CSCNC IOMOD2 User's Guide

Cool Systems CNC 4 Axis Servo Machine Controller

Features

- Connects over a dedicated 100 Mbps Ethernet connection
- Smooth motion on up to 4 simultaneous Teknic ClearPath servo motors
- Uses a 600 W unregulated power supply for heavy power loads
- 4 relay outputs: 2 Form C SPDT, 1 120V 2 A, 1 120V 5 A
- 8 optically isolated digital inputs
- Supports homing, jogging, probing, MPGs, THC and PWM/motor spindle control
- Can be configured to be used with S3CNC, LinuxCNC, or Mach3 and Mach4
- Unbranded enclosure ideal for OEMs
- Customization available

Product Brief

Cool Systems CNC (CSCNC) is Stepper3’s latest motion control product. The controller is powerful, compact, low-cost, and can control up to four Teknic ClearPath servo motors. It has provisions for all of your machine’s I/O: AC loads, contact closures, limit switches, torch height controllers, and more. It even features an easy connection matching the Hypertherm Plasma Torch pinout.

At the heart of CSCNC is Stepper3’s Ether-Mach motion controller for S3CNC, Mach3, and Mach4. It plugs directly into the main breakout board, much like most of the components, making the controller sturdy and low cost.

The box features what we call IOMODs that interface with your machine’s motors and tools. IOMOD2 is our new generation of servo-based CNC controllers for use with Router and Plasma.

CSCNC Contents

- 1 CSCNC control box
- 1 AC Power Cable
- *Note: I/O and motor cables not included. Please see guide for part numbers and pinouts or contact Stepper3 for pricing

Table of Contents

1: CSCNC Front Panel

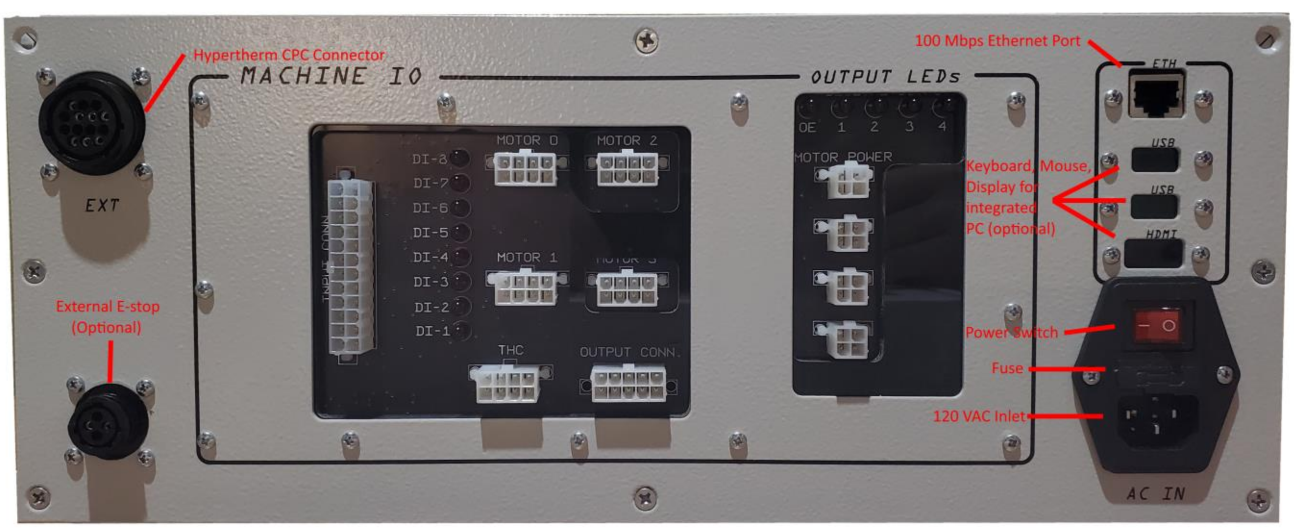
The front of the controller has the illuminated main power switch, and optional E-Stop button (cover pictured). In order to turn on the controller, make sure the box is plugged in and switched on in the rear (see CSCNC Rear Panel). Then make sure the E-Stop is not active (pressed down if included). If it is active, twist to release.

Now you can turn on the power switch, and you will see the front lamp lit and hear the fan running at this time.

Note: Do NOT connect motors while CSCNC controller is powered. Doing so may damage drives and/or cables.

2: CSCNC Rear Panel

This section covers the connections on the rear of the panel. It excludes I/O connections from the IOMOD. Below is a labeled diagram of the rear panel connections, and the following sections explain them in detail.



2.1: AC Power Inlet

The AC power inlet features a C14 inlet, power switch, and main fuse holder.

The C14 inlet is a common AC power cable that is used with industrial and commercial equipment such as PCs. One is included with your CSCNC purchase.

The inlet has a fuse holder, where a 15A fuse can easily be changed. It also has a holder for a spare (not included).

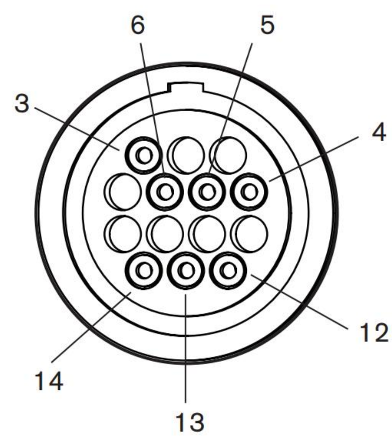
The power switch is a redundant switch. There is one included at the front of the control box for convenience. This switch can stay always on for most use cases.

2.2: 100Mbps Ethernet Connector

The 100 Mbps Ethernet connector can have different purposes, depending on your CSCNC controller configuration. As of now, the CSCNC controller supports S3CNC, Mach3, Mach4, and LinuxCNC. For these configurations, a host computer can connect to the drive box over a standard 100Mbps Ethernet connection to interface with the CNC motion controller inside the box.

