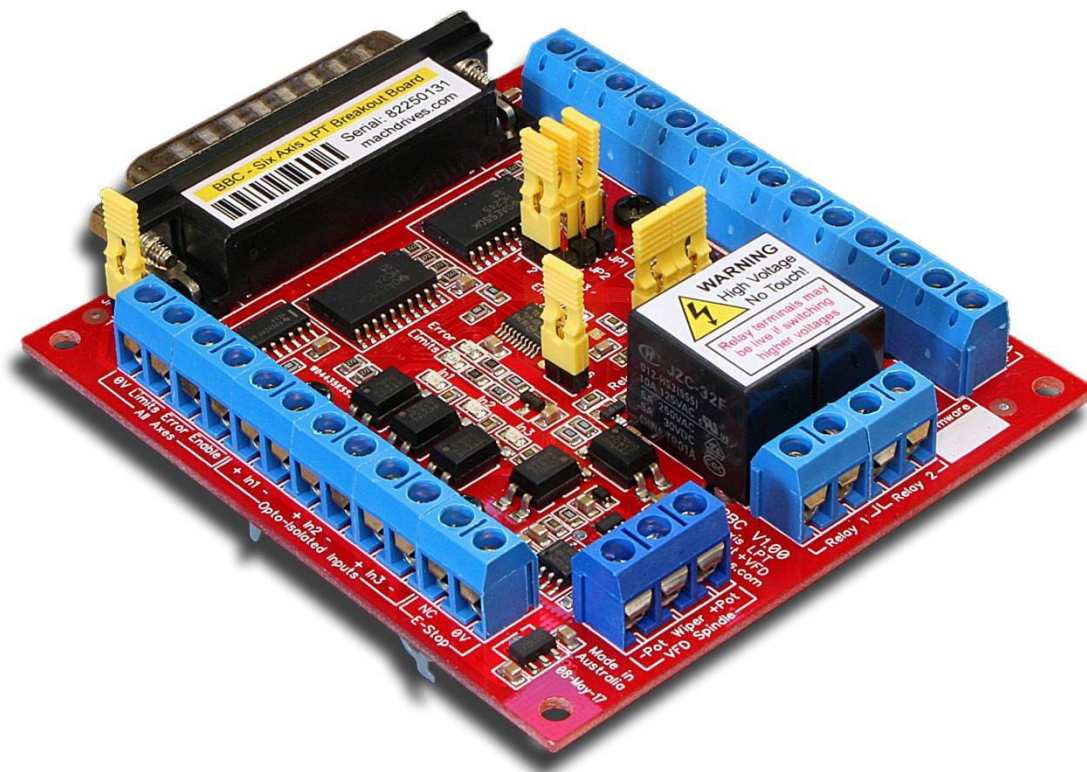

BBC Series

6 Axis Breakout Board with VFD Support



User Manual

www.steppermotorcanada.ca

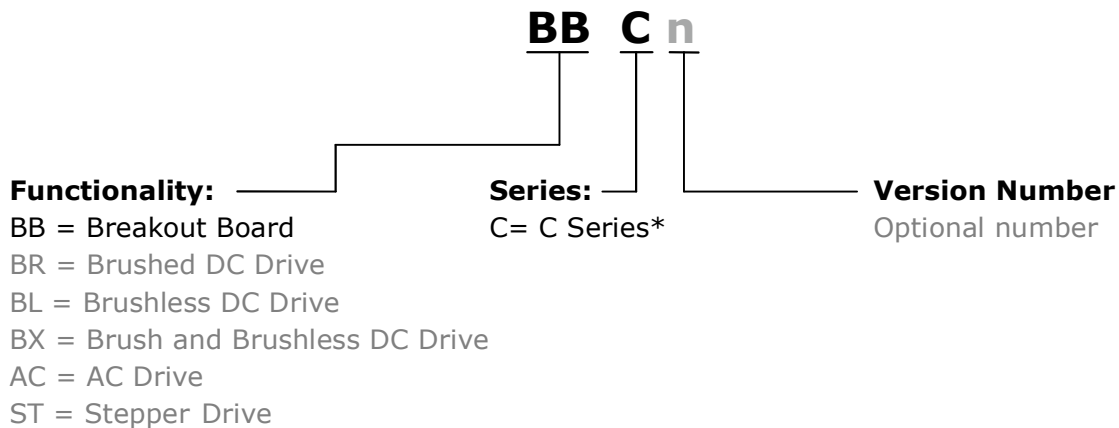
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Product Identifier



*C Series = 6 axis breakout for VFD motor spindle

Document Revision History

Document Name: BBCM

Version	Date	Details
1.0	06-Jun-2017	Initial Release

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CONTENTS

1.0 Safety	6
1.1 Warnings	6
2.0 WARRANTY	6
3.0 INTRODUCTION.....	7
3.1 Breakout Board Description	7
3.2 Breakout Board Features	7
3.3 Breakout Board Layout	8
3.4 Jumper Settings	8
4.0 INSTALLATION	9
4.1 Unpacking the Breakout Board	9
4.2 Environmental Requirements	9
4.3 Mounting the Breakout Board	10
4.4 Connecting the +12V Supply	11
4.5 Connecting the E-Stop Switch	12
4.6 Connecting to the PC.....	13
4.6.1 Charge Pump/ Enable Overview	14
4.6.2 Configuring the Charge Pump Output	14
4.6.3 Configuring the Enable Output	14
4.6.4 Configuring the Error Input	15
4.6.5 Configuring Noise Debounce	15
5.0 CONNECTING MACHDRIVES SERVO DRIVES	16
5.1 Connecting BRA Servo drives	16
5.2 Connecting BRB/BRC Servo drives.....	16
5.3 Configuring Step/Direction Outputs.....	17
6.0 CONNECTING NON-MACHDRIVES STEPPER/SERVO DRIVES	17
7.0 CONNECTING LIMIT/HOME SWITCHES.....	18
7.1 Connecting BRA Servo Drives	18
7.2 Connecting all Other Stepper/Servo Drives	18
7.3 Configuring Limit/Home Switches	18

8.0 Relay Outputs	19
8.1 Configuring Relay Outputs	19
9.0 Opto Inputs.....	20
9.1 Configuring Opto Inputs	20
10.0 VFD Control.....	21
10.1 Connecting the Analogue Input.....	21
10.2 Configure the VFD to use the Analogue Input.....	21
10.3 Configure the VFD Analogue Input Jumper	22
10.4 Connecting the Forward/Reverse Relays	22
10.5 Configure the VFD to use the Forward/Reverse Relays	22
10.6 Setting the Motor Parameters	22
10.7 Configuring Mach3	23
10.8 Checking the Speed Calibration	23
11.0 LED INDICATORS	24
12.0 SPECIFICATIONS	25

