OF THIS DOCUMENT

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Introduction

Welcome and thank you for purchasing the RCNC Brushless Motor Controller from LOGICNC.COM. The RCNC allows brushless motors typically used for radio control vehicles to be used on CNC machine tools. Brushless motors make an ideal choice for driving the spindle of machine tools due to their small size, low maintenance, low noise and high performance. The RCNC provides a simple and economical method of controlling a brushless motor through Mach3 or EMC2.

Safety Information

⚠ **CAUTION**

THIS DEVICE SHALL ONLY BE USED ON A <u>FULLY ENCLOSED AND SAFETY INTERLOCKED</u> MACHINE TOOL.

⚠ CAUTION

THE RCNC DOES NOT PROVIDE EMERGENCY STOP CAPABILITY FOR THE SPINDLE – ADDITIONAL MEANS TO ALLOW EMERGENCY STOP IS REQUIRED AND IS THE RESPONSIBILITY OF THE USER OF THIS DEVICE

NEVER RELY ON SOFTWARE AS A METHOD OF EMERGENCY STOP!

⚠ CAUTION

THE RCNC DOES NOT USE AN ENABLE SIGNAL TO ARM THE SPINDLE – IF POWER IS BEING SUPPLIED TO THE MOTOR, IT COULD START AT ANY TIME! THIS INCLUDES WHEN THE PARALLEL PORT INITIALIZES DURING COMPUTER STARTUP OR MACH3 / EMC2 STARTUP!

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⚠ CAUTION

ALL OF THE PARALLEL PORT SIGNALS FROM THE COMPUTER PASS THROUGH THE RCNC TO THE CNC DRIVER BOARD – THIS INCLUDES THE PIN USED FOR SPINDLE PWM CONTROL. IF THIS WILL CAUSE UNDESIRED OPERATION OR CREATE A SAFETY HAZARD, IT IS THE RESPONSIBILITY OF THE USER TO RECTIFY THIS SITUATION.

Requirements

The minimum requirements to use the RCNC Brushless Motor Controller are as follows:

1. PC running either Mach3 or EMC2
2. A brushless Electronic Speed Control (ESC) with a Battery Eliminator Circuit (BEC) [1]
3. A brushless motor typically used for radio control vehicles
4. A suitable power supply for the chosen ESC/Motor combination

(1) The BEC on the Electronic Speed Control provides the power supply for the RCNC – it will <u>NOT</u> operate without it. The BEC must supply the standard 5V – supplying a voltage higher than 5.5V can permanently damage the RCNC. If the chosen ESC does not have an onboard BEC, an external BEC may be used.

Tips on selecting hardware:
1. There are two types of brushless motors used for radio control vehicles – Outrunner and Inrunner. The best choice for running a machine spindle is an Outrunner motor due to its higher torque and lower speed.
2. Due to the high speed and (relatively) low torque of brushless motors used in radio control, it may be necessary to "gear down" the motor when connecting it to the spindle in order to decrease the speed and increase torque. This is typically accomplished using a belt drive with a small pulley on the motor and a larger one on the spindle drive. An example of such a configuration is shown below in Fig. 1.
3. When selecting an ESC, it is beneficial to step up to a larger controller than is minimally necessary for the chosen motor (i.e. purchase a 30A controller for a motor which has a maximum current of 20A). This will allow the ESC to run cooler and help prolong its life. ESCs with built in heat sinks are also preferable since they provide their own passive cooling.
4. Depending on the motor/esc and the type of machining performed, a cooling fan may be required to keep the esc and/or motor at a suitable temperature. Following tip 3 above should ensure that a cooling fan is not required for the ESC.
5. Talk to your local hobby shop! They can help you select a quality brushless motor and ESC combination.

Specifications

Connectors: DB25 female –> DB25 male parallel port connectors

Note: DB25 gender changers may be used if your hardware requires a male-male or female-female connection

Futaba compatible female connector for connection to ESC

ESC output pulse: Standard servo pulse of 1.0 - 2.0 ms at a frequency of 20ms

RoHS compliance: The RCNC is lead-free and RoHS compliant

RCNC Hardware Configuration

To configure the RCNC for use with Mach3 or EMC2 please follow these instructions:

1. Open the RCNC enclosure
2. Locate the DIP switch on the circuit board (pictured in Figure 1)
   Select the appropriate parallel port pin which will be used to control the spindle by moving the corresponding switch number to the "On" (Up) position. The DIP switch position number and the corresponding parallel port pin is shown in Table 1 and Figure 1. All other switch positions must be in the "Off" (Down) position. **Operating the RCNC with more than one switch position in the "On" position may cause undesired/uncommanded spindle control and may permanently damage the RCNC and any connected hardware.**
3. Press the two halves of the RCNC enclosure back together.
4. Ensure PC is powered down.
5. Ensure CNC driver board is powered down.
6. Remove the parallel port cable from your existing CNC driver board and plug it into one end of the RCNC.
7. Plug the other end of the RCNC into your existing CNC driver board.
8. Connect your Electronic Speed Control (ESC) to the 3 pin connector on the RCNC, paying close attention that the pinout of your male ESC connector matches that of the RCNC connector. See Figure 2 for the RCNC connector pinout. Depending on the brand of ESC purchased, the connector wires may be different colors from that used on the RCNC – typical pinouts are shown in Figure 3. **Connecting the + and – wires in reverse will destroy the RCNC!**

Dip switch No.	1	2	3	4	5	6	7	8	9	10	11	12
Parallel port pin	1	14	2	3	16	4	17	5	6	7	8	9

