

# Axes Pairing Overview

For the most part, this document pertains to all versions of CNC10 although some features discussed are available only in CNC10v 2.63 and above. For differences between your version and CNC10v 2.63+, please see TB000: "Software Update Highlights".

## Axes Pairing FAQ

### What you CAN do:

1. You CAN pair up to two sets of axes using either a DC or AC based system.\*
2. You CAN specify different amounts for backlash compensation for each axis in a pair.
3. You CAN run each axis in opposite directions. (wiring modifications required)
4. You CAN command the slave axis independently in a program if needed.
5. You CAN run system test.
6. You CAN pair the X, Y or Z axes with the either the 4<sup>th</sup> or 5<sup>th</sup> axis.
7. You CAN use G10 to command axes to pair or unpair.
8. You CAN command a move to hardstop(s) to square the machine if needed.
9. You CAN specify different limit switch settings for each axis in a pair.
10. You CAN run Drag Plot on the master axis (X,Y or Z) of an axes pair.
11. You CAN perform a PID data collection using the master axis (X,Y or Z) of an axes pair.

### What you CAN'T do:

1. You CAN'T run Autotune with an axes pair (unless the paired axes are turned OFF)
2. You CAN'T use laser compensation tables for any axis in a pair.
3. You CAN'T use different values for travel limits for any axis in a pair.
4. You CAN'T use different values for encoder counts/rev for any axis in a pair.
5. You CAN'T use different motor revs/unit or units/rev ratios for any axis in a pair.
6. You CAN'T use different max rates for any axis in a pair.
7. You CAN'T use different PID values for any axis in a pair.
8. You CAN'T use different values for Deadstart or Delta Vmax for any axis in a pair.
9. You CAN'T pair the X, Y or Z axes with each other.
10. You CAN'T set direction reversal on only one axis of a pair.
11. You CAN'T jog the slave axis independently.
12. You CAN'T run drag plot on the slaved axis of an axes pair.
13. You CAN'T use MDI to command an independent move of the slaved axis. (the slaved axis will immediately return to it's slaved position as soon as the MDI command is complete)

\*5<sup>th</sup> axis pairing requires that the system utilize SD3 and/or SD1 drives. Systems utilizing a DC3IO, Servo1, Servo3IO, Optic1 or Noptic1 can pair only one axis, the fourth.

## Control Configuration for Paired Axes Systems

The Centroid mill control can support up to two sets of paired axes which can be configured as follows:

**Parameter 64 Value**

Value	Meaning
0	No Pairing (Default)
1	Pair 4 <sup>th</sup> axis with X Axis
2	Pair 4 <sup>th</sup> axis with Y Axis
3	Pair 4 <sup>th</sup> axis with Z Axis
16	Pair 5 <sup>th</sup> axis with X Axis
32	Pair 5 <sup>th</sup> axis with Y Axis
48	Pair 5 <sup>th</sup> axis with Z Axis
64	Pair 5 <sup>th</sup> axis with 4th Axis

In order to pair both the 4<sup>th</sup> and 5<sup>th</sup>\* axes on the same system add the 4<sup>th</sup> axis value with the 5<sup>th</sup> axis value. Example: To pair the 4<sup>th</sup> axis with the X axis AND pair the 5<sup>th</sup>\* axis with the Z axis, the value entered into parameter 64 would be 49. (1 + 48)

### **PID Configuration screen – From main screen F1 (Setup)->F3(Config)->F4(PID)**

For all system configurations, confirm that the values for slaved axis - 4<sup>th</sup> or 5<sup>th</sup> axis are identical to that of the master axis - X, Y or Z axis. (Kp, Ki, Kd, Ka, Kv1, Kg and Accel).

For systems (both AC and DC) that utilize SD3 and SD1 drives, select **F8 (Drive)** and confirm that the values for the slaved axis (4<sup>th</sup> or 5<sup>th</sup> axis) are identical to that of the master axis - X, Y or Z axis. (Motor Poles, Current Select, Drive Angle, Kp, Ki, Kd, %Fixed & %Rpm) for each axis in a pair.

### **Machine Configuration screen – From main screen F1 (Setup)-> F3(Config)->F2(Machine)->F2(Motor)**

For all system configurations, confirm that the revs/unit (or units/rev), encoder counts/rev and direction reversal of the slaved axis are identical to that of the master axis. Limit Switches, Home Switches and Lash Comp can be set as needed and do NOT need to be identical to that of the master. Screw Comp MUST be set to N (Off) for any axis in an axes pair.