1.0 SAFETY



1.1 Warnings

- Installation and operation of this product involves the use of software, firmware, electronics and documentation. Software and firmware can contain bugs, electronic components can fail and documentation can contain errors. Such defects can cause electrical or mechanical hazards that could result in property or equipment damage, personal injury or death. Electrical and mechanical hazards are also present during normal installation and operation of this product and associated equipment. You and any associated third parties shall be suitably qualified or experienced to access such risks and ensure this product is installed and operated safely in accordance with your local regulations and industry best practice.
- While every care has been taken in preparation of this manual, it may still contain errors or omissions. Where the contents of this manual differ from, or conflict with your local regulations or industry best practice, then your local regulations or industry best practice shall prevail. If in any doubt please contact Machdrives support for clarification before proceeding.
- Always ensure machine motor power is removed by a mechanical or electromechanical means before placing any body parts in the path of connected machinery. Never solely rely on electronics or firmware for safety.
- Relay terminal connections and the underside of the circuit board can present an electric shock hazard if the relay is used to switch high voltages. Make sure the PCB is insulated from any conductive surfaces with appropriate clearance and creepage distances.

2.0 WARRANTY

This product is warranted to be free of material defects and workmanship and conform to the published specifications.

This product is warranted for a period of 12 months from the time of installation, or 18 months from time of shipment, whichever comes first. Products replaced under warranty are covered under the original warranty period.

Physical damage or operation of the product outside of the published specifications is not covered by warranty.

All warranty claims must obtain a Return Material Authorization (RMA) number before returning the product. Defective products will be repaired or replaced at the manufacturer's sole discretion. The customer is responsible for the cost of returning the product to the manufacturer. The manufacturer is responsible for the cost of returning the product to the customer by standard airmail service.

No other warranties, expressed or implied, including a warranty of merchantability and fitness for a particular purpose, extend beyond this warranty.

3.0 INTRODUCTION

Thank you for choosing Machdrives for your new project. We want your experience to be a positive one, so please contact support if you have any questions about this product or its use.

This user manual describes the Machdrives BBC breakout board and its commissioning as part of a CNC machine or similar system. Please read all sections carefully to ensure the best performance of your system.

3.1 Breakout Board Description

Machdrives BBC breakout board is designed to interface CNC control software running on a personal computer to CNC hardware such as stepper or servo drives, E-Stop and limit switches, touch probes and a spindle motor.

The BBC model breakout is specifically designed for machines using air or water cooled spindle motors controlled via a variable frequency drive (VFD)

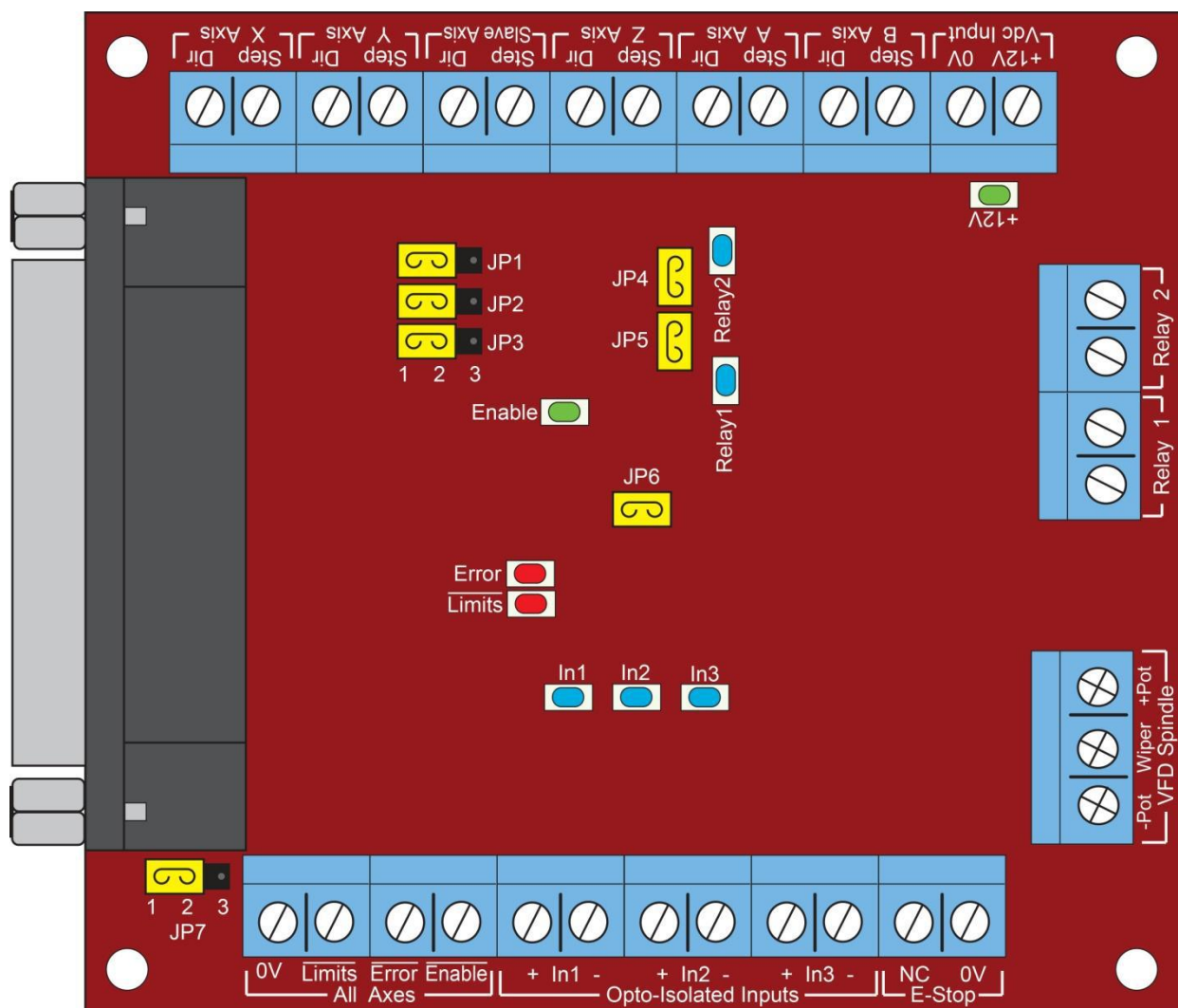
This breakout board is open frame and optionally DIN rail mountable, and is designed to be installed in an enclosed control cabinet.

A small isolated +12VDC power supply is required to power the logic circuitry and relays.