Table 1 – DIP switch numbers and corresponding parallel port pins
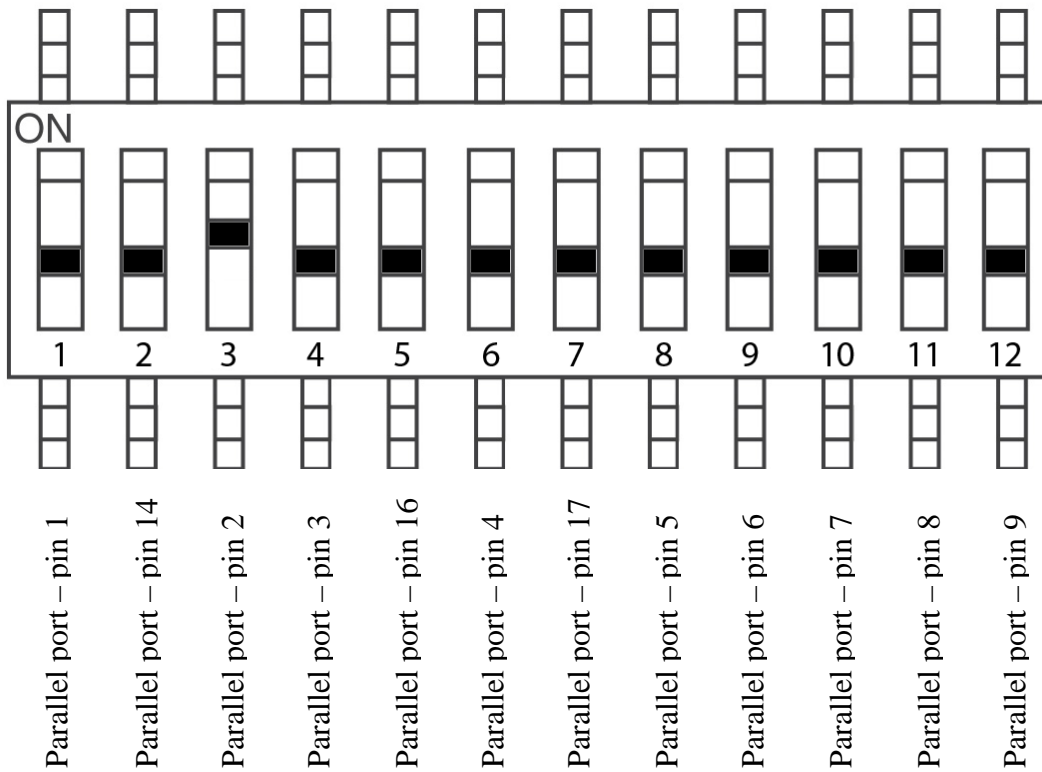

Figure 1 – DIP switch number and corresponding parallel port pin for spindle control