### **Jog configuration Screen - From main screen F1 (Setup)->F3(Config)->F2(Machine)->F1(Jog)**

For all system configurations, confirm that the values for slaved axis - 4<sup>th</sup> or 5<sup>th</sup> axis are identical to that of the master axis - X, Y or Z axis. (Slow Jog, Fast Jog, Max Rate, Deadstart, Delta Vmax and Travel limits)

## What You Need To Know About Homing -and Squaring- Paired Axes

Often machines that use an axes pair will rely on the paired motors, rather than the mechanical rigidity of the machine, to ensure that an axis stays square to the machine. When relying on the motors in this fashion it is critical that the homing sequence have some method of bringing the machine into a position that is known to be square and that this position be verified in some way such as PLC feedback (prox. switches), hard stops or visual confirmation by the operator.

Centroid offers 4 basic methods of performing the homing sequence: Jog, Home Switch, Hard Stop\* and Ref Mark-HS. The “Jog” method simply prompts the user to jog all axes to desired home location and press Cycle Start to set machine home. The Home Switch, Hard Stop\* and Ref Mark-HS methods perform the homing sequence by running a job called cnc10m.hom at machine startup. This file, found in the /cncroot/c/cnc10 directory, can be modified as needed to change the homing behavior and homing direction for each axis on your machine. Further details for each method, as well as suggested modifications of these methods, are outlined below:

**\*\*All code and configuration data provided below is an EXAMPLE ONLY. Machine and control configurations vary greatly, these examples may not apply to your machine.**

### **Homing configuration - From main screen F1 (Setup)->F3(Config)->F1(Control)**

Use the arrow keys to select the currently defined homing method, press the space bar to toggle through the choices and press F10 to save.

### **Brief Description of Homing methods (by order of preference)**

- 1. Combination of Hard stop homing and prox switches – Recommended Method\*\*** This method uses proximity switches to determine in which direction the motors are skewed, brings the axis into rough square using these same switches and then brings the axis into true square using hard stops.
- 2. Modified Home Switch\*\*** This method uses proximity switches to determine in which direction the motors are skewed and then brings the axis into true square using these same switches.
- 3. Modified Hard Stop\*\*** This method uses hard stops to determine in which direction the motors are skewed and then brings the axis into true square using these hard stops.
- 4. Home Switch** This method uses proximity switches to home the axes and square the machine.
- 5. Hard Stop** This method uses hard stops to home the axes and square the machine.
- 6. Ref Mark-HS** This method requires that the user jog some or all axes to reference marks before beginning the homing sequence. Since there is no way to jog a slaved axis independently, this method is only viable if proximity switches are being used on the paired axes or on machines for which the machine is responsible for maintaining square for all axes.
- 7. Jog** This method simply prompts the user to jog all axes to the desired location for each axis and then press Cycle Start to set home at those locations for all axes. Since there is no way to jog a slaved axis independently, this method is only viable on machines for which the machine is responsible for maintaining square for all axes.

\*\*Hard Stop” is actually a variation of the “Home Switch” homing method.

\*\*Requires purchase of “sub program and macros” software option.

### **Detailed Description of Homing methods -by order of preference**

**1. Combination of hard stop homing with proximity switches.** Requires: Software travel limits must be set, “Machine home at power up” option = “Home Switch” in the Control Configuration screen, all limit and home switch PLC inputs for axes pair be set to 0 in Motor Parameters screen, Sub programs and Macros software option, modified PLC, modified cnc10m.hom, hard stops that are aligned square to the machine and proximity switches aligned so that they are roughly square to the machine.

**This is the recommended method.** It is the easiest to configure (no need to align encoder index pulses) and allows the control to safely and accurately home and square up the machine. The use of proximity switches it allows the control to determine the skew and square up an axis without danger of exceeding the mechanical travel of an axis which can cause considerable damage to the machine and/or control components.

How \$10 in switches can save you \$1000's

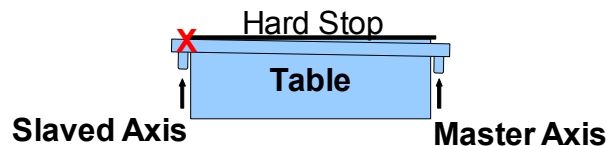


Figure 1

In the figure above, it is clear that if a move was commanded to the master axis hard stop, the slaved side of the gantry will be well past its the mechanical limit before the master side of the gantry is commanded to stop.

In figure 2 below, the use of proximity switches at points A & B (and making a slight change to the cnc10m.hom and PLC programs) prevents the catastrophic situation illustrated in figure 1. Instead of commanding a move directly to a hard stop, a move is first commanded until either of the proximity switches opens. The cnc10m.hom program then determines which axis is leading based on which switch opened and can then brings the machine into approximate square by commanding the trailing axis to move until it's switch opens as well. A partial example of a cnc10m.hom program which has been configured to use proximity switches in this manner is included here for your reference.