2.3: Hypertherm Plasma Torch CPC Connector

The Hypertherm Plasma Torch CPC connector matches the standard pinout found on Hypertherm units as shown below. The table below describes: the Hypertherm control signal, which digital inputs and outputs (explained in more detail in the IOMOD2 section) the connector uses, and the corresponding Ether-Mach I/O pins.



Hypertherm Signal	Hypertherm CPC Pins	IOMOD2 Signal	Ether-Mach Pin Name
Start Plasma	3, 4	DO-2	Port 1 Pin 14
Transfer (start motion)	12, 14	DI-3	Port 1 Pin 12
Voltage Divider	5 (-), 6 (+)	n/a (pass through to THC)	n/a
Ground	13	n/a (connect shield to Hypertherm unit only)	n/a

2.3.1: Hypertherm CPC Connector Parts List

Below is a table listing the parts required to make a cable that plugs into the CSCNC controller and connects to a Hypertherm unit. You may want to purchase more pins in the event that a pin is destroyed while crimping.

Description	P/N	Qty.
CPC Connector	206044-1	2
CPC Strain Relief	206070-8	2
CPC Pins	1-66099-5	13
Shielded Cable	5304FE 008500	(depends on your needs)

2.4: PC Connections

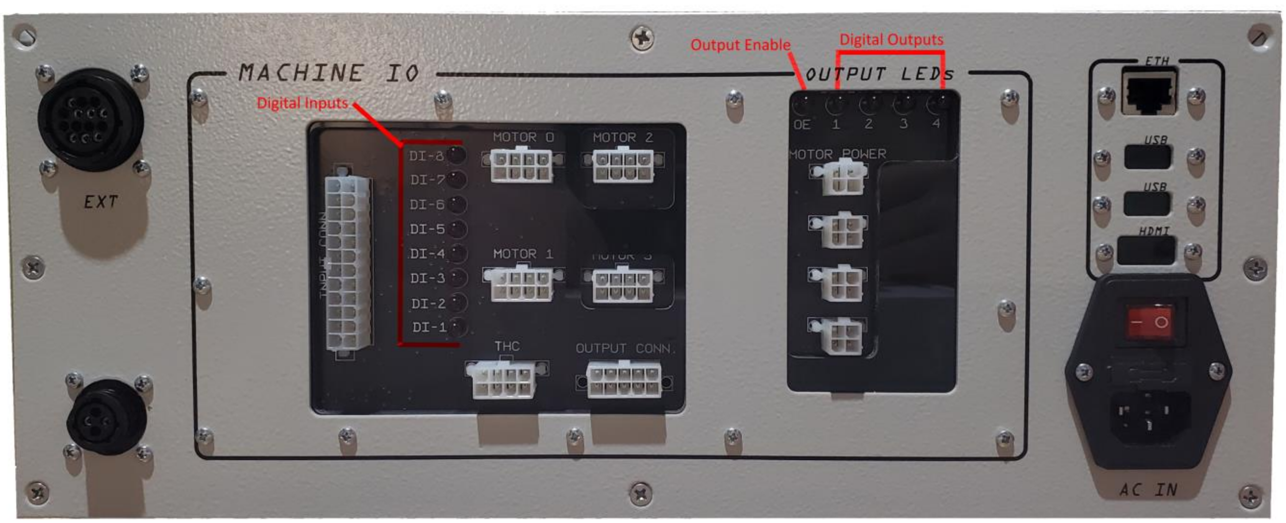
The CSCNC controller has the ability to house an (optional) PC directly within the controller. This repurposes the 100 Mbps Ethernet connector to now act as your network connection, while the 2 USB ports are for mouse and keyboard, and the HDMI port is for your display.

3: IOMOD2

IOMOD2 has connections for your machine’s I/O and motors as well as diagnostic LEDs used to troubleshoot your machine.

3.1: I/O LEDs

The IOMOD2 has a total a 15 LEDs: 4 digital outputs, 1 output enable, and 8 digital inputs. These LEDs can be used for diagnostics to make sure outputs are receiving a signal, and your inputs switches are working and properly wired.

