Controller User Manual

Welcome

Thank you fellow maker for purchasing the Buildbotics CNC Controller. By doing so, you are supporting our company vision of providing a world-class Open-Source tool chain for CNC machining. This controller sits squarely at the center of that vision. We think you have made an excellent choice, and are confident that you will agree.

We are working closely with the Open-Source community to continually improve the controller and the Open-Source tools that make up the CNC tool chain. You are formally invited to join the Open-Source community and contribute in any way you choose.

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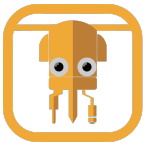

Examples of Buildbotics logo images

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Disclaimer

Last updated: August 30th, 2017

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Quick Start Guide

Following this quick start guide should get you up and running. Refer to the remainder of the manual for more complete and concise descriptions.

Things you need

Buildbotics CNC Controller

Stepper motors (NEMA 23 or smaller)

Buildbotics premade motor cables

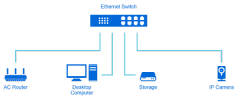
4 wire connectors for each motor. (16-22 AWG wire nuts work fine). You may want to solder final connections.

DC power supply that supplies between 12 and 36 Volts and a Buildbotics premade power supply cable.

Alternatively use a power adapter with a matching plug. The Meanwell GST280A24-C6P is an excellent choice.

USB gamepad (if you plan to do local jogging)

Ethernet cable



Ethernet local area network

A Computer on the same local network with a web browser installed.

Manual or datasheet for your stepper motor.

Connections

Connect motors

Refer to the motor manual or datasheet to identify the A+, A-, B+, and B- coil wires. Attach the motors to the Buildbotics premade cables using the following table.

Motor wire	Premade cable wire color
A+	Red
A-	Black
B+	Yellow
B-	Purple

Attach network cable

Plug the Ethernet network cable into the RJ-45,"**ENet**" connector on the back of the controller. Plug the other end into a jack on the local area network.

Connect gamepad (optional)

Plug the USB gamepad into a "**USB**" port on the back of the controller.

Connect power supply

Attach the red wires on the premade power cable to the V+ connections on the power supply and the black wires to V-. Plug the power cable into the power connector, "**12-36VDC**", on the

back of the controller. Alternatively, if you have a power adapter with a compatible connector (e.g. Meanwell GST280A-C6P), just plug it directly into the power connector.

Turn on the “Enable” switch

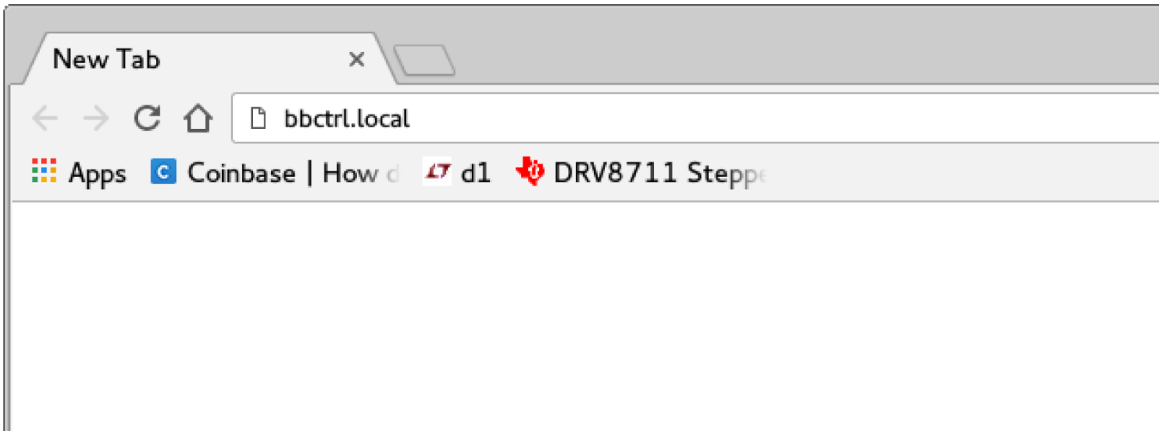
Plug in the power supply and turn on the “Enable” switch. The controller LCD screen will illuminate. When “Ready” appears in the upper left corner, it is ready to operate.

Jog motors (if gamepad attached)

Use the joysticks on the gamepad to move the motors.

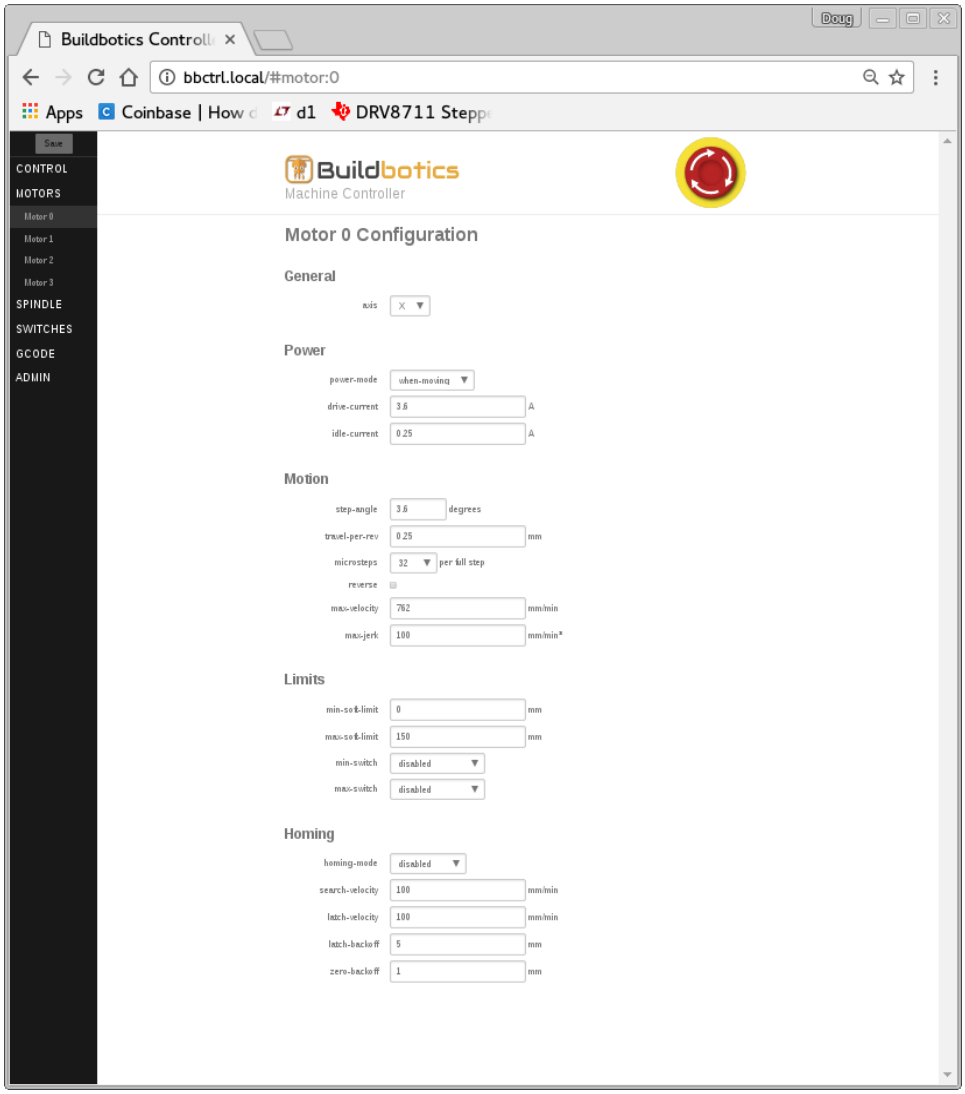
Connect via web browser

Open a browser on a computer that is connected to the same local network as the controller. Then, enter “bbctrl.local” in the address bar.



Configure motors

Access the configuration screen by selecting the motor label in the left panel of the web page. Motor 0 is associated with the port labeled “**X**” on the back of the controller. Motor 1 is labeled “**Y**”, motor 2 is labeled “**Z**”, and motor 3 is labeled “**A**”.



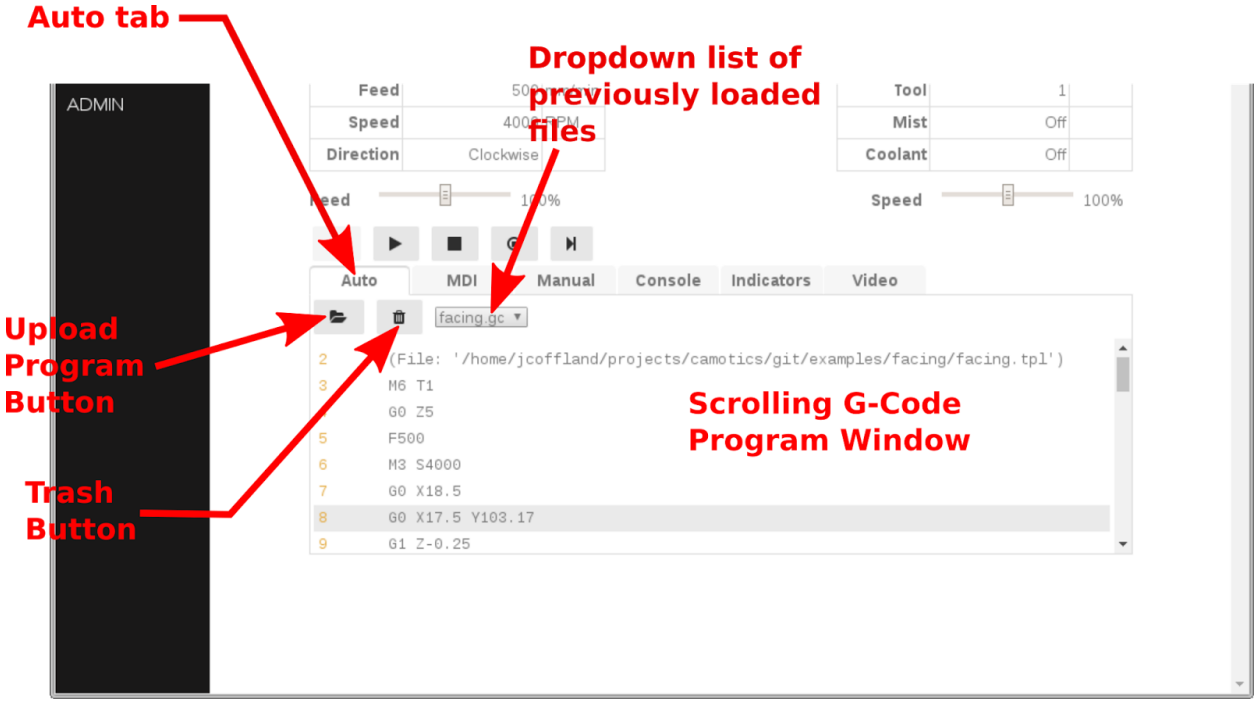
Do the following things at the configuration screen for each motor port:

- Assign the axis to the motor
- Set the “drive-current” to the full load current found in the motor manual.
- Set the “idle-current” to approximately 20% of that value.
- Set the “step-angle” to the value found in the motor manual.

The remaining values can be set and adjusted based on experimentation with your final machine.

Run test program

Select “Control” from the left panel on the web page to open the Control screen. Then use the “Auto” tab to load new G-Code programs, select existing G-Code programs, delete existing G-Code programs, and inspect G-Code programs. The G-Code program that is loaded into the Auto tab G-Code Program window will be executed when the “Play” button is clicked.



Overview

Buildbotics is committed to providing a CNC tool chain that is easy to use, affordable, and completely Open-Source. Key to this commitment is the Buildbotics CNC Controller.

The Buildbotics 4-Axis CNC Controller hardware and software are completely Open-Source. All basic features needed for machine homing and loading and executing G-Code files are included.

An important distinguishing feature of the Buildbotics 4-Axis CNC Controller is that it does not require a dedicated computer to run. Rather, it is a stand-alone device that acts as a web server. Users can configure and control it from a web browser that connects through an Ethernet port.

Another unique feature is the use of very inexpensive gamepads for local control. Just plug it into one of the USB ports and start jogging the machine on any axis.

Plug a webcam into a USB port and the Buildbotics Controller becomes a video server. You can now keep an eye on cutting operations while you watch the game in another room.

Limit switches, Z-axis probing, PWM spindle control, RS-485 spindle control, and e-stop interfaces are all made available through a DB25 connector on the back. We can provide an enclosed DB25 breakout board for easy access to these pins.

Two load switches, each capable of supplying up to 15 amps are provided as well. These can be used for powering heater beds, extruders, and whatever else you can think of.

Buildbotics can provide pre-made cables for connecting to the motors, power supply, and load switches. These cables really save time when connecting up a new machine. To make life even easier, the power connector is compatible with some standard power adapters.

Heat dissipation was carefully considered throughout the design. As a result, the controller electronics are inside a sleek enclosure with no fan. Cuttings won't get sucked into the controller even when operating right next to the CNC machine. Exposed electronics are a thing of the past.

The controller is integrated with CAMotics; a popular Open-Source CAM and CNC Simulator. CAMotics allows importing G-Code, DXF, or STL files. Alternatively, CAMotics allows writing cutting programs in Javascript. After simulating, CAMotics converts the output to G-Code and can connect directly to the Buildbotics controller and provide a real-time simulation as the machine is cutting.

The combination of CAMotics and Buildbotics provides the elusive Open-Source tool chain. This tool chain works great. There's still a lot of work to do. Please consider joining our growing list of Open-Source contributors.

Performance is critical for CNC Controllers. The Buildbotics CNC Controller is a powerhouse working on 12-36 Volts DC, supplying up to 6 amps on each motor, and generating over 200,000 steps per second on each axis. S-curve acceleration and deceleration eliminate machine movements caused by sudden starts and stops. These capabilities provide smooth and fast operation on nearly any machine running NEMA 17 or 23 stepper motors and many machines running NEMA 34 stepper motors.

Safety

Machine tools are inherently dangerous. Users must be trained on all hazards associated with the machine before use. Examples of hazards commonly associated with machine tools include:

- Electrical energy
- High noise
- Dust (often toxic)
- Flying material and parts
- Pinch points
- Sharp edges
- Rotating machinery
- Rapidly moving parts
- Fire
- Heat

These hazards are often complicated, and often exacerbated, by allowing computers to control them. The Buildbotics CNC Controller is a computer that controls machine tools. Users must be on constant guard against the possibility that the controller will cause the machine to do something that is unexpected. Users are responsible for mitigating these hazards prior to use of the Buildbotics CNC Controller.