3.2 Breakout Board Features

- Supports up to six Step/Dir servo or stepper drives (X, Y, Z, A, B and Slave).
- Slave X or Slave Y jumper select.
- Slave normal direction or Slave reverse direction jumper select.
- Isolated VFD support for analogue 0-10V or 0-5V.
- DIN rail mounting (optional).
- PC parallel (LPT) port or SmoothStepper control via DB25 male connector.
- Buffered I/O lines.
- Charge pump or simple enable support.
- E-Stop switch support.
- Limit switch support. Can be used with mechanical or inductive proximity switches.
- Two general purpose relays rated at 250V 5A.
- Three opto-isolated inputs for Touch probe etc.
- 9 LED indicators to simplify setup and trouble shooting.
- Digital noise filtering on all control lines.
- 32 bit ARM CPU for enhanced safety interlock logic and high accuracy VFD control.

3.3 Breakout Board Layout



3.4 Jumper Settings

The breakout board configuration can be changed with the following seven jumpers (shown in yellow above).

- JP1:** 1-2: Slave axis Step uses X Step (default)
2-3: Slave axis Step uses Y Step
- JP2:** 1-2: Slave axis Direction uses X Direction (default)
2-3: Slave axis Direction uses Y Direction
- JP3:** 1-2: Slave axis direction same as master (default)
2-3: Slave axis direction opposite to master

- JP4:** ON: DB25 pin 16 is Relay 2 (default)
OFF: DB25 pin 16 is B axis Direction
- JP5:** ON: DB25 pin 8 is Relay 1 (default)
OFF: DB25 pin 8 is B axis Step
- JP6:** ON: Enable the drive using the Charge Pump (default)
OFF: Enable the drive with a simple low logic level
- JP7:** 1-2: Configure input resistor as Pull-Up (default)
2-3: Configure input resistor as Pull-Down

4.0 INSTALLATION

This chapter covers the physical installation of the breakout board and cable connections.

4.1 Unpacking the Breakout Board



Your BBC breakout board is shipped in anti-static wrapping and, like all electronic devices, can be damaged or degraded by static electricity. Avoid wearing synthetic clothing like nylon and polyester and discharge any static electricity by touching an earthed metal object before unpacking the drive. Where possible wear natural fibers like cotton and an anti-static wrist strap during installation.

Unpack your board and inspect it for any visible damage. Contact Machdrives support if any issues are discovered. Do not attempt to install a damaged board.

The serial number is located on the main label on top of the relays. This number identifies your board and is required for any warranty claims.

4.2 Environmental Requirements

To ensure safe and reliable operation of your board, it is important that it is installed in an appropriate environment.

Ambient temperature:	0°C to 40°C (32°F to 104°F)
Altitude:	Maximum 2,000m (6,000 ft)
Humidity:	90% maximum - non condensing
Atmosphere:	No explosive or corrosive gases
Contamination:	No wood dust, plasma cutting dust, metal chips etc.

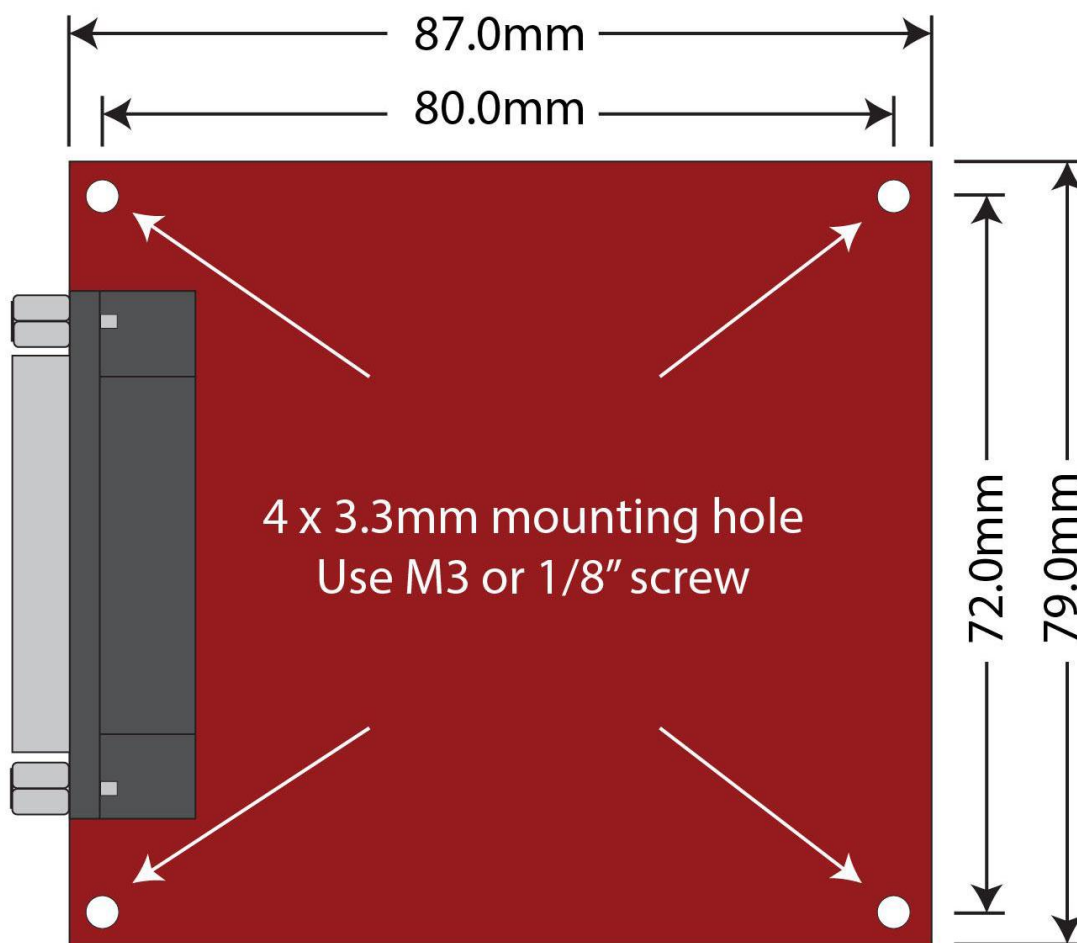
4.3 Mounting the Breakout Board

Your BBC breakout board must be securely mounted before use. Four 3.3mm mounting holes are provided for this purpose on 80mm by 72mm centers. The board can also be DIN rail mounted if this option was chosen at the time of purchase.

The board has exposed electrical pins on the underside and should not be used when resting on, or in contact with a conductive surface. It is recommended that the board is mounted on standoffs or spacers. Ensure the spacer height is sufficient to meet any local electrical regulations with regard to creepage and clearance distances with using the relays with higher voltages.

The board generates very little heat by itself, but could be affected by heat from other devices in the vicinity. Aim for the best cooling practical for your installation to maximize operational life.

Note: Your local electrical regulations may also impose requirements that affect your installation, such as mounting the board in an earthed metal cabinet.