Note: Figure 1 shows the proper configuration for setting up the RCNC to use parallel port pin 2 for spindle control (DIP switch position 3 is in the "On" (Up) position and all others are in the "Off" (Down) position)
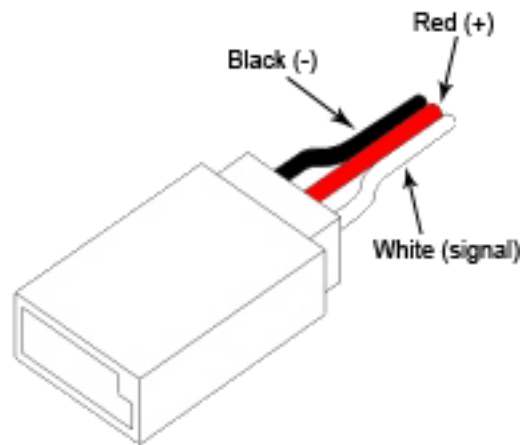
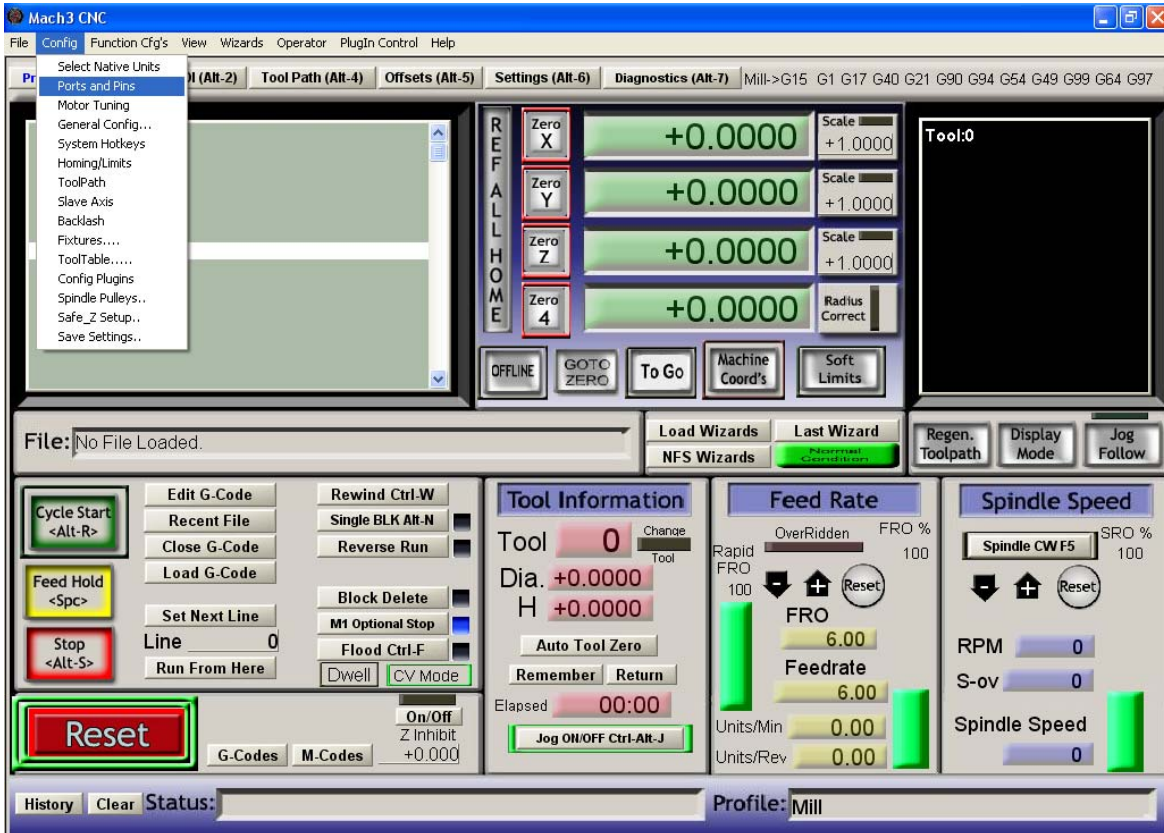**Figure 2 – RCNC connector pinout**
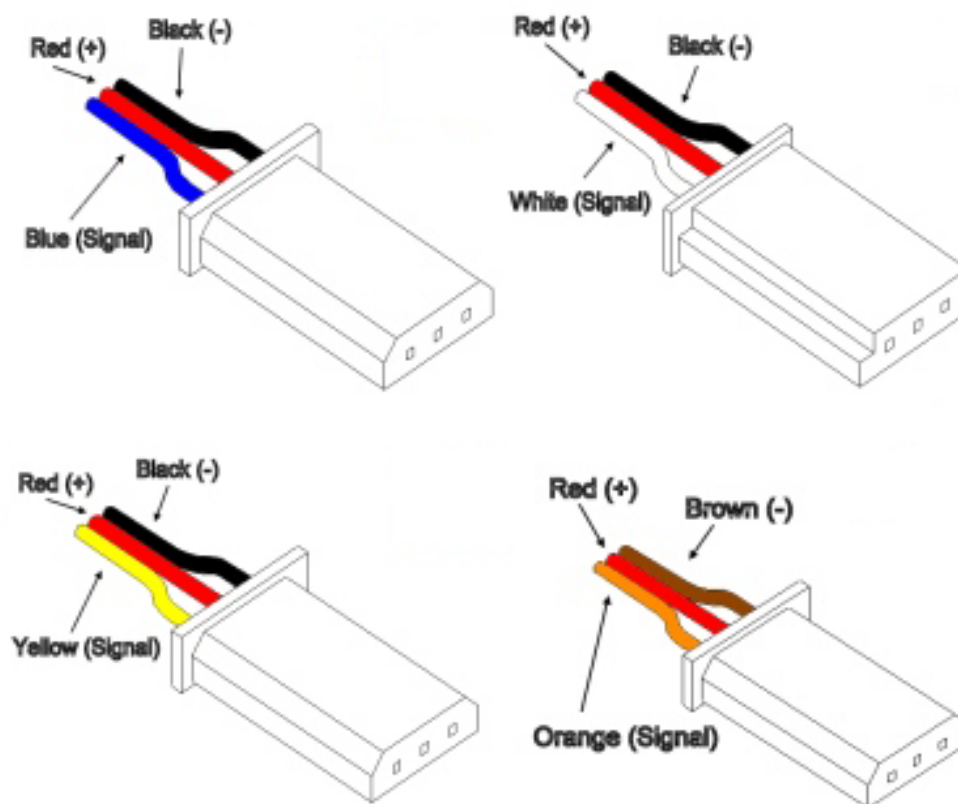
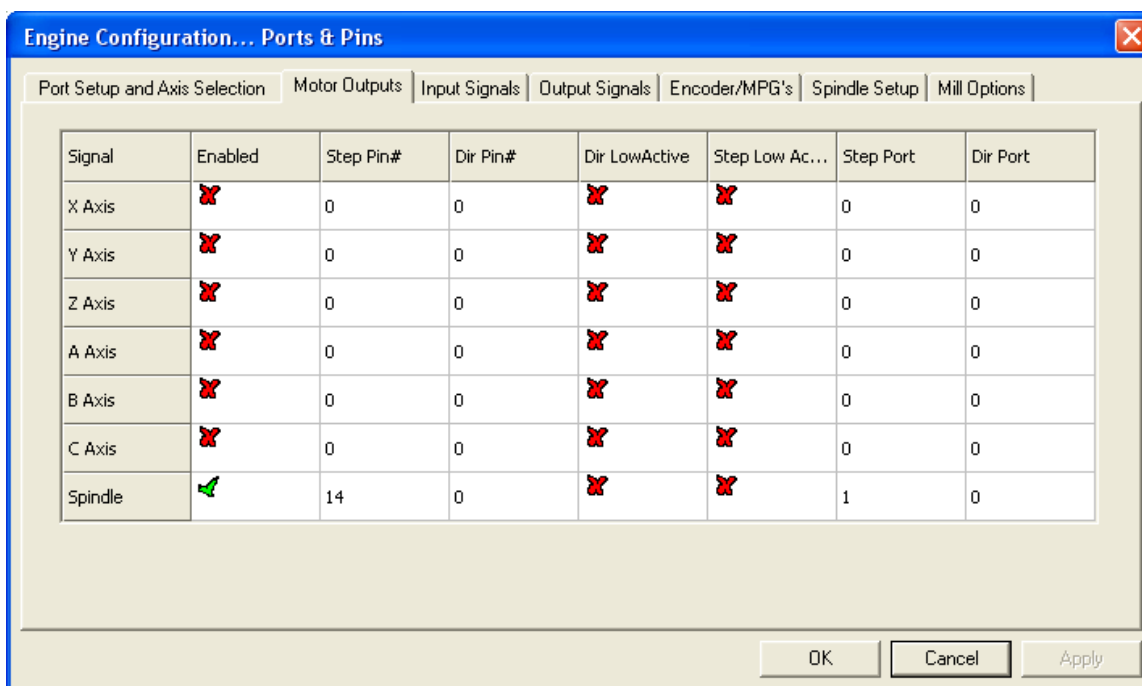**Figure 3 – Typical connector pinouts found on Electronic Speed Controls**

Configuring the RCNC with Mach3

1. Select Config -> Ports and Pins

2. Select the Motor Outputs tab
   a) In the spindle row enter the pin number to be used to control the spindle into the "Step Pin#" column
   b) In the "Step Port" column enter the parallel port number (typically 1 – if you only have one parallel port)

Engine Configuration… Ports & Pins

Port Setup and Axis Selection | Motor Outputs | Input Signals | Output Signals | Encoder/MPG's | Spindle Setup | Mill Options

Signal	Enabled	Step Pin#	Dir Pin#	Dir LowActive	Step Low Ac...	Step Port	Dir Port
X Axis	✗	0	0	✗	✗	0	0
Y Axis	✗	0	0	✗	✗	0	0
Z Axis	✗	0	0	✗	✗	0	0
A Axis	✗	0	0	✗	✗	0	0
B Axis	✗	0	0	✗	✗	0	0
C Axis	✗	0	0	✗	✗	0	0
Spindle	✓	14	0	✗	✗	1	0