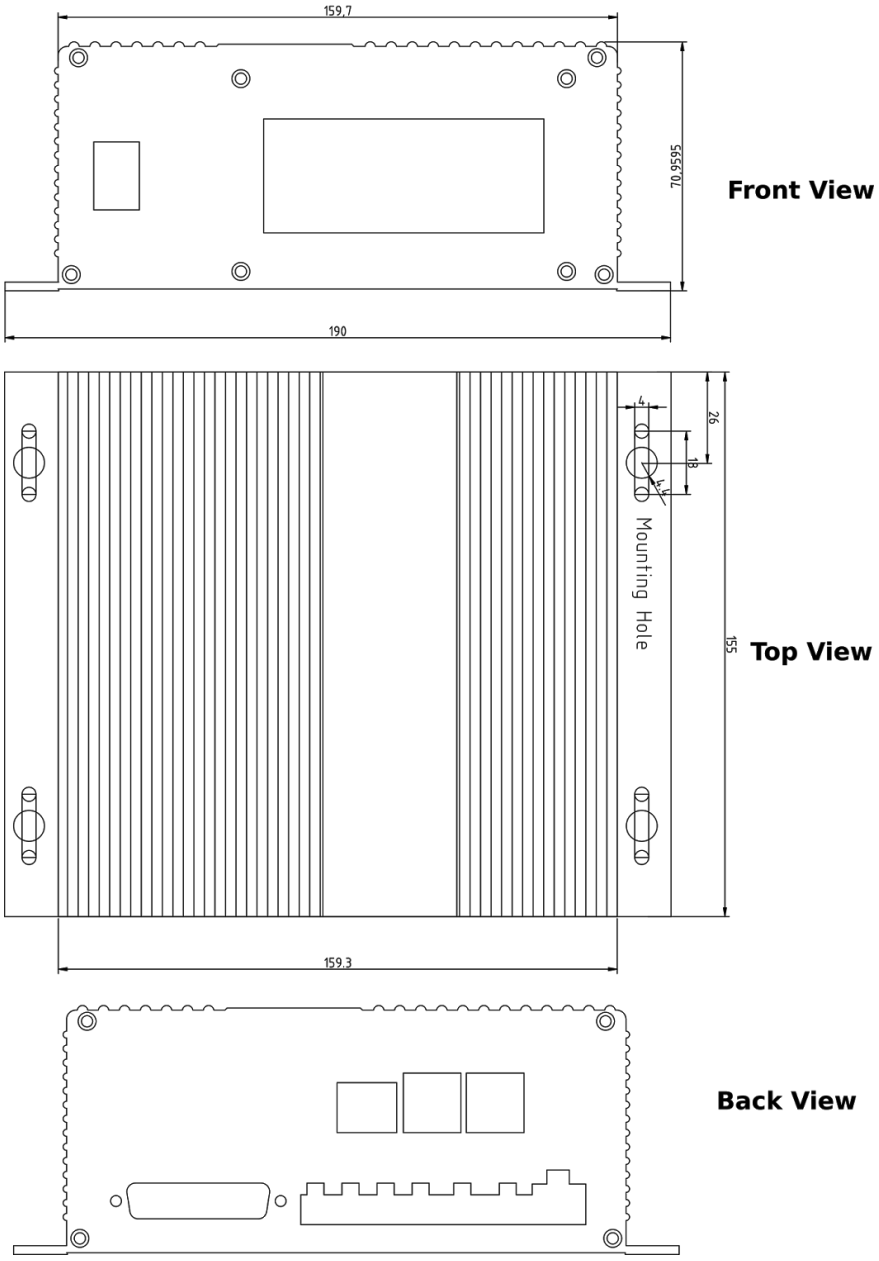
Buildbotics LLC is not responsible for any personal injuries or damages to property that may be caused by the use (or mis-use) of the Buildbotics CNC Controller. It is the user's responsibility to ensure all hazards, or potential hazards associated with the use of the Buildbotics CNC Controller are mitigated prior to use.

Furthermore, the Buildbotics CNC controller is not designed for use in life-safety or other critical applications. Buildbotics LLC does not authorize the use of the Buildbotics CNC Controller in applications where failures, unexpected behavior, mis-use, or even expected behavior could threaten life safety or cause damage to critical applications.

Users that find these restrictions and limitations unacceptable should contact the Buildbotics LLC customer service department for a refund prior to using or energizing the product.

Dimensions

All dimensions in millimeters



Physical and Electrical Specifications

	Minimum	Maximum	Units
Weight	1		Kilogram
Height	71		millimeters
Width at base	190		millimeters
Width	159		millimeters
Temperature	0	32	°C
Humidity	0	90	%
Input Voltage	12	36	Volts
Motor Current		6	Amps (peak) per motor coil.
Step rate		250,000	Steps per second
Microstepping	1	128	microsteps/step
Input Current		25	Amps
Load 1 Current		15	Amps
Load 2 Current		15	Amps
Total output current		25	Amps
Motor coil resistance	0.6		Ohm
Motor coil inductance	1	20	milli-Henries (mH)

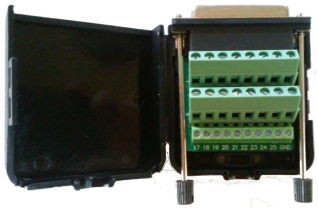
Unpacking

The Buildbotics CNC Controller package should include the following items:

- A Buildbotics CNC Controller

- A pre-made power cable

- A 25-pin breakout board



If any of these items are missing or appear to have been damaged during shipping, please contact our customer service department at customer-service@buildbotics.com .

Turning on the controller

Turn off the “Enable” switch, connect power, and then turn on the “Enable” switch. After enabling the controller, the LCD screen will immediately light up, then display “Controller booting Please wait…” after about 2 seconds, and then fully boot within approximately 17 seconds.

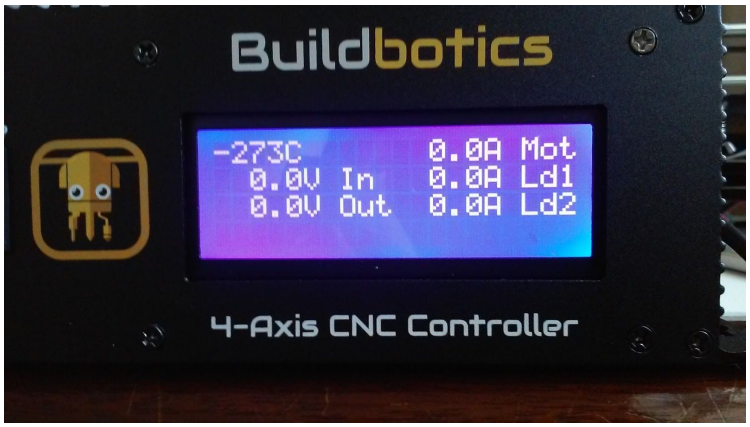
LCD Display

The LCD Display is located on the front panel of the Buildotics Controller and presents status information. The LCD display will immediately illuminate after power is connected and the Enable switch is switched to “Enable”. After enabling the controller, the LCD screen will immediately light up, then display “Controller booting Please wait…” after about 2 seconds, and then fully boot within approximately 17 seconds. Once this display is presented, the Buildbotics

Controller is ready to communicate via its web server and is ready to send commands to connected motors and peripherals.

LCD display presented when system initialization and booting has completed

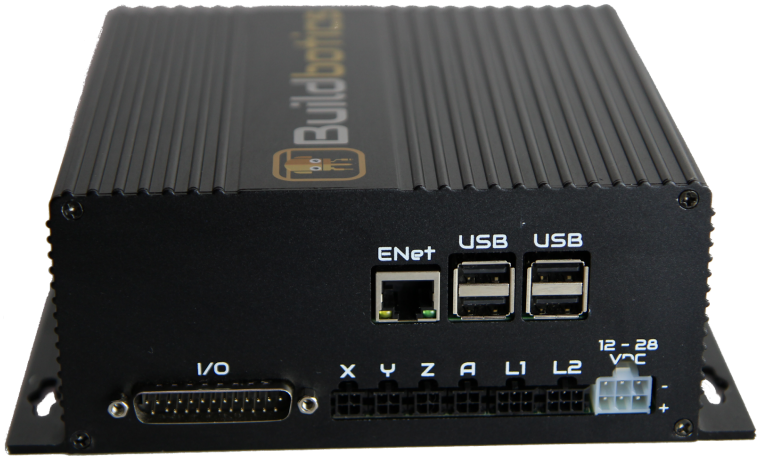
If a gamepad is plugged in, you can scroll through two additional screens by pressing on the left or right side of the screen selector button on the gamepad. One push to the right brings up a status screen that displays the temperature inside the enclosure, the input voltage (IN), the voltage sent to the motors (Out), the total motor current (Mot), the current sent on Load 1 (Ld1) and the current sent on Load 2 (Ld2).



Another push to the right brings up the network screen which shows the hostname and IP address that are assigned to this controller.

Connections

Connections to the Buildbotics Controller are made through the back panel, shown here.



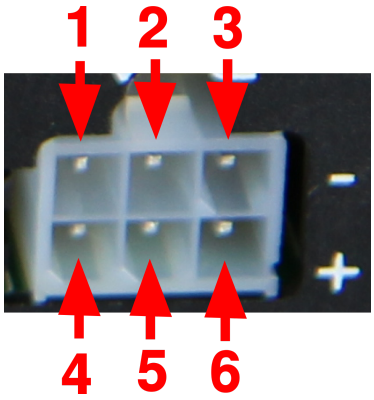
The connections include:

- A 100 mbps Ethernet connection (labeled ENet)
- 4 USB ports labeled (USB)
- A 25 pin I/O connector (labeled I/O)
- 4 motor driver ports (labeled X, Y, Z, and A)
- 2 load connectors (labeled L1 and L2)
- A DC Input power connector (labeled 12-36 VDC)

Power Supply

The Buildbotics Controller runs from a single power supply with voltage between 12 and 36 Volts DC.

The 12 to 36 volt power connector can accept voltages from 12 to 36 Volts DC and can sink up to 25 amps of DC current.



Power supply connector pin numbering

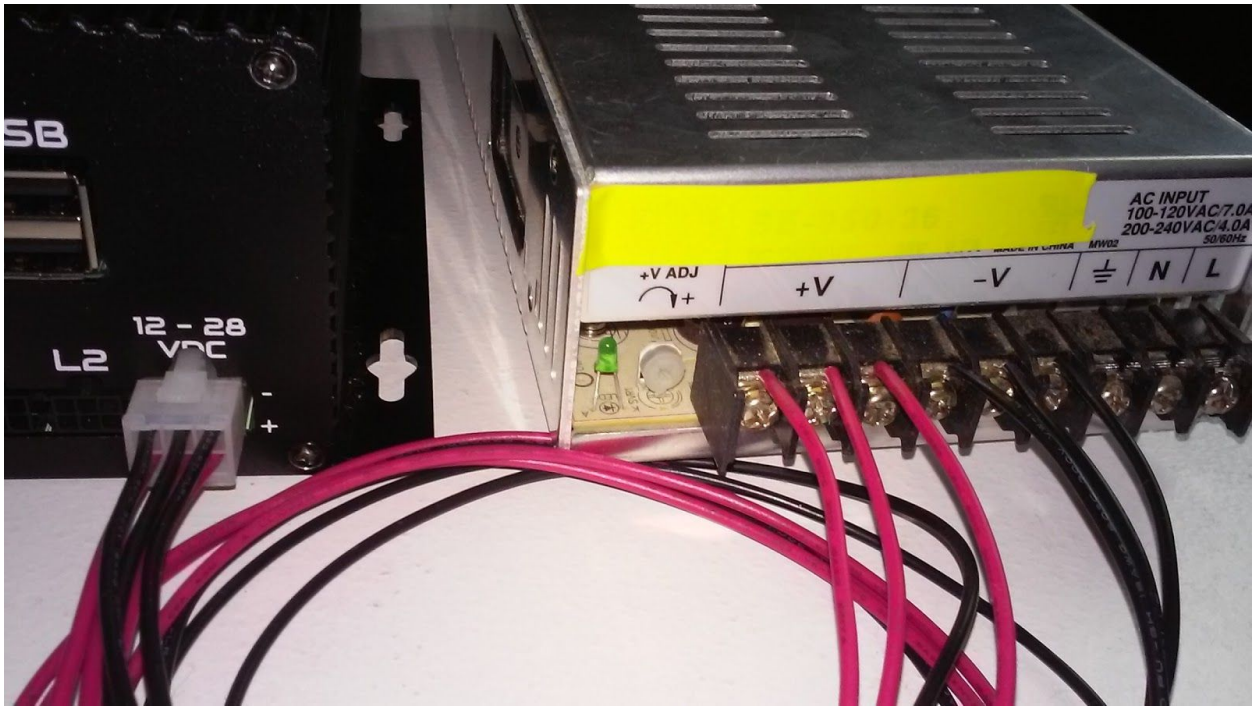
The power connector is 6-pin connector. Pins 1, 2, and 3 are on the top row and are connected to ground. Pins 4, 5, and 6 are on the bottom row and are connected to dc power between 12 and 36 volts.

The connector has reverse polarity protection built in. **However, connecting power and ground to the top row or to the bottom row simultaneously will provide a short circuit and a potentially violent failure.** The connector mates with a Molex 39-01-2060 that is equipped with Molex 39-00-0038 female pins. Buildbotics offers pre-made power supply cables that connect directly to the Power Supply Connector and can be wired directly to a DC power supply.

Buildbotics recommends using the pre-made power supply cable because attaching wires to the 36-00-0038 female pins and inserting the pins into the 39-01-2060 housing requires some practice. If you choose to build your own cable, make sure that the wire and pins used are big enough to handle the current requirements for your application. This cable is shipped with the Buildbotics controller. Additional cables can be ordered at www.buildbotics.com . The part number is 1001.

Pre-made power supply cable (Part Number 1001)

The following picture shows a typical power supply connected to the power supply connector using the Buildbotics supplied power supply cable (P/N 1001). Notice that the three bottom pins on the power supply connector are attached to the +V terminals and the three top pins on the power supply connector are attached to -V terminals on the DC power supply.



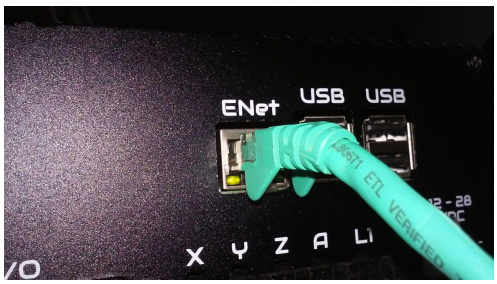
The Power Supply connector on the back of the Buildbotics Controller is compatible with the Mean Well GST280A12-C6P 12-Volt and the Mean Well GST280A24-C6P 24-Volt power supplies. The following picture shows a Mean Well GST280A24-C6P 24-Volt power supply connected to the Buildbotics Controller. If 24 Volts or 12 Volts with 280 watts meet the needs of your application, this is an excellent solution. The Mean Well GST280A24-C6P power supply can be purchased from a number of sources including Bravo Electronics (www.bravoelectro.com).

Buildbotics Controller connected to Mean Well GST280A24-C6P power supply

Finally, Buildbotics offers a 36V, 450 Watt power modular power adapter via our web site.

Ethernet

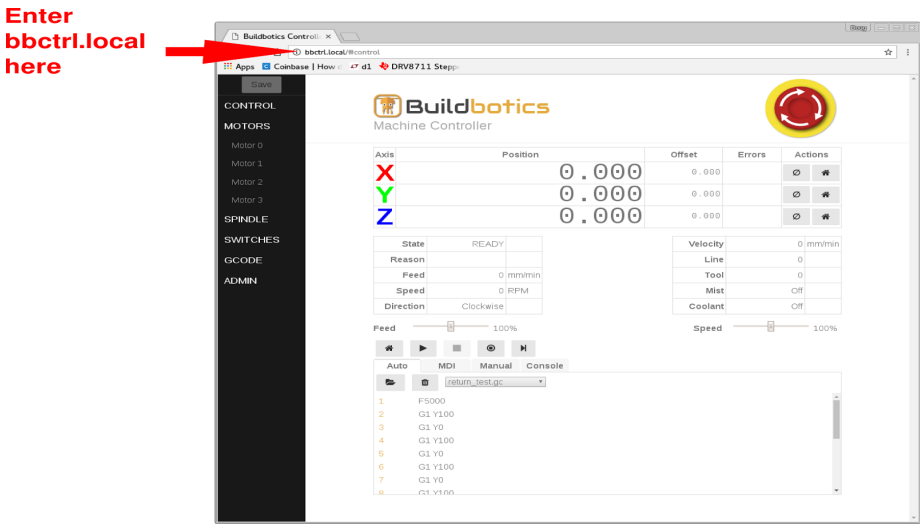
The Buildbotics controller connects to standard ethernet networks via the 10/100Mbps Ethernet RJ-45 port on the back panel. To attach the Buildbotics Controller to the local network, simply plug a standard CAT 5 or CAT 6 Ethernet cable into the jack labeled “Enet” on the back of the controller and plug the other end into a network port on an ethernet network router or switch.



Buildbotics Controller connected to Ethernet Cable

After the Buildbotics controller is attached to a network, it can be accessed from the local network by entering the hostname concatenated with .local (“hostname.local”) or the IP address of the Buildbotics Controller into the address bar on any standard browser. The default

hostname is “bbctrl”. So, new controllers can be accessed by putting “bbctrl.local” in the address bar of the browser.



Enter “hostname.local” (default “bbctrl.local”) or the IP address of the controller in the address bar of a standard browser to access the control screen on the Buildbotics Controller

Gamepad

A gamepad can be used to control movement on the X, Y, Z, and A axes and to scroll through screens on the controller. The gamepad attaches to the Buildbotics CNC Controller via any of the four USB ports on the back panel. Once attached, the gamepad can be used to move the CNC head in any direction at various speeds.

While many gamepads can work, Buildbotics has tested the Logitech F310.

Gamepad Controls

The following image shows the control positions on the Logitech F310 gamepad. The exact position of other gamepads will differ.

The following table describes the actions that can be achieved using the gamepad.

