

Triple BEAST

Bene's Advanced Stepper Drive

3-axis high performance power amplifier for stepper motors with integrated interface card

Installation manual



Brief product description

The "Triple BEAST" is a complete stepper motor controller for three axes. All components for the control of a small milling, engraving or turning machine are integrated in a housing with dimensions of only 100x102x55mm. Only a power supply unit for the power supply is still required. The effort for mounting, wiring and the possibilities for errors are thus reduced to a minimum.

The Triple BEAST offers all the advantages of the individual BEAST power amplifier at extremely low cost, such as very quiet motor running with continuous sinusoidal commutation and complete short-circuit and overload protection. Only the maximum current and the maximum operating voltage are limited to 5A and 55V compared to the "big brother". For applications with 4 axes, or if a more powerful motor is required, a connection option for an additional output stage is available.

Due to high efficiency and a sophisticated thermal concept, only little heat loss is generated, so that despite the small dimensions, practically no overheating problems occur.

Safety Instructions

The Triple-BEAST stepper motor controller may only be installed and commissioned by qualified personnel. Please read the operating instructions carefully and follow all instructions exactly. Improper installation or operation of the device can cause damage to the electronics or the machine and can result in dangers to the health of the operating personnel. The system manufacturer, who assembles the electronics and other components to form the overall system, and the system operator are responsible for compliance with the legal regulations.



Caution: Danger to life! Operate the device exclusively with a voltage source isolated from the mains supply and ensure that the limit values specified in the technical data are observed! Machine, motor and housing must be grounded according to the regulations. Devices operated with mains voltage must be checked and approved by a specialist. Make the first tests with disassembled motors or remove drive belts or couplings. This prevents injuries or damage due to unexpected movements of the machine.

System requirements

To obtain a functional drive system, the following components are required in addition to the Triple-BEAST control:

1. One to three two-phase stepper motors with a rated current between 1.4 and 5A (up to 6A with restrictions). Three- or five-phase motors or high-impedance motors from printers and disk drives are not suitable.
2. A power supply unit for the voltage supply. with an output voltage between 24 and 55V. Stabilization is not absolutely necessary. More detailed selection criteria are listed in the chapter0.
3. A signal source for the step and direction signal to control the power amplifier. This can be a PC with appropriate software, optionally with additional hardware (e.g. smoothstepper).

Recommended motors

The table below lists some recommended combinations with motors from Benezan Electronics. The applications mentioned above only represent an approximate selection. If you wish a more precise calculation of the drives, please contact Benezan Electronics.

Motor Type	Dimensions	Phase current	Operating voltage	Application
HS56-0818	56 x 56mm	1,8A	24..48V	Miniature machines, pick & place, cutting and pen plotters
HS56-1442	56 x 76mm	4,2A	24..48V	Small to medium-sized milling and engraving machines in aluminium profile design
HS60-2150	60 x 90mm	5,0A	48..55V	Small to medium-sized milling and engraving machines in aluminium profile design
HS86-3263	86 x 78mm	5,0A	48..55V	Milling machines for metal working, larger portal machines, plasma cutting machines

The Triple BEAST control also works with many motors from other manufacturers. Please make sure, however, to use only modern hybrid motors that are suitable for microstep operation. The best results and highest dynamics are achieved with motors with flange sizes from 56 to 60mm and phase currents from 3 to 5A. The operation of larger motors with 86mm flange dimension is possible, but with restrictions. For motors with 6A rated current the full torque is not reached, because the output stage only delivers max. 5A. With large motors with 4A rated current, high speeds cannot be achieved due to the high inductance.

If you need high torque and high speed at the same time, it is advisable to use a BEAST single output stage, which allows higher operating voltage and motor currents up to 10A. If only one motor with higher power is required, for example for a heavy Z-axis, the combination with Triple-BEAST and single BEAST as 4th axis is possible.