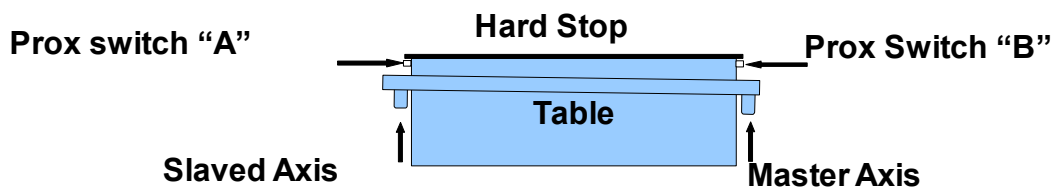


Figure 2

**Combination of Hard stop homing with proximity switches (continued)**

## Example of cnc10m.hom for “Hard Stop With Proximity Switches”

Paired axis homing section of cnc10m.hom program that utilizes hard stops and proximity switches

```
-----  
;Comments:  
;Axes are already paired, X = master, W = slave and homing using M91.  
; X – limit = PLC input 1, W- limit = PLC input 7  
-----  
N1000  
M105 /X /10 F30 ;Move in minus direction at 30ipm until either master or slave limit switch opens.  
IF !#6001 Then Goto 1100 ;If X axis tripped first, goto section to move W until it trips too.  
IF !#6007 Then Goto 1200 ;If W axis trips first, go to section that “walks” the axes.  
  
N1100  
M105 /W /7 F30 ;Move W minus direction at 30ipm until slave limit switch opens.  
M26 /X ;Axes are now reasonably square, resync axes at current position  
Goto 1300 ;Go to move to hard stop section  
  
N1200 ;Because the X (master axis) can't be moved independently, the W axis has to be  
G91 W.05 ;”walked” off the switch and the cycle restarted until the X axis trips first  
IF !#6007 Then Goto 1200 ; If W hasn't cleared yet, back off another .05  
IF #6007 Then Goto 1000 ; If W axis has cleared, restart move to switch cycle  
  
N1300 ;Now that the axes are roughly square, it is safe to home to the to hard stops  
M91 /X L1 ;Move master axis to hard stop L1 switch specifies NOT to return to index pulse  
IF ABS [#23904] < 5 Then Goto 1400 ; If PID Out for slaved axis < 5, the slave axis is ready to home. G91  
W .05 ;If PID Out for slave is >= 5 then move the slaved axis off the hard stop before  
;homing. This distance assumes that the limit switches for the master and slave axes ;are  
adjusted to within .05” of square.  
N1400  
M91 /W L1 ;Home W axis to hard stop L1 switch specifies NOT to return to index pulse  
M26 /X/W ;Set home for master and slaved axes at current position  
-----  
; End sample section of cnc10m.hom  
-----
```

## Example CPU PLC modifications:

```
;Comment: Declare Gantry_Limit on unused input  
Gantry_Minus_Limit is INP10
```

```
;Comment: Make Gantry_Limit = Master minus limit OR the Slave minus limit  
Gantry_Minus_Limit = / X_Minus_Limit OR / W_Minus_Limit
```

## Detailed Description of Homing methods (continued)

C:\Documents and Settings\Administrator\Desktop\CNC Services\surfboard shaping machine\Axis\_pairing\_overview.odt

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**1.Modified Home Switch** Note: This method is **NOT** recommended because it is possible to damage the machine and/or the control components while searching for the index pulse. It can also be difficult to align the index pulses.

Configuration and requirements: “Machine home at power up” option = “Home Switch” in the Control Configuration screen. In the Motor Parameters screen, all limit switch PLC settings be 0 and the home switch PLC inputs must be set to the correct PLC input number. Software travel limits must be set correctly, Sub programs and Macros software option, modified PLC, modified cnc10m.hom, paired axes proximity switches must be aligned so that the machine is roughly square when to the switches are tripped the encoder index pulses on the master and slave motors for each axes pair must be aligned so that they occur in a position in which the machine is in true square.

Method: Like the combined hard stop and proximity switch method, this method uses proximity switches to determine in which direction the motors are skewed and then brings the axis into rough square by bringing the trailing axis until it's home switch is tripped. From here the index pulses are used (rather than hard stops) to bring the machine into true square. It uses the same PLC modification as the method that combines hard stops and proximity switches. The custom cnc10m.hom file is similar to that used in the “Hard Stop With Proximity Switches” example with differences noted below:

```
N1300
M91 /X      ;Move X to switch and back to index pulse
M91 /W      ;Move W to switch and back to index pulse
M26 /X      ;Resync axes - Everything below this is removed.
```

**2.Modified Hard Stop** Note: This method is **NOT** recommended because it is possible to damage the machine and/or the control components while searching for the hard stop.