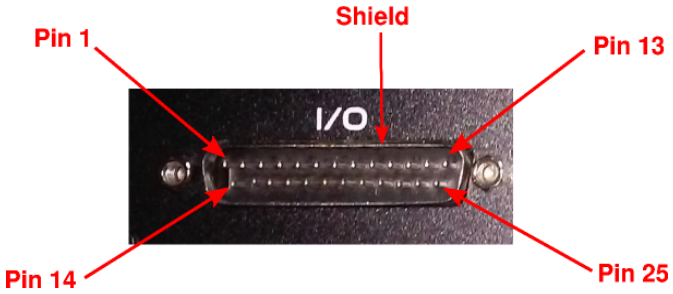
Movement	Buttons	Comments
Simultaneous X and Y movement	**X/Y stick**	Causes the CNC head will move in the direction that the X/Y stick is moved.
X movement only	**X/Y stick** and **Horizontal Lock** simultaneously	Restricts movement to X-axis only
Y movement only	**X/Y stick** and **Vertical Lock** simultaneously	Restricts movement to Y-axis only
Simultaneous A and Z movement	**Z/A stick**	Causes up and down and rotational movement.
Z movement only	**Z/A stick** and **Vertical Lock** simultaneously	Causes up and down movement only.
A movement only	**Z/A stick** and **Horizontal Lock** simultaneously	Causes rotational movement only.
Very slow speed	**Speed 1**	Set movement speed to 1/128th of full speed.
Slow speed	**Speed 2**	Set movement speed to 1/32nd of full speed.

Medium speed	**Speed 3**	Set movement speed to 1/4th of full speed.
Full speed	**Speed 4**	Set movement speed to full speed.
Scroll to next LCD display	Press right side of **Screen selector**	Moves to the next LCD display (Initial Display, Status Display, or Network Display)
Scroll to previous LCD display	Press left side of **Screen selector**	Moves to the previous LCD display (Initial Display, Status Display, or Network Display)

Note - There is a small switch on the back of the F310 gamepad that is labeled “X” and “D”. It must be switched to the “X” position.

DB25 I/O Port

The Buildbotics controller is equipped with a male DB25 connector for access to a number of I/O ports. The DB25 I/O Port is found on the back panel of the Buildbotics Controller.



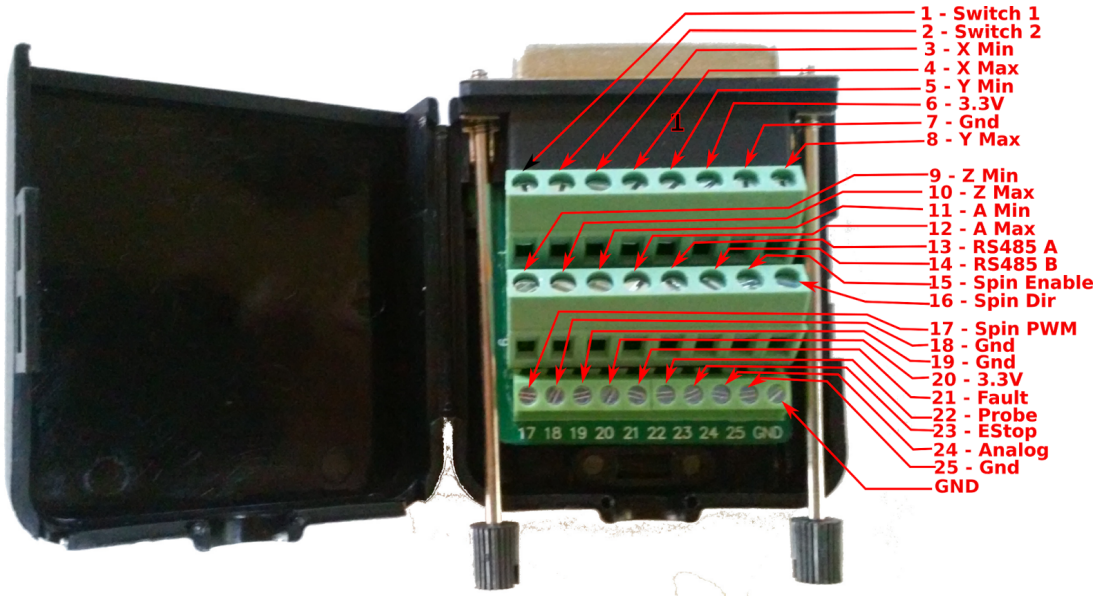
DB25 I/O Port

The following table describes each pin on the DB25 IP port.

Pin	Name	I/O	Possible values	Description
1	Switch 1	O	V_{OL}, V_{OH}	Logic level load switch output
2	Switch 2	O	V_{OL}, V_{OH}	Logic level load switch output.
3	Min X	I	Open, short	Limit switch
4	Max X	I	Open, short	Limit switch
5	Min Y	I	Open, short	Limit switch
6	+3.3V	O	$V_{3.3}$	3.3 volt source, 26.1 ohms source impedance

7	Gnd			
8	Max Y	I	Open, short	Limit switch
9	Min Z	I	Open, short	Limit switch
10	Max Z	I	Open, short	Limit switch
11	Min A	I	Open, short	Limit switch
12	Max A	I	Open, short	Limit switch
13	RS485 A	I/O		Spindle control (negative side of rs485 differential pair)
14	RS485 B	I/O		Spindle control (positive side of rs485 differential pair)
15	Spin Enable	O	V_{OL}, V_{OH}	Spindle enable
16	Spin Dir	O	V_{OL}, V_{OH}	Spindle direction
17	Spin PWM	O	V_{OL}, V_{OH}	Spindle speed control (pulse width modulated signal alternating between V_{OL} and V_{OH})
18	Analog 2			TBD
19	Gnd			
20	+3.3V	O	$V_{3.3}$	
21	Fault	O	V_{OL}, V_{OH}	High (V_{OH}) signal indicates a fault.
22	Probe	I	V_{OL}, V_{OH}	Tool height probe
23	EStop	I	V_{OL}, V_{OH}	Emergency stop switch
24	Analog	I	0-$V_{3.3}$	TBD
25	Gnd			
Shield	Gnd			

Typically, a female DB25 breakout board is used to interface with the DB25 I/O Port. The following image shows a DB25 breakout board that is used for interfacing with the Buildbotics Controller.



DB25 Breakout board

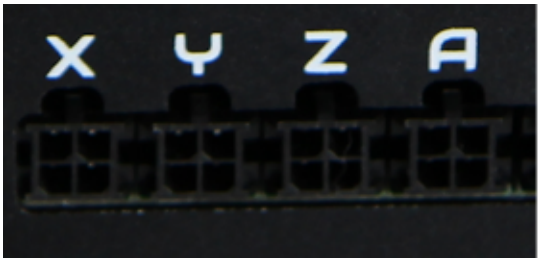
Motors

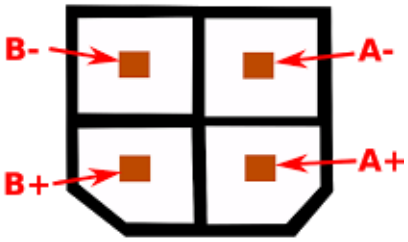
The Buildbotics Controller has four motor outputs, labeled X, Y, Z, and A. Each motor driver can drive a separate axis with a single motor. Alternatively, two motors can be connected in parallel on a single driver output.

The motor driver outputs can supply up to 6 amps peak current (3 amps average current) to each coil. Each motor has two coils. The current through each motor coil is an approximated sine wave and there is 90° phase shift between the two coil drivers on each motor output. Since the currents are out of phase, the peak total current to each motor output can be as high as 8.48 amps. Since the total current budget for the Buildbotics Controller is 25 amps, it is not recommended that all four motor driver outputs be configured for 6 amps. Users should refer to the data sheet for the motors being used and configure the motors for the current rating shown in the data sheet. See, the configuration section for more information on this subject.

The voltage output from each motor driver is a pulse width modulated (PWM) voltage with an amplitude equal to the input DC voltage being supplied to the Buildbotics Controller from the power supply.

The motor connectors are shown below. All four motor connectors are wired the same. The connectors mate with Amphenol 10127716-04LF connectors equipped with Amphenol 10127718-001LF female crimp pins.





When connecting motors:

- Connect the B+ pin (lower left) to the positive side of the B coil on the motor.
- Connect the B- pin (upper left) to the negative side of the B coil on the motor.
- Connect the A+ pin (lower right) to the positive side of the A coil on the motor.
- Connect the A- pin (upper right) to the negative side of the A coil on the motor.

These connections will cause your motor shafts to turn either clockwise or counterclockwise. If the motors are turning in the wrong direction, simply reverse either the A+/A- pair or the B+/B- pair. Do not reverse both pairs.

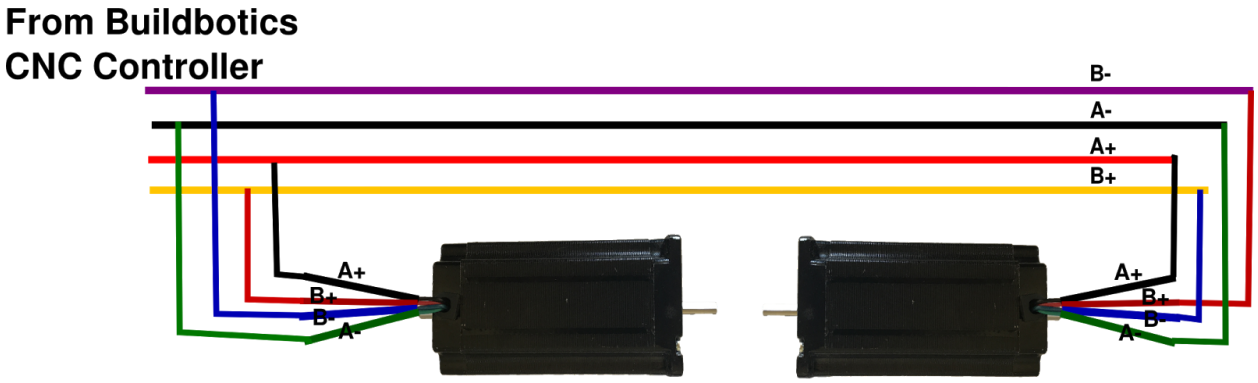
It takes some practice to properly attach the Amphenol 10127716-04LF connectors equipped with Amphenol 10127718-001LF female crimp pins to a cable. In order to avoid this difficulty, Buildbotics supplies motor cables with connectors that are compatible with the motor connectors in 5 foot, 10 foot, and 15 foot lengths. Buildbotics motor cables are wired as follows:

Conductor	Premade cable wire color
A+	Red
A-	Black
B+	Yellow
B-	Purple

Buildbotics pre-made motor cable

Some CNC machines have two motors driven from a single axis. In this case, it is recommended that two motors be wired in parallel. In most cases, the two motors will face one-another and must turn in opposite directions.

If the motors must turn in opposite directions, then one of the motors will have either the A+/A- pair reversed or the B+/B- pair reversed (but not both). Notice that the following image shows the B+/B- pair reversed on the motor on the right which causes the motors to turn in opposite directions.



Additional information regarding wiring to the various types of stepper motors is provided in Appendix III - Stepper Motor Wiring

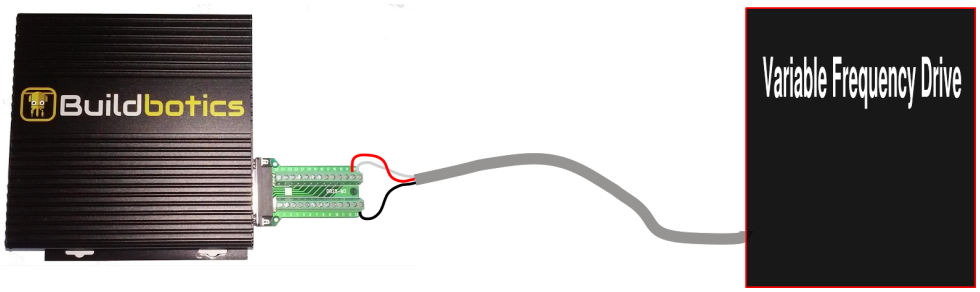
Spindle

Buildbotics Controller Spindle Configuration

The Buildbotics Controller can control a spindle through a PWM interface. Additionally, it can control a Huanyang VFD through an RS-485 interface, which in turn controls the spindle. In most cases, the spindles require their own power source while the Buildbotics Controller only provides the control signals for starting, stopping, and adjusting the speed of the spindle.

RS-485

The Buildbotics Controller provides an RS-485 interface for driving spindles.



RS485 Spindle Connection

Use the following procedure to connect a VFD to the Buildbotics Controller:

1. Disconnect power from the VFD controller, the spindle, and the Buildbotics Controller
2. Connect the plus side of the RS485 pair to pin 13 on the DB25 breakout board
3. Connect the minus side of the RS485 pair to pin 14 on the DB25 breakout board
4. Shielded twisted pair cable is recommended for the connection from the Buildbotics Controller. If you use shielded twisted pair cable, connect the shield to ground on the VFD and to a GND pin on the 25-pin breakout board.
5. Connect the DB25 breakout board to the back of the Controller
6. Reconnect power.

The Buildbotics Controller has been tested and shown to work with the Huanyang HY01D523 Variable Frequency Drive. Please refer to Appendix I for instructions on how to connect and configure the HY01D523 VFD to operate with the Buildbotics Controller.

PWM

Use the following procedure to connect to a PWM spindle controller:

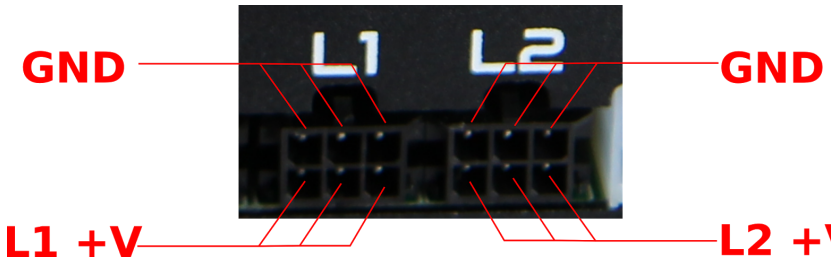
1. Disconnect power from the spindle, the spindle controller, the spindle power supply, and the Buildbotics Controller.
2. Connect Spin Enable pin (15) on the DB25 breakout board to the Enable terminal on the spindle controller.
3. Connect the Spin Dir pin (16) on the DB25 breakout board to the Direction terminal on the spindle controller.

4. Connect the Spin PWM pin (17) on the DB25 breakout board to the PWM terminal on the spindle controller.
5. Connect one of the Gnd pins (7, 19, or 25) on the DB25 breakout board to the Ground terminal on the spindle controller.
6. Connect the spindle controller to its power supply. (Refer to the manual for the spindle controller and the spindle power supply.)
7. Connect the spindle controller to the spindle. (Refer to the manuals for the spindle and the spindle controller.)
8. Connect the DB25 breakout board to the DB25 I/O Port on the Buildbotics Controller.
9. Connect power to the Buildbotics Controller and the Spindle power supply.

The Buildbotics Controller has been tested and shown to work with the 400 Watt spindle and controller kit. Please refer to Appendix II for instructions on how to connect and configure the spindle and controller kit to operate with the Buildbotics Controller.

Load Connectors

The Buildbotics CNC Controller is able to power miscellaneous DC loads through the L1 and L2 connectors. L1 and L2 are Amphenol Minitek 10127720-06LF connectors and mate with Amphenol 10127716 6-position connectors equipped with 10127718-001LF crimp pins.



The top three pins on L1 and L2 are connected to ground. The bottom three pins of L1 supply a voltage equal to the controller input voltage, as do the bottom three pins of L2. Note, the voltages on L1 and L2 are supplied independently.

