

BIGBEAST

Bene's Advanced Stepper Drive

High power output stage with water cooling for stepper motors



Brief product description

The "BIGBEAST" is a powerful and compact stepper motor output stage for applications in CNC-and automation technology. With its phase current adjustable within wide limits from 1.8 to 1 0A, it can be used for all common two-phase motors from 56mm (NEMA23) to 1 10mm (NEMA42) flange size. The water cooling and the extended voltage range of up to 120V makes it particularly suitable for large motors.

The output stage is constructed with discrete MOSFETs. The high supply voltage range up to 120V offers significant advantages over most integrated power stage ICs at higher speeds and more safety margin against damage from voltage spikes. An integrated short-circuit protection makes the electronics insensitive to the most common errors.

Microstep control and a new type of continuous sinusoidal commutation significantly reduces noise and resonance at low speeds. Active damping also prevents vibrations at high speeds and enables very high speeds that cannot be achieved with low-cost solutions.

Targeted circuit measures such as optical decoupling of all control signals and limited edge steepness of the circuit breakers (Active Slope Control) ensure a maximum of interference immunity and a minimum of interference radiation. This increases reliability and helps you to comply with EMC regulations. Of course the device also complies with the latest RoHS regulations.

1 Safety Instructions

The BIGBEAST stepper motor output stage 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 power amplifier and other components to form the overall system, and the system operator are responsible for compliance with the legal regulations.

Caution: Danger to life! The device can be operated with voltages up to 160V. In the event of a fault, voltage peaks of up to 200V may occur briefly. If you operate the system with more than 60V, the installation and commissioning may only be carried out by a trained electrician or must be approved by such an electrician. No liability is accepted for damage or injury resulting from failure to observe the safety regulations or improper use.

Always use a power supply unit with potential separation (no autotransformer or variac)! Machine, motor and housing must be grounded according to the regulations.



2 System requirements

To obtain a functional drive system, the following components are required in addition to the BIGBEAST power amplifier:

1. A two-phase stepper motor with a rated current between 1.8 and 10A. 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 80V. Stabilization is not absolutely necessary. More detailed selection criteria are given in chapter 3.2.
3. A signal source for the step and direction signal to control the power amplifier. This can be a PC with appropriate software, an external CNC control (e.g. BEAMICON), or for test purposes also a frequency generator.

2.1 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
HS56-1442	56 x 76mm	4,0A	36..50V	Smaller milling machines in aluminium profile construction
HS86-3263	86 x 78mm	6,0A	48..70V	Milling machines for metalworking, larger portal machines
SM2862	86 x 96mm	6,0A	60..80V	
HS86-5880	86 x 118mm	8,0A	60..120V	
SM2863	86 x 127mm	6,0A	70.. 160V	
HS86-8588	85 x 157mm	9,0A	80..160V	

The BIGBEAST power amplifier also works with many engines from other manufacturers. Please note, however, that under certain circumstances full performance may not be achieved.

3 Installation

3.1 Assembly

The output stage is designed for mounting on a 35mm DIN rail ("top-hat rail"). Hook the power amplifier into the rail with the terminal side facing up, then press the bottom side with the control connection firmly onto the rail until it snaps into place. Alternatively, it can also be attached to a mounting plate using M3 screws or spacer bolts. To ensure trouble-free operation, the following rules must be observed during installation:

- When using water cooling, the unit should be installed with the water connections facing downwards. When mounted on a heat sink, the mounting position is arbitrary.
- Only deionised water with a suitable corrosion protection agent may be used (available from specialist dealers for PC water cooling systems). Antifreeze for car radiators is *not* suitable.
- The BIGBEAST is protected against failure of the cooling system (pump) by an over-temperature safety device. However, continuous operation without cooling can reduce the service life and is not permitted.
- At full load (160V 10A) a pumping capacity of about 1 l/min is required. The water temperature should not exceed 50°C at the inlet and 60°C at the outlet.

3.2 Power supply connection

The supply voltage must be between 24 and 160V. A stabilized power supply is not necessarily necessary, an unregulated power supply consisting of transformer, rectifier and filter capacitor is completely sufficient. Please note, however, that the voltage range must be maintained even with mains and load fluctuations (usually $\pm 10\%$).