OK | Cancel | Apply

3. Select the "Spindle Setup" tab
    a) In the "Motor Control" group check the Use Spindle Motor Output checkbox
    b) In the "Motor Control" group check the PWM control checkbox
    c) In the "Motor Control" group enter 10 into the "PWMBase Freq" textbox
    d) In the "Motor Control" group enter 0 into the "Minimum PWM" textbox
    e) If you are not using a spindle feedback sensor (which you most likely aren't), ensure that all of the checkboxes in the "Special Functions" group are left unchecked.
    f) Click "Apply"
   g) Click "OK"
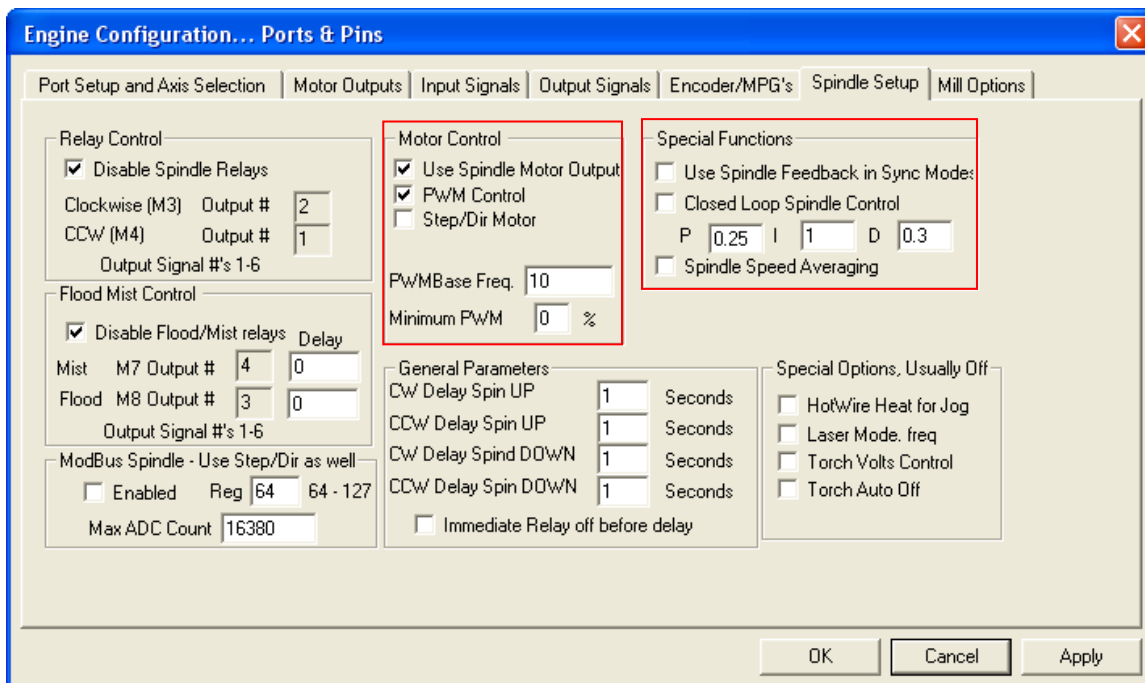
4. Select Config -> Spindle Pulleys
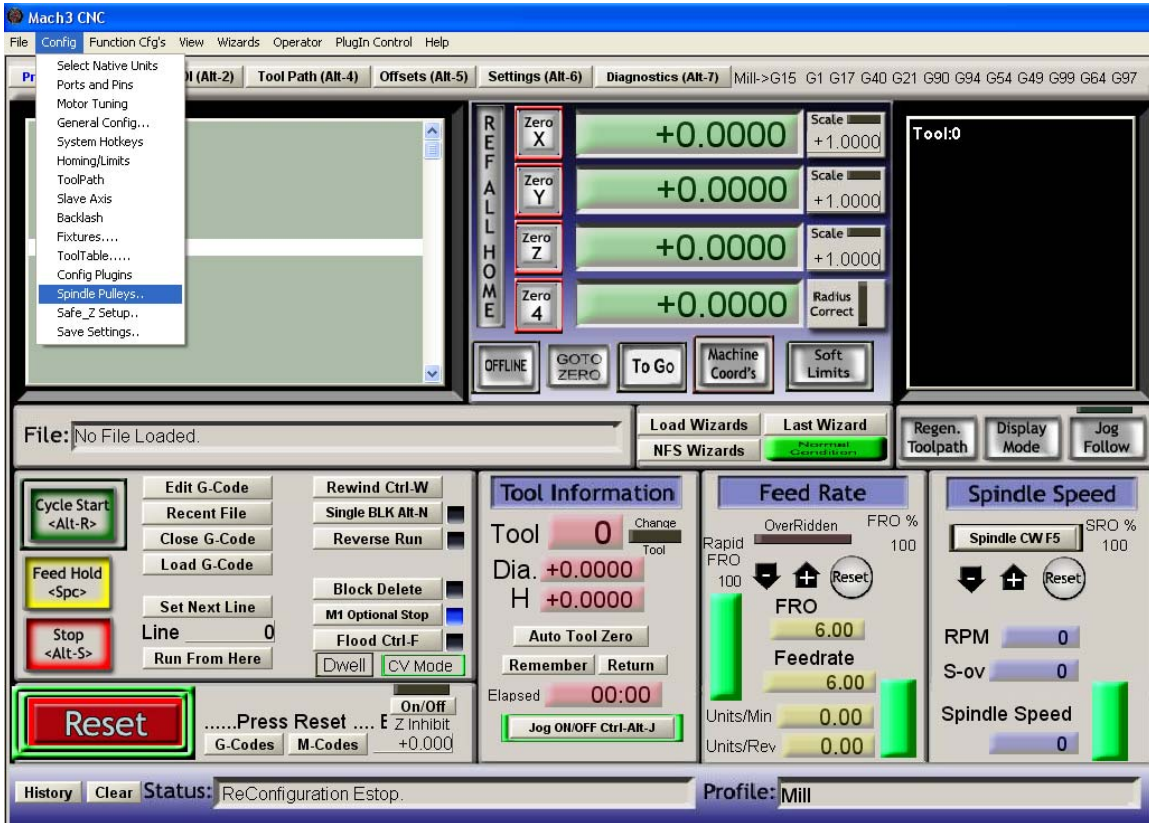
5. In the "Pulley Selection" box :
   a) select the appropriate pulley number
   b) enter 0 for the "Min Speed", 10000 for "Max Speed" and 1 for "Ratio".
   (These values will be changed after the final configuration)
   c) Click "OK"
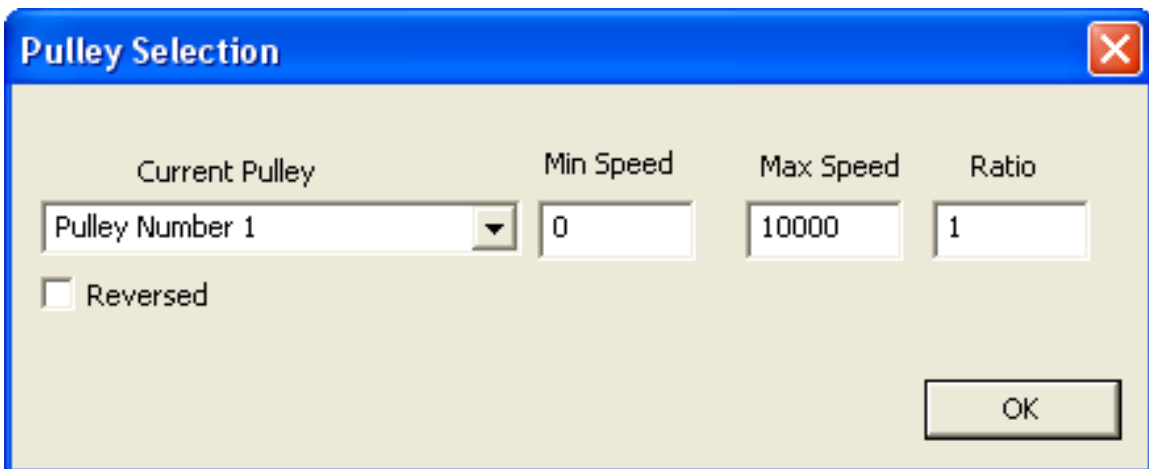