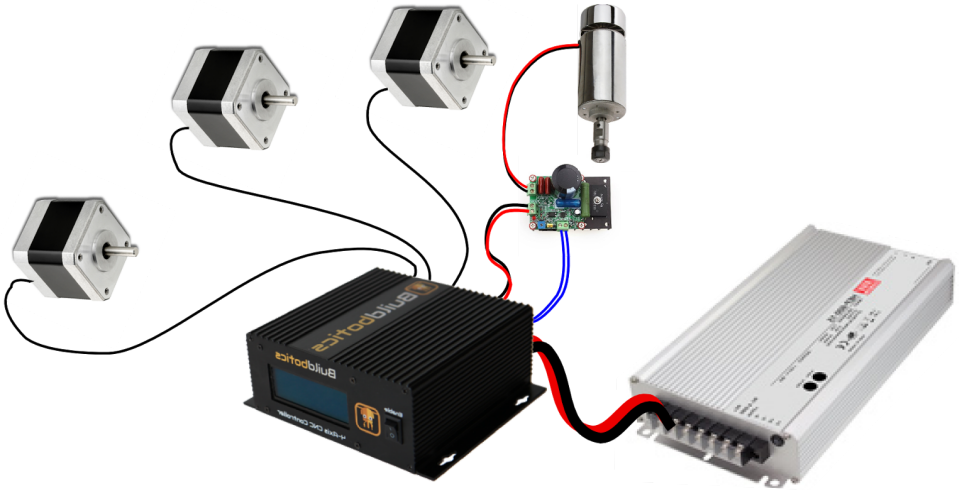
Each of L1 and L2 are capable of supplying up to 15 amps. However the total power budget for the Buildbotics controller is 25 amps, so L1 and L2 cannot both supply 15 amps at the same time.

It takes some practice to properly attach the Amphenol 101277120-06F connectors equipped with Amphenol 10127718-001LF female crimp pins to a cable. In order to avoid this difficulty, Buildbotics supplies load cables with connectors that are compatible with the motor connectors in 5 foot, 10 foot, and 15 foot lengths. Buildbotics load cables are wired as follows:

- Red, Blue, and Grey -> +V (bottom three pins)
- Yellow, Orange, and Green -> GND (top three pins)

Power budget

The total current supplied to all motors and loads cannot exceed 25 amps. Additionally, the current rating of the power supply which is likely to be less than 25 amps. Be cognizant of the total current budget of the Buildbotics Controller, the current rating of the input power supply, and the voltage and power requirements of the loads and stepper motors when deciding whether to drive a load from a Load port on the Buildbotics Controller.



Power consumption budget example

Example - A Buildbotics Controller is powered by a Mean Well HEP-600-36 power supply, which can supply 600 watts (16.7 Amps) at 36 Volts DC. The spindle shown is being driven from L1 and consumes 400 watts, or 11.1 Amps. That leaves 5.6 amps total for the three motors. These particular motors are rated at 1.8 amps peak in each coil, so the total peak current serving the motors is 7.6 Amps. 11.1 + 7.6 = 18.8 amps which exceeds the limit of the power supply. A more conservative design would make one or more of the following changes:

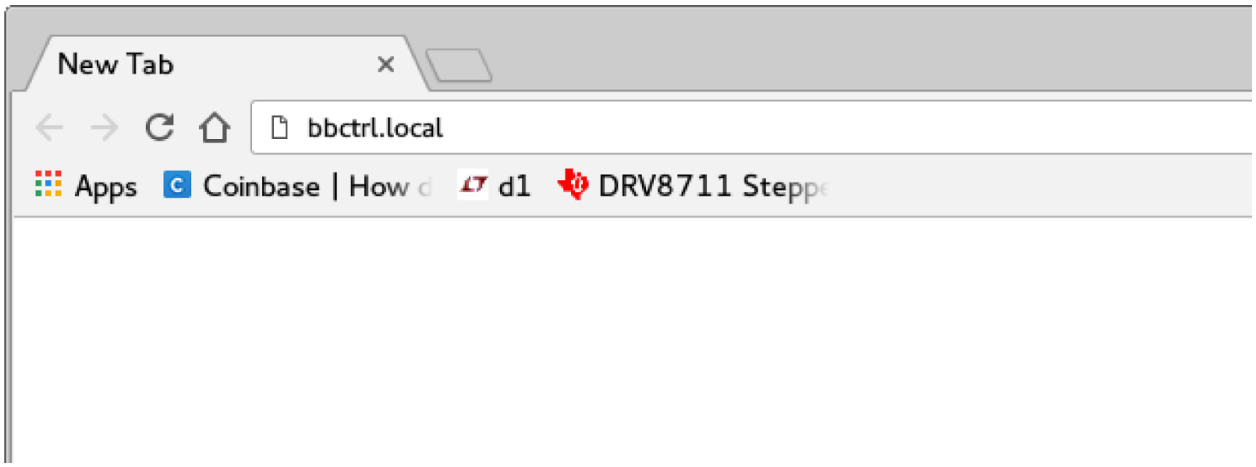
- Increase the power supply size.
- Use smaller motors.
- Go to a smaller spindle
- Power the spindle from another source

Web Interface

The Buildbotics Controller contains a built-in web server. It can be accessed, configured, and controlled from a standard browser.

Connecting to the Buildbotics Controller

The Buildbotics Controller can be accessed from any computer on the same local subnet that is running a standard web browser. If the Buildbotics Controller is attached to the same local subnet as your computer and it is the only Buildbotics Controller on that subnet, simply open a web browser and enter "*hostname*.local" in the address bar where *hostname* is the name of the Buildbotics Controller. The default name is "bbctrl", so you can access a new Buildbotics Controller by entering "bbctrl.local" in the browser address bar.



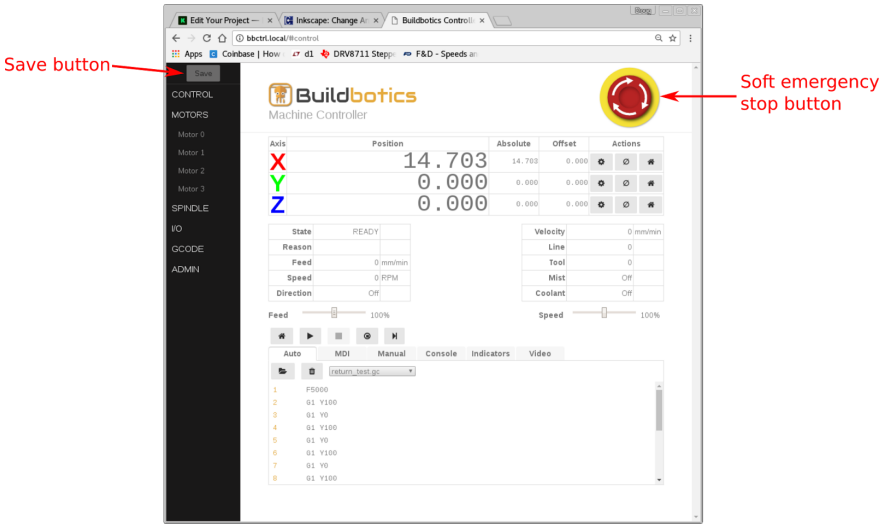
Alternatively, enter the IP address for the Buildbotics Controller into the address bar of the browser. The IP address can be acquired by scrolling to the network screen on the LCD display using a Gamepad.

Accessing the Buildbotics Controller from outside the local subnet is not supported.

Users will be presented with the web page shown below after entering *hostname.*local (or the Buildbotics Controller IP address) into the address bar.

Notice that all pages have the "Save" button in the upper left corner and the "Emergency Stop" button the upper right.

Whenever any configuration change is made, the "Save" button will turn from grey to green. You must click the green "Save" button before changes are actually sent to the Buildbotics Controller and saved.



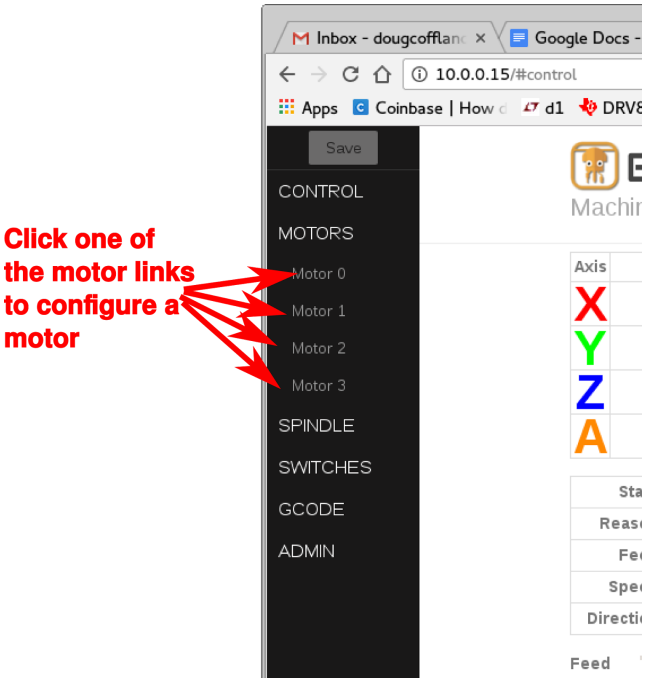
Clicking the emergency stop button will stop all motors from turning and disable the spindle (if the spindle is controlled by the Buildbotics Controller). Once clicked, the outer ring on the emergency stop button will turn from solid yellow to blinking between yellow and orange. The Buildbotics Controller will not cause any movement of the motors or re-enable the spindle until the emergency stop button is released by clicking it again. When clicked again, the outer ring will change from blinking between yellow and orange to solid yellow and motion can resume.

Note that the National Fire Protection Agency (NFPA 79) requires that the class of emergency stop button be determined through a risk assessment. The soft estop button on these web pages cannot be used as a safety protection. If your risk assessment requires an emergency stop button be installed for safety purposes, then Buildbotics LLC recommends installing a listed hardware Emergency Stop button in line with system power.

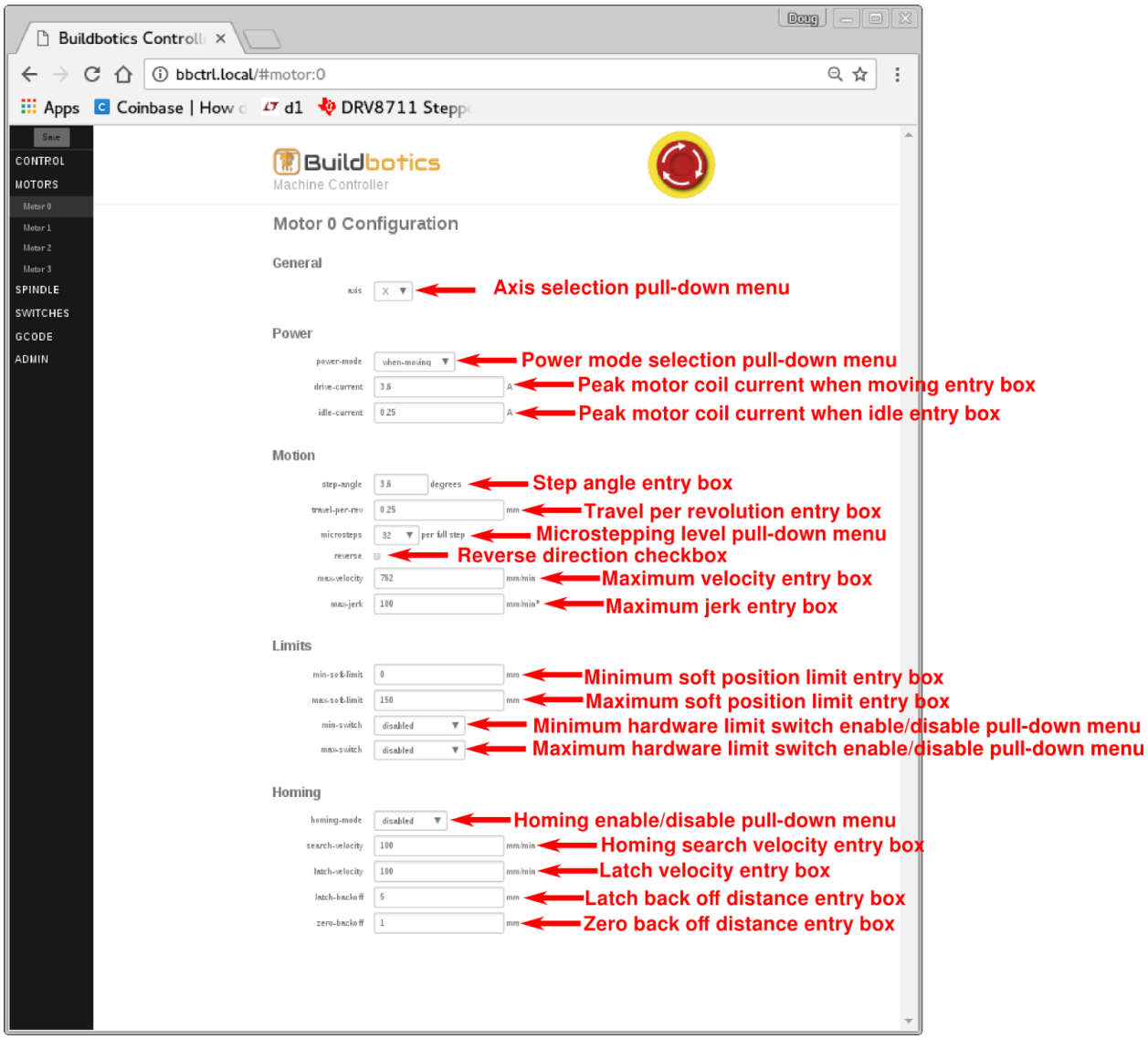
Configuring the Buildbotics Controller

Configuring Motor Drivers

The Buildbotics Controller has four motor driver ports, labeled X, Y, Z, and A. These correspond to Motor 0, 1, 2, and 3 respectively. Click the motor driver port listed in the left hand pane to access the configuration screen for that port.



After clicking a motor link as shown, the motor driver configuration screen will open. The screenshot shown below is for configuring motor driver 0 (the one labeled X on the back panel). All four motor configuration screens are the same.



Even though the back panel motor ports are labeled X, Y, Z, and A, any axis can be assigned to any port. The axis selection pull-down menu allows selecting the axis that will be assigned to this motor driver port. Available selections include X, Y, Z, A, B, and C.

The “Power” section allows configuring the amount of current that will flow to the motors.

The power-mode pull-down menu allows specifying when current is applied to the motors. Selections available include:

- “disabled” - Current will not be supplied on this motor driver port.
- “always on” - Current will always be supplied on this motor driver port.

- “In-cycle” - This motor driver is enabled whenever any motor is moving.“
- when-moving” - Current will only be supplied on this motor when it is moving. This selection can be used to save power and reduce heat in the motor and driver.

The drive-current entry box allows setting the maximum peak current in amps that is supplied to each motor coil. Users should look up this value on the motor data sheet. When connecting two motors in parallel on a single port, the maximum current should be set to double that shown in the motor data sheet.

The Idle-current entry allows specifying the holding current in amps that is supplied when the motor is not moving. In many cases, this can be set to zero. Some systems may require a value that is greater than zero to ensure that the motor holds its position when not moving.

The “Motion” section allows configuring the speed and direction of the motor.

The step-angle entry box allows specifying the step angle in degrees that the motor turns with each full motor step. Users should consult the motor data sheet to determine this value. Most modern stepper motors have 200 steps per revolution, or 1.8° per step. If this is the case, enter 1.8 in the step angle entry box.

The travel-per-revolution entry box tells the controller how far the axis will move in millimeters with each revolution of the motor. This is a function of the gear ratio between the motor and the pinion belt, lead screw, or ball screw used to move the axis.

> *Example - An axis having a ball screw with 2.5 millimeters per turn that is driven by a 10-to-1 gear reduction would move 2.5 x .1 = 0.25 millimeters per turn.*
>
> *Example - An axis that is driven by a belt and pinion system where the belt pitch is 3 millimeters per tooth and the motor pulley has 20 teeth would move 60 millimeters per revolution.*
>
> *Example - An axis that uses an 8 millimeter pitch lead screw that is directly driven by the stepper motor would travel 8 millimeters for each revolution.*

The microsteps pull-down menu allows specifying the level of microstepping to be used for this axis. Microstepping allows smoother and more accurate motion by subdividing motor steps. For instance, setting microstepping to 32 subdivides each motor step into 32 microsteps. Selections available for microsteps per step include 1, 2, 4, 8, 16, 32, 64, and 128. The highest levels of microstepping may cause difficulty at high motor revolutions per minute (RPM). In most cases 32 seems to be a good balance.

Checking the reverse check box causes the axis to move in the opposite direction.

The maximum-velocity entry box allows setting the maximum speed at which the axis will move in millimeters per minute. Typically, users will want this value to be as high as possible without experiencing motor stalls.

A good practice is to experiment with your machine to determine the maximum velocity for each axis, and then set the maximum velocity to about 80% of that value for the actual use of the machine. Note, this is the speed at which rapid moves will occur on your machine. Cutting feed rates are set in G-code and will typically be less than the maximum velocity set in the maximum velocity entry box. The axis will not move at a rate greater than this value even if the feed rate set in G-Code is greater than the value set here.