The maximum current with which the power supply unit is loaded is approx. $2/3$ of the motor current. However, the continuous load is lower in most applications. For the operation of 3 motors with 4A each, for example, a power supply unit with $3 \times 4A \times 2/3 = 8A$ peak current and about 5A continuous load capacity is sufficient. An electrolytic capacitor with about 1000 μ F per A motor current is recommended to keep voltage fluctuations caused by mains hum and short load changes small. A little more won't hurt either, but the capacitor should not be too big either, otherwise the current peaks in the rectifier and transformer will be too big.

Connect the positive pole of the power supply unit to terminal 1 (label 24.. 120V DC) and the negative pole to the Connect terminal 2 (Power Ground label). **Attention**, wrong polarity can damage the power amplifier, especially if the power supply does not have a fast fuse or current limiter

If necessary, several BIGBEAST power amplifiers can be operated in parallel on one power supply unit. Please note please make sure that the negative connection (Power Ground) is connected to the heat sink and therefore automatically to the (potential earth) is connected. The connecting cables between the power supply unit and the power amplifiers should be laid in a star shape and as short as possible, i.e. each power amplifier should have its own direct connection to the power supply unit.

3.3 Motor connection

The output stage is suitable for the operation of two-phase motors. These usually have four or eight connections. For motors with eight connections, two windings can be connected in parallel or in series. The following formula can be helpful as a decision aid - serial or parallel: The supply voltage should be in the range of 10 to 25 times the rated motor voltage. If the nominal voltage is not given, it can be calculated by multiplying the winding resistance by the nominal current. Example:

Motor data: 8 connections, 0.8 Ω per winding, rated current 3A per winding, 6A parallel parallel connection $2 \times 0.8\Omega$ gives $0.4\Omega * 6A = 2.4V$

Series connection: $2 \times 0.8\Omega$ gives $1.6\Omega * 3A = 4.8V$

Line voltage $48V = 20 \times 2.4V = 10 \times 4.8V$

In this case both types of connection would be possible. However, parallel connection allows higher speeds, and is therefore usually preferred.

Motors with 6 terminals can also be used, but this is not recommended as these are mostly older models designed for unipolar operation with obsolete power amplifiers. Old Motors, which can usually be recognized by their round,

cylindrical housing, are not designed for microstep operation and show increased vibration and reduced torque.

Connect one winding of the motor to terminals 3 and 4 (A-B), the second winding to terminals 5 and 6 (C-D). The polarity and sequence is irrelevant for the function, but determines the direction of rotation of the motor. If the motor turns in the wrong direction, this can be corrected by reversing the polarity of one (not both) of the windings. Alternatively, the direction of rotation can be reversed with DIP switch No. 4 (see below).

Attention, never disconnect the terminal connection to the motor or power supply unit when the power supply unit is switched on. The output stage is protected against interruption of the motor cable. However, a rotating motor acts like a generator when switched off and returns energy to the output stage. It cannot absorb the energy if the connection to the power supply has been disconnected and may be damaged. Furthermore, the contacts of the connectors are affected by sparking.

3.4 Settings

The phase current is selected with the rotary coding switch "Current Set". No measuring device and no external components are required, only a screwdriver. The phase current corresponds to the maximum current through a winding or the magnitude value of the current vector (i.e. not the rms value) according to the following table:

Switch position	Phase current	Switch position	Phase current
0	1,8A	8	5,0A
1	2,0A	9	5,5A
2	2,4A	A	6,0A
3	2,8A	B	6,5A
4	3,2A	C	7,0A
5	3,6A	D	8,0A
6	4,0A	E	9,0A
7	4,5A	F	10,0A



Attention Be sure to set the correct phase current before switching on the power supply. Too high a current - even for a short time - can damage the motor. If you do not need the full torque of the motor, you can also set a slightly lower current. This significantly reduces heat generation. Do not set less than 70% of the rated current, otherwise the motor will run may not be properly "round".