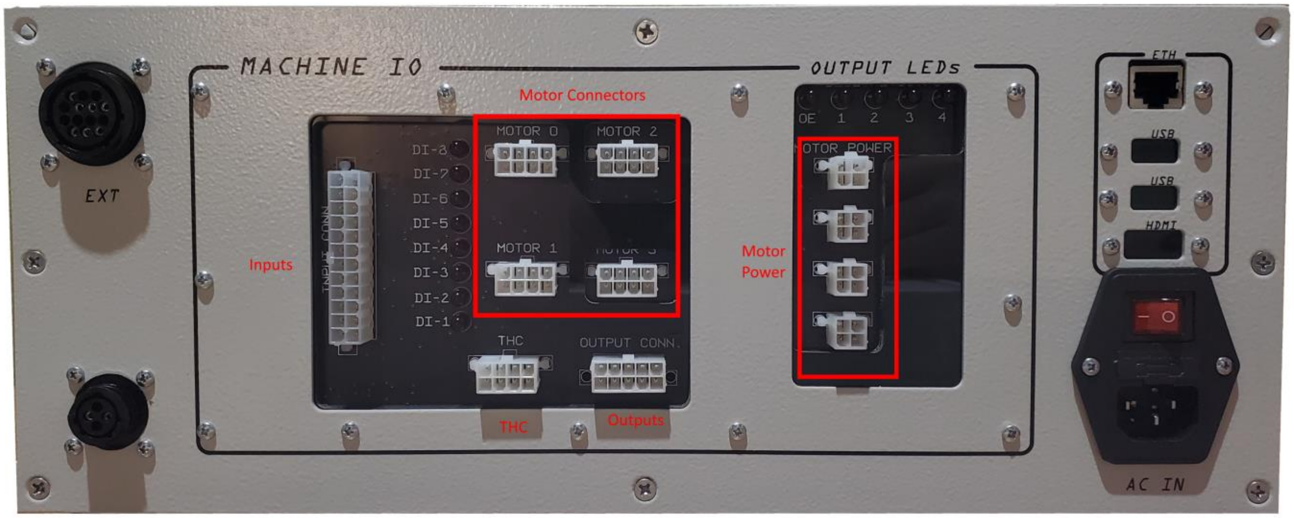


The output enable signal is inactive whenever the control software is in E-stop. This requires proper configuration in the Ether-Mach plugin as explained in the table below. The Ether-Mach and S3CNC section points to where to find information on configuring your Ether-Mach controller.

IOMOD2 Function	Ether-Mach Pin Name	Ether-Mach Pin Function
Output Enable	Port 1 Pin 17	Charge Pump

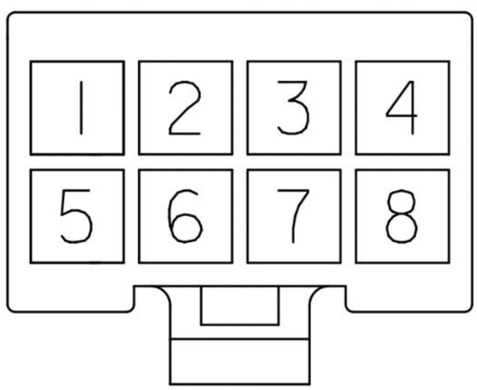
3.2: Pinouts

In order to properly connect components to your CSCNC controller, you will need to have the proper hardware pinouts, as well as software pinout mappings for the Ether-Mach board. The connectors are labeled on the controller, as well as on the image below.



3.2.1: Servo Motor Signal and Power Connector

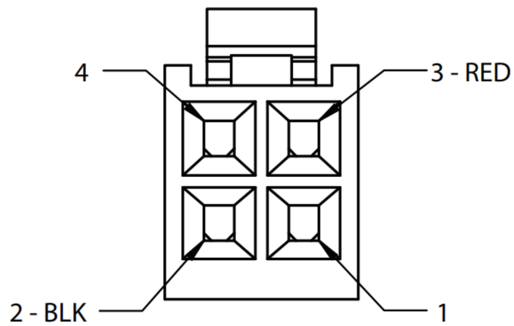
Each Servo motor connects to the IOMOD using Molex Mini-Fit Jr. connectors. The pin numbering convention follows that of the part, which is etched in the physical part on the wire-entry side of the plug. Below is the diagram and pinout for the 8-pin motor signal connector



Molex Mini Fit Pin Number	Teknic ClearPath Signal
1	*Fault +
2	Step +
3	Direction +
4	Reset +
5	*Fault -
6	Step -
7	Direction -
8	Reset -

*Note the fault signals are internally wired in the CSCNC box in series. If your system has less than 4 Teknic ClearPath motors, you must place an 8-pin Mini-fit Jr. connector that has a jumper wire between positions 1 and 5, in the unpopulated signal slots on the CS box. Otherwise you will not be able to use this signal properly.

For the Teknic ClearPath power connector, the pin numbering convention also follows that of the part, which is etched in the physical part on the wire-entry side of the plug. Below is the diagram and pinout for the 4-pin motor power connector.



Molex Mini Fit Pin Number	Teknic ClearPath Power
1	*GND
2	GND
3	V+
4	*V+

*Note there is no need to use all 4 power connections per motor. Typical Teknic ClearPath wiring is on pins 2 and 3 only.

The table below shows the required configuration in the Ether-Mach plugin. This means motion in Mach3 on the X axis or Mach4 on motor 0, will be output to the physical connection for Motor 0 on the CSCNC controller. In S3CNC, we recommend using motors 0, 1, and 2 for axes X, Y, and Z, respectively, and using motor 3 for the A or a slaved axis.

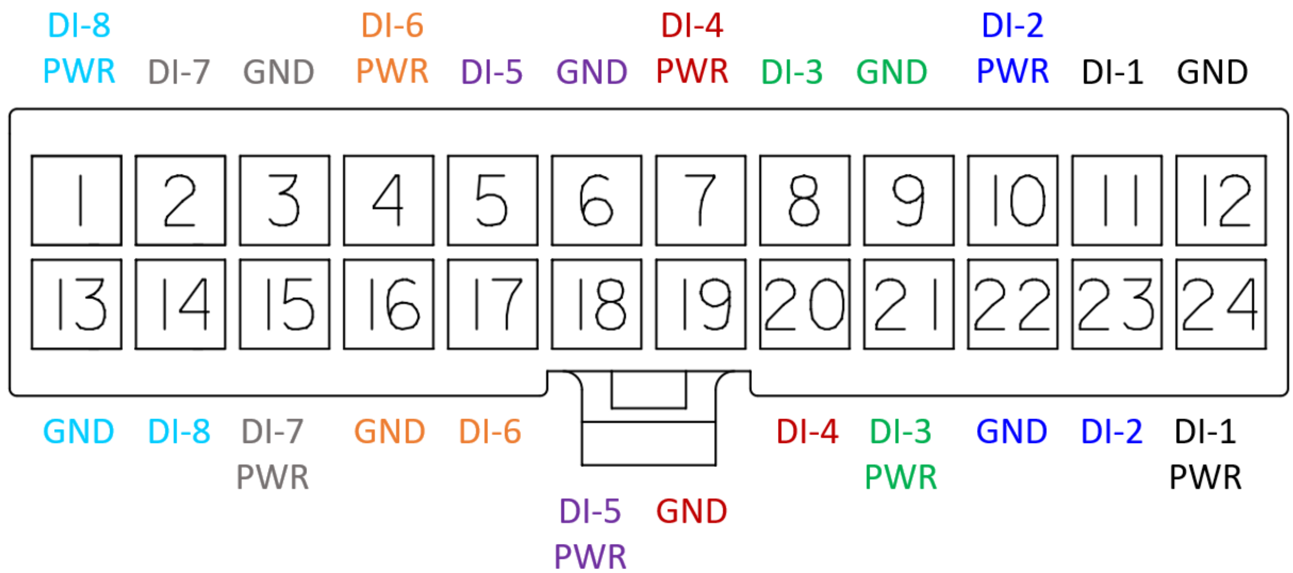
IOMOD2 Function	Ether-Mach Pin Name	Ether-Mach Pin Function	Active Low?
Motor 0	Port 1 Pin 2	Stepper 0 Dir	No
Motor 0	Port 1 Pin 3	Stepper 0 Step	No
Motor 1	Port 1 Pin 4	Stepper 1 Dir	No
Motor 1	Port 1 Pin 5	Stepper 1 Step	No
Motor 2	Port 1 Pin 6	Stepper 2 Dir	No
Motor 2	Port 1 Pin 7	Stepper 2 Step	No
Motor 3	Port 1 Pin 8	Stepper 3 Dir	No
Motor 3	Port 1 Pin 9	Stepper 3 Step	No
Reset	Port 2 Pin 14	General Purpose	Yes
Fault	Port 2 Pin 13	General Purpose	Yes