6. In the "Program Run" tab of Mach3:
    a) Ensure that the Mach3 Reset button is not active and your emergency stop is not active
    b) Press the "Spindle CW F5" button
    c) Enter 1000 into the "Spindle Speed" box and press Enter.
    d) If the spindle starts, record this rpm for later use
    e) If the spindle does not start repeat step c) except increment the spindle speed by 100 each time (i.e. 1100, 1200) until the spindle starts turning. Record the speed at which the spindle starts turning for later use.
    f) Using a tachometer, measure the actual minimum speed of the spindle using the spindle speed setting found above; then change the spindle rpm setting to 10000 and measure the actual maximum speed. Record these two values for later use.
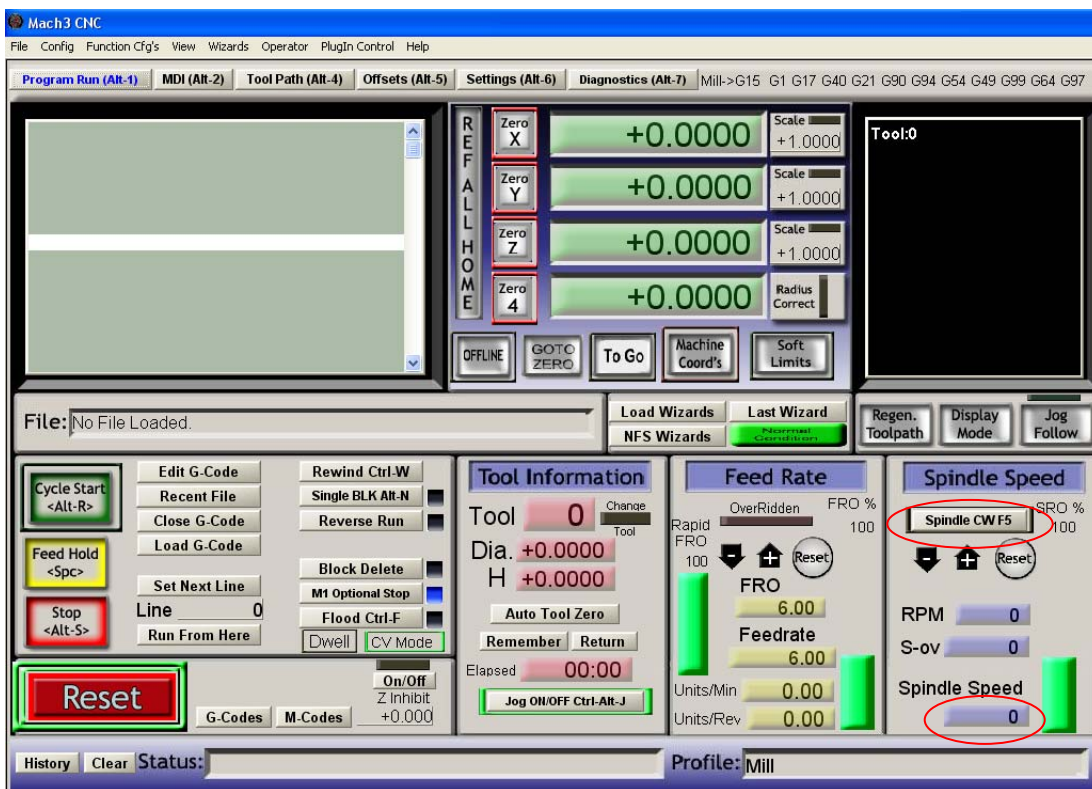
7. Take the spindle speed setting recorded in step 6 and multiply it by .01
(i.e. spindle begins rotating at 3000 rpm setting -> 3000 x .01 = 30)