The BIGBEAST power amplifier has a current reduction, which can either be automatic or controlled via an input signal. With automatic current reduction, the phase current is reduced to approx. 60% of the set maximum value if no step signal has been received for longer than approx. 0.6s. This reduces the losses and thus the heating of the motor to less than half, while there is still sufficient torque available to hold the position.

With heavy loads, such as CNC metalworking, the automatic current reduction is not recommended, because otherwise, with straight lines parallel to the axes, the non-moving axis may lose steps when lateral forces are applied. To avoid this, the explicit current reduction via the input signal should be selected here. The control system then only activates the current reduction if *all* Axles stationary.

The Piano DIP switches have the following assignment (pressing down activates the option):

Switch No.	Meaning
1	Motor size
2	active vibration damping
3	automatic current reduction
4	reverse direction

Switch No. 2 activates the vibration damping, which prevents resonance at medium and high speeds. The recommended position is switch 1 off (up) and switch 2 on (pressed). For motors with extremely high torque and high inertia, the characteristic of the internal filter can be adjusted by pressing switch 1. If the signal source for the step signal has excessive jitter (large fluctuations in period duration), it may be necessary to switch off damping completely (switch no. 2 off).

3.5 Status display

The output stage indicates the current status with 3 LEDs. The meaning of the possible combinations is listed in the following table:

Colour combination	Meaning	Cause
-	switched off	Operating voltage too low
green	Operation, full current	-
yellow	Operation, current reduction	no step signal or current reduction signal
flashing red	Overheating	Ambient temperature too high or ventilation impeded
red/yellow flashing	Overcurrent	Short circuit, wrong connection or motor defective

3.6 Signal connections

The step and direction signals are connected to the RJ-45 socket marked "Command Input". The power amplifiers can be connected directly to the BEAMICON V4 controller or the breakout board from Benezan Electronics using standard Ethernet patch cables (1:1, no crossover or X!). The wire colours are valid when using Cat5 Ethernet patch cables from Reichelt. Pin 1 is located on the side of the housing corner.

BIGBEAST RJ-45 jack		Wire colour
8	Status output -	brown
7	Status output +	white/brown
6	Step Input +	green
5	Direction entrance -	white/blue
4	Direction entrance +	blue
3	Step Input -	white/green
2	Current reduction -	orange
1	Current reduction +	white/orange

If you are not using a BeamiconV4 or breakout board, you can connect the power amplifier as follows:

- All negative inputs are connected to ground and the positive inputs are driven with a TTL or CMOS signal

- All positive inputs are connected to +5V or +3.3V and the negative inputs are driven by a low-active driver (or open collector).

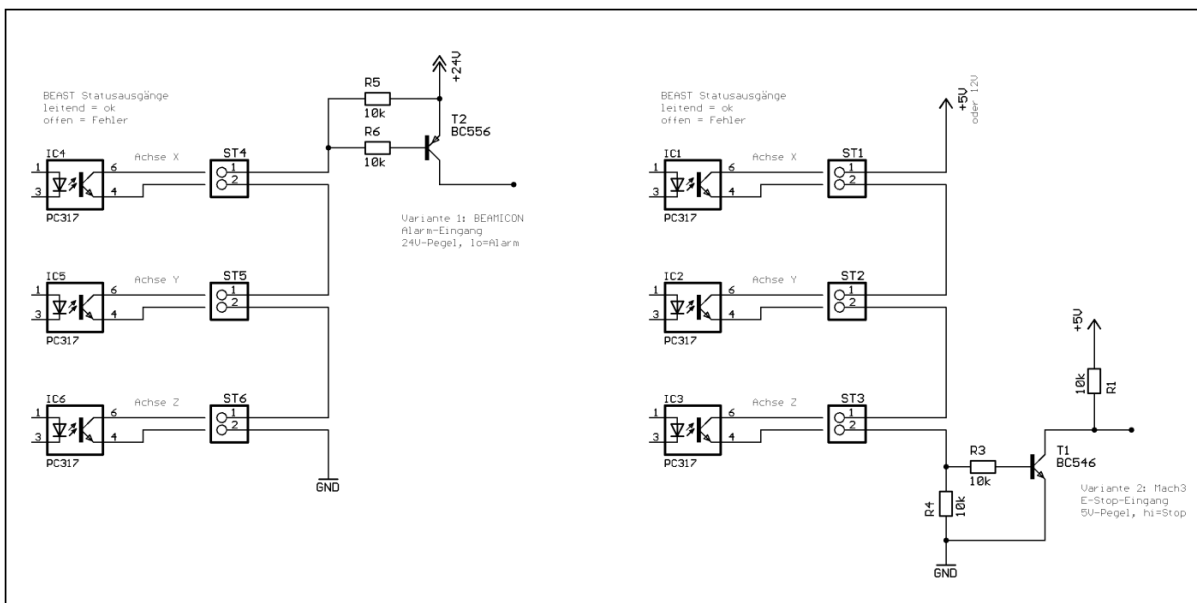
- Positive and negative inputs are controlled with complementary drivers (RS422). The status output is conductive in normal operation (+ and - connected), interrupted in case of error message. If the negative output is connected to ground, an open-collector signal with 0=Ok and 1=error is obtained at the positive output.

