

Cobra CNC Compact Electronic Board

2 to 5 axes, 2A 24V (35V max)

Users' manual

Hardware revision: 1.5

Manual revision: 0.5

Cobra compact electronic board is best suited to control a 3 axes CNC machine, or for any other kind of CNC machines from 2 to 5 axes, robots, animatronics, when you seek easy of use, set up, tuning and cabling, compactness, low cost, reliability and scalability of a single-board solution, with no heat sinks whatsoever, with an expandable axes number that keeps up with your increasing needs in time without compromises on motor power and speed, movement fluidity and precision, thanks to the single supply voltage of 24V (max 35V, suggested 28-29V), output current up to 2A, bipolar chopping and micro stepping driving technology. Assortment is completed by two relay driven outputs with the contact separated from main board by isolation milling, 5 digital inputs, enable/disable dedicated input, signalling leds, active buffering of PC signals to improve reliability and resilience to communication errors, for a set of features never seen before all together on a compact board eurocard format, professionally boxed in high quality enclosures (as option). This is possible by using latest generation chip technology, with high electric efficiency, less heat produced, and general system integration, that allows to reduce board space while improving several electrical characteristics. Both board and enclosures are designed and made in Italy, where the genius of electronic engineers meets historical high standards in industrial design for the pleasure to use, and the pleasure to look at.

Main features

- up to 5 axes on a single compact board
- bipolar driving scheme
- current setting via trim pot (set from 0,3A to 2,0A) with chopping closed loop control
- drives bipolar 4 or 8 wires stepper motors up to 2A
- drives unipolar 6 wires stepper motor up to 2,8A (with bipolar-series cabling)
- pure sinusoidal current wave form
- single DC supply of 24V (typ) 12V (min) 35V (abs max) 28-29V (recommended)
- microstep selectable 1:1 1:2 1:4 or 1:16 by only 2 jumpers (defaults to 1:4 without jumpers)
- 5 digital inputs (end stops, touch probe, emergency stop, etc.) on 0,100" spaced contact strip
- 2 relay outputs (spindle, electrical tool, vacuum cleaner, working zone lighter, etc.)
- 2 led signalling relay asserted, 1 led signalling supply good
- copper planes for EMI rejection and heat sinking with no aluminium heat sinks design
- all PC inputs are actively buffered by dedicated integrated circuits
- dedicated input to enable/disable drivers power stage
- handy connection on detachable high quality screw terminals
- isolation milling between relay switch and remainder of circuit
- connects to PC printer port (pc connection cable included in the scope of delivery)
- stepper motors available in various size (sold separately)
- power supply available (sold separately)
- professional enclosure with silk-screened and industrially punched aluminium panels available (sold separately)
- mounting holes and isolated (nylon) hex spacers when purchased without enclosure
- no heat sinks, no fans, thanks to latest generation, high efficiency electronics, for minimum footprint, and maximum reliability

Disclaimer

By choosing to continue reading manual and using boards, you accept all stating of this paragraph. Copyright holder of this user manual does not allow to forward information hereby to third parties, if not expressly authorized by copy right holder. You may read on screen or print for personal use if you own the electronic board cobra. Printed and electronic copies of this manual must be kept until you keep the board, and destroyed if you destroy or pass to third parties the board.

The stuff presented in these pages and the cobra board itself, are for hobby and didactic use, is supplied as parts kit, for you to experiment with electrical circuits and steppe motors for research or hobby. We don't guarantee the security or suitable for a specific purpose of this stuff. Use at your own risk. Get informed on security standards in your legislation before connecting, using or powering up the board, and adhere accordingly for your safety.

Product potentiality is shown at time of purchase. If you're not satisfied, return within allotted time frame for a refund. By keeping the product, you accept suitability for your needs and sell is considered final.

Building and using CNC machines is dangerous! Building and using electrical plants at mains voltage is dangerous and potentially lethal! It is customer duty to gather information about how to get a safe machine or plant, and follow these direction carefully. We don't report on this user manual these policies, not to deceive that following, you'll be safe. You must get informed on how to make a machine secure, and follow these directions carefully.