BBC Mounting Hole Locations (not actual size)

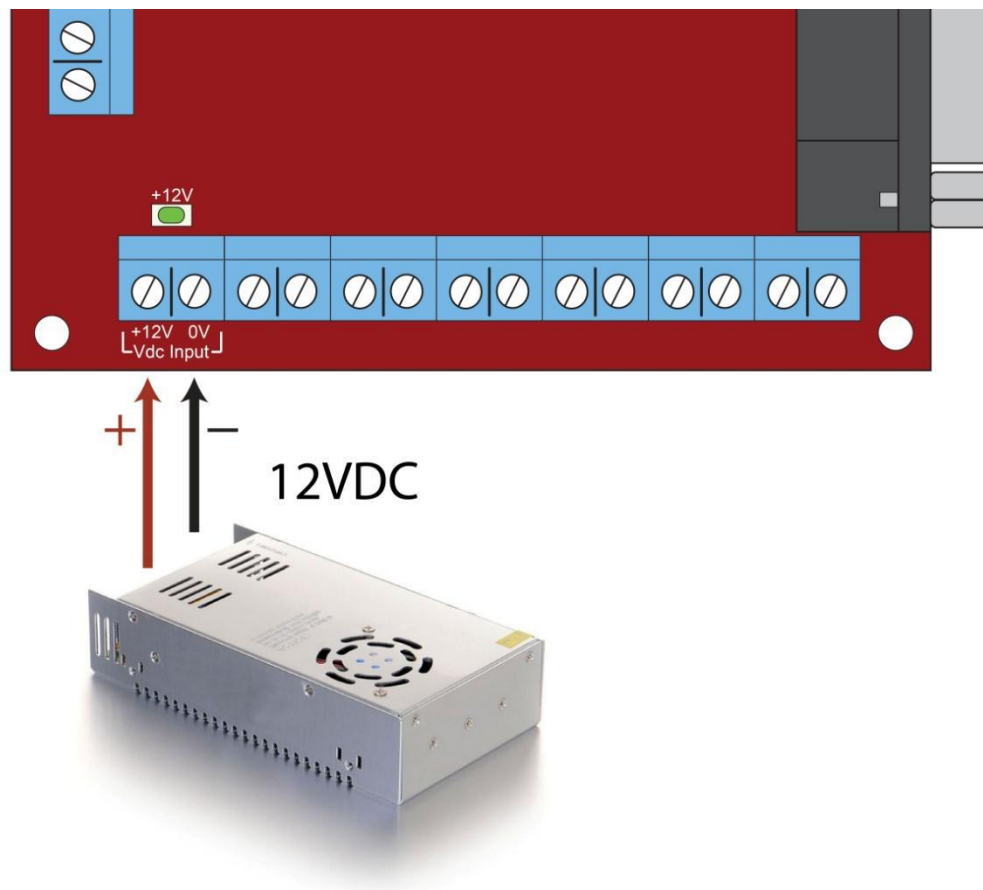
4.4 Connecting the +12V Supply

A small isolated +12VDC power supply of 200mA capacity or more is required to power the drive control circuitry and the relays.

Connect the power supply positive to the +12V terminal and the negative to the 0V terminal. The input has reverse polarity protection to protect against accidental supply reversal damage.

Route the +12V cable well away from motor cables and twist together or use shielded cable for maximum noise immunity. If using a shielded cable, earth the shield at both ends.

The green +12V LED will be illuminated when power is being supplied to the board.



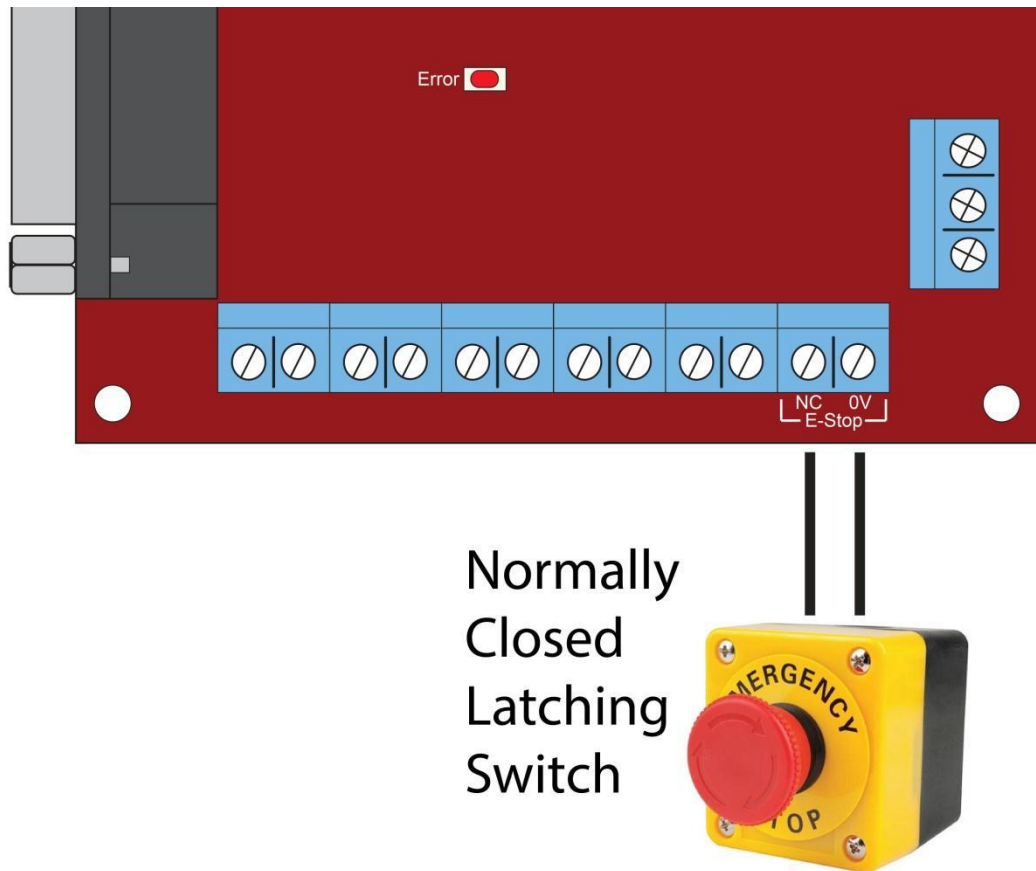
4.5 Connecting the E-Stop Switch

An E-Stop input is provided as a safety feature to allow rapid shutdown of all the breakout board functions. On activation of the E-Stop the following occurs.

- All axis motor drives are disabled.
- All relays are opened.
- The analogue spindle control voltage goes to 0V.
- An error condition is signaled back to the control PC via the DB25 pin 10 ERROR.

The board cannot be enabled again until the E-Stop condition is cleared. To clear the E-Stop condition the connection between the Normally Closed (NC) and 0V terminals must be closed.