Configuration and requirements: Software travel limits must be set correctly, “Machine home at power up” option = “Home Switch” in the Control Configuration screen, all PLC inputs for limit and home switches for axes pair be set to 0 in the Motor Parameters screen, Sub programs and Macros software option, modified cnc10m.hom and hard stops that are aligned square to the machine.

Method: This method uses hard stops to determine in which direction the motors are skewed and then brings the axis into true square using the hard stops. The PLC program is standard. The custom cnc10m.hom file is similar to that used in the “Hard Stop With Proximity Switches” example with differences noted below:

```
N1300
M91 /X L1      ;Move master axis to hard stop. The L1 specifies NOT to return to index pulse.      IF
ABS [#23904] < 5 Then Goto 1400 ; If PID Out for slaved axis < 5, the slave axis is ready to home. G91 W .05
;If PID Out for slave is >= 5 then move the slaved axis off the hard stop.
N1400
M91 /W L1      ;Home W axis to hard stop L1 switch specifies NOT to return to index pulse
M26 /X/W      ;Set home for master and slaved axes at current position
```

### **Running paired axes in opposite directions**

It is often required that the two axes in an axes pair run in opposite directions. This can be accomplished only by modifying the motor and encoder wiring of the slaved axis. Before attempting to configure your motors, please be sure to disconnect the motor from the drive mechanism of the machine. Failure to do so can result in damage to the machine, motor and/or servo drive. Additionally, you should first configure direction reversal for the master axis so the master axis (X, Y or Z) motor moves in the correct direction and then modify the motor and encoder wiring of the slaved axis to configure it to move in the opposite direction. There is never any need to modify the wiring of the master axis motor or encoder.

**For DC Systems:**

1. Make sure that the direction reversal and the travel limits of the slaved axis are set identically to that of the master axis.
2. Exchange the wiring on the A and B channels from the encoder. (A<->B, /A<->/B)
3. The Positive (red) and Negative (black) motor power leads need to be exchanged on the drive.

**Encoder Cable Connections**

**DC3IO, Servo1, Servo3IO, Optic1 or N-Optic1**

	<b>Master Axis (Std)</b>	<b>Slave Axis (Reversed)</b>
Pin	Wire Color	Wire Color
1	N/C	N/C
2	BLK/RED (GND)	BLK/RED (GND)
3	BLK/GRN (/Z)	BLK/GRN (/Z)
4	BLK/WHT (/A)	BLK/BLU (/B)
5	BLK/BLU (/B)	BLK/WHT (/A)
6	GRN (Z)	GRN (Z)
7	WHT (A)	BLU (B)
8	BLU (B)	WHT (A)
9	RED (+5)	RED (+5)

**SD3 or SD1 Based Systems with DC motors\***

	<b>Master Axis (Std)</b>	<b>Slave Axis (Reversed)</b>
Pin	Wire Color	Wire Color
1	BLU (A)	GRN (B)
2	GRN (B)	BLU (A)
3	ORG (Z)	ORG (Z)
4	N/C	N/C
5	N/C	N/C
6	BLU/BLK (/A)	GRN/BLK (/B)
7	GRN/BLK (/B)	BLU/BLK (/A)
8	ORG/BLK (/Z)	ORG/BLK (/Z)
9	N/C	N/C
10	N/C	N/C
11	BLK (GND)	BLK (GND)
12	RED (+5)	RED (+5)
13	N/C	N/C
14	N/C	N/C
15	N/C	N/C

**Running paired axes in opposite directions (continued)**

**For AC Systems:**

1. Make sure that the direction reversal and the travel limits of the slaved axis are set identically to that of the master axis.
2. Exchange the following channels in the encoder wiring: A <-> B, /A<->/B, /V<->W & /W<->V
3. Exchange the U & W motor power leads at the drive.

**For SD3 or SD1 Based Systems with AC Motors:**

	<b>Master Axis (Std)</b>	<b>Slave Axis (Reversed)</b>
Pin	Wire Color	Wire Color
1	BLU (A)	GRN (B)
2	GRN (B)	BLU (A)
3	ORG (Z)	ORG (Z)
4	BLU/WHT (V)	WHT/BLK (/W)
5	RED/WHT (K)	RED/WHT (K)
6	BLU/BLK (/A)	GRN/BLK (/B)
7	GRN/BLK (/B)	BLU/BLK (/A)
8	ORG/BLK (/Z)	ORG/BLK (/Z)
9	GRN/WHT (U)	BLK/WHT (/U)
10	WHITE (W)	RED/BLK (/V)
11	BLK (GND)	BLK (GND)
12	RED (+5)	RED (+5)
13	BLK/WHT (/U)	GRN/WHT (U)
14	RED/BLK (/V)	WHITE (W)
15	WHT/BLK (/W)	BLU/WHT (V)