Maximum efforts has been taken in writing this users' manual, but we cannot exclude errors. We assume no responsibility for direct or indirect damage or missed profit in consequence to use, abuse, misuse of cobra board, attached accessories, or information or incorrect information reported in this users manual. Electrical compatibility with own hardware is due to customer. We suggest connecting cobra board to an added printer port and not to main printer port on mother board, as a good practise with any power circuit connected to PC. Stepper motors and electronic boards are tested working at time of sell. Sold material must not be used in any context where its malfunction can cause personal injury to persons, or damage to stuff, direct or indirect. Any modification or repair on board implies waiver of any warranty.

Board connections

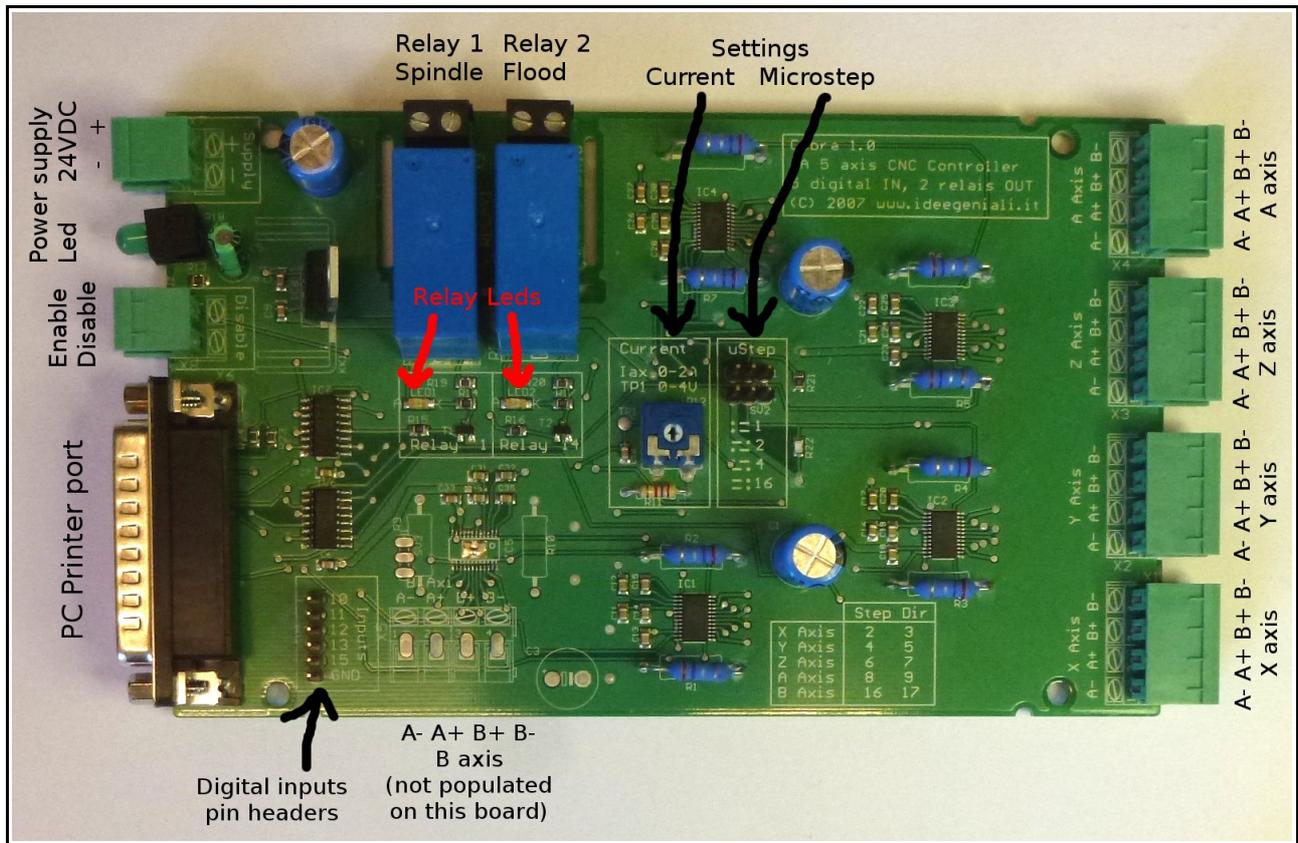


Photo of board, top view. In photo we see a 4 axes board.

On your board more or less parts can be populated, depending on axes number.