    a) Enter this value into the "Minimum PWM" textbox within the "Spindle Setup" tab of Config -> Ports and Pins.

    b) Click "Apply"

    c) Click "OK"
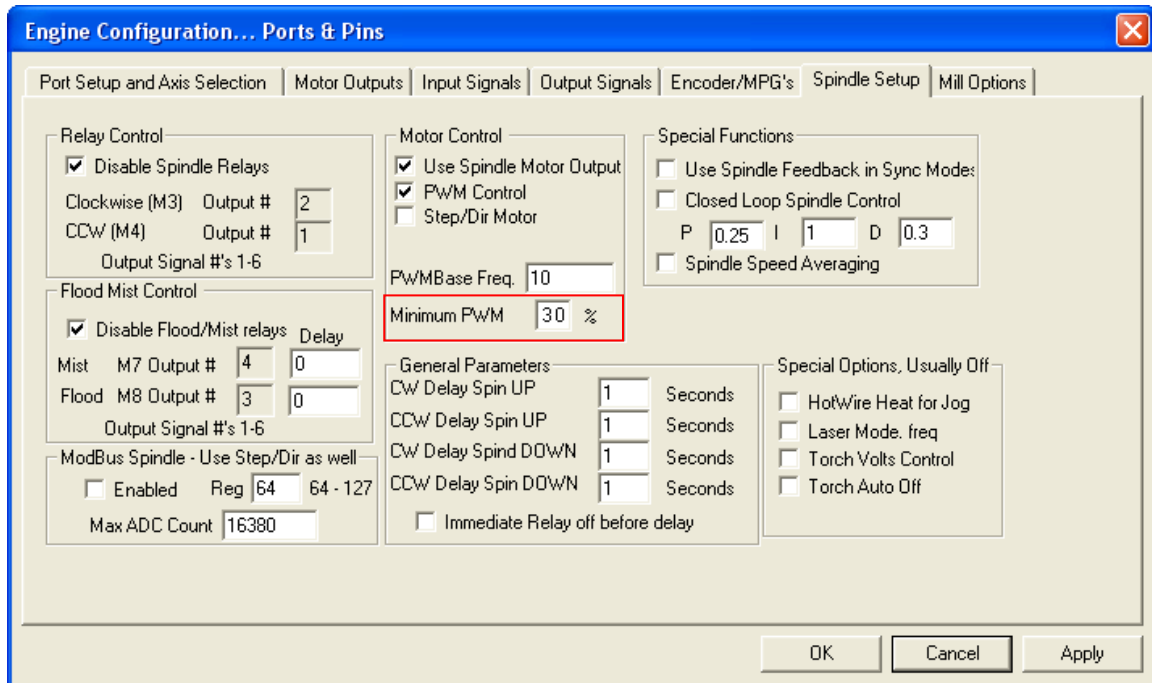
8. Open Config -> Spindle Pulleys again
   a) Enter the minimum speed setting found in step 6 into the "Min Speed" box
   b) Enter the maximum speed setting found in step 6 into the "Max Speed" box
   c) Click "OK"

Pulley Selection

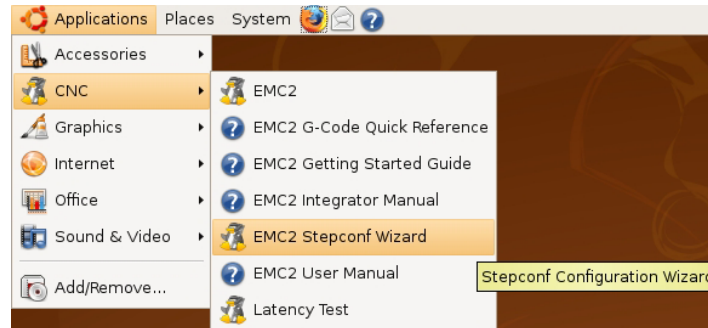| Current Pulley	Min Speed	Max Speed	Ratio
Pulley Number 1 ▼	3000	10000	1

☐ Reversed

OK

9. The RCNC is now configured for use Mach3 – happy chips!

Configuring the RCNC with EMC2

1. Start the stepconf wizard of EMC2 and modify an existing profile or create a new one. For details on the Stepconf Wizard not related to spindle control see the EMC2 documentation.