3.2.2: Digital Inputs

There are 3 signals per digital input on IOMOD2: DI-x PWR, DI-x (signal), and GND (ground). When using normal mechanical switches, an input is active by shorting a digital input to ground. For example, to activate DI-7, connect DI-7 to the adjacent ground signal.

The DI-x PWR is used to power active devices such as inductive proximity sensors at 24VDC. Each DI-x PWR pin is rated at a maximum of 200 mA continuous, and a total of 800 mA can be drawn through all DI-x PWR pins simultaneously.

The pinouts are shown in the diagram below for the 24 pin Molex Mini-Fit Jr. connector. The pin numbering convention follows that of the part, which is etched in the physical part on the wire-entry side of the plug.



The table below shows the corresponding Ether-Mach pin mapping. In S3CNC, simply assign the pins to the input you wish to use within the *Configurator*. In Mach 3 and Mach 4, the signals in the plugin need to be configured as General Purpose Pins (default). Then the inputs can be mapped normally in Mach3 or Mach4.

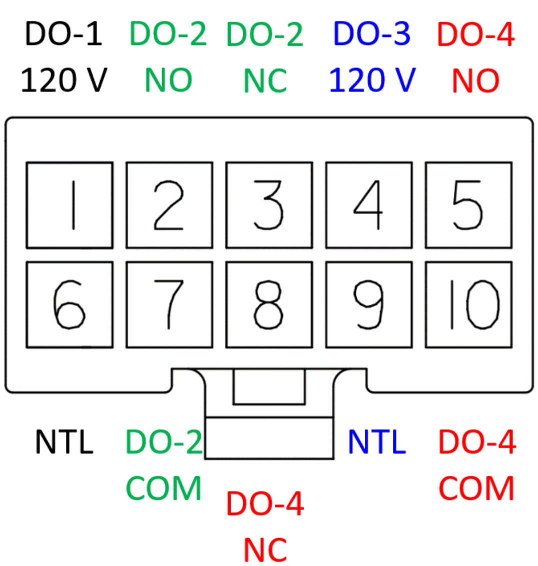
IOMOD2 Function	Ether-Mach Pin
DI-1	Port 1 Pin 10
DI-2	Port 1 Pin 11
DI-3	Port 1 Pin 12
DI-4	Port 1 Pin 13
DI-5	Port 1 Pin 15
DI-6	Port 2 Pin 10
DI-7	Port 2 Pin 11
DI-8	Port 2 Pin 12

Note: The THC and Hypertherm connector make use of DI-3, DI-5, and DI-6. If these features are being used, then the inputs on the Input Connector cannot be used independently. Operation will be unstable if both are connected at the same time.

3.2.3: Digital Outputs

There are 4 digital outputs. DO-1 (2 Amps) and DO-3 (5 Amps) switch 120V AC on when active, and off when deactivated. DO-2 and DO-4 are Form C Single Pole Double Throw (SPDT) relay, whose outputs come directly out of the connector for use with any application requiring a contact closure.

The pinouts are shown in the diagram below for the 10 pin Molex Mini-Fit Jr. connector. The pin numbering convention follows that of the part, which is etched in the physical part on the wire-entry side of the plug.



The table below shows the corresponding Ether-Mach pin mapping. In S3CNC, simply assign the pins to the output you wish to use within the *Configurator*. In Mach 3 and Mach 4, the signals in the plugin need to be configured as General Purpose Pins (default). Then the outputs can be mapped normally in

Mach3 or Mach4.

IOMOD2 Function	Ether-Mach Pin
DO-1	Port 1 Pin 1
DO-2	Port 1 Pin 14
DO-3	Port 1 Pin 16
DO-4	Port 2 Pin 1

Note: The Hypertherm connector makes use of DO-2. If the Hypertherm Torch connector is being used, then the output on the Output Connector cannot be used independently. Operation will be unstable if both are connected at the same time.