In photo we see board, top view. In remainder part of users manual, up, down, left, right, will be referred to this board orientation. Front, Rear, left side and right side are referred to the boxed version with enclosure depicted below. So right side (of boxed board) corresponds to down (of the top view bare board) and so on.



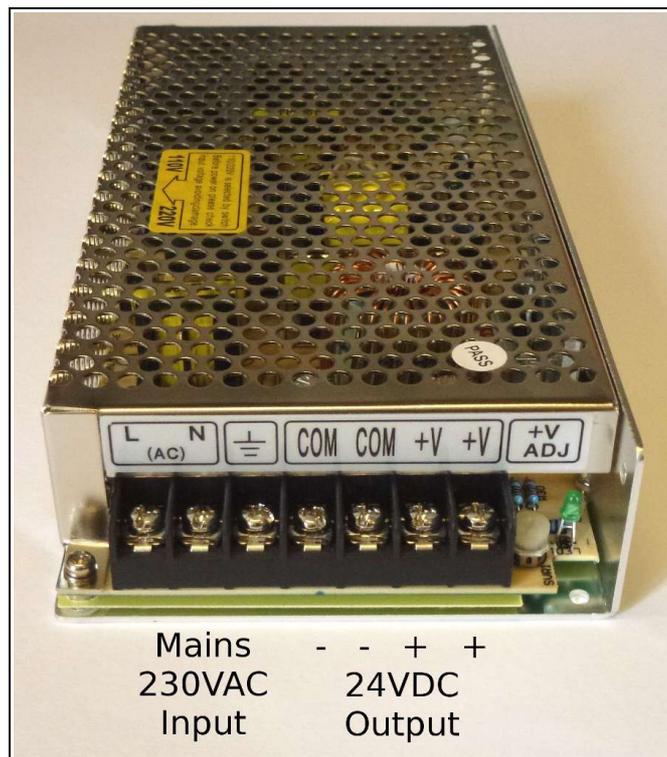
Front (picture on the left) and rear (picture on the right) of boxed board

Before connecting power to the board, please make sure it doesn't look damaged. Before connecting power, please make sure to have read and understood the whole users manual and specifically connections, having tuned correctly current setting trim pot, make sure on how (colour scheme) stepper motors must be connected, and only then, start cabling. If you have any doubts, please contact us for assistance. For first trials, we suggest leaving relays, digital inputs and enable/disable

unconnected / not used, and concentrate on trim pot setting, and connections to stepper motors, power supply and PC printer port. After first working trials, you may extend system functionality including end stop switches, emergency stop input, and loads to relay. Please always work on a flat surface, electrically isolated (made out of wood, not metal), and free of any object: if you forget a screwdriver below the board, it will short circuit and destroy parts, if not start a fire hazard. We suggest buying the board already boxed in plastic enclosure, so to limit fatality hazard.

Power supply

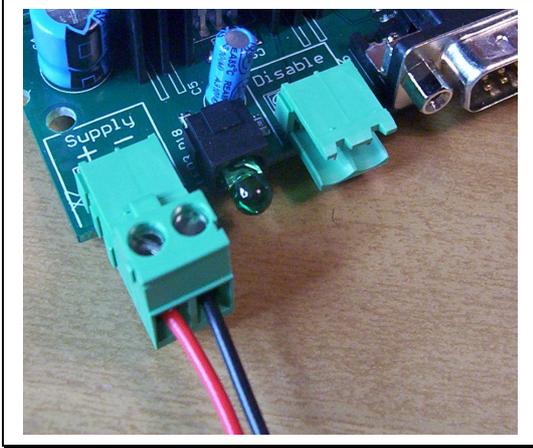
Boards works at 24VDC nominal. It will work from 12VDC to 35VDC (maximum absolute ratings). We suggest using 24VDC for practical reasons (it's easy to find a 24VDC power supply) or 28-29V for improved performances. Don't go beyond 30VDC or you risk exceeding 35V with spikes. Don't go closer to 12V for reduced performances. Please note at 12V the relay won't switch, but you can use the stepper motors and digital inputs. Relay need 24V or 30V. With nema17 motors, you may stay at 12VDC without appreciable reduction in performances. With nema23 stepper motors, you'll notice some reduction in performances in respect to 24VDC which is to be preferred. Please note you must supply specified voltage to board, regardless of connected stepper motors nominal voltage. The board chopping closed loop regulator will ensure proper output voltage to the stepper motors, adjusting voltage so to match set current, and will meet stepper motor nominal voltage automatically. Just to state this even more clear: if you attach a 5V nominal voltage stepper motors, cobra board must be powered at 24VDC, it's the board that will automatically reduce this supply from 24V to 5V, via chopping driver, to match motor electrical characteristics.