The maximum-jerk entry box allows setting the amount of jerk that the axis will experience when changing from one velocity to another. The Buildbotics Controller provides smooth S-curve acceleration and this value sets the rate of change of acceleration. Higher jerk values will cause acceleration to change more abruptly and potentially cause the axis to jerk at the beginning and end of acceleration periods. The jerk entry box allows users to maximize acceleration rates while minimizing jerks.

The “Limits” section allows configuring hard and soft limits for the axis being configured.

The min-soft-limit entry box sets the minimum absolute position in millimeters for the axis. The axis will not be allowed to travel below this position.

The max-soft-limit entry box sets the maximum absolute position in millimeters for the axis. The axis will not be allowed to travel beyond this position.

The min-switch pull-down menu determines the type of physical limit switch that is used for signaling that the axis has reached its minimum position. The choices are:

- disabled - no limit switch is being used
- normally-open - The switch closes when the minimum position is reached.
- normally-closed - The switch opens when the minimum position is reached.

The max-switch pull-down menu determines the type of physical limit switch that is used for signaling that the axis has reached its maximum position. The choices are:

- disabled - no limit switch is being used
- normally-open - The switch closes when the maximum position is reached.
- normally-closed - The switch opens when the maximum position is reached.

The “Homing” section allows configuring the homing procedure for the axis.

The homing-mode sets the method used for homing the axis. The choices are:

- manual - the axis is manually homed by the user. If manual homing is selected, the search-velocity, latch-velocity, latch-backoff, and zero-backoff fields are not used.
- search-min - The axis will travel towards its minimum position until the limit switch at the minimum position is activated. This option requires that a switch is installed at the minimum position and configured in the min-switch field for the axis.
- search-max - The axis will travel towards its maximum position until the limit switch at the maximum position is activated. This option requires that a switch is installed at the maximum position and configured in the max-switch field for the axis.

The search-velocity field sets the velocity at which the axis will travel when searching for the limit switch in millimeters/minute. This value should be set to a rate slow enough to ensure that the axis can decelerate and stop within the travel distance of the switch lever or plunger.

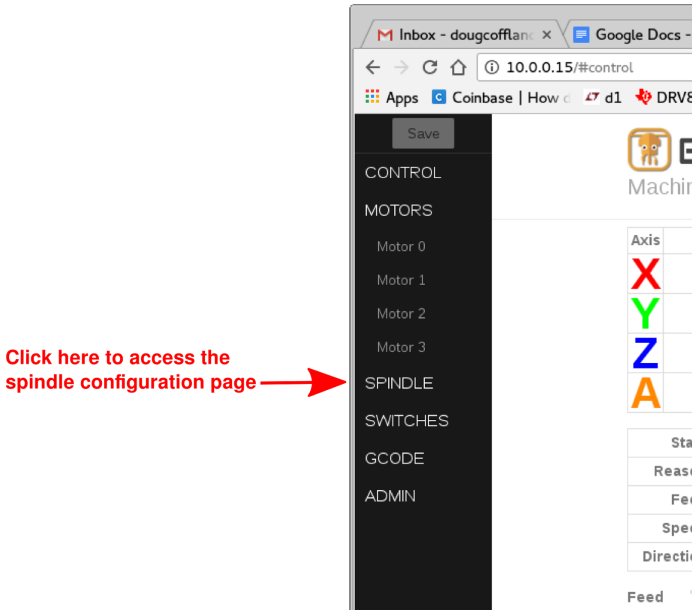
The latch-velocity is the velocity that the axis will travel when backing away from the switch.

The latch-backoff is the distance that the axis will move away from the switch to ensure that it deactivates.

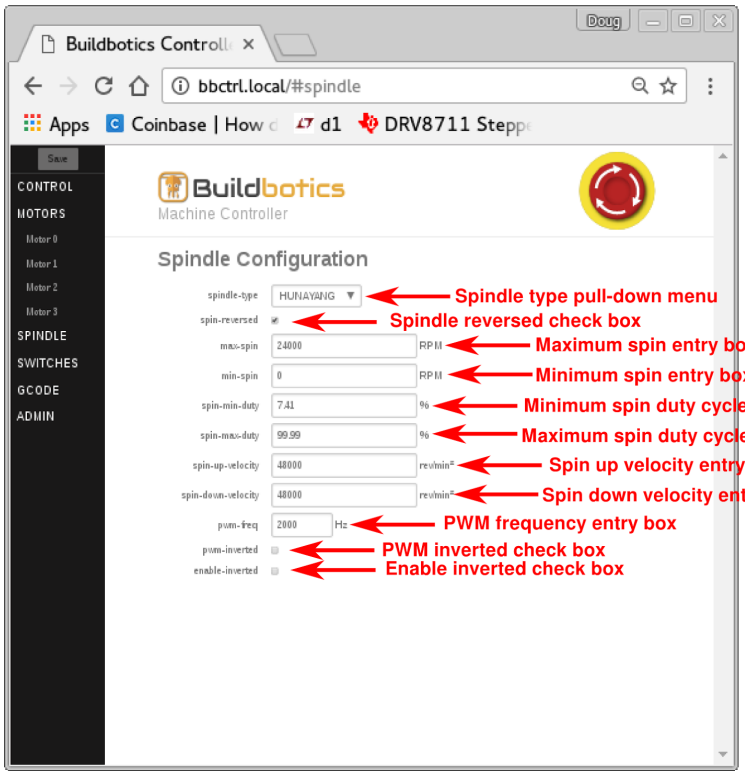
The zero-backoff is the additional distance that the axis will move away from the switch before setting the axis coordinate to zero.

Configuring the Spindle

Click the “SPINDLE” link in the left hand pane to access the Spindle configuration page.



After clicking the “SPINDLE” link, the spindle configuration screen opens as shown below.



The Buildbotics Controller offers a lot of flexibility for connecting to a variety of different spindles. In most cases, only a subset of the configuration fields shown will actually be used to control any specific spindle. For instance, Huanyang Variable Frequency Drives (VFD’s) are

completely controlled through the RS-485 interface. As such, users need only configure the spindle-type pull-down menu to configure the Buildbotics Controller for controlling spindles through Huanyang VFD's.

The spindle type pull-down menu allows specifying whether spindle-type is a Huanyang VFD or a Pulse Width Modulated (PWM) controlled spindle. If the Huanyang option is selected, none of the remaining fields affect the spindle operation.

The spindle-reversed checkbox causes the spindle to turn in the opposite direction.

The remaining fields on the Spindle configuration page have no effect if the Huanyang spindle-type is selected.

The max-spin entry field sets the velocity in revolutions per minute at which the spindle will turn when the maximum PWM duty cycle is set by the spindle controller. This value can either be acquired from the spindle and controller documentation or from measurements.

The min-spin entry field sets the velocity in revolutions per minute at which the spindle will turn when the minimum PWM duty cycle is set by the spindle controller. This value can either be acquired from the spindle and controller documentation or from measurements.
The min-spin-duty field sets the minimum PWM duty cycle in percent that will be sent from the spindle controller to the spindle.

The max-spin-duty field sets the maximum PWM duty cycle in percent that will be sent from the spindle controller to the spindle.

The spin-up-velocity field sets the rate at which the spindle will accelerate in revolutions per minute squared.

The spin-down-velocity field sets the rate at which the spindle will decelerate in revolutions per minute squared.

The pwm-freq field sets the PWM pulse rate in PWM pulses per second (or Hertz).

The pwm-inverted checkbox causes the PWM signal to invert when checked.

The tool-enable-mode pull down menu selects the action to be taken on the enable pin to cause the spindle to come on. The following options are provided:

- disabled - the spindle is disabled
- lo-hi - the spindle is enabled by a transition from low to high on the enable output pin

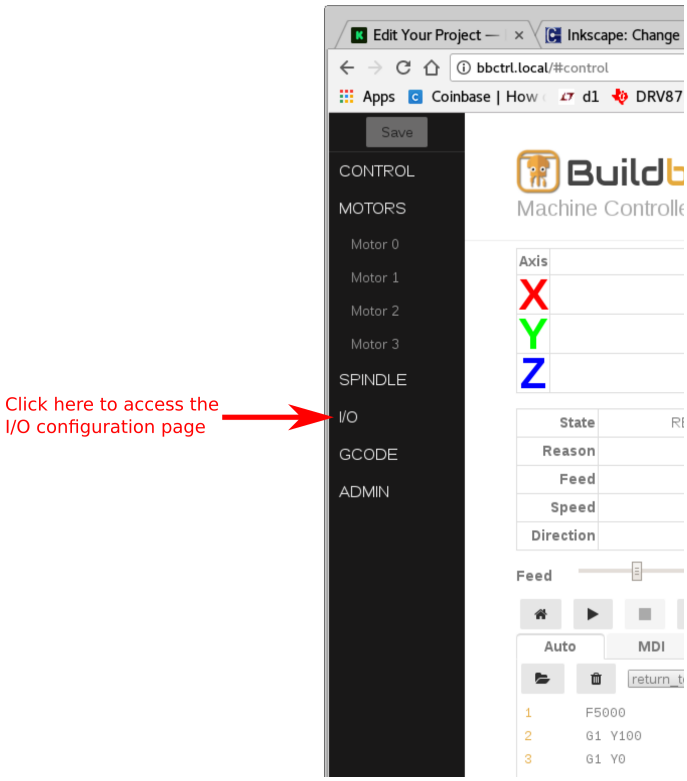
- hi-lo - the spindle is enabled by a transition from high to low on the enable output pin
- tri-lo - the spindle is enabled by a transition from tristate to lo on the enable output pin
- tri-hi - the spindle is enabled by a transition from tristate to high on the enable output pin
- lo-tri - the spindle is enabled by a transition from lo to tristate on the enable output pin
- hi-tri - the spindle is enabled by a transition from high to tristate on the enable output pin

The tool-direction-mode pull down menu selects the action to be taken on the dir pin to cause the spindle to turn in the reverse direction. The following options are provided:

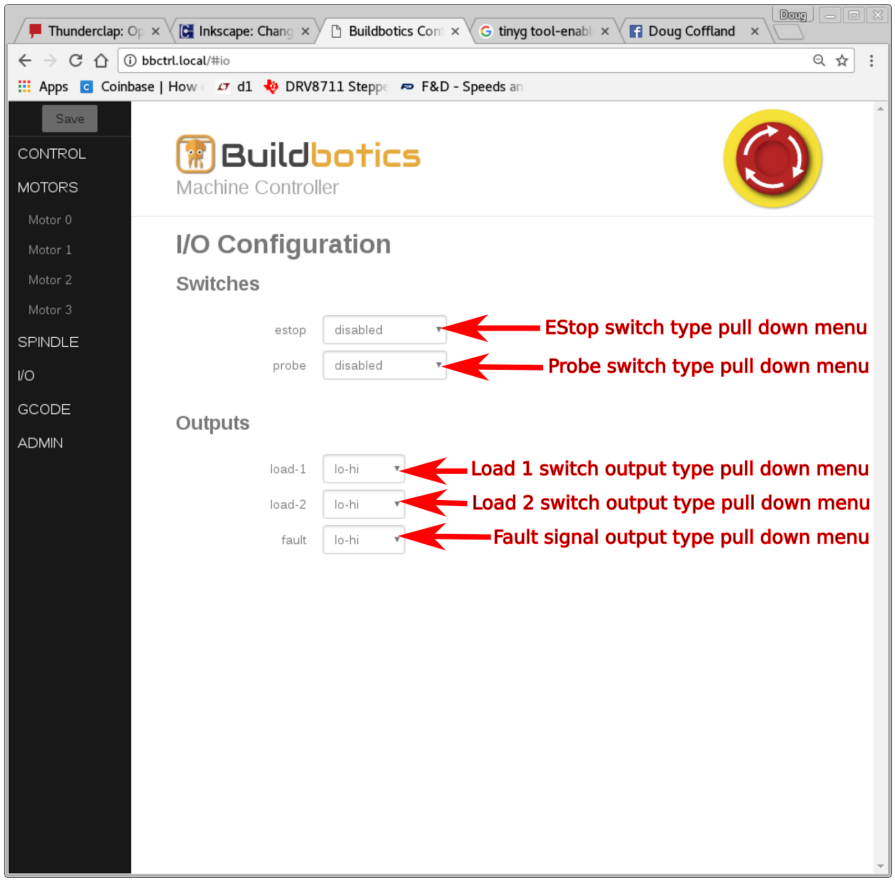
- disabled - the spindle is direction pin is disabled
- lo-hi - the spindle is reversed by a transition from low to high on the dir output pin
- hi-lo - the spindle is reversed by a transition from high to low on the dir output pin
- tri-lo - the spindle is reversed by a transition from tristate to lo on the dir output pin
- tri-hi - the spindle is reversed by a transition from tristate to high on the dir output pin
- lo-tri - the spindle is reversed by a transition from lo to tristate on the dir output pin
- hi-tri - the spindle is reversed by a transition from high to tristate on the dir output pin

Configuring I/O switches

Click the I/O link in the left pane to access the I/O Configuration page.



After clicking the I/O link the I/O Configuration page opens.



The estop pull down menu selects the type of estop switch that is used. The options are:

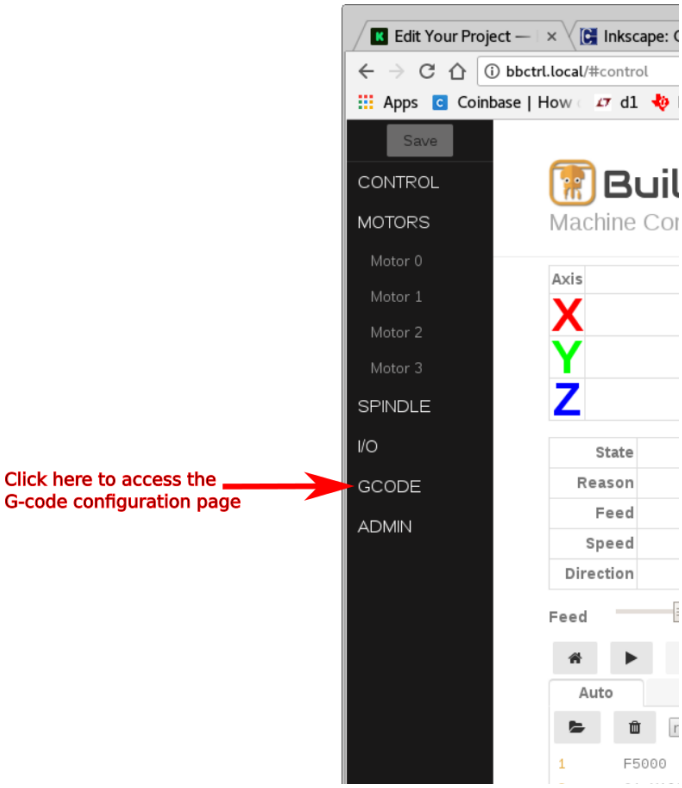
- disabled - No estop is being used by the Buildbotics controller. Note - it is still possible that an estop switch is connected to the machine but does not make use of the controller.
- normally-open - An estop switch is connected to the Buildbotics controller and the switch is closed when tactive.
- normally-closed - An estop switch is connected to the Buildbotics controller and the switch is opened when active.