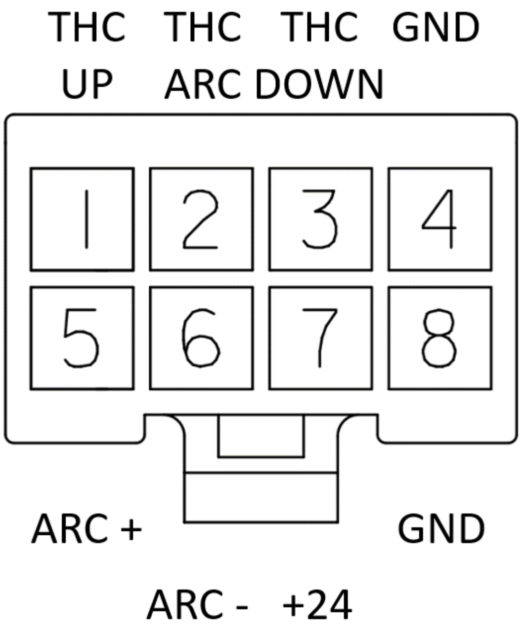
3.2.4: THC

The torch height controller (THC) connector is to be used with Up/Down torch height controllers such as the S3THC. These signals can be used directly with the Ether-Mach motion controller.

The diagram below shows the torch height controller pinouts. The up, arc, and down signals are typically from contact closures that share a common point. Connect this common point to the ground pin on pin 4.

The torch height controller can be powered by the +24 (pin 7) and ground (pin 8) provided.

The Arc+/- signals come from the Hypertherm Voltage divided output. This is a low voltage signal typically not exceeding 7 volts. Please consult your Hypertherm and torch height controller user manuals for proper wiring.



The table below shows the pin mapping for the Ether-Mach controller. These are the same mappings as described in the Digital Inputs section.

THC Signal	IOMOD2 Signal	Ether-Mach Pin Name
THC UP	DI-5	Port 1 Pin 15
THC ARC	DI-3	Port 1 Pin 12
THC DOWN	DI-6	Port 2 Pin 10

Note: The Hypertherm connector also makes use of DI-3 (THC ARC/transfer). We recommend using the signal from the torch height controller when using torch height control.

3.3: Connectors Parts List

3.3.1: Servo Motors

The quantities below are for a 4-axis unit.

Description	P/N	Qty.
4P Mini-Fit Receptacle	39-03-9042	4
8P Mini-Fit Receptacle	39-03-9082	4
4P Mini-Fit Strain Relief	2047250004	8
8P Mini-Fit Strain Relief	2047250008	8
Mini-Fit Sockets	39000047	40
Shielded Power Cable	5202-FE	(depends on your needs)
Shielded Signal Cable	Belden 9540	(depends on your needs)

3.3.2: Digital Inputs

Description	P/N	Qty.
24P Mini-Fit Jr. Receptacle	39-01-2245	1
Mini-Fit Jr. Sockets	39-00-0039	24
Shielded Cable	(depends on your needs)	(depends on your needs)

3.3.3: Digital Outputs

Description	P/N	Qty.
10P Mini-Fit Jr. Receptacle	39-01-2105	1
Mini-Fit Jr. Sockets	39-00-0039	10
Shielded Cable	(depends on your needs)	(depends on your needs)

3.3.4: THC

Description	P/N	Qty.
8P Mini-Fit Jr. Receptacle	39-01-2085	1
Mini-Fit Jr. Sockets	39-00-0039	8
Shielded Cable	9944 060100	(depends on your needs)

4: Ether-Mach and S3CNC

If you are using S3CNC, please see the S3CNC manual for configuring your I/O. All I/O for the CSCNC controller can be setup within the S3CNC configurator.

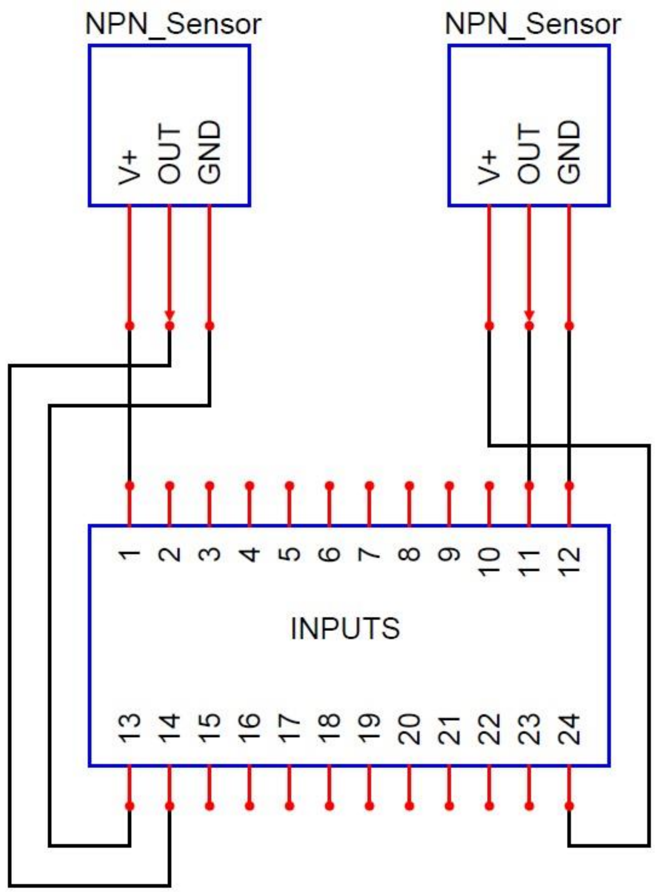
If you are using Mach3 or Mach4, you may reference the Ether-Mach plugin and manuals at ether-mach.com. The plugin automatically detects the firmware installed for the board you use. However if you do ever need to perform a firmware upgrade, it is worth noting that this controller contains the CS edition of the Ether-Mach board.

5: Wiring Examples

The following sections go over wiring to the general purpose inputs and outputs on the controller for sensors, switches, and loads commonly used on a CNC machine.