Power supply rated 100W/24V we sell (optionally) with board

Suggested power supply for cobra, sold separately, is a switching mode power supply specifically designed for stepper motors. It has a trim pot to adjust output voltage from around 22V to around 28V: we suggest rotating it full clockwise, to gather maximum output voltage, 28-29V. This power supply has two screw terminals for + and two for -. You may use any of each to power cobra,

they're internally connected together. When connecting DC power from power supply to cobra at Supply input, please respect + and – markings, shown on bare board screen printing or on front panel aluminium screen printing. Please note board is NOT PROTECTED from power supply inversion, if you exchange + with -, it will be damaged. And risk of fire hazard.



Power supply input. Led is OFF, therefore there is no power applied

Please use 1mmq section AWG17 (AWG16 or 18 will do) cables, we suggest using red (for +) and black (for -) colour, which is standardized approach, not to get confused. The green led next to power supply input signals that power is applied, and the internally generated 5V logic supply is being produced correctly. So it's a “power good” and not just “power applied” indicator. Please DON'T connect power now, at first read the whole user manual, then do the connections.

A note on correct using of detachable screw terminals. They are to be used with this procedure. Detach the screw terminal from board, insert cables, tighten screws, so that the screwdriver mechanical torsion won't impact or be transmitted to the solder joints on board. Once you're finished with screwdriver, you may attach the terminal to board again. It is a good advice to use ring lugs on cables for connection to power supply, if you have those, so that the risk of cable detach with short circuits and other issues is reduced. If you don't use lugs, please make sure the copper wire is connected properly and firmly, and there are no small wiring exiting from the terminal that could touch unwanted places.

It's a good idea to insert a power on/off switch. You may insert a mains voltage switch, even of the luminous kind, and a fuse at mains voltage, BEFORE the power supply. Please make sure the electrical plant you're building is safe. The power switch comes handy, because you want board powered off before you load controlling software on PC, to avoid unwanted movements. Please we stress that mains voltage is LETHAL, work safe. Maybe you want to put the power supply inside a isolated box purchased at a local electrician supplies store.

Using other kind or brands of power supply unit

We recommend using 100W/24V power supply unit available as option with the board, but you may use any 24VDC capable of 5A. If you use recommended power supply unit, you may just skip reading this paragraph. If you use your own power supply, it is not necessary – and sometimes it is even not desirable – that power supply unit being stabilized. With an unstabilized power supply,

filter capacitors should be 4700uF/35V; apart of generous filter capacitors, you don't need any other specific requirement. Cobra needs power from p.s.u. and not controlled voltage, logic voltage are generated internally and are well stabilized internally. You need power reserve from p.s.u. and some times stabilized p.s.u. can be slower than unstabilized kind at adapting to impulsive power requirements typical of chopping driving techniques. We remind you that to realize a unstabilized power supply at 24VDC-5A, the transformer used must be 18VAC-90VA. Once you rectify and level 18VAC, they turn into 24VDC. Bridge diodes must be 8A/100V. If you rectify and level a 24VAC voltage, you'd end up at 35VDC, which is too much for cobra.

If your power supply is stabilized, likely it's switch mode and not linear, for these big power. Any kind will do, if you experience poor performances, just add a 2200uF/35V capacitor just at the power entering the cobra board, in the screw terminals, and should fix any issue at absorbing the impulsive current requirement peaks of the chopping drivers. If your power supply is performing well, you don't need any extra electrolytic capacitor, because there are already such capacitors inside the board, and others inside the output stage of your power supply. Only if you experience poor performances, may add capacitor to improve transient response.