To activate the E-Stop condition the connection between the NC and 0V terminals must be opened. If this feature is not used then a jumper wire should be installed across these two terminals.

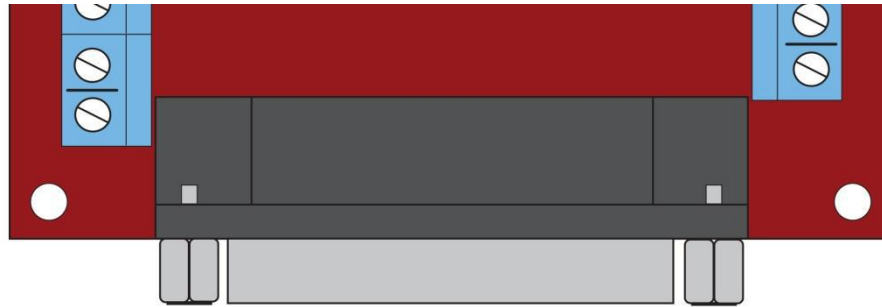


You should never rely solely on electronics and firmware to stop all machine motion in an emergency. It is recommended that a double pole E-Stop switch is used and the other pole opens a latching contactor that removes all power to the machine motor drives and spindle.

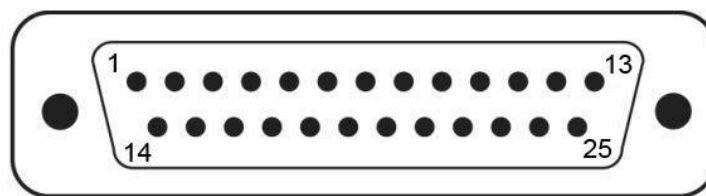
The E-Stop functionality should be reserved for emergencies only and should not be used for normal starting and stopping of the machine.

4.6 Connecting to the PC

The breakout board connects to a PC or motion controller such as a SmoothStepper via a male DB25 connector. CNC controller software such as Mach3 communicates with the breakout board through this port. A good quality shielded cable, as short as practical, is recommended to provide protection against switching and motor noise.



DB25 Male Connector



Breakout Board DB25 Male Locations

Pin	Description	Direction	Active	Pin	Description	Direction	Active
1	X Direction	PC → BB	High	10	Error	PC ← BB	High
2	X Step	PC → BB	High	11	Opto 1	PC ← BB	High
3	Y Direction	PC → BB	High	12	Opto 2	PC ← BB	High
4	Y Step	PC → BB	High	13	Opto 3	PC ← BB	High
5	Z Direction	PC → BB	High	14	CPump/ $\overline{\text{EN}}$	PC → BB	Low
6	Z Step	PC → BB	High	15	$\overline{\text{Limits}}$	PC ← BB	Low
7	A Step	PC → BB	High	16	BDir/Rly2	PC → BB	High
8	BStep/Rly1	PC → BB	High	17	A Direction	PC → BB	High
9	Spindle	PC → BB	High	18+	Ground	PC ↔ BB	N/A

DB25 Pin Out

4.6.1 Charge Pump/ Enable Overview

The PC enables and disables the breakout board via the DB25 port pin 14 (CPump/). The enable signal can be a simple logic level change, or preferably a pulse stream from the charge pump generator. The charge pump signal is preferred as it prevents spurious signals activating breakout board functions during the controller PC startup and shut down.

4.6.2 Configuring the Charge Pump Output

Make sure the Charge Pump jumper on the breakout board is ON.

Configure the output signal for pin 14 to use the Charge Pump feature and use Active Low as shown. Check no other output signal is using pin 14.

Signal	Enabled	Port #	Pin Number	Active Low
Charge Pump		1	14	

Make sure that the tick box "Charge Pump on in EStop" under "General Configuration" is cleared as shown.

General Configuration

☐ Charge Pump on in EStop

Your CNC controller will now send a stream of pulses over pin 14 when it enables the CNC machine and hold the pin high when the machine is disabled.

The breakout board requires the pulse stream frequency of greater than 5KHz. Mach3 typically outputs a 12.5KHz Charge Pump pulse stream.

4.6.3 Configuring the Enable Output

Note: It is preferred to use the Charge Pump Setup above. Only configure Simple Enable Setup if your CNC software does not have Charge Pump functionality.

Make sure the Charge Pump jumper on the breakout board is OFF.

Configure the output signal for pin 14 to use Enable 1 and Active Low as shown. Check no other output signal is using pin 14.




Signal	Enabled	Port #	Pin Number	Active Low
Enable 1		1	14	

4.6.4 Configuring the Error Input

The Error input provides a means for the breakout board to notify the controller PC that an error condition has occurred. This can happen for any of the following reasons.

- The user has activated the E-Stop switch
- A motor drive has signaled an error condition to the breakout board.

Configure the E-Stop input signal to use pin 10, Active High as shown. Check no other input or output signal is using pin 10.

Signal	Enabled	Port #	Pin Number	Active Low	Emulated	HotKey
EStop		1	10			0

4.6.5 Configuring Noise Debounce

The printer cable between the breakout board and the PC can pick up noise from motors and switching that may cause false signals. This can be prevented by setting the “Debounce Interval” in the “Inputs Signal Debouncing/Noise rejection” section on the “General Configuration” page. A value of 20ms (500 x 40us) works well.

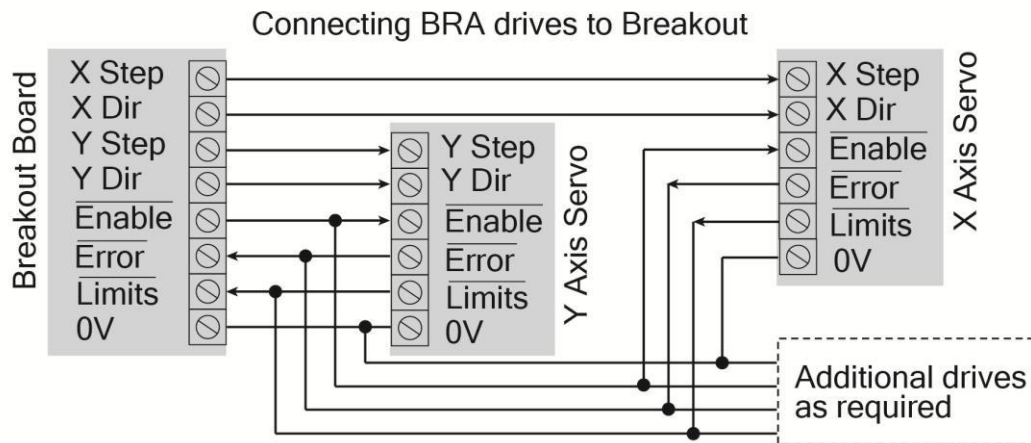
Inputs Signal Debouncing/Noise rejection
Debounce Interval: x 40us

5.0 CONNECTING MACHDRIVES SERVO DRIVES

This section details connecting and configuring Machdrives brand servo drives. For other brand servo and stepper drives please see section 6.