5.1: NPN Sensors

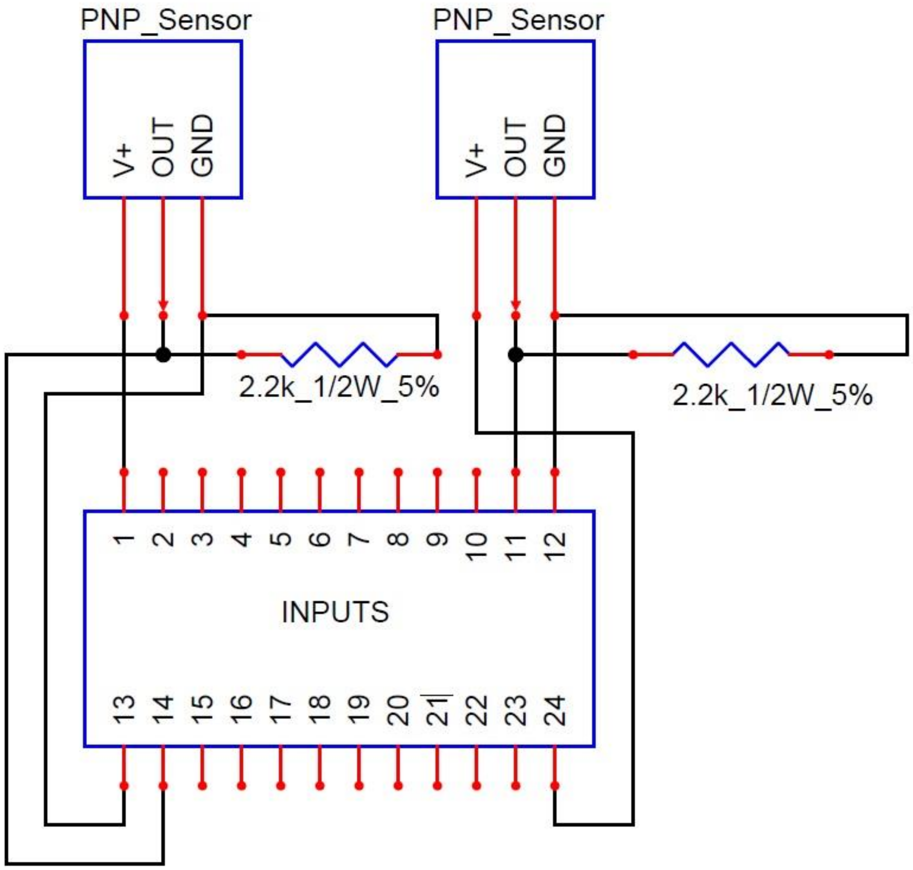
A common device that can be wired to a CNC controller is an NPN sensor. NPN sensors *sink* current, which is exactly what the inputs on the CSCNC controller is designed for. Wiring to the input connector is simple as shown below, where we have an NPN sensor connected to DI-8 (left) and DI-1 (right).



An NPN sensor can be either normally on or normally off. A normally off sensor is more common, and only conducts when the sensing element is activated. When the sensor is conducting, it is considered ON by the CSCNC controller. This turns on the DI-X LED on the outside of the CSCNC controller. It also registers as a logic HIGH to the control software via the motion control card (or parallel port). Conversely the input is OFF when the sensor is not conducting.

5.2: PNP Sensors

Another common device that can be wired to a CNC controller is a PNP sensor. PNP sensors *source* current, which the CSCNC controller is not inherently capable of doing. However, it is possible to accomplish with an external component, particularly a pull-down resistor (between 2 and 3 kOhm, ½ Watt, 5% Tolerance). Wiring to the input connector is simple as shown below, where we have a NPN sensor connected to DI-8 (left) and DI-1 (right).

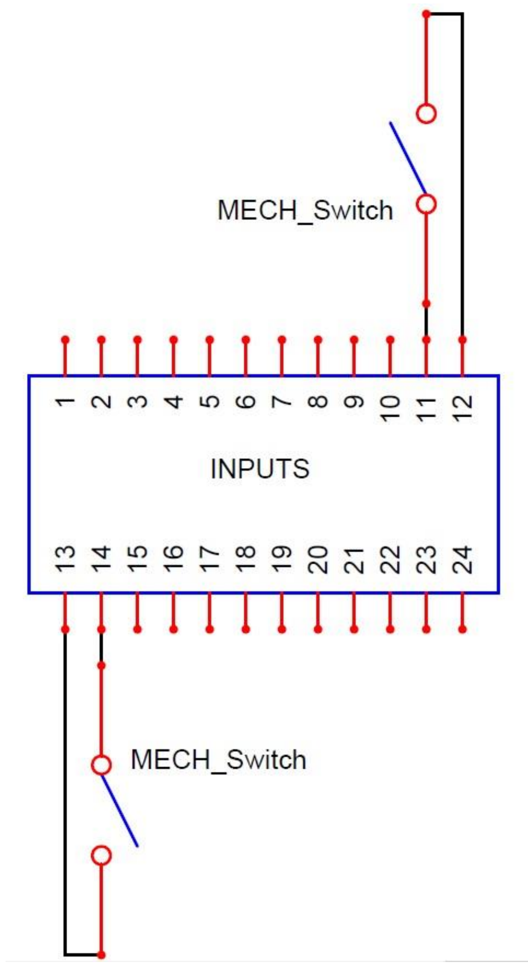


A PNP sensor can be either normally on or normally off. A normally off sensor is more common, and only conducts when the sensing element is activated. Because of the external circuitry, the logic is REVERSED from that of an NPN sensor.

When the sensor is conducting, it is considered OFF by the CSCNC controller. This turns OFF the DI-X LED on the outside of the CSCNC controller. It also registers as a logic LOW to the control software via the motion control card (or parallel port). Conversely the input is ON when the sensor is not conducting.