The probe pull down menu selects the type of probe switch that is used. The options are:

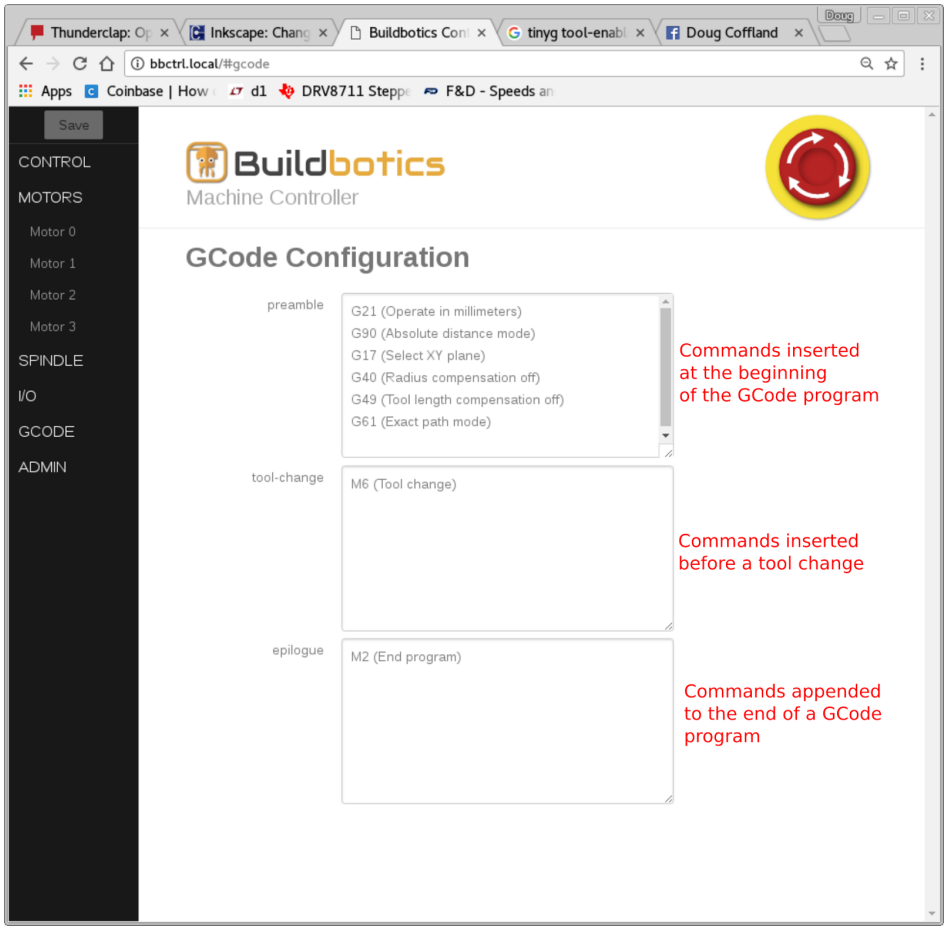
- disabled - No disable is being used by the Buildbotics controller.
- normally-open - A probe switch is connected to the Buildbotics controller and the switch is closed when active.
- normally-closed - A probe switch is connected to the Buildbotics controller and the switch is opened when active.

G-Code configuration

Click the GCODE link in the left pane to access the G-Code Configuration page.



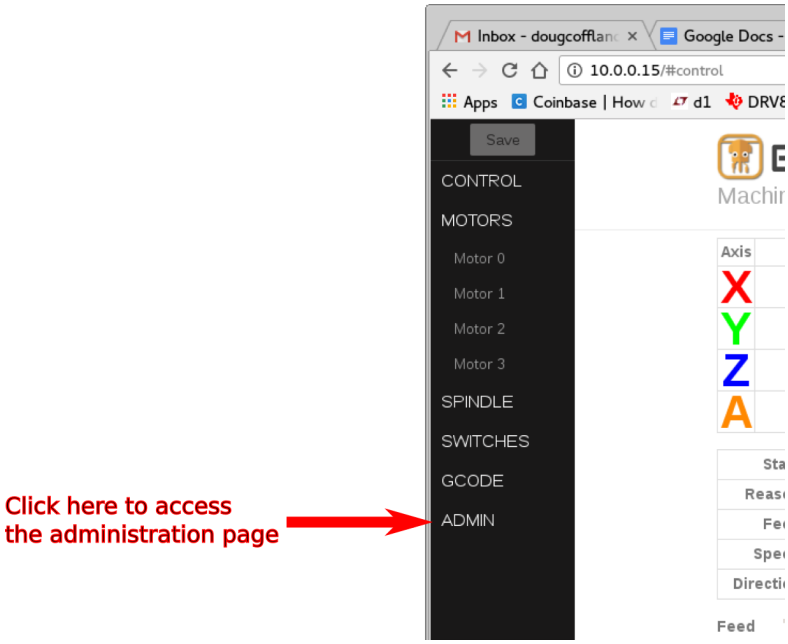
After clicking the GCODE link, the G-Code Configuration page opens.



The G-Code Configuration page allows inserting G-Code commands into G-Code programs at the beginning, end, and before tool changes.

Administration

Click “ADMIN” in the left pane to access the Administration page.



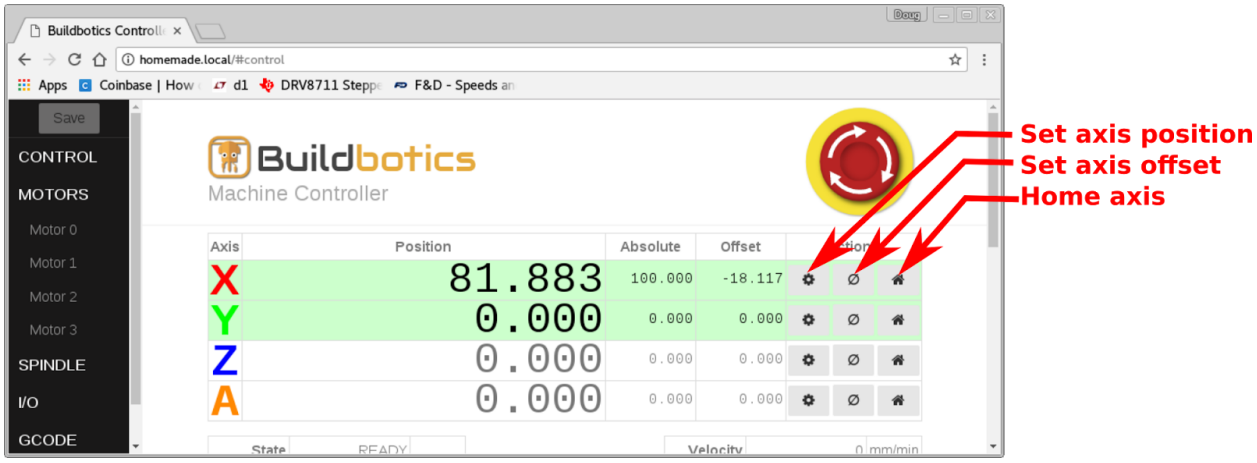
Operating the Buildbotics Controller

The Control page provides real time status and feedback information about the attached machine, and allows controlling the machine through manual jogging, running G-Code commands, or through G-Code programs.

Axis table

The Axis table is at the top of the control page and gives the following information for each active axis:

- Position - This is the logical position. G-Code commands and programs will move relative to this position. For instance, the command “G0 X10” will cause the X axis to move to 10mm and 10.000 will reflect in this field.
- Absolute - This is the actual position of the machine relative to its homed value. This value will also show on the Buildbotics controller LCD screen.
- Offset - Offset is equal to Absolute - Position. This is useful when you want your program to run from some position other than home. For instance, the physical home value may be at the lowest position along an axis, but the program causes the axis to move to negative values. The offset can shift the zero position to another point along the axis.



Three action buttons are provided for each axis in the right column of the axis table. These buttons behave differently depending the value assigned to “homing-mode” in the Motor Configuration. The possible homing modes are “manual”, “switch-min”, and “switch-max”.

Manual homing

When ‘homing-mode” is set to “manual”, the buttons behave as follows:

Home axis

In the “manual” homing mode, clicking the “Home axis” (rightmost) button prompts the user to set the absolute position. The Absolute value will be set to the valued entered by the user. The Position value will be set to the Absolute value plus the Offset value. The background color for the table row for the axis turns green to indicate that the axis has been homed.

Set axis offset

In the “manual” homing mode, clicking the “Set axis offset” (center) button sets the Offset value to the reciprocal of the current Absolute value and sets the Position value to 0.000.

Set axis position

In the “manual” homing mode, clicking the “Set axis position” (leftmost) button prompts the user for a value. That value is ignored. After that, the behavior is the same as the Set axis offset button after that.

Switch-min homing

When “homing-mode” is set to “switch-min”, the buttons behave as follows:

Home axis

In the “switch-min” homing mode, clicking the “Home axis” (rightmost) button causes the following procedure to be executed:

1. The axis moves toward the minimum limit switch at the velocity specified in the “search-velocity” field until the minimum limit switch is activated.
2. The axis backs away from the minimum switch until it de-activates, or until the “latch-backoff” distance is reached.
3. The axis backs off an additional distance as specified in the “zero-backoff” field.

4. The “Absolute” value is set to the value in the “min-soft-limit” field.
5. The “Position” value is set to the “Absolute” value plus the “Offset” value.
6. The background color for the table row for the axis turns green to indicate that the axis has been homed.

Note - this assumes that the minimum switch is configured and working correctly.

Set axis offset

In the “switch-min” homing mode, clicking the “Set axis offset” (center) button sets the Offset value to the reciprocal of the current Absolute value and sets the Position value to 0.000.

Set axis position

In the “switch-min” homing mode, clicking the “Set axis position” (leftmost) button prompts the user for a value. That value is ignored. After that, the behavior is the same as the Set axis offset button after that.

Switch-max homing

In the “switch-max” homing mode, clicking the “Home axis” (rightmost) button causes the following procedure to be executed:

1. The axis moves toward the maximum limit switch at the velocity specified in the “search-velocity” field until the maximum limit switch is activated.
2. The axis backs away from the maximum switch until it de-activates, or until the “latch-backoff” distance is reached.
3. The axis backs off an additional distance as specified in the “zero-backoff” field.
4. The “Absolute” value is set to the value in the “min-soft-limit” field.
5. The “Position” value is set to the “Absolute” value plus the “Offset” value.
6. The background color for the table row for the axis turns green to indicate that the axis has been homed.

Note - this assumes that the maximum switch is configured and working correctly.

Set axis offset

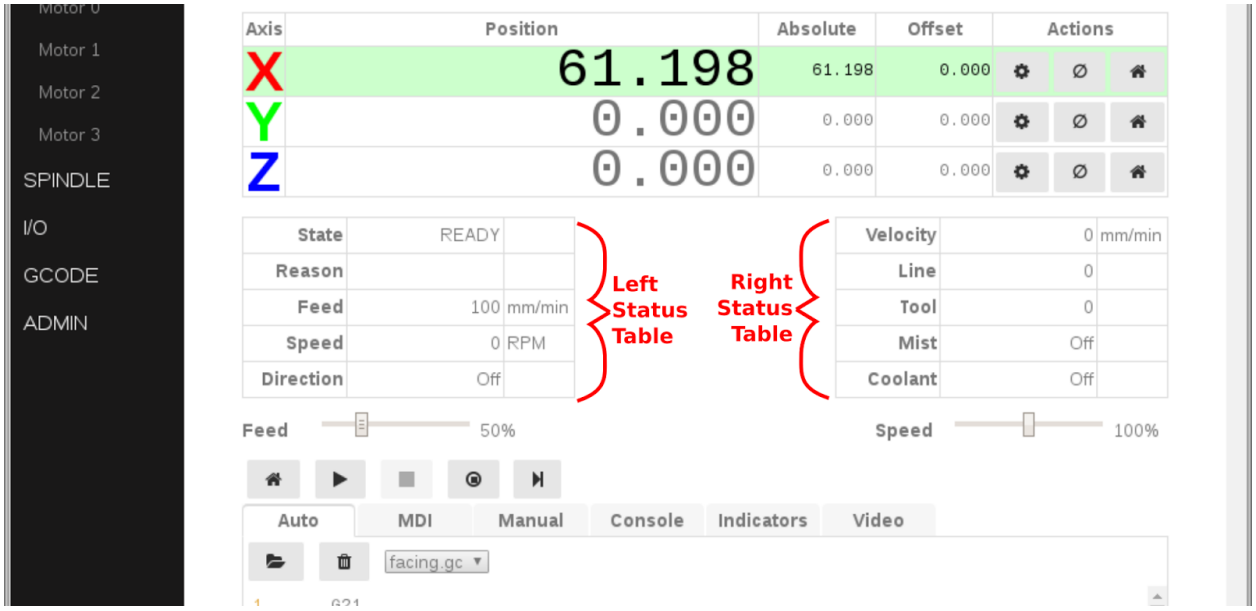
In the “switch-max” homing mode, clicking the “Set axis offset” (center) button sets the Offset value to the reciprocal of the current Absolute value and sets the Position value to 0.000.

Set axis position

In the “switch-max” homing mode, clicking the “Set axis position” (leftmost) button prompts the user for a value. That value is ignored. After that, the behavior is the same as the Set axis offset button after that.

Status Tables

Two status table are provided near the center of the Control page. These tables provide real-time information about the state of the machine and programs.



Left Status table

State

The state field reflects the state of the CNC controller. The value in this field is the same as the status displayed in the upper left corner of the LCD screen on the Buildbotics controller. The possible values in the state field are:

- READY
- ESTOPPED
- RUNNING
- STOPPING
- HOLDING
- MACHINING
- HOMING
- PROBING
- CALIBRATING
- JOGGING

Reason

The reason field is often blank, but may report a reason if the machine is in an unexpected state. More details can be found by selecting the “Console” tab in lower part of the Control page.

Feed

The Feed field reflects the feed rate as set by an executing program or a G-Code “F” command entered via the MDI tab in the lower part of the Control page.

Speed

The Speed field reflects the rotational speed of the spindle as set by an executing program or a G-Code “S” command entered via the MDI tab in the lower part of the Control page.

Direction

The Direction field reflects the direction that the spindle is turning. Possible values are:

- “Off” - This is the initial state before the spindle has been started, and the state that it returns to when an “M5” G-Code command has been executed.
- “Clockwise” - This means that the spindle is turning clockwise and enters this state when an “M3” G-Code command has been executed. This assumes that the “reversed” checkbox on the Spindle configuration page has been set correctly for the spindle being controller. If not, the spindle could actually be turning the opposite direction.
- “Counterclockwise” - This means that the spindle is turning counterclockwise and enters this state when an “M4” G-Code command has been executed. This assumes that the “reversed” checkbox on the Spindle configuration page has been set correctly for the spindle being controller. If not, the spindle could actually be turning the opposite direction.

Right status table

Velocity

This field reflects the actual velocity that the machine head is moving relative to the workpiece.

Line

This field reflects the current line being executed in a G-Code program.

Tool

This field reflects that tool number that is current being used. The value is set as a result of executing a “T” G-Code command.

Mist

This field has not yet been implemented.

Coolant

This field has not yet been implemented.

Feed

The Feed slider is located just below the “Left status table” but is not yet implemented.

Speed

The Speed slider is located just below the “Left status table” but is not yet implemented.

Control buttons

Five control buttons are provided in the lower half of the Control page.

Home

The “Home” button causes all three axes to find their home positions using the procedures described for the homing buttons in the Axis table. The Z axis is homed first followed by X, then Y, and then the A axis.

Play/Pause

The “Play” button causes the program that is currently loaded under the Auto tab in the lower part of the Control screen to begin executing.

When a program is executing, or a G-Code command is executing, or a homing operation is underway, the “Play” button becomes a “Pause” button. Clicking the “Pause” button causes the operation that is currently running to stop and turns the button back to a “Play” button. Clicking it again resumes the operation that was underway when the “Pause” button was clicked.

Stop

Clicking the Stop button causes any programs, GCode commands, or homing operations to stop executing.

Pause on M1

Clicking this button causes the program to pause the next time an M1 command is encountered. This allows setting breakpoints in G-Code programs.