Supported stepper motor

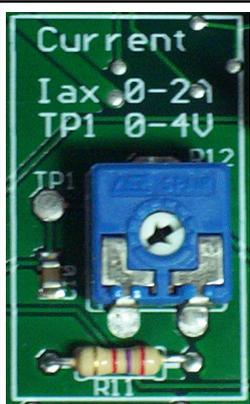
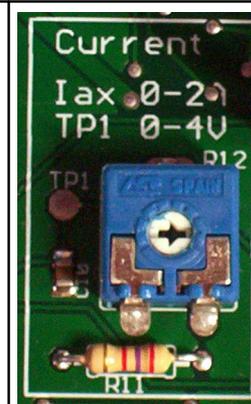
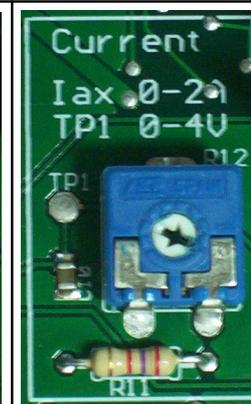
Board is suitable to drive pure bipolar stepper motors (with 4 wires), stepper motors with 6 wires connected in bipolar-series (not using central tip, therefore using 4 wires out of the 6 available), and 8 wires motors, usually connected in bipolar-series to reduce current requirements. Board is not suitable for 5 or 10 wires stepper motors (which are very rare nowadays). Board can drive 2 phases or 4 phases stepper motors, won't drive 3 phases or 5 phases stepper motors (which are very rare nowadays). We do not recommend bipolar parallel connection, because it requires higher currents that usually won't match the 2A maximum requirements for cobra.

How to set working current

You may adjust working (set) current for board, to adapt to the stepper motors connected. Trim pot has a small white arrow, that can be rotated with a small screwdriver. If you have a plastic screwdriver, it's better. You may also use a metal screwdriver, but pay attention to apply gentle forces, since trim pot is a small and delicate electronic part. You have 270° of rotation, at start of scale, you have 0,0A setting. At half scale (at noon), you get 1,0A. At extreme right/clockwise, you have 2,0A. Intermediate positions for intermediate current settings.

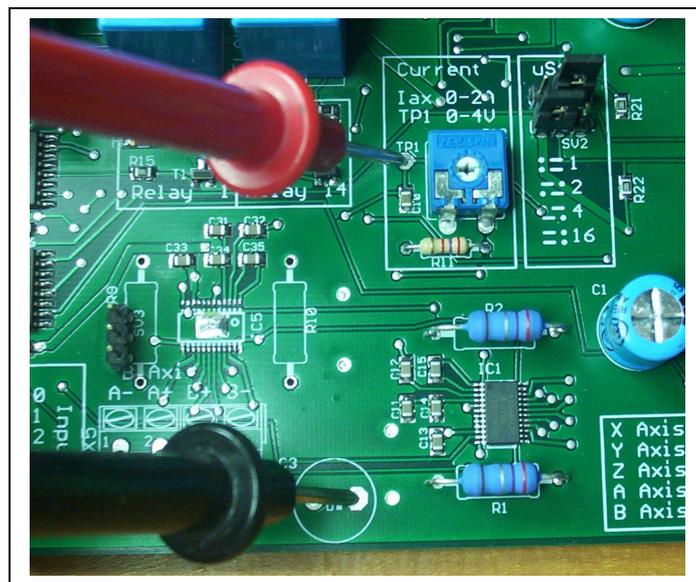
The first part of the scale, from 0,0A to 0,3A is not reliable in setting. We suggest using smaller boards for such small motors. The high part of the scale, is not reliable. We suggest using bigger boards for motors requiring 2A continuously. Use cobra board for stepper motors requiring 1A-

1,5A for maximum performance and reliability. Please note that most stepper motor will work OK – if not better – with a current inferior to that declared by constructor as nominal.

				
0,0A “8 hour” (scale start) (not recommended)	0,3A “9 hour” (minimum regulated)	1,0A “12 hour” (middle scale)	1,75A “3 hour” (max recommended)	2,0A “4 hour” (scale end) (not recommended)

*Some settings for working current.
For intermediate current, use intermediate positions.*

A visual rough positioning of trimmer position is usually all you need. Stepper motor work ok with a range of regulations. If you want to precisely set working current, and own a multimeter, you may follow this procedure. Remove power supply. Wait 5 seconds. Unplug stepper motors. Connect power supply. Use a multimeter in Volt DC position, 20V scale-limit. Put black tip on board GND, a suitable point is negative pad of C3. Put red tip on TP1 (test point 1), please make sure not to touch any other board point or to short circuit anything at power supply connected, or you'll damage board.