5.3: Mechanical Switches

The most common device that can be wired to a CNC controller is a mechanical switch. Mechanical switches are commonly used in homing and limit switches and other pushbuttons. Wiring to the input connector is simple as shown below, where we have a mechanical switch connected to DI-8 (left) and DI-1 (right).



A mechanical switch can be either normally open or normally closed. A normally open switch conducts when the switch is activated. When the switch is conducting (i.e. closed), it is considered ON by the CSCNC controller. This turns ON the DI-X LED on the outside of the CSCNC controller. It also registers as a logic HIGH to the control software via the motion control card (or parallel port). Conversely the input is OFF when the switch is not conducting (i.e. open).

5.4: An Aside on Normally Open Versus Normally Closed Switches

Typically normally closed switches are used when their presence is CRITICAL to operation (i.e. a limit switch that prevents the machine from resting on a hard stop). When a critical signal comes back to the CNC control software, we typically call that signal a *fault*. So consider that we cannot have the machine running if that *fault* signal active.

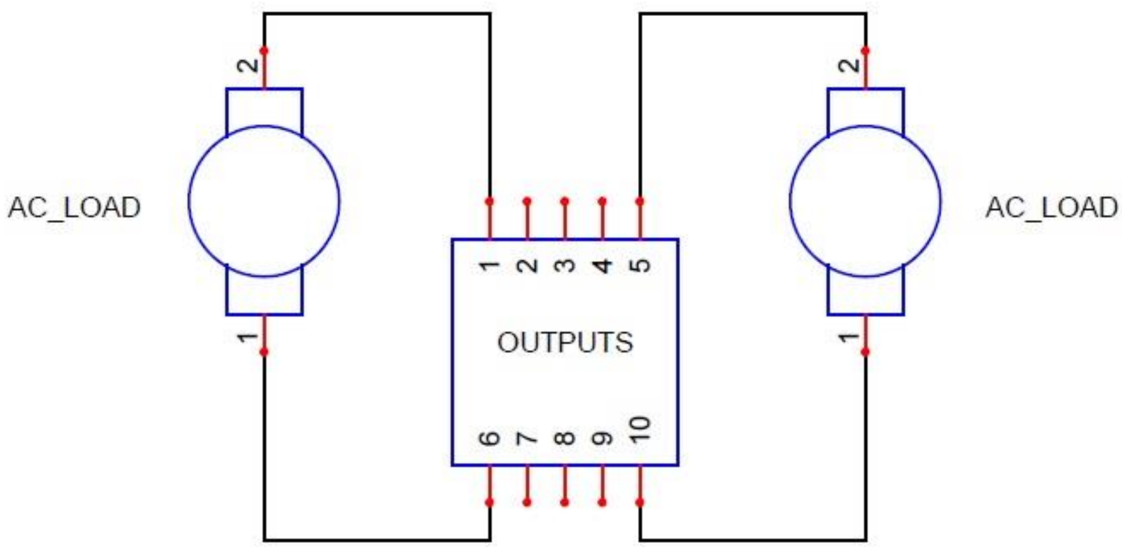
Why does this matter? A normally open and a normally closed switch can tell the controller if it has been activated. But, what happens if we are not able to detect that fault signal? What if the switch is disconnected?

For a normally closed switch, this is no problem. Recall that the switch opens when it is activated, triggering the *fault*. If you remove the switch from the controller, it is also an open circuit. With the input removed, the control software enters the same *fault* state. This is a good thing. We do not want operation to continue, without that critical switch.

With a normally open switch on the other hand, there is a problem. Recall, that the switch CLOSES when it is activated, triggering the *fault*. If you remove the switch from the controller, it is an open circuit. The input is now in a DIFFERENT state from the *fault* state. In fact, the disconnected state is the same as the *normal/inactive* state of the switch. Now we have no feedback at all that the switch is not working, and we could cause damage to the machine without knowing that the switch is disconnected or malfunctioning.

5.5: AC Outputs

The AC outputs, DO-1 and DO-3 connect directly to the output connector as shown below. When the output is activated, 120V is seen across the load and returns through the control box to neutral.