Single Step

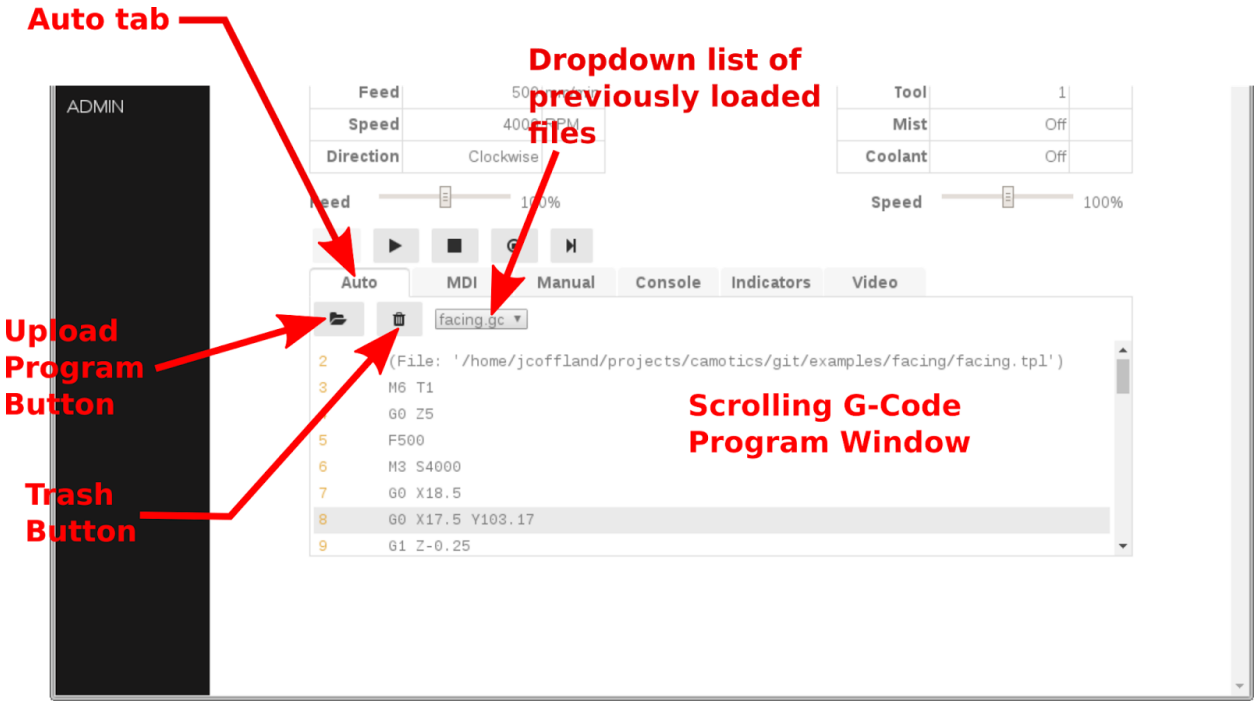
Clicking the Single Step button causes the next line of code in the currently loaded G-Code program to execute.

Tabbed section

The bottom portion of the Control page consists of a tabbed section. There are six tabs in the tabbed sections. Each tab opens a different window.

Auto tab

The Auto tab allows loading new G-Code programs, selecting existing G-Code programs, deleting existing G-Code programs, and inspecting G-Code programs. The G-Code program that is loaded into the Auto tab G-Code Program window will be executed with the “Play” button is clicked.



Upload Program

The Upload Program button opens a file selector dialog that allows the user to select G-Code programs on the local computer and download them to the Buildbotics controller. Once, downloaded, the G-Code program is displayed in the scrolling G-Code program window and added to the drop down list of previously loaded files.

Trash

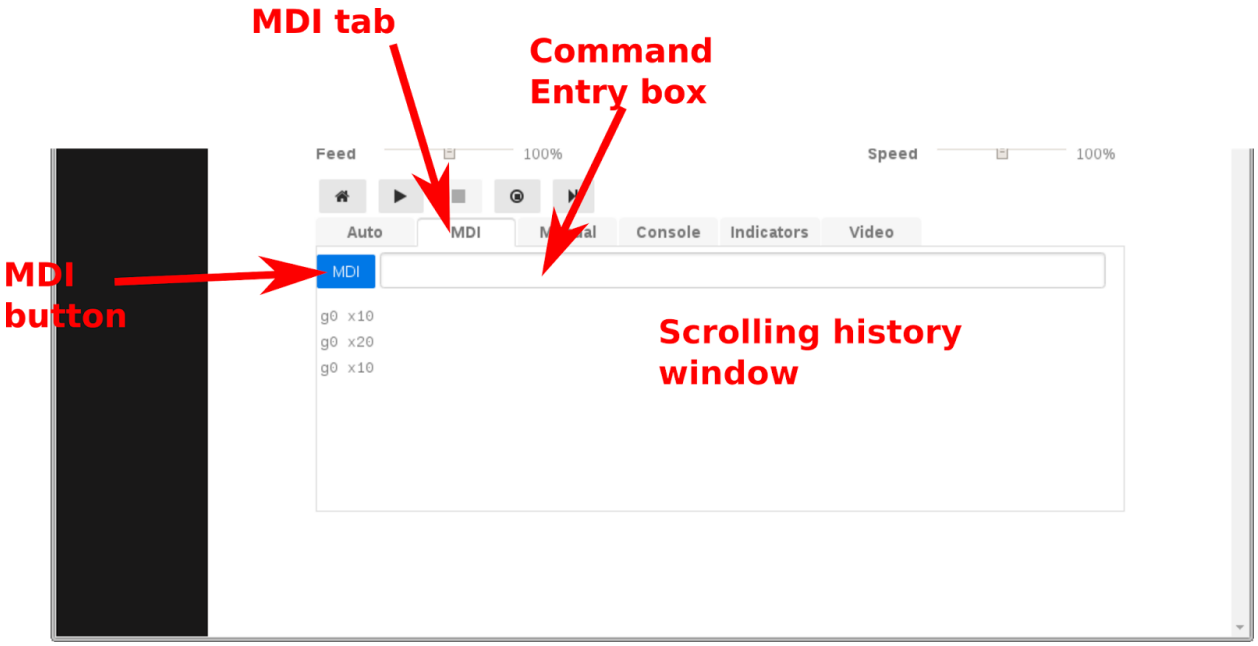
Clicking the Trash button deletes the file that is currently loaded into the scrolling G-Code program window.

Dropdown list of previously loaded files

The drop down list of previously loaded files allows the user to load G-Code programs that were previously stored in the Buildbotics controller. Once loaded into the program window, these programs can be executed by clicking the Play button.

MDI tab

The Manual Data Input (MDI) tab allows the user to control the machine by manually entering G-Code commands.



Command entry box

Users can type individual G-Code commands, or strings of commands, into the command entry box. The commands in the command entry box will be executed when the MDI button is clicked, or when the user hits the “Enter” key.

MDI button

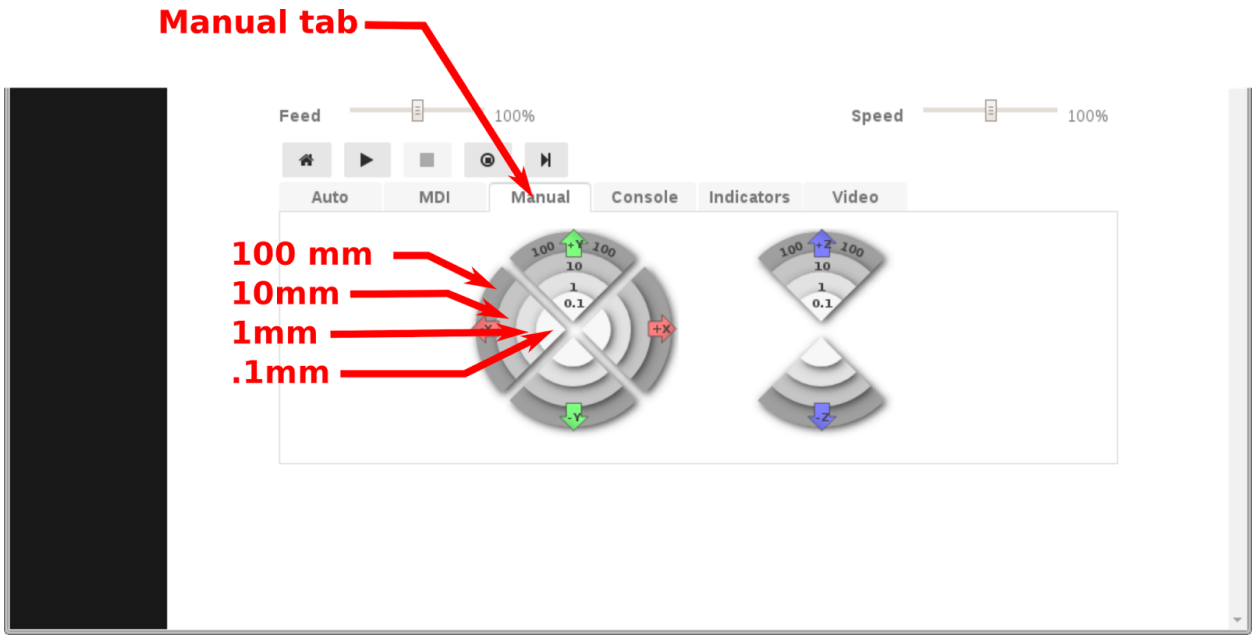
Clicking the MDI button executes the commands in the command entry box.

Scrolling history window

The scrolling history window displays a list of all MDI commands that have been executed since the browser accessed the controller, or since the last browser refresh. The commands are listed with the most recent command at the top. Clicking any of the commands in the list replaces the contents of the command entry box with that command.

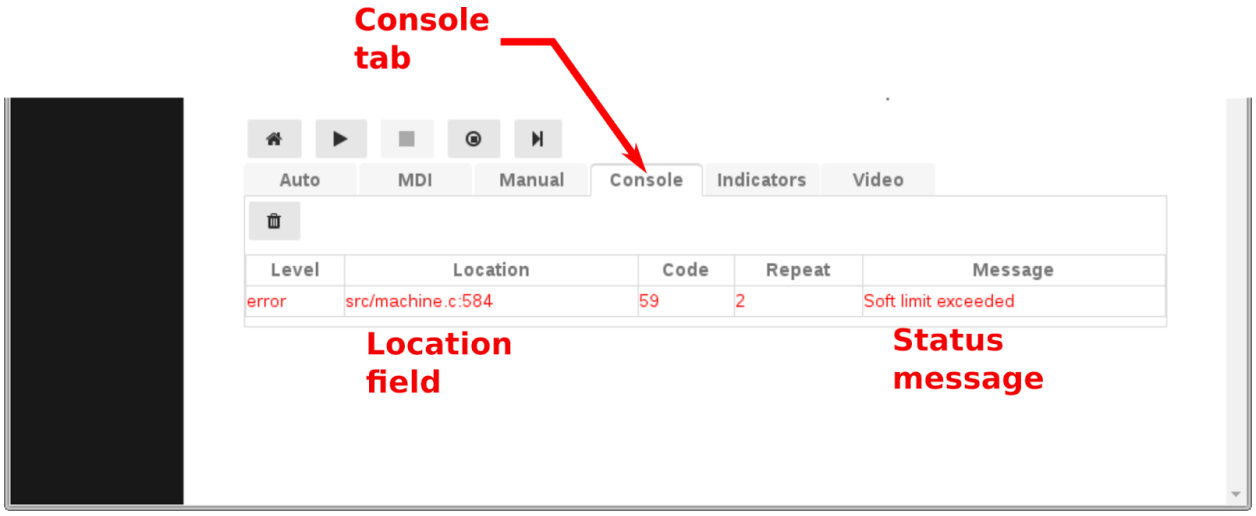
Manual tab

The manual tab allows users to jog the machine on the X, Y, or Z axes. Clicking the outer ring causes the axis to move by 100 mm; the next ring moves 10mm, the third ring moves 1.., and the inner ring moves .1mm.



Console tab

The console tab displays a running list of error and status messages. The most recent message is appended to the bottom of the list. The console tab can assist in troubleshooting problems. The Message field gives a brief description of the issue and the Location field sometimes gives the source code file and line number where the issue was encountered. The Repeat field reports the number of times that the issue has occurred.



Indicators tab

The indicators tab provides status information about the machine including switch states, input and output voltage and current, and temperature.

Video tab

When a webcam is connected to the Buildbotics controller, the video tab provides a display for that live video.

Applications Programming Interface

Troubleshooting

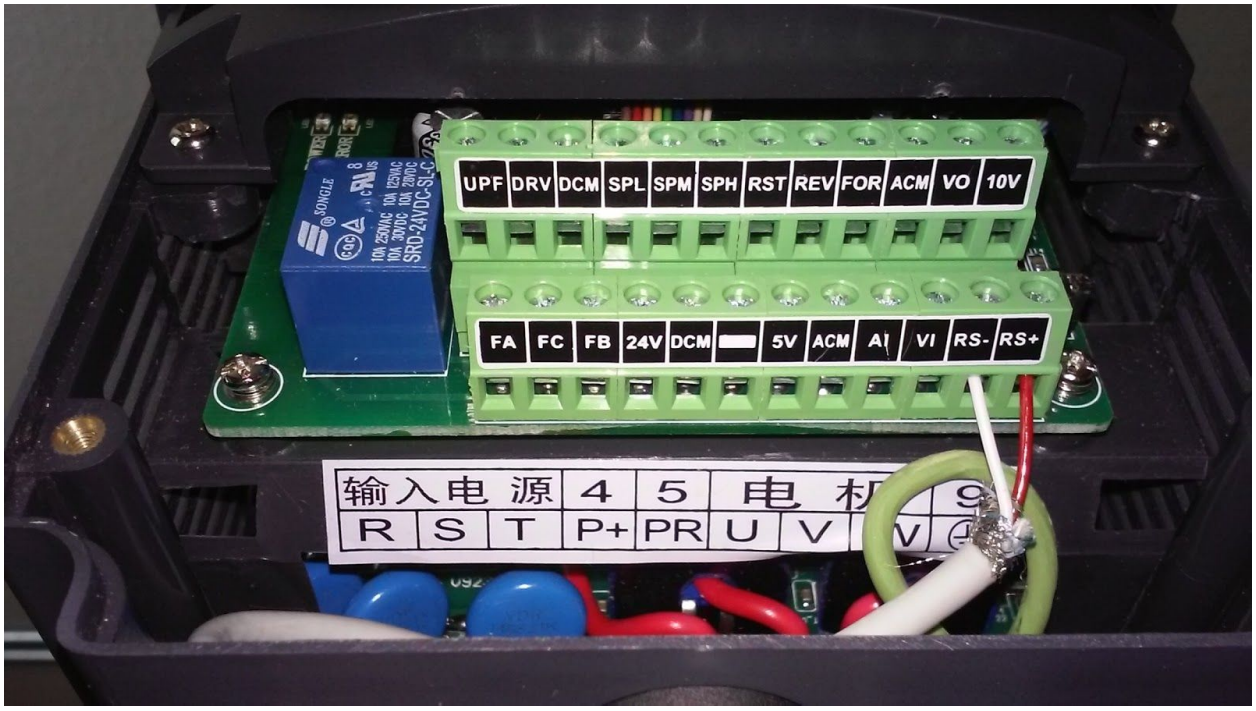
Think of all failure modes and make suggestions on how to fix the problem.
Provide link to blog for resolving problems.

Contact Information

Appendix I - Connecting and Configuring Huanyang HY01D523 Variable Frequency Drive and Spindle

Use the following steps to connect the Huanyang VFD to the Buildbotics Controller:

1. Disconnect power from the Huanyang VFD and from the Buildbotics Controller.
2. Connect the RS485 wiring to the Buildbotics Controller as shown in RS485 Spindle section of the manual.
3. Remove the front cover from the Huanyang VFD.
4. Connect the wire that is attached to pin 13 on the 25-pin breakout board to the RS+ terminal on the VFD.
5. Connect the wire that is attached to pin 14 on the 25-pin breakout board to the RS- terminal on the VFD
6. Replace the cover.
7. Apply power to the VFD (220VAC).