5.1 Connecting BRA Servo drives

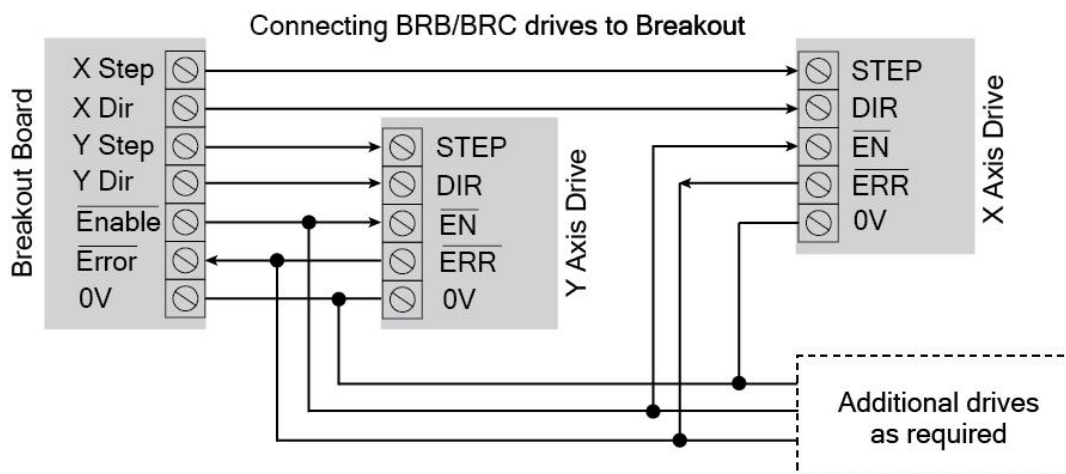
Machdrives BRA servos have isolated control circuitry, so connecting up is straight forward. All the signals match exactly in name and polarity. Simply connect up as shown below.



As the BRA drives contain limit switch logic, any limit switches should be connected directly to the drive limit inputs. See the BRA user manual for more details on setting up limit switches.

5.2 Connecting BRB/BRC Servo drives

Machdrives BRB/BRC servos have isolated control circuitry, so connecting up is straight forward. All the signals have the same levels and polarity for straight through connection. Simply connect up as shown below.



The BRB/BRC drives do not contain limit switch logic so any limit switches should be connected to the breakout board input as detailed in chapter 7.

5.3 Configuring Step/Direction Outputs

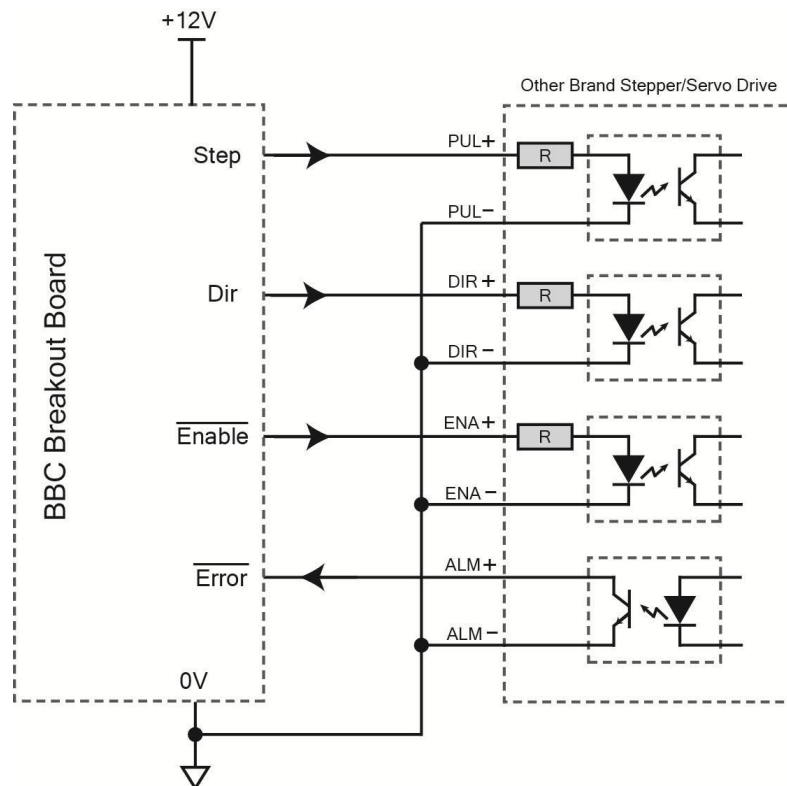
Both the Step and Direction signals are active high and should be configured as shown below. A step occurs on the low to high transition of the step signal. A low on the Dir pin indicates axis movement in the positive direction, a high indicates movement in the negative direction. If an axis is not used then make sure a cross appears in the "Enabled" column. Unused axis pins can be used as general purpose outputs.

Signal	Enabled	Step Pin #	Dir Pin #	Dir Low Active	Step Low Active	Step Port	Dir Port
X Axis	✓	2	1	✗	✗	1	1
Y Axis	✓	4	3	✗	✗	1	1
Z Axis	✓	6	5	✗	✗	1	1
A Axis	✓	7	17	✗	✗	1	1
B Axis*	✗	8	16	✗	✗	1	1

*The B axis shares pin 8 and 16 with relays 1 and 2 respectively. The B axis and the relays cannot both be used at the same time. Use JP4 and JP5 to choose between the relays and the B axis.

6.0 CONNECTING NON-MACHDRIVES STEPPER/SERVO DRIVES

On most other brand drives the control circuitry shares the same ground as the power switches and motor, therefore opto-couplers are used to isolate the individual signals. Connection is as shown below. For drives with no ALM output simply leave the input unconnected.



Configuring the Step/Dir outputs in software is the same as shown in section 5.3.

7.0 CONNECTING LIMIT/HOME SWITCHES

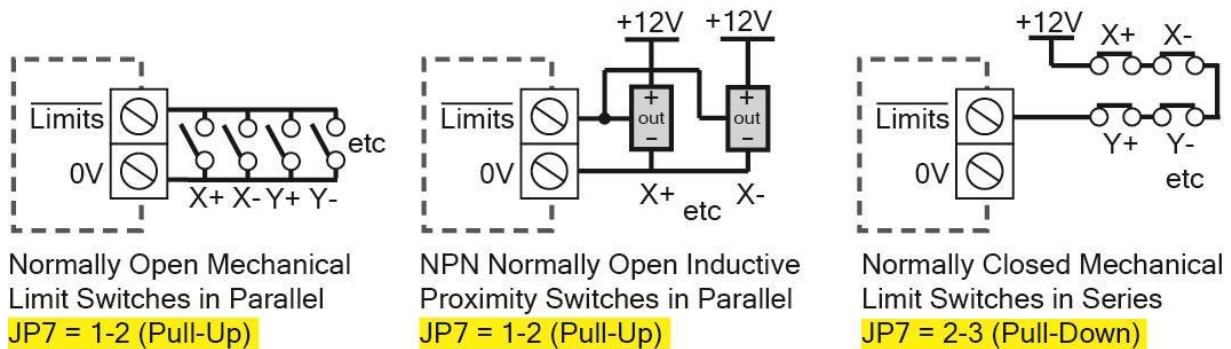
This section details connecting and configuring Limit/Home switches.