Installation

Connections Overview

All terminal numbers are numbered from top to bottom as shown in the adjacent figure. Reference switch inputs (8-pin terminal X3, top left)

No.	Description
1	Reference switch X voltage output (+12 or +24V)
2	Reference switch X Signal input
3	Reference switch Y Voltage output (+12 or +24V)
4	Reference switch Y Signal input
5	Reference switch Z voltage output (+12 or +24V)
6	Reference switch Z Signal input
7	Reference switch 4th axis voltage output (+12/24V)
8	Reference switch 4th axis Signal input

Relay outputs

(6-pin terminal X4, bottom left)

No.	Description
1	230V~ L Input
2	230V~ N Input
3	Relay 1 L Output
4	Relay 1 N Output
5	Relay 2 L output
6	Relay 2 N output

Power supply

(2-pole terminal V, right side)

No.	Description
1	Motor voltage input(+24..+55V)
2	Ground 0V

Additional functions

(6-pole terminal X2, top right)

No.	Description
1	Ground 0V for brake
2	Holding brake Output
3	Analog output ground 0V
4	Analog output 0..10V
5	Emergency stop switch Input
6	Emergency stop switch +12V output

Power supply

(5-pole terminal X1, bottom right)

No.	Description
1	5V output (max. 150mA)
2	Ground 0V
3	12V output (max. 300mA)
4	Ground 0V
5	24V input (15..55V,max.0,3A)

Motor connections

(4-pin terminals M1 to M3, right side)

No.	Description
1	Winding 1
2	
3	Winding 2

Assembly

The output stage is designed for mounting on a 35mm DIN rail ("top-hat rail") in a housing. **Protect the unit from flying chips, dust and cooling water.** Damage caused by metal chips or moisture will void the warranty. Hook the controller into the rail with the motor connections facing up, then press the heat sink firmly onto the rail until it clicks into place. Alternatively, it can also be fastened from the rear with self-tapping self-tapping screws B3.5x10 or spacer bolts on a mounting plate. In this case the clip for the DIN rail must be removed. Attention - never use a longer screw than the one supplied (M4x16) to screw on the clip. Otherwise they could damage the power components mounted on the inside of the heat sink.

Since the output stage becomes more or less hot during operation depending on the motor current, the following rules must be observed during installation:

- Make sure that there is free air circulation. The distance to other devices, housing wall, cable ducts, etc. should be at least 2 cm on all sides.
- If possible, the heat sink should be mounted vertically with vertical fins.
- For motor currents up to a maximum of 3 x 4.2A, natural convection is sufficient, i.e. a fan is not required if the air circulation is not obstructed by a housing that is too small.
- For motor currents from 3 x 5A or >13A in total, supported cooling with a fan is advisable. A small processor fan for PCs, for example, can be used for this purpose. A 12V connection is provided for the power supply of the fan (X1 terminals 2+3), which can supply up to 300mA.

Overheating cannot lead to the destruction of the controller, because an integrated overtemperature protection switches off the motor current when the maximum temperature is exceeded. Nevertheless, it is advisable not to operate the output stage permanently at the upper temperature limit, as this will reduce its service life.

Power supply connection

The supply voltage must be between 24 and 55V. For most applications a 48V switch mode power supply is ideal because these power supplies are small, light, relatively inexpensive and easy to connect. They are also overload-proof and usually have inrush current limiting and mains filter already integrated.

However, a stabilized power supply is not necessarily required, an unregulated power supply consisting of transformer, rectifier and filter capacitor is also suitable. Please note, however, that the voltage range must be maintained even with mains and load fluctuations (usually $\pm 10\%$). Also make sure you have suitable fuse protection. If necessary, inrush current limitation and an interference filter may be necessary.

The maximum current with which the power supply unit is loaded is approx. $2/3$ of the motor current. However, the continuous load load is lower in most applications. For the operation of 3 motors with 4A each, for example, a power supply unit with 3 x 4A x $2/3 = 8A$ peak current and about 5A continuous load capacity is sufficient. An electrolytic capacitor with about 4700 μ F at the power supply output is recommended to keep voltage fluctuations small due to fast load changes.