The step signal reacts to the positive edge, i.e. when pin 3 becomes positive with respect to pin 6. When changing direction, a distance of min 2µs should be kept to the preceding and following positive edge. One step corresponds to a 10th full step, i.e. a standard motor with a step angle of 1.8° has 2000 steps per revolution with the BIGBEAST power amplifier.

The current reduction is active (60%) when voltage is applied to the input. If no or automatic lowering is desired, the input can be left open.

3.7 Stop on error

For machines with several axes, it is essential to provide a circuit that informs the central control about possible error states of individual axes and triggers the controlled stop of all axes. With milling machines, for example, damage to the workpiece and the machine can occur if only one axis stops and the others continue to move. If the BIGBEAST power amplifiers are connected to a BEAMICON V4 controller or a suitable breakout board, the status outputs of all axes are automatically linked and switched to the alarm input of the controller. If other controllers are used, a small external circuit is necessary.



The picture above shows two circuit examples, one for 24V level (Beamicon, PLC systems) and one for 5V level (PC parallel port, Mach3 without breakout board or from another manufacturer). The status outputs of the BIGBEAST power amplifiers are connected in series. A fault in at least one output stage, the interruption of a cable or a power failure will certainly lead to an alarm message to the control system.

The pull-up resistor R1 can be omitted in most cases because it is already internally integrated in the parallel port of the PC. This means that in most cases no external 5V supply is necessary. Up to 5 axes can be connected in series.

4 Technical data

4.1 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	200	V
Storage temperature ¹	-40	+85	°C
Operating temperature	+1	+70	°C
Voltage at signal inputs	-6	+6	V
Voltage at status output	-5	+30	V
Current at status output		20	mA
Potential difference between supply voltage and Signal inputs (optical coupler)	-100	+100	V

4.2 Electrical connection values

Parameters	min.	max.	Unit
Operating voltage	+24	160	V
Current consumption without motor		50	mA
Ambient temperature	0	+50	°C
Coolant Temperature	+1	60	°C
Level logical 0 for signal inputs	-5	+0.8	V
Level logic 1 for signal inputs	+3	+5.5	V
Current consumption signal inputs at +5V	4	12 ₂	mA
Current consumption signal inputs at +3.3V	3	6	mA
Pulse width for step signal	2		µs
Setup time Direction signal valid until step ³	2		µs
Level logical 0 for status output		0.8	V
Crotch frequency	0	200	kHz
Delay time automatic current reduction	0.5	0.7	s
Threshold over temperature	70	85	°C
Current control accuracy	-10	+10	%
Wire cross section for terminals	0.5	2.5	mm ²
Number of microsteps per full step		10	-
Microsteps/revolution for standard motor ⁴	2000		-

¹ only empty and without coolant, coolant must not freeze

² This is the maximum current that flows when 5V is applied directly. A normal CMOS driver (e.g. 74HC245) with 8mA driver power is still sufficient to drive the input at 4.5V.

³ Step is executed on rising edge, i.e. transition from logical 0 to logical 1

⁴ Standard motor: 1,8°/full step, 200 full steps/revolution