7.1 Connecting BRA Servo Drives

BRA series servo drives incorporate built in limit switch logic so any limit switches should be connected directly to the drive. The drive output is then connected to the breakout board input as shown in section 5.1

7.2 Connecting all Other Stepper/Servo Drives

The input is active low with an internal pull-up/pull-down resistor configured via JP7. To signal a limit condition the input should be activated by pulling it low. Either Normally Open (NO) or Normally Closed (NC) limit switches can be used as shown below. If this feature is not required it should be left unconnected with JP7 on 1-2.



7.3 Configuring Limit/Home Switches

All limit and home inputs are passed in to Mach3 on pin 15. This input is active low, with a low level indicating a limit or home position has been reached. The example below shows limits and home configured for the X, Y and Z axes with the other axes not being used.

Signal	Enabled	Port #	Pin Number	Active Low	Emulated	HotKey
X ++	✓	1	15	✓	✗	0
X --	✓	1	15	✓	✗	0
X Home	✓	1	15	✓	✗	0
Y ++	✓	1	15	✓	✗	0
Y --	✓	1	15	✓	✗	0
Y Home	✓	1	15	✓	✗	0
Z ++	✓	1	15	✓	✗	0
Z --	✓	1	15	✓	✗	0
Z Home	✓	1	15	✓	✗	0
A ++	✗	1	0	✗	✗	0

8.0 RELAY OUTPUTS

The BBC breakout board includes two relays for general purpose output. The relays share signal lines with B axis Step and Dir signals. Jumpers JP4 and JP5 must be ON for relay 1 and 2 to operate.





All relay contacts are normally open (NO) and are rated at 250VAC 5A each. **If high voltages are connected to the relay terminals then the exposed electrical pins on the underside of the board present an electrocution hazard. The board should not be used when resting on, or in contact with a conductive surface.** It is recommended that the board is mounted on standoffs or spacers. Ensure the spacer height is sufficient to meet any local electrical regulations with regard to creepage and clearance distances.

The relays can be used for any purpose such as ON/OFF control of spindle motor, coolant pump, vacuum etc. If the switched load can exceed the 5A relay rating then the relay should be used to switch a higher current device such as a contactor or solid state relay.

8.1 Configuring Relay Outputs

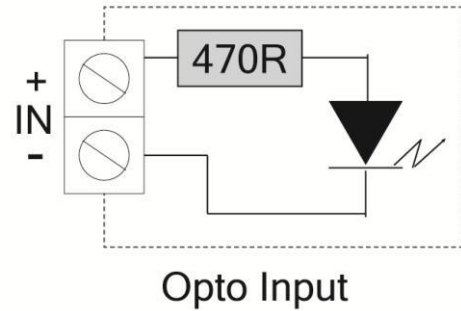
The Relay outputs are active high with a high level activating the relay and closing the contacts. Software configuration is as shown below. Check no other output signals are using pins 8 and 16 and that jumpers JP4 and JP5 are ON.

If the B axis is used then the relay functionality is not available.

Signal	Enabled	Port #	Pin Number	Active Low
Output #1		1	8	
Output #2		1	16	

9.0 OPTO INPUTS

There are three general purpose isolated inputs that can be used to signal ON/OFF conditions to the PC controller such as a touch probe for zeroing of Z axis. Inputs are active when the plus terminal is positive with respect to the negative terminal by 5V. If higher voltages are to be used, an additional series resistor should be added to limit the ON current to around 8mA. For 12V use a 820R series resistor and for 24V a 2K2 series resistor is recommended.



9.1 Configuring Opto Inputs

Three opto-isolated inputs are available on pins 11, 12 and 13. These are active high and can be used to signal an input condition change to the PC controller.

The example below shows how to configure Opto 1 input (pin 11) as a touch probe for zeroing the Z axis. Opto 2 and Opto 3 inputs are configured as general purpose inputs #1 and #2 respectively.

Signal	Enabled	Port #	Pin Number	Active Low	Emulated	HotKey
Input #1	✓	1	12	✗	✗	0
Input #2	✓	1	13	✗	✗	0
Input #3	✗	1	0	✗	✗	0
Input #4	✗	1	0	✗	✗	0
Probe	✓	1	11	✗	✗	0

10.0 VFD CONTROL

IMPORTANT: Make sure your motor is set up and running correctly (direction/speed) using the VFD front panel manual controls before attempting to control the motor from the breakout board.

The breakout board can control a variable frequency drive that is typically used to drive an air or water cooled spindle motor. The board outputs an analogue voltage according to the G -Code "S" command.

The VFD circuitry on the breakout board is opto-isolated to block any VFD electrical interference and as it emulates a potentiometer, it automatically works with any 0-10V or 0-5V input VFD providing full range 0-100% control.

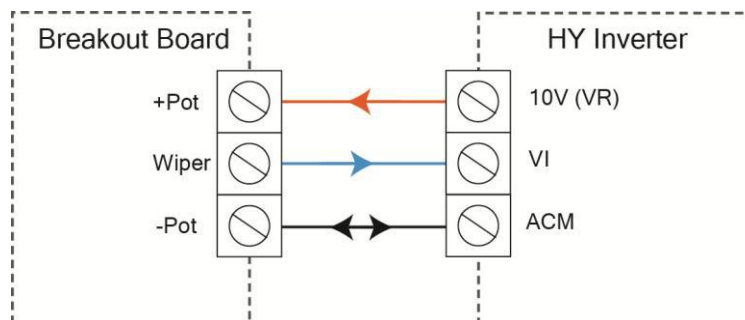
The examples in this section use Mach3 as the PC controller software and a Chinese HY inverter as the VFD. Other software and inverters will be different, but the principles will be similar.

10.1 Connecting the Analogue Input

Most VFDs are designed to allow connection of an external potentiometer to manually control the speed. The BBC breakout board uses these connections to emulate the potentiometer and allow a CNC controller such as Mach3 to control the inverter's speed.

The VFD manual will normally show a diagram with the ends of the potentiometer connected to an analogue +10V and 0V terminal, and the wiper connected back to an analogue input. On the HY inverters the +10V is called "10V" or "VR", the 0V is called "ACM" and the voltage input is called "VI".