Connect the positive pole of the power supply unit to terminal "V" connection 1 (on the side, labelled +24..55V) and the negative pole to connection 2 (labelled GND). **Attention, wrong polarity can damage the power amplifier**, especially if the power supply has no fast fuse or current limiter. **Never connect or disconnect the supply connection under load. Do not switch the secondary side of the power supply (DC voltage) with switches or fuses.** The resulting arc can cause damage. Only switch the power supply unit on and off on the primary side (mains AC voltage). The protection should also be provided on the primary side. Please note that the negative connection (Power Ground) is connected to the heat sink and thus automatically to the housing (potential earth).

For most applications, the power supply unit that supplies the motor voltage can also be used to supply the PC interface (terminal X1). Connect the positive pole to X1 terminal 5 and the negative pole to terminal 4. Only if you use inductive proximity switches with 24V and the motor supply voltage is higher than 24V, an extra 24V power supply unit is required. For details please refer to the chapter "Limit switches".

Motor connection

When using prefabricated cables for stepper motors from Benezan Electronics the connection of the motors is very easy. Connect the wires numbered 1..4 to the terminals M1, M2 or M3 marked A to D. Connect the cable lug of the shield connection to the flat plug next to the terminal. Plug the XLR connector of the motor into the female connector on the other side of the cable - ready.

For motors from other manufacturers you must consult the relevant data sheet to identify the wire colours of the coil connections. For motors with 4 connections you can also use a continuity tester. Connected terminals belong to the same coil.

Connect the terminals of one coil to A and B, the terminals of the other coil to C and D. Interchanging the coils or the connections of the same coil with each other only changes the direction of rotation, but does not affect the function. Only with crossed connections (e.g. a coil at A-C or A-D) the motor does not work.

Settings and displays

The Triple-BEAST control has ten so-called piano switches on the left side to select the operating mode of the power amplifiers and the phase current of the motors. A pressed switch is switched on (1 = ON, in the picture to the left), in the upper position (in the picture to the right) it is switched off (0 = OFF).

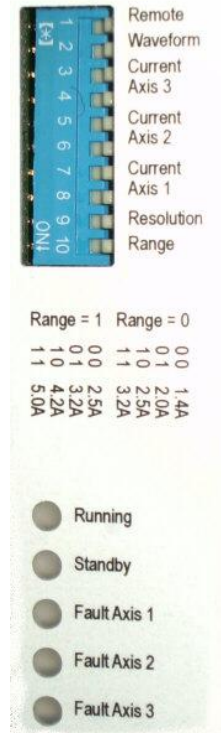
No.	Description
1	0 = Standard, 1 = Parameter setting via software instead of piano switch (currently not supported)
2	Waveform: 0 = pure sine, 1 = sine with harmonics
3	Selection of motor current for axis no. 1 (X)(fine adjustment, see small table below)
4	
5	Selection of motor current for axis no. 2 (Y)(fine adjustment)
6	
7	Selection of motor current for axis no. 3 (Z)(fine adjustment)
8	
9	Microstep resolution: 0 = 1/10 (2000/rev), 1 = 1/5 (1000/rev)
10	Motor current range (rough adjustment): 0 = 1.4..3.2A, 1 = 2.5..5A

Switch No. 10 is used for rough selection of the motor current range for all axes simultaneously. Simultaneous operation of very small and very large motors is therefore not possible. Depending on the selected range, the fine adjustment can then be carried out separately for each motor with the switches 2...8.

Switch No. 2 can be used to adjust the waveform of the motor current. Some motor types do not have an exact sine wave but a waveform slightly distorted in the direction of a triangle. The optimal waveform can be determined experimentally, and leads to a reduction of vibrations in certain speed ranges.

Switch No. 9 is used to select the resolution. In normal position this is 1/10 microstep (corresponds to 2000 steps/revolution for the standard motor with 200 full steps/revolution). When the switch is held down, it switches to 1/5 microstep (corresponds to 1000 steps/revolution).

While other stepper motor power stages often offer a confusingly large number of possible resolutions, this is not necessary with the Triple-BEAST. Higher resolutions are usually only used to reduce disturbing jerking caused by single steps, while the step size is then out of reasonable proportion to the accuracy of the mechanics, is basically useless and only unnecessarily increases the required clock frequency. The Triple-BEAST power amplifier, on the other hand, does not need a finer subdivision of the steps, because it is pleasantly quiet even with only 1/5 or 1/10 microstep. No single steps are noticeable because the motor is driven with a continuous sine wave instead of a staircase function. For example, you can cover the speed range up to 1350/min with 1/10 microstep at 45kHz clock frequency and still do not have to do without the quiet operation of finer resolution. For even higher speeds or software that can only manage 20kHz or less, there is the 1/5 setting.