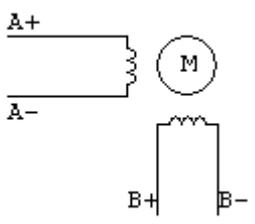
Test point 1 below red tip and GND reference below black tip

Rotating trimmer from scale start to scale end, you'll read voltages from 0V to 4V on multimeter, that correspond to current regulation from 0A to 2A. Therefore axis current in Amperes is half the voltage at TP1 in Volts. This is reminded you by screen printing on board, stating "Iax 0-2A, TP1 0-4V". At half scale, you'll read 2V on multimeter and current for axes is set to 1,0A. As stated before, you don't need at all such precise regulations with multimeter for stepper motors to operate, they operate in a generous range of values. And usually you must set current lower than nominal of motor for better performances. I.e. for 1,2Nm stepper motors, it is advised to point the arrow to 1 o'clock or 2 o'clock instead of 3 o'clock.

Stepper motors connection and current setting

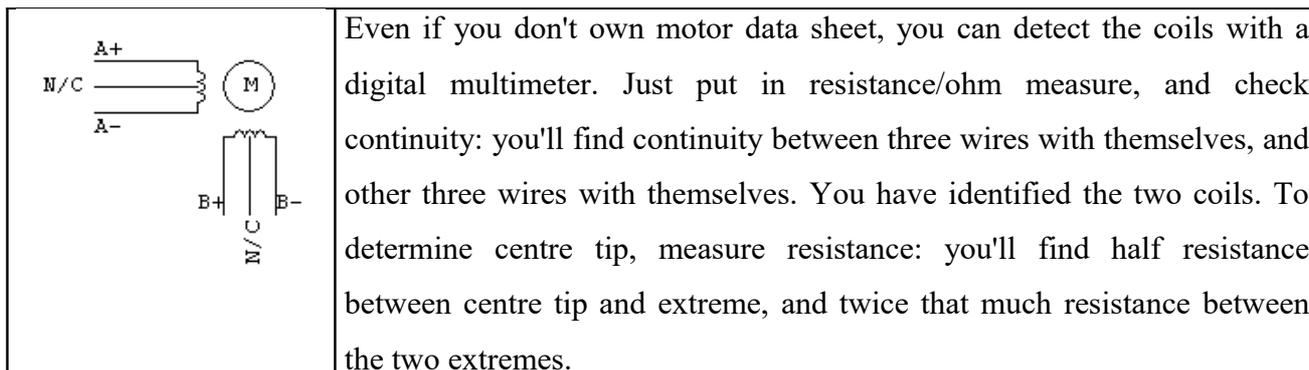
4 wires stepper motors

For 4 wires stepper motors, there are no doubts. The current setting is just the same as that declared by motor manufacturer. And you connect one coil between A+ and A-, and the other coil between B+ and B-.

	<p>Even if you don't own motor data sheet, you can easily detect the coils with a digital multimeter. Just put in resistance/ohm measure, and check continuity: you'll find continuity between the two wires of the same coil, and not between wires of different coils. Therefore it is easy to see which is which, in a 4 wires stepper motor.</p>
---	--

6 wires stepper motors

For 6 wires stepper motors, connection is easily understood: to drive them in bipolar, you don't use the central tip-point of the coils, but use only the extreme points. Current setting is tricky: the manufacturer declares current when used in unipolar (which is not the case with cobra board). You must divide this number by 2 square root, i.e. 1.414 to get the current setting for cobra. Example: manufacturer declares 0.95A phase current for a 6-wires stepper motor? You must set $0.95 / 1.414 = 0.67$ A in cobra trim pot.



8 wires stepper motors

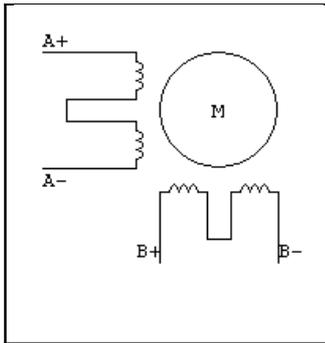
For 8 wires stepper motors, things get somewhat complicate. But not that much. 8 wires is very versatile, you can connect them in unipolar, bipolar-series or bipolar-parallel. Unipolar connection is not used with cobra. By choosing bipolar-series or bipolar-parallel, you will end up with two different current settings for the same motor.