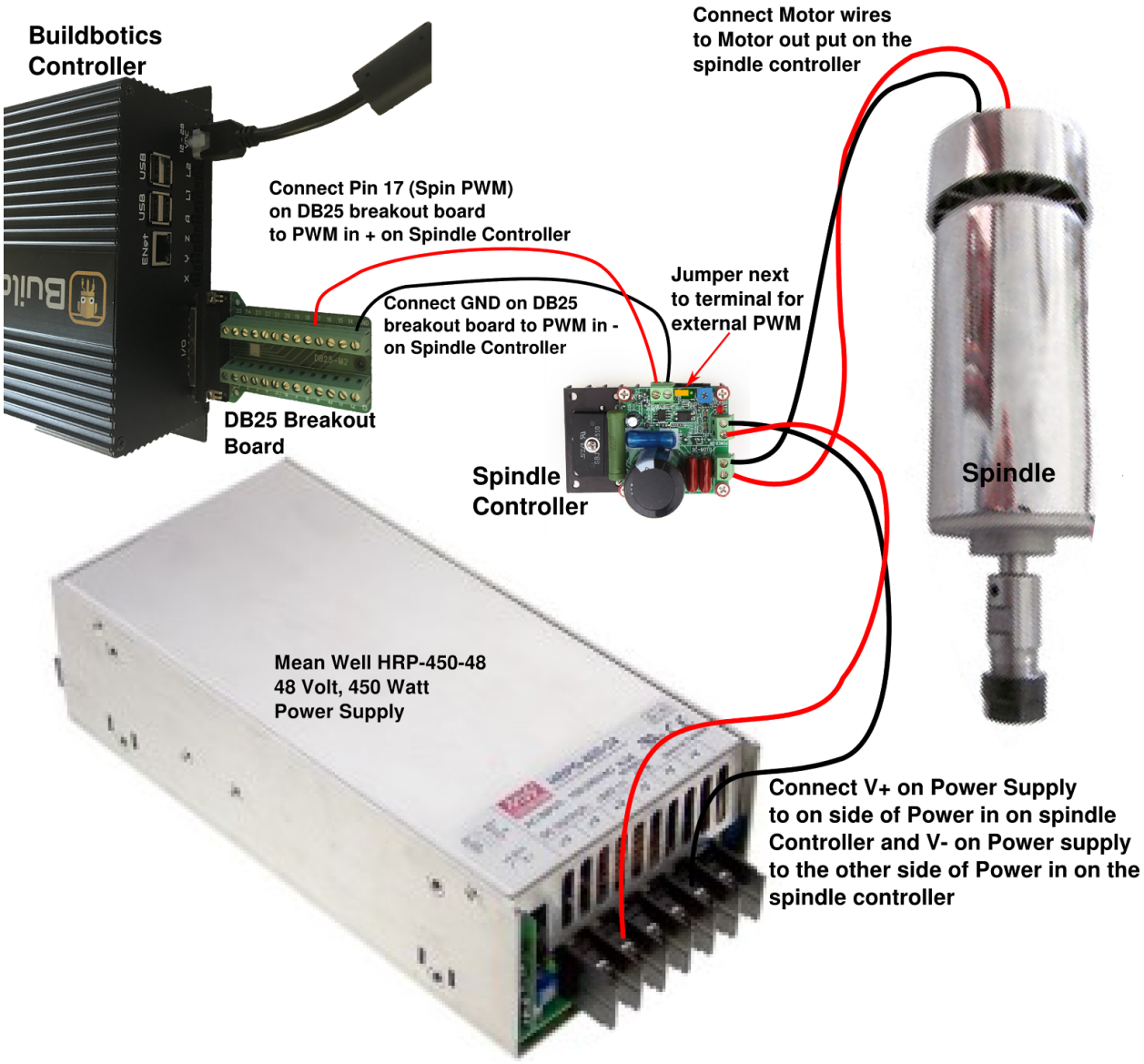
Using procedure in the Huanyang manual, set the following register values:

1. Set PD000 to 0 - unlock parameters
2. To avoid confusion, reset the VFD to factor resets by setting PD013 to 8.
3. Set PD001 to 2 - Command source is RS485
4. Set PD002 to 2 - Speed source is RS485

5. Set PD164 to 3 - 38400 b/s
6. Set PD165 to 3 - 8 Bit No Parity - RTU
7. Set PD000 to 1 - lock parameters

Finally, configure the Buildbotics Controller for spindle control as described in the Buildbotics Controller Spindle Configuration section.

Appendix II - Connecting and configuring a spindle and controller kit to the Buildbotics Controller

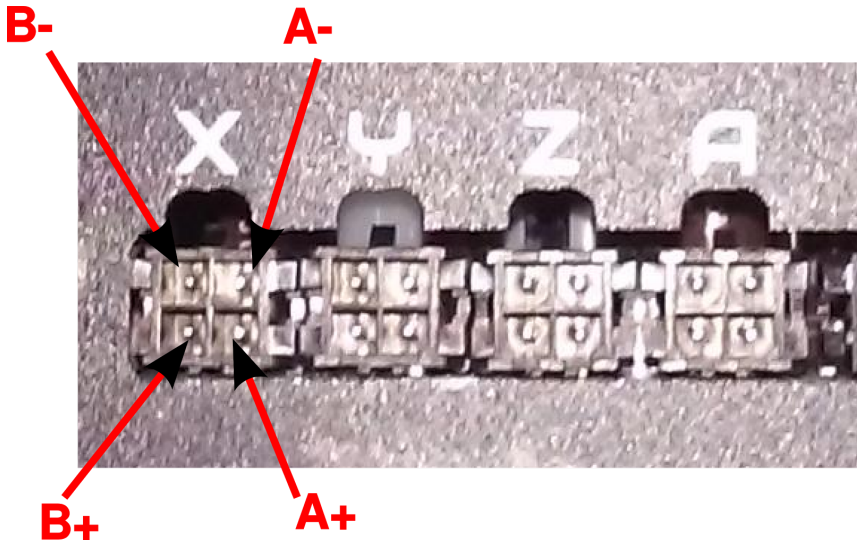


Appendix III - Stepper Motor Wiring

The Buildbotics CNC Controller provides four bipolar stepper motor drivers. It cannot drive unipolar stepper motors. Fortunately, most stepper motors can be wired up as bipolar motors.

Connecting a stepper motor to a Buildbotics CNC Controller requires properly connecting the four wires from the driver to the right wires on the motor. Unfortunately, stepper motors come in a variety of configurations and it is not always immediately obvious how to hook them up. There are several characteristics that make stepper motors different from one another. One big difference is the number of wires emanating from the motor. It is not uncommon to encounter motors with 4, 5, 6, or 8 wires coming out of the motor. This article discusses each of those configurations.

The Buildbotics CNC Controller provides four motor driver outputs through the back panel on ports labeled X, Y, Z, and A. All four of these ports are wired the same and they look like this:

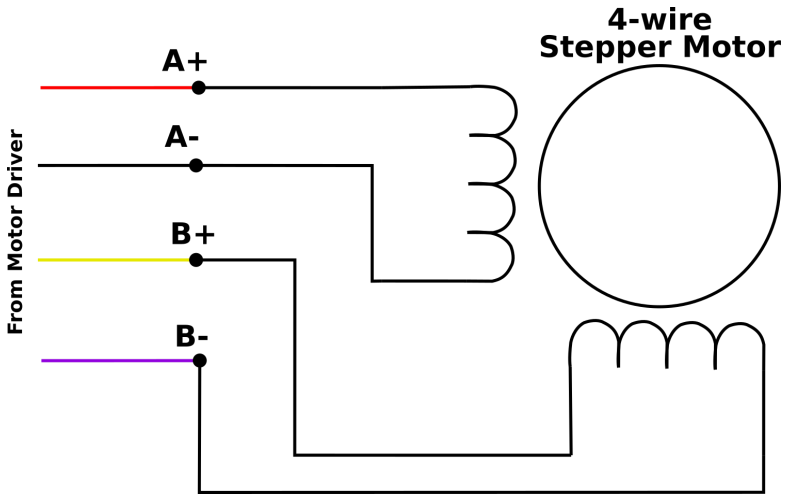


Each output has four pins. The upper left pin is B-, the lower left is B+, the upper right is A-, and the lower right is A+. B- and B+ must drive one of the motor coils and A- and A+ must drive the other motor coil.

Buildbotics provides pre-made cables that connect to the driver outputs on one end and nothing connected on the other. These cables are color coded such that the A+ wire is red, the A- wire is black, the B+ wire is yellow, and the B- wire is purple.

Connecting 4-wire motors

Connecting 4-wire stepper motors requires connecting A+ and A- to one of the motor coils and B+ and B- to the other motor coil.



The trick is figuring out which wires make up the coil pairs. Here's three ways to figure this out:

1. Find the documentation for the motor. Assuming you don't already have it, read the model number off of the motor and then search for it on the Internet. With a little effort, it is usually possible to get a datasheet for the motor. The datasheet will usually specify the wires by A+, A-, B+, and B-, or at least show which wires by color attach to which coils.
2. If you can't find the datasheet, but have an ohmmeter, measure the resistance between any two of the motor wires. If you measure a near short, then that pair makes up one coil, and the other two wires make up the other coil. If it is an open, then measure between the first wire and another wire and then to the fourth wire until you find a near short. Notice that I say near short because the coil is a long thin wire and has some resistance. Once the pairs are identified, then arbitrarily assign one pair as "A" and the other as "B" and arbitrarily assign one wire as "+" and the other as "-" within each pair. Then connect the wires as shown. There is a 50% chance that the motor will turn backwards when connecting this way. If it does turn the wrong way simply reverse one (not both) of the pairs and the motor will turn the other direction.
3. If you don't have an ohmmeter, then most people can identify the pairs by feel. Stepper motor shafts turn fairly easily when the motor coils are open, but are more difficult to turn when a coil is shorted. First, leave all four motor coils open and turn the motor shaft to get a feel for how hard it is to turn. Then twist any two wires together. If the motor is significantly harder to turn, then you have shorted one of the coils and identified a pair.

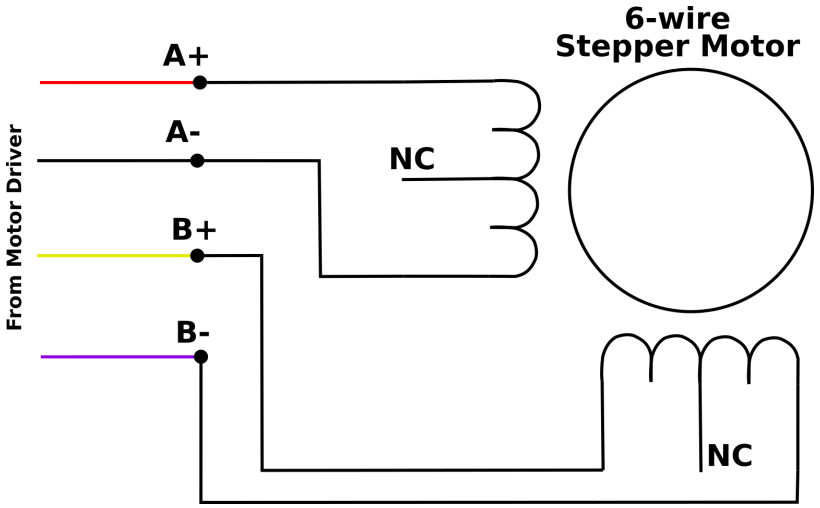
If not, disconnect the two wires from each other and connect a third wire to the first wire. If the motor doesn't get harder to turn, disconnect the third wire from the first wire and connect the fourth wire. One of the four combinations should be harder to turn and that is one coil and the two wires make up the other coil. Once the pairs are identified, then arbitrarily assign one pair as "A" and the other as "B" and arbitrarily assign one wire as "+" and the other as "-" within each pair. Then connect the wires as shown. There is a 50% chance that the motor will turn backwards when connecting this way. If it does turn the wrong way simply reverse one (not both) of the pairs and the motor will turn the other direction.

Connecting 5-wire motors

5-Wire motors are strictly unipolar motors and cannot be wired as bipolar motors. As such, they are not compatible with the Buildbotics CNC Controller.

Connecting 6-wire motors

6-wire motors can be configured as either unipolar or bipolar series motors. The Buildbotics CNC Controller does not support unipolar motors. The bipolar series connections are shown here.



6-wire motors have two center-tapped coils and expose the ends of the coils and the center tapped conductor of the coil. That's three wires for each of the two coils. The center taps are not connected and the coil ends are connected as shown. The trick is figuring out which wires belong to each coil and which of those wires are the center conductor. Here are two methods:

1. Find the documentation for the motor. Assuming you don't already have it, read the model number off of the motor and then search for it on the Internet. You may have to call the vendor. With a little effort, it is usually possible to get a datasheet for the motor.

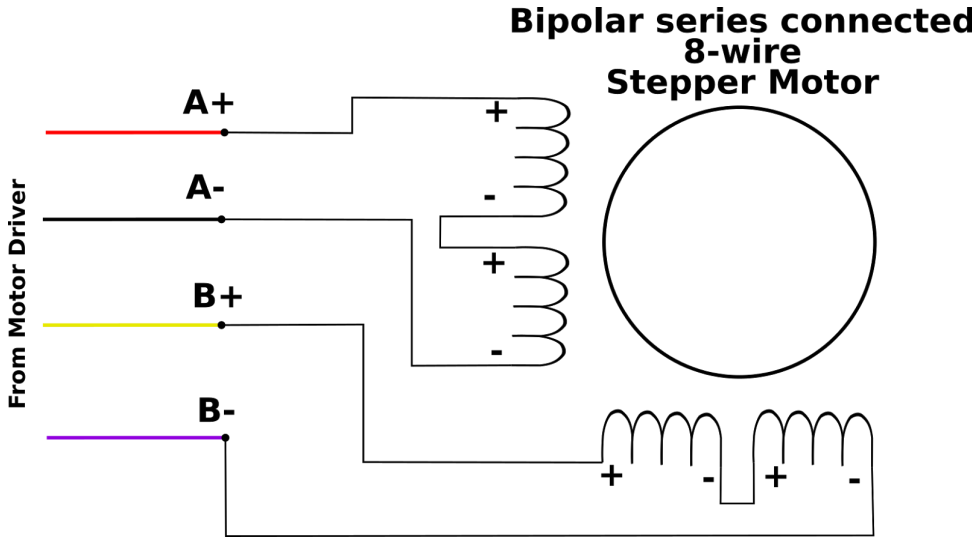
The datasheet will usually specify the wires by A+, A-, B+, and B-, or at least show which wires by color attach to which coils.

2. Use an ohmmeter to identify the individual coils. Any wires that appear to be connected through a few ohms will be part of one coil. Wires that appear to be open are part of the different coils. Arbitrarily choose one of the coils as “A” and the other as “B”. Once the coils have been identified, measure the resistance between each of the three wires on that coil. The resistance between the two coil ends will appear to be about twice the resistance between the either coil end and the coil center tap. When the coil ends have been identified, arbitrarily choose one of the ends to be “+” and the other to be “-” for each coil. Then connect the wires as shown. There is a 50% chance that the motor will turn backwards when connecting this way. If it does turn the wrong way simply reverse one (not both) of the pairs and the motor will turn the other direction.

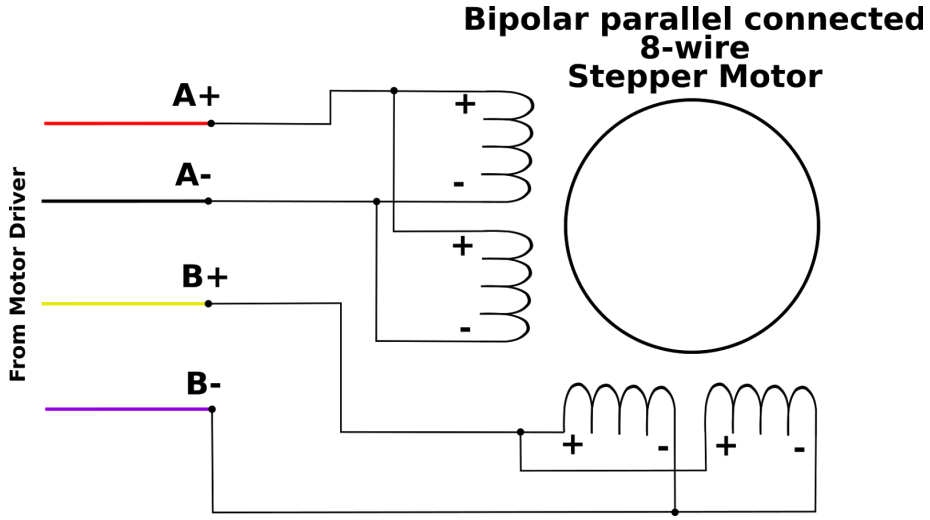
Connecting 8-wire motors

Eight wire motors can be configured as unipolar, bipolar series, or bipolar parallel motors. The Buildbotics CNC Controller does not support unipolar connections. Before configuring an 8 wire motor, you must first decide whether to configure the motor as a bipolar series or a bipolar parallel motor. Bipolar parallel connected motors will generally provide higher top speed, but will require 4 times as much current as a series connected motor. A series configuration should be used if the parallel configuration current exceeds the output capability of the driver. This is especially true for larger motors. In the case of the Buildbotics CNC Controller the maximum current is 6 amps for any individual motor.

The following diagram shows the connections to be made for an 8-wire series connected bipolar stepper motor.



The next diagram shows the connections for an 8-wire parallel connected bipolar stepper motor.



It is not realistic to sort out all of the possible combinations of connections with an ohmmeter or by feel. You need the datasheet for the motor to hook it up. Assuming you don't already have it, read the model number off of the motor and then search for it on the Internet. You may have to contact the vendor to get the motor datasheet. The data sheet will usually specify the wires by A1+, A1-, A2+, A2-, B1+, B1-, B2+, and B2-, or something like that. Given that information, simply wire the motors as shown in the diagrams above.

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