Status LEDs

The status displays of the power amplifiers are located on the left side (see picture above right). The different colours or combinations thereof indicate the following operating states:

LEDs	Lettering	Description
(green)	Running	Motor(s) running, no current reduction
(yellow)	Standby	Motors stand still, current reduction
(red blinking)	Fault Axis...	A single red flashing LED indicates a short circuit, overload or faulty wiring on the corresponding motor. The other motors and the yellow or green LED remain active.
(red blinking)	Fault Axis...	If all red LEDs flash simultaneously when the green and yellow LEDs are switched off, the output stage is overheated. All motors are switched off.
(yellow/red alternating)	Fault Axis...	If the yellow and all red LEDs flash alternately, the power stage has been deactivated due to overvoltage. The cause can be braking energy from the motors or an incorrectly dimensioned power supply unit.

The LEDs on the upper side indicate the status of the PC interface.



LEDs	Lettering	Description
1 (green)	Power	Power supply ok
2 (green)	Batch pump	Watchdog (charge pump) active
3 (red)	Drive fault	One or more output stages report an error
4 (red)	E-Stop	Emergency stop switch activated or line interrupted
5 (yellow)	Relay 1	Relay 1 switched on (spindle motor)
6 (yellow)	Relay 2	Relay 2 switched on (coolant or suction)

PC connection

The breakout board is connected to the PC with a parallel port cable (SUBD25 male/female). The cable should have all pins connected through 1:1, especially all ground pins (18..25). The recommended maximum length is 3m.

The pin assignment of the LPT port is designed for Mach3, EMC or WinPCNC. When using other programs (e.g. CNC-Profi, PC-Lathe) an adapter plug may be required to adapt the pin assignment (so-called patch box). Please understand that Benezan Electronics cannot support every program available on the market. The perfect function is only guaranteed together with Mach3.

The pin assignment is listed in the following table:

No.	Description	No.	Description
1	Spindle, relay1, PWM	14	Cooling, relay 2
2	Direction X	15	Reference switch 4th axis
3	Measure X	16	Watchdog, current reduction
4	Direction Y	17	PWM, current reduction
5	Bar Y	18	Signal ground
6	Direction Z	19	Signal ground
7	Measure Z	20	Signal ground
8	Direction 4th axis	21	Signal ground
9	4th axis cycle	22	Signal ground
10	Reference switch Z	23	Signal ground
11	Emergency stop	24	Signal ground
12	Reference switch Y	25	Signal ground
13	Reference switch X		

Some pins have multiple assignments so that the interface can be adapted to different programs. The selection is made by the jumpers directly next to the SUBD-25 connector. The contact pins are numbered from right 1 to left 11. A jumper always connects two adjacent pins.

(2-1) If this jumper is inserted, the watchdog is bridged, i.e. step signals and relays can always be switched. This is necessary for control software that does not support a charge pump or toggle signal. This has the disadvantage that unwanted movements or switching operations are triggered when booting the PC, if the signals of the LPT port are undefined, or dongle queries take place. When the jumper is not inserted, the watchdog is active and step signals and relays are only "armed" if the software outputs a valid charge pump signal.

(9..3) These contacts are jointly used to configure the PWM signal, the current reduction and the signal source for relay 1. The following combinations are possible:

- 8-7, 6-5, 4-3: Relay 1 on if PWM>10%, current reduction pin 17, PWM on pin 1, watchdog pin 16
- 9-8, 7-6, 5-4: relay 1 at pin 1, PWM at pin 17, current reduction pin 16, no watchdog (1-2 bridges)
- 7-6, 5-4: relay 1 at pin 1, PWM at pin 17, no current reduction, watchdog pin 16
- 8-7, 5-4: relay at pin 1, no PWM, current reduction pin 17, watchdog pin 16

(16..12) These jumpers are used to set the supply voltage for the limit switches and to enable the fourth axis (see below)



Reference switch inputs

Up to 4 switches or inductive sensors can be connected. If the 4th axis is not used or does not require a reference switch, a tool length sensor can also be connected here, for example.