Connect the breakout to the inverter as shown below. All three wires are required for operation.



10.2 Configure the VFD to use the Analogue Input

By default the VFD uses the front panel controls to adjust the motor speed. The following parameters need to be set to switch speed control over to the analogue input.

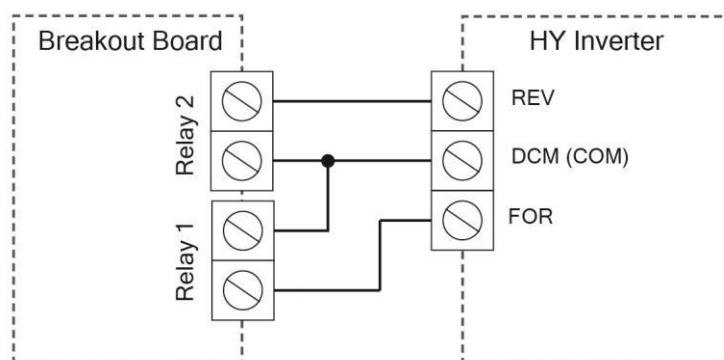
- PD002 = 1 Use external potentiometer for speed control
- PD070 = 0 Analogue input range is 0-10V (default)

10.3 Configure the VFD Analogue Input Jumper

In addition to the parameter changes above, the HY inverter requires a jumper change to use the external potentiometer. Jumper J1 is located on the right hand side of the control terminal block and must be changed from pins 2-3 (VR) to pins 1-2 (VI).

10.4 Connecting the Forward/Reverse Relays

After setting up the analogue input, the inverter speed will now be controlled via the breakout board, however starting and stopping will still be controlled by the inverter front panel RUN/STOP buttons. To allow the breakout board to start and stop the motor, one of the available relays is used to signal forward operation and another for reverse operation if this function is required. If neither relay is activated the inverter will stop. Connect the breakout relays to the inverter as shown below.



In this example Relay 1 runs the motor in the forward direction and Relay 2 runs the motor in the reverse direction.

10.5 Configure the VFD to use the Forward/Reverse Relays

By default the VFD uses the front panel RUN/STOP buttons to control the motor. The following parameters need to be set to switch control over to the breakout board relays.

- PD001 = 1 Use FOR/REV terminal for run control
- PD044 = 2 FOR terminal runs motor forward (default)
- PD045 = 3 REV terminal runs motor in reverse (default)

10.6 Setting the Motor Parameters

General set up of the motor is outside the scope of this document and support should be obtained from the supplier of the motor or VFD. Numerous excellent resources are also available online such as the CNCZone.

Follow your supplier's recommended settings, with particular attention to the following parameters: PD003, PD004, PD005, PD008, PD011, PD014, PD072, PD073, PD141, PD142, PD143, PD144.

10.7 Configuring Mach3

Mach3 controls the spindle speed by outputting a Pulse Width Modulated (PWM) signal with duty cycle from 0 to 100% corresponding to 0-100% of configured speed.

Configure the spindle on the "Motor Outputs" screen to use pin 9, active high as shown below.

Signal	Enabled	Step Pin #	Dir Pin #	Dir Low Active	Step Low Active	Step Port	Dir Port
Spindle		9	9			1	1

Configure the relays to control forward and reverse on the "Spindle Setup" screen. Set Clockwise (CW) to use Output # 1 and CCW to use Output # 2. Check that the "Disable Spindle Relays" box is cleared.


Configure the "Motor Control" section on the "Spindle Setup" screen. Tick "Use Spindle Motor Output" and tick "PWM Control". Set the "PWMBase Freq" to "7". Note: The PWM base frequency must be between 3Hz and 12Hz with 7Hz being the recommended value. If using a SmoothStepper be sure to tick "PWM" and set the "Base Hz" to 7 on the ESS main configuration screen.

Configure the "Pulley Selection" on the "Spindle Pulleys" screen. Choose pulley number 1 and set the "Max Speed" to your spindle maximum RPM i.e. "24000". Set the Ratio to "1"

10.8 Checking the Speed Calibration

The breakout board will automatically provide the correct analogue output voltage corresponding to the supplied PWM duty cycle with a full range error typically under 0.1% (1 part per thousand).

While the BBC output voltage is highly accurate, some low cost VFD's may not have a similarly accurate input circuit, with the actual RPM varying slightly from the commanded voltage. Fine tuning of the actual speed can be achieved by slight variations of the pulley selection "Max Speed" value.

On HY inverters the VFD display can be switched between Frequency/AMPS/RPM by pressing the  key on the front panel.

Remember in your G-Code to always issue the "S" code to set the speed BEFORE issuing the "M3" code to start the inverter. If the "M3" code is issued first Mach3 will use the speed setting from the previous operation which may not give the intended result.

11.0 LED INDICATORS

Your BBC breakout board has nine LED indicators to simplify set up and diagnosis.

The LED are either green, red or blue. Each color signifies a different type of indicator.

- **Green:** Normal operation. All green LEDs must be ON for normal operation.
- **Red:** Abnormal condition. All red LEDs must be OFF for normal operation.
- **Blue:** Informative only.

The following table describes the meaning of each LED when illuminated.

LEDs	Color	Notes
+12V	Green	+12VDC is present.
Enable	Green	The breakout board functionality is enabled.
Error	Red	The breakout board is signaling an error condition to the PC
	Red	The breakout board is signaling a limit switch activation to the PC
Relay1	Blue	Relay 1 is activated and the contacts are closed.
Relay2	Blue	Relay 2 is activated and the contacts are closed.
In1	Blue	Opto-coupled Input 1 is active.
In2	Blue	Opto-coupled Input 2 is active.
In3	Blue	Opto-coupled Input 3 is active.

12.0 SPECIFICATIONS

Value	Minimum	Typical	Maximum
Electrical			
+12V Input	11VDC	12VDC	13VDC
+12V Supply Current			180mA
VFD speed accuracy		<0.1% error	
Relay Contacts Voltage			250VAC
Opto-Coupler On Current		8mA	50mA
Relay Contacts Current			5A
Step Frequency			2MHz
Input PWM Base Frequency	3Hz	7Hz	12Hz
Logic Low Input	-0.3V		+0.8V
Logic High Input	+2.6V		+5.3V
Mechanical			
Length	87mm (3.4")		
Width	79mm (3.1")		
Mounting Hole Diameter	3.3mm (1/8" approx)		
DIN Rail Mounting	Optional at time of purchase.		
Weight	77g (2.7oz) without DIN rail adapters		
Material	Bare PCB.		
Environmental			
Ambient Temperature	0°C (32°F)		40°C (104°F)
Humidity			90%RH
Atmosphere	No explosive or corrosive gases		
Contamination	No wood dust, plasma cutting dust, metal chips etc.		
Ingress Protection	IP00		