2. In the "Parallel Port Setup" screen select "Spindle PWM" for the pin you would like to use for spindle control (image below shows Pin 14 selected) and click "Forward"
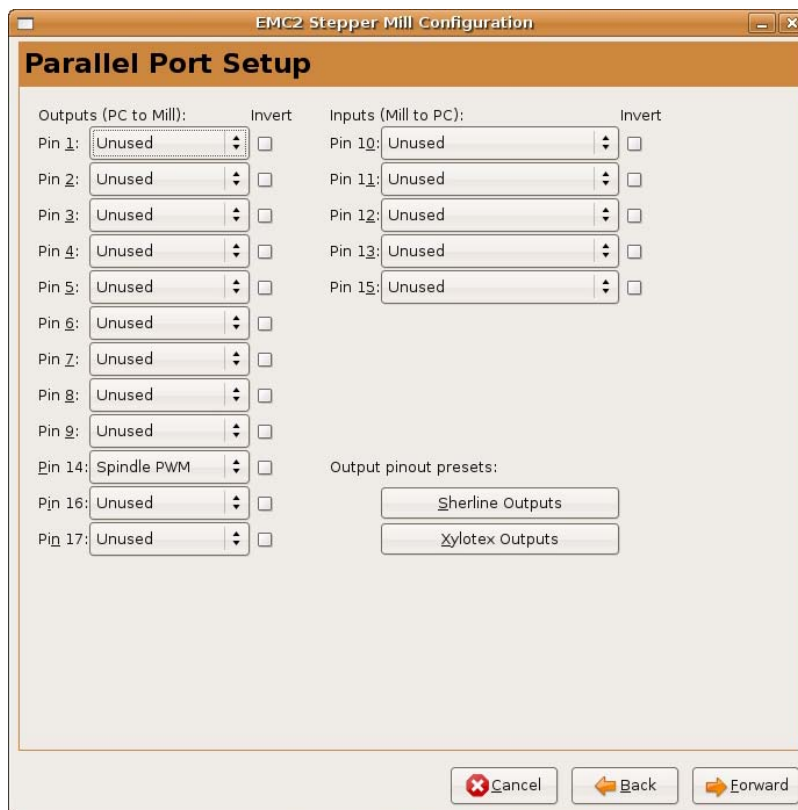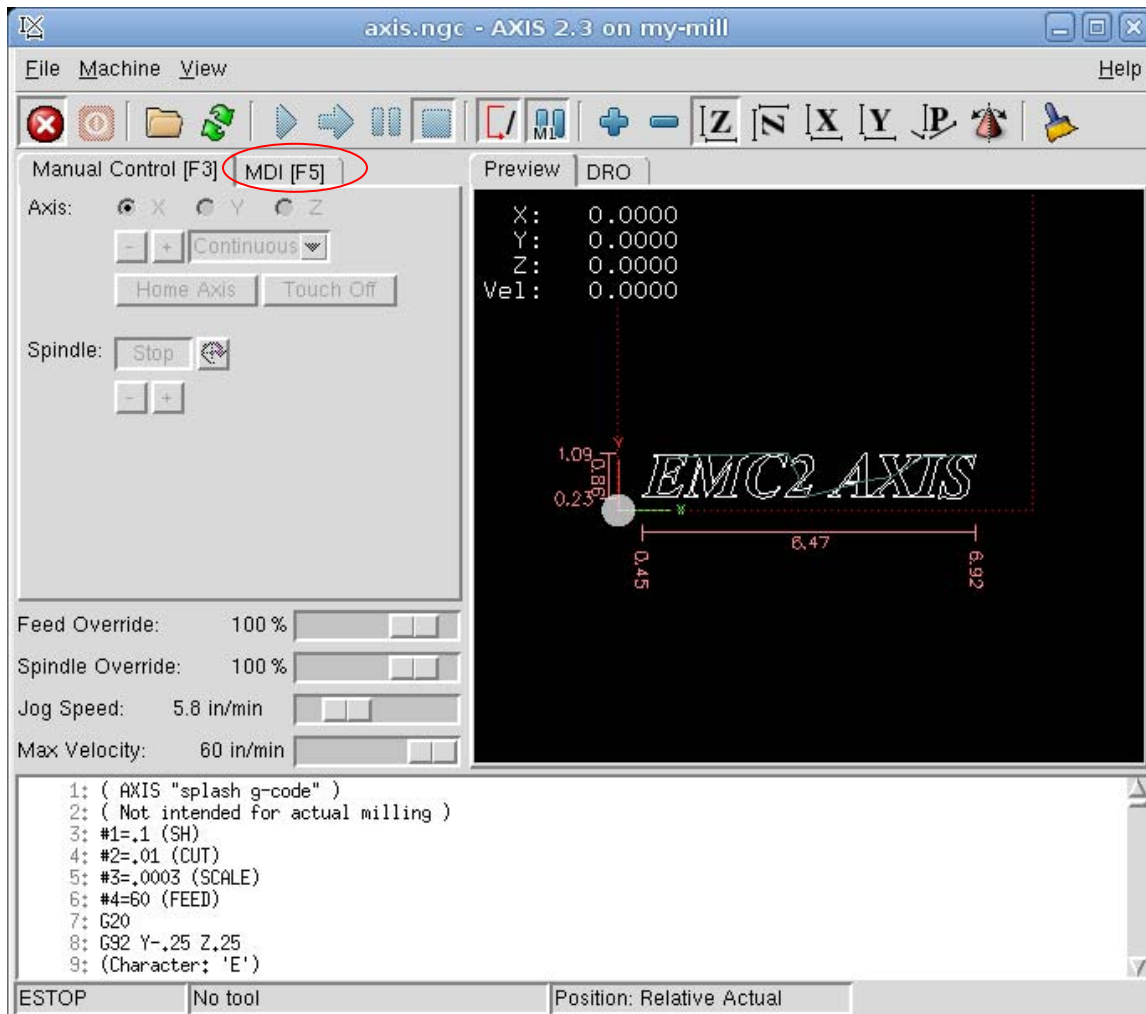
3. When you reach the "Spindle Configuration" screen:
   a) Enter 10.0 into the "PWM Rate:" textbox
   b) Enter 2000 into the "Speed 1:" textbox
   c) Enter 8000 into the "Speed 2:" textbox
   d) Enter 0.2 into the "PWM 1:" textbox
   e) Enter 0.8 into the "PWM 2:" textbox
   f) Continue through the rest of the configuration screens and save the profile.

4. Launch EMC2 and then click on the MDI tab

5. In the MDI tab:
   a) Enter M3 S1000 into the "MDI Command:" box and click "Go".
   b) If the spindle starts, record this rpm for later use
   c) If the spindle does not start repeat step a) except increment the spindle speed by 100 each time (i.e. 1100, 1200) until the spindle starts turning. Record the speed at which the spindle starts turning for later use.
   d) Using a tachometer, measure the actual minimum speed of the spindle using the spindle speed setting found above; then change the spindle rpm setting to 10000 and measure the actual maximum speed. Record these two values for later use.
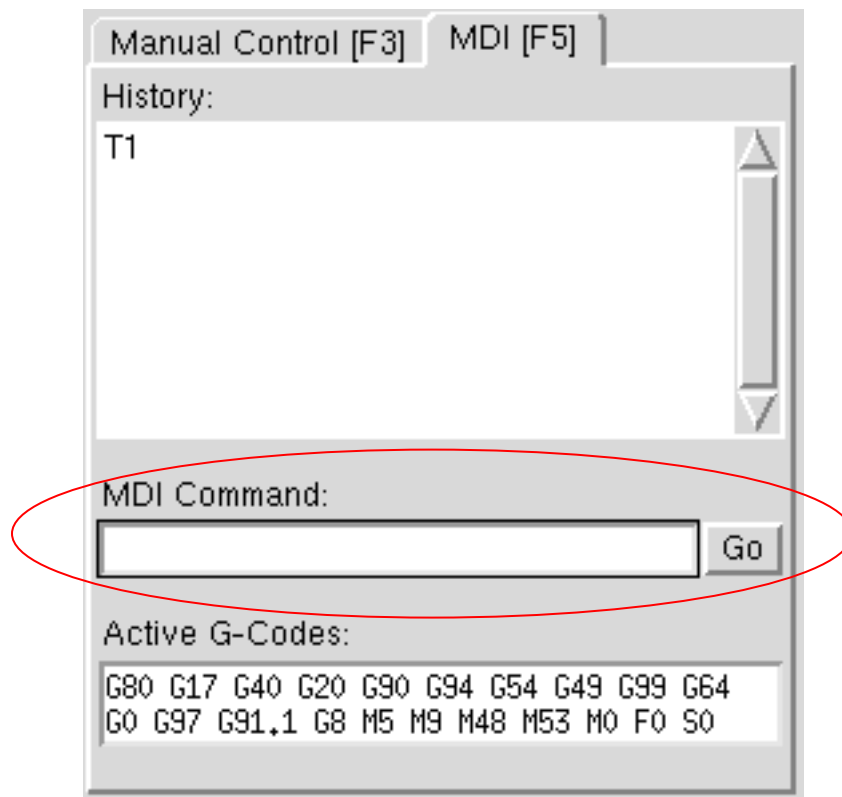
6. Open the .HAL file for your machine configuration
7. Note: A sample .HAL file can be found in the <u>downloads</u> section of the LOGICNC.COM website, as well as calculators for finding the gain and offset used in steps 12 and 13.
8. Near the top of the file there are several lines beginning with "loadrt"
   At the end of these lines insert a new line with the text:
   loadrt scale
9. Below the "loadrt" section, find the lines beginning with addf and ending with "servo-thread"
   At the end of these lines insert a new line with the text:
   addf scale.0 servo-thread
10. Find the lines dealing with spindle pwm. An example spindle config from a .HAL file is shown below. ***Note: Line numbers have been added for clarification.***