Mechanical switches or inductive proximity switches of the PNP type can be used. For mechanical switches the jumper 14-13 must be plugged in. In this case, the supply voltage at X1 is arbitrary (15..55V). A common power supply unit can be used for the motor output stages.

If proximity switches are used, the jumper 13-12 must be plugged in and the supply voltage at X1 must be 24V. If the motor voltage is higher, two separate power supplies are required. The sensors should be connected as follows: brown (+24V) to terminal 1, 3, 5 or 7, blue to the ground connection of the power supply, black (signal) to terminal 2, 4, 6 or 8.

The inputs are inverting, i.e. the corresponding LPT pin is high when the switch input is open (low) and low when the switch input is closed (high). Normally closed or normally open contacts can be used if the polarity is selected accordingly in the PC software.

The switch inputs have a Schmitt trigger function and are interference suppressed with a low-pass filter, so that there is usually no need to fear interference even with unshielded cables.

Additional functions

An emergency stop button and optionally a holding brake (Z-axis) and the speed signal for a frequency inverter are connected to terminal X2.

Emergency stop

The PC interface has several independent functions that serve to stop the machine in case of problems:

1. An emergency stop button (mushroom/panic button) must be connected to terminals X2.5 and X2.6. If the contact is opened, relays 1 and 2 are forcibly switched off. A push-button emergency stop is indicated by LED No. 4 (red, see figure page 6). Additionally an emergency stop is reported to the PC (LPT pin 11)
2. If the status output of one or more output stages reports an error or if this line is interrupted, an emergency stop signal is sent to the PC. The power stage error is indicated by LED No. 3 (red). For the three internal power amplifiers there are additional status LEDs on the left side.
3. In case of an emergency stop (no matter if mushroom button or status error) the relay for the holding brake is switched off, so that the mechanical brake is blocked (if present).
4. If the watchdog is active (jumper 1-2 not plugged in), relay outputs and step signals are only enabled if a valid watchdog signal is detected.

Speed control (analog output)

In order to be able to specify the speed for a frequency inverter, the control system has an analog output 0..10V. A voltage proportional to the duty cycle of the PWM signal (PWM = pulse width modulation) is output at pin 1 or 17 of the LPT port. Here 0% (low) corresponds to a voltage of 0V, 10% corresponds to 1V, 20% corresponds to 2V etc. up to 100% and 10V.

The frequency of the PWM signal (PWM base frequency) should be at least 45Hz so that the ripple of the analog signal is not too high. At Mach3 this allows a resolution of 10 bit at 45kHz kernel speed.

If all functions of the controller are needed at the same time, the number of available LPT pins will be limited. Therefore it is possible not to switch relay 1 via an extra pin, but always when the analog signal is higher than 1V (see jumper page 7). This means that only a single, common pin is required for speed and spindle start. The minimum pulse width should be set to 10% in this case.

Holding brake

When using ball screws, smooth-running servomotors or very heavy Z-axes, an electromechanical holding brake must be provided to prevent the vertical axis from moving down by itself when the drive is switched off. Such brakes are usually operated with 24V. They are blocked when no voltage is applied and open when the voltage is switched on.

The breakout board has a relay output for such a holding brake. The brake is always switched on (released) when the power supply is switched on and no emergency stop is active and no output stage reports an error.

The output has an integrated free-wheeling diode and is suitable for switching inductive loads. If the brake is to be operated pneumatically, hydraulically or with a voltage other than 24V, an external contactor or solenoid valve is required. The output voltage of the brake at X2 is always equal to the operating voltage at X1, i.e. if the motor supply voltage is greater than 24V, two separate power supplies are required.