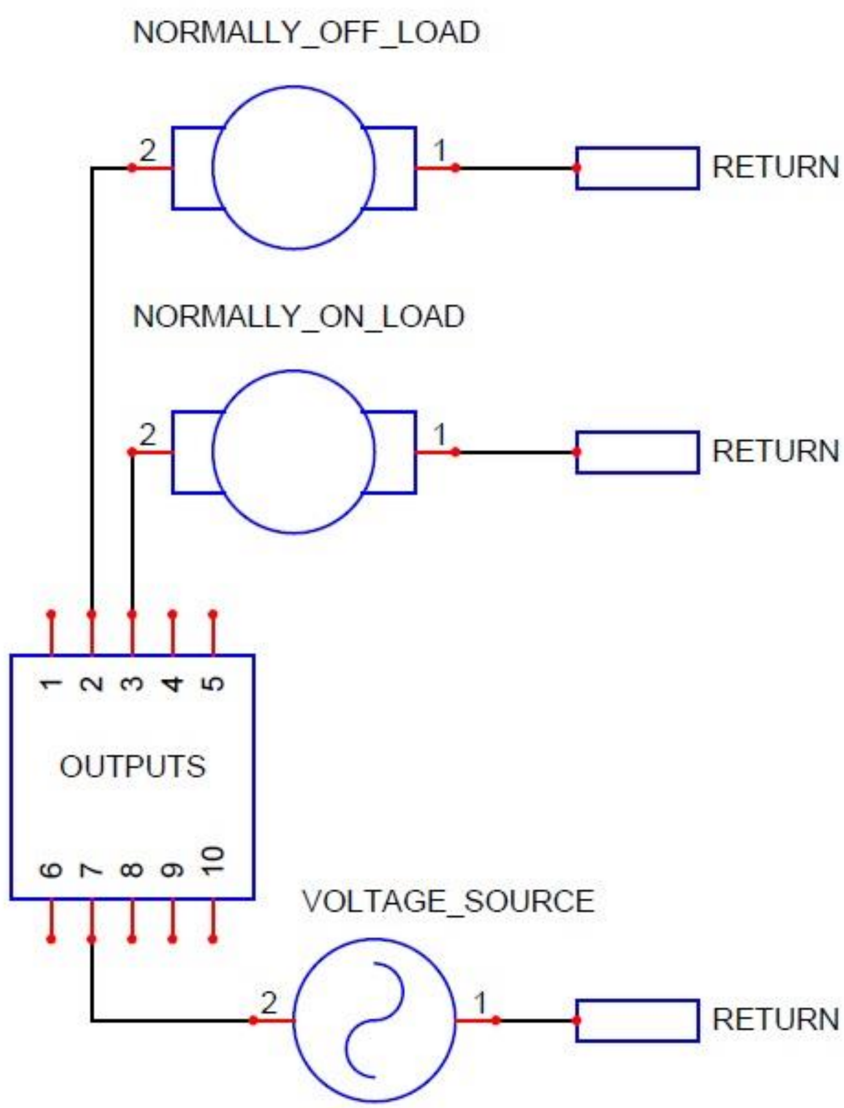


Recall that DO-1 is limited to 2A and DO-3 is limited to 5A.

5.6: Form C SPDT Outputs

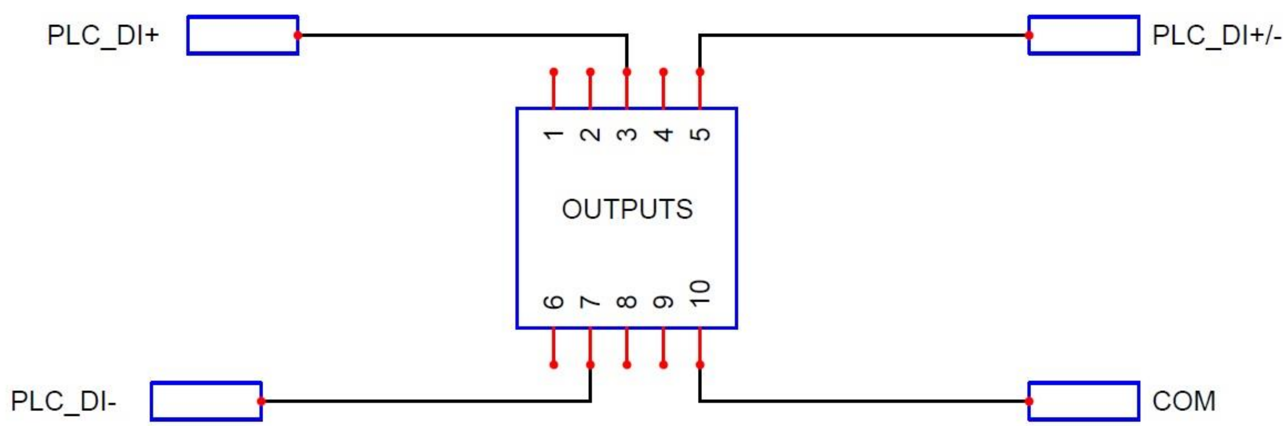
The Form C SPDT Outputs allow for custom wiring of outputs of different voltage levels, separate sources, and using both normally closed and normally open signals. It can also be used for inputs to other devices (i.e. Programmable Logic Controllers (PLCs), Variable Frequency Drives (VFDs), other machine tools, etc.).

Below is an example of using DO-2 to control two loads using an external voltage supply (can be AC or DC). One load is normally on; when DO-2 is off, the load is active if the external supply is powered. The other load is normally off; when DO-2 is on, the load is active if the external supply is powered.



Another example is shown below, where you can wire the contact closure to a PLC or VFD. Typically PLCs and VFDs have digital inputs (DI), where the positive and negative terminals are broken out individually, or all of the negative terminals are connected internally to a common point (COM) and the individual positive terminals are the inputs (the same can be said for all positive terminals connected to COM and individual negative).

The example below shows a PLC with a COM terminal and input using the normally open output of DO-4 of the CSCNC controller as well as a PLC with an individual positive and negative input using the normally closed output of DO-2 of the CSCNC controller.



6: Electrical Ratings

	Units	Min	Typ.	Max
AC Input				
Input Current	A	-	-	15
Motors				
Supply Voltage[1] @ 115 VAC In	V	59.1	60	62.6
Inputs				
“DI-X PWR” current draw (individual)	mA	-	-	200
“DI-X PWR” current draw (simultaneous total)	mA	-	-	800
“DI-X” sink current[2]	mA	5	10	10
“DI-X PWR” voltage	V	-	24	-
Outputs				
DO-1[3]	-	-	-	2A @ 120VAC
DO-2	-	-	-	5A @ 120VAC 4A @ 30VDC
DO-3[3]	-	-	-	5A @ 120VAC
DO-4	-	-	-	5A @ 120VAC 4A @ 30VDC

[1] 75 Volt option available by request
[2] Input impedance of 2.4 kOhms. 10mA drawn when input shorted to ground
[3] These outputs are connected internally to 120 VAC and have 5x20mm fuses sized for their ratings

7: Physical Dimensions

The CSCNC control box is 13” x 15” x 6” and weighs approximately 35 lbs. There are four 0.2” mounting holes on the bottom of the enclosure that have rubber feet placed in them. Those feet can be removed with hand tools and the enclosure can be mounted directly on a machine. A detailed drawing of the bottom is shown below (dimensions shown in inches).