Line 1 - net spindle-cmd <= motion.spindle-speed-out => pwmgen.0.value
Line 2 - net spindle-enable <= motion.spindle-on => pwmgen.0.enable
Line 3 - net spindle-pwm <= pwmgen.0.pwm
Line 4 - setp pwmgen.0.pwm-freq 10.0
Line 5 - setp pwmgen.0.scale 10000.0
Line 6 - pwmgen.0.offset -2.77555756156e-17
Line 7 - setp pwmgen.0.dither-pwm true

Line 8 - net spindle-pwm => parport.0.pin-16-out

11. Change the value for scale on Line 5 to the maximum rpm you measured in step 5. (i.e. if the maximum rpm measured was 8300 then this line will be:
    setp pwmgen.0.scale 8300.0

12. Insert a new line after Line 5 with the text:
    setp pwmgen.0.gain .00016

    replace the value of .00016 with the result of 1/(max speed – min speed) (i.e. if the max speed measured in step 5 is 8300 and the min speed measured in step 5 is 2000 then 1/(8300-2000) = 1/6300 = .00016

13. Modify line 6:
    pwmgen.0.offset -2.77555756156e-17

    change **-2.77555756156e-17** to the result of min speed x gain

(i.e. for the min speed of 2000 found in step 5 (and used in step 8) and the gain of .00016 found in step 8 the value is 2000 x .00016 = .32)
The line will be changed to read:
pwmgen.0.offset -.32

14. The RCNC is now configured for use with EMC2 – happy chips!

FAQ

Q: What else do I need to complete a brushless motor setup?

A: A brushless motor (obviously!), a brushless ESC (Electronic Speed Control) which has a 5V BEC (Battery Eliminator Circuit) and a DC power supply to drive everything.

Q: How many different speeds does the RCNC allow?

A: The full range of the RCNC is 100 steps. For a 10000 rpm motor this allows speed control in increments of 100 rpm from 0 to 10000. Depending on the ESC/motor combination used, all steps may not be available since RC brushless motors typically cannot run at low rpm. If the minimum speed the motor will run at is 3000 rpm – there will be 70 speed steps (increments of 100 rpm from 3000 to 10000).

Q: Is the RCNC RoHS (Reduction of Hazardous Substances) compliant?

A: Yes the RCNC is RoHS compliant

Q: Can the RCNC run the spindle in forward and reverse rotation?

A: The RCNC itself will only run the spindle in one direction, but brushless motors used in radio control vehicles allow the direction of rotation to be reversed by swapping any 2 of the 3 wires from the ESC. This will allow use of tools rotating in both directions, but will not be software controllable since the ESC wires need to be swapped each time the spindle direction is required to reverse directions.

Q: I have a question that is not answered in this manual…can you help me?

A: Yes, we can! Please contact us at info@logicnc.com

Legal

Definitions

RCNC RCNC is defined as the RCNC brushless motor controller sold by www.logicnc.com, or any variant thereof.

LOGICNC.COM LOGICNC.COM is defined as the website www.logicnc.com, its owners, and its operators.

Notice of Liability and Warranty disclaimer

Machine tools, especially computer numerical controlled (CNC) machine tools are dangerous devices. In order to use the RCNC motor controller on any machine or for any reason, you must agree to the following:

I agree that no one other than the owner of the RCNC will be, under any circumstances, responsible for the operation, safety, and use of this machine. I agree there is no situation under which I would consider LOGICNC.COM to be responsible for any losses, damages, or other liability suffered through the use or misuse of the RCNC. I will hold no one other than myself responsible for any material loss, personal damages, secondary damages or any undesired response by the RCNC while running any machine or device. I fully accept the entire risk as to the quality and performance of the RCNC. Should the RCNC prove defective, I assume the entire cost of any and all incidental or consequential damages.

I fully accept all responsibility for the operation of any machine or device using the RCNC or any derivative of the RCNC, and for its operation by others who may use the RCNC. It is my responsibility to warn any others who may operate any machine or device under the control of the RCNC of the limitations so imposed. In no event will LOGICNC.COM be liable for any damages, including loss profits, or direct, indirect, incidental, special, or consequential damages resulting from any defect in the device, even if they have been advised of the possibility of such damage. I agree fully to compensate and hold harmless LOGICNC.COM for any losses due to legal actions brought against the company which are directly or indirectly related to the operation of the RCNC.

I understand and acknowledge that LOGICNC.COM makes no guarantee or warranty, either express or implied, with respect to the device, its merchantability, or its fitness for any particular purpose. The device is purchased solely on an "as is" basis. Moreover, I expressly release LOGICNC.COM from any and all liabilities caused by the negligence of LOGICNC.COM arising out of the use or misuse of the RCNC.

The RCNC is provided "AS IS" without warranty of any kind whether expressed or implied including but not limited to merchantability and suitability for a particular purpose.

In no event shall LOGICNC.COM be liable for any damages whatsoever (including, without limitation, damages for loss of business profits, business interruption or any other losses). The user assumes the entire cost of all necessary servicing, repair or correction and any incidental or consequential damages, to the maximum extent permitted by applicable law for the RCNC and any connected machine or device.

I the purchaser and/or user of the RCNC will indemnify, hold harmless and defend LOGICNC.COM from and against any claims or lawsuits including for attorney's fees, which arise or result from the use or misuse of the RCNC.

I the purchaser and/or user of the RCNC acknowledge that I have read, understand and agree to these conditions and agree to be bound by its terms and conditions.

I the purchaser and/or user of the RCNC agree that this is the complete and exclusive statement of the agreement for the use of the RCNC and that this supersedes any proposal, prior agreement or communication regarding the RCNC, whether oral or written.

I the purchaser and/or user of the RCNC agree that I have read, agree with, and will follow all of the safety instructions given in the "Safety Information" section of this document.

I fully accept the above statements, and I will comply at all times with safety requirements pertinent to my area or country, and will endeavor to ensure the safety of all operators, as well as anyone near or in the area of my machine.