Connection for 4th axis

An external power amplifier for a 4th axis can be connected to the RJ45 socket on the upper side. This can be a single BEAST, a UHU or stepper motor output stage or a servo controller from another manufacturer. For BEAST or UHU a simple patch cable can be used. When connecting external power amplifiers the following pin assignment applies:

No.	Description
1	Current reduction
2	Signal ground
3	Clock
4	+5V
5	Direction
6	+5V
7	Status (0=ok, 1=error)
8	Signal ground

If the output stage does not provide a status signal, pins 7-8 must be bridged or jumper 15-16 must remain plugged in. For BEAST or UHU with status signal it should be disconnected.

Commissioning and troubleshooting

If you are using the control unit for the first time, please check the following points again before switching it on:

- Are all terminal blocks correctly aligned in the slots?
- Is the power supply (24 to 55V=) correctly connected (terminal X1 on top **and** terminal V on the right)?
- If the supply voltage is higher than 28V, jumper JP3 must be set to position 13-14 (limit switch supply 12V).
- Is the emergency stop switch connected? For test purposes only, a jumper may be connected between pins 5 and 6 of X2 as an alternative. An emergency stop switch is legally required on a machine.
- Check again whether the setting of the remaining jumpers matches the pin assignment of your control software.

If these conditions are met, you can connect to the PC, switch on the supply voltage and start the control software. After activating the software (at Mach3 you have to press the reset button) the state of the LED lights should be as follows

- the two green LEDs "Power" and "Charge Pump" must light up,
- the two red LEDs "Drive Fault" and "E-Stop" must be off
- the two yellow LEDs Relay 1 and Relay 2 must be off.

If this is not the case, please refer to the chapter "Troubleshooting" below. If everything is in order, you can now check the movement of the motors and the function of the relays and switches.

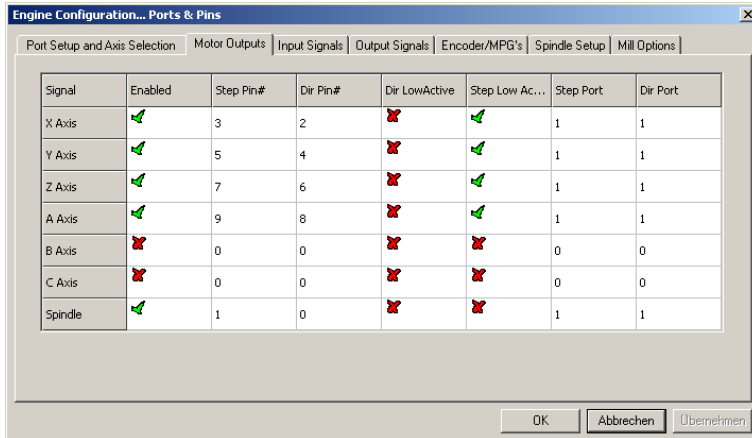
Troubleshooting

The following table gives an overview of the most common errors and the possible causes.

No.	Symptom	Cause
1	LED "Power" (green) is not lit	Power supply (terminal X1 and terminal V on the right) not connected or wrongly polarized.
2	LED "Charge Pump" (green) is not lit	At pin 16 of the LPT port a square wave signal with $\geq 10\text{kHz}$ must be output. If the software does not support this, jumpers 1-2 must be inserted.
3	LED "Drive Fault" (red top) is on, LEDs "Fault Axis 1-3" (red side) are off	Jumper 15-16 is missing, the 4th axis is not (correctly) connected or switched off
4	LED "Drive Fault" (red top) lights up, LEDs "Fault Axis 1-3" (red side) flash	One or more output stages report an error (overheating or short circuit, see page 6)
5	LED "E-Stop" (red) lights up, LED "Standby" (yellow) flashes	The emergency stop switch (X2 Pin 5 and 6) is not connected or pressed.
6	Relays do not switch	a) yellow LEDs light up, but relays do not switch: see 5 b) yellow LEDs do not light up: Jumper incorrectly inserted or software pin assignment not configured correctly
7	Motors do not turn	a) green LED "ChargePump" is not lit: see 2 b) Step/direction pins reversed? (LPT pins 2,4,6,8 = direction, pins 3,5,7,9 = step)
8	Frequency converter Speed fluctuates	PWM frequency (base freq.) too low, min. 45Hz
9	No function of the emergency stop signal (LPT pin 11)	Pin 11 must be configured as "active low" in the software, LED "Drive Fault" (see 3) and "E-Stop" (see 4) must be off.
10	In case of "Reset" or emergency stop the motors take one step	Polarity of step signal wrong (inverted)