Some manufacturer declare all of the three current you get from the motor when connected in these three ways. e.g. SY54STH51-1008 stepper motor has 0.7A when connected in bipolar-series, or 1.0A when connected in unipolar, or 1.4A when connected in bipolar-parallel. And the manufacturer declares the three of them. So it's easy to understand.

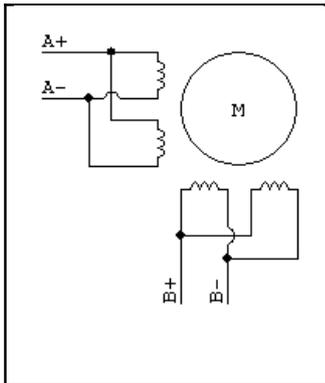
Some other manufacturer just declare one of these three data. When only one is given, it's the phase current, valid in unipolar connection. For SY54STH51-1008 it's 1.0A. Just divide by 2 square root 1.414 to get the bipolar-series figure: $1.0 / 1.414 = 0.7A$ or multiply by 2 square root 1.414 to get the bipolar-parallel figure: $1.0 * 1.414 = 1.4A$.

You may have noticed that the bipolar-parallel current is always twice as the bipolar-series current. So what is better? Bipolar-series or bipolar-parallel? For bigger motors, you must use bipolar-series to get the lower figure, since cobra can handle only up to 2A. For smaller motors, you may choose both connection. Bipolar-series gives better performances at lower speeds, Bipolar-parallel gives better performances at higher speeds. So it's up to your machine needs to choose one.

If you don't have data sheet, with a multimeter, all you can tell for a 8 wires motors are the 4 half-coils. But you'll never know what half-coils constitute the coil pulling the motor in the same phase. You'll have to try a connection, if it doesn't work try the other way round.



Bipolar series connection: of the eight leads of the stepper motor, four are connected to cobra board A+ A- B+ B- screw terminal posts. The other four leads are connected in two couples of two wires each, and are not connected to cobra board.



Bipolar parallel connection: two leads connect into each of the four screw terminal posts on cobra board.

N/C = Not Connected

For 4 wires stepper motor, each lead connect to a cobra board screw terminal post.

For 6 wires stepper motors, four leads connect to board, two of the 6 leads don't connect.

For 8 wires stepper motors, series connection, four leads go to cobra board. The other 4 leads connect between themselves, in two couples of two. Each couple is isolated from the other couple.

For 8 wires stepper motors, parallel connection, two leads connect to each screw terminal post.

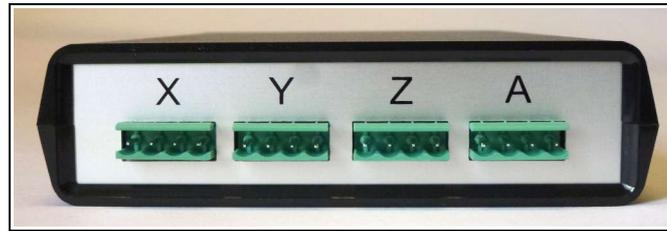
Stepper Motors above 2A

You can not connect motors requiring more than 2.0A to cobra board. You may think that cobra will just output less current into the motor than needed, motor will turn, with reduced performances. No, this is not the case. Cobra board can get damaged by the high inductance of bigger motors, so you must not connect motors requiring more than 2.0A of current. Must choose a 4A electronic to drive >2.0A stepper motors. Cobra board is only suitable <2.0A.

Stepper motors connections

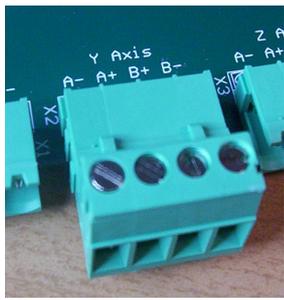
The motor outputs are on detachable screw terminals. You must use detachable screw terminals this way: power off board, wait 5 seconds, unplug screw terminal from board, insert wire, tighten screw, plug into powered off board, power on and use the board. You must not tighten with screwdriver with plugged connectors, or you'll transmit mechanical stress on solder joints of the board. Also,

you must not connect or disconnect motors at powered on board. Power off, wait 5 seconds, connect or disconnect, power on again.