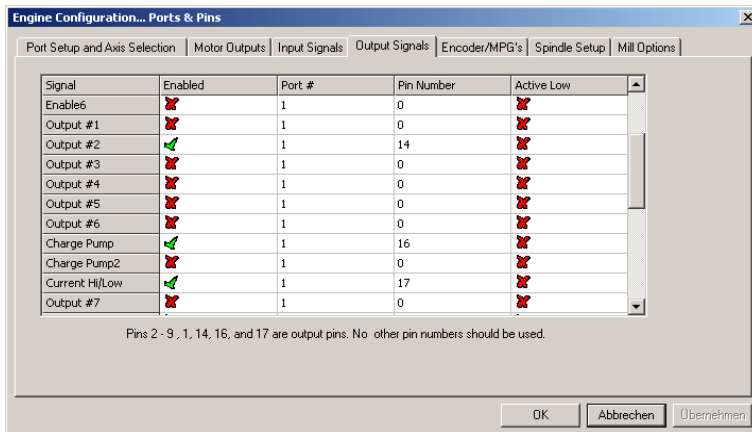
Configuration of the software

Example configuration Mach3



The pictures on the left show the settings for the standard configuration (jumpers 3-4, 5-6 and 7-8 inserted). Further settings

- XHome Pin 13
- YHome Pin 12
- ZHome Pin 10
- AHome or length sensor (sample) Pin 15
- RelayControl:M3 and M4 → Output#1M7 and M8 → Output#2
- Motor Control: ✓ Use Spindle Motor Output ✓ PWM Control PWM Base Freq. = 45 Minimum PWM = 10%



At Mach3 the pins for step and direction signals can be swapped as desired. This makes it possible to use the external, fourth axis also as X, Y or Z, which is advantageous, for example, if the Z axis is particularly heavy and therefore requires more drive power.

Other control software

The TripleBeast also works well with NCdrive, EMC², WinPCNC and other CNC programs. For reasons of space, we will not go into the configuration of this software here. If you have difficulties, please ask your dealer or Benezan Electronics.

Technical data

Absolute limit values

The following parameters must not be exceeded under any circumstances to prevent damage to the device:

Parameters	min.	max.	Unit
Operating voltage	-0.5	+63	V
Storage temperature	-40	+85	°C
Ambient temperature during operation	-20	+70	°C
Voltage at PC connection (SUBD25)	-0.5	+5.5	V
Voltage at limit switch inputs	-5	+63	V
Voltage at the relay terminals		30	Vdc
		250	Vac
Current per relay contact (X4)		8	Aeff
Current at brake relay (X2)		5	A
Current at analog output 0..10V		20	mA

Electrical connection values

Parameters	min.	max.	Unit
Operating voltage	+24	55	V
Power consumption without motors		80	mA
12V output max. load		300	mA
5V output max. load		200	mA
Ambient temperature	0	+50	°C
Level logical 0 for signal inputs	-0.5	+0.8	V
Level logic 1 for signal inputs	2.5	+5.5	V
Current consumption signal inputs at 0..5V	0	1	mA
Pulse width for step signal	2		µs
Setup time Direction signal valid until step ¹	2		µs
Hold time Step to direction signal Change	2		µs
Level logical 0 for status output		0.8	V
Level logical 1 for status output	3		V
Crotch frequency	0	200	kHz
Watchdog (Charge pump) Frequency	10	100	kHz
Delay time automatic current reduction	0.5	0.7	s
Threshold over temperature	70	85	°C
Current control accuracy	-10	+10	%
Cable cross section for terminals Supply	0.5	2.5	mm ²
Cable cross section for terminals Motor	0.22	1	mm ²
Number of microsteps per full step	5	10	-
Microsteps/revolution for standard motor ¹	1000	2000	-

¹Step is executed on rising edge, i.e. transition from logical 0 to logical 1

¹ Standard motor: 1.8°/full step, 200 full steps/revolution