Rear pannel of boxed cobra board, with header for detachable screw terminals

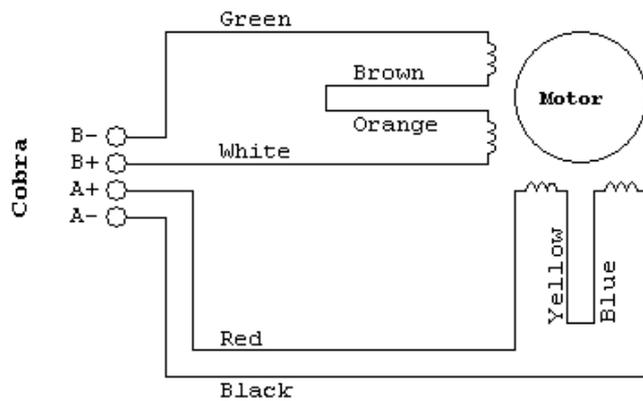
On bare board screen printing, and on rear panel of boxed cobra, find the axes names: X axis, Y axis, Z axis, A axis on right side of bare board, rear panel of boxed board. B axis is available on down side of bare board, left side on boxed board. Each axis has two driving stages A and B, each of which has a positive and negative pole. Find A- A+ B+ B- marked on screen printing. Or remember these are found in this order: A- A+ B+ B-, from left to right, on boxed cobra.



4 outputs to drive stepper motors are marked A- A+ B+ B- on screen printing. One coil of stepper motor connects between A- and A+, the other coil between B+ and B-. Please refer to colour scheme for your stepper motors to know which wire goes where.

Stepper Motor SY57STH51-1008B

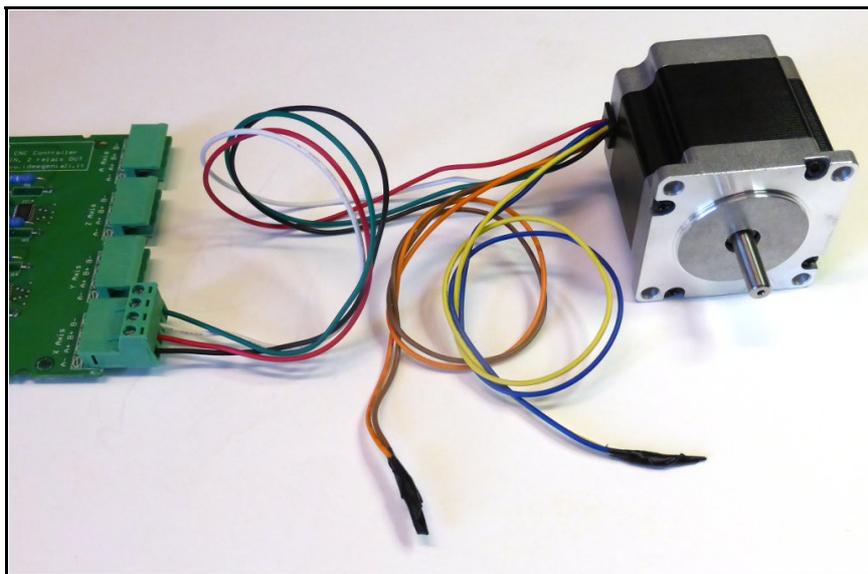
It's a 8 wires stepper motor, retention torque 1.0Nm. Its rated phase current is 1.0A. This is valid for unipolar drive. For bipolar-parallel drive, you would multiply this number for 1.4 = 1.4A (not applicable to cobra board). For bipolar-series drive (we use this for cobra) divide phase current 1.0A by 1.4 and get $1.0 / 1.4 = 0.7A$. So we'll point current setting trimmer to 10 o'clock.



It's a 8 wires motor to be wired in bipolar-series.

A-: Black
A+: Red
B+: White
B-: Green
Yellow with Blue
Orange with Brown

Current setting trimmer: 10 o'clock



SY57STH51-1008B stepper motor wired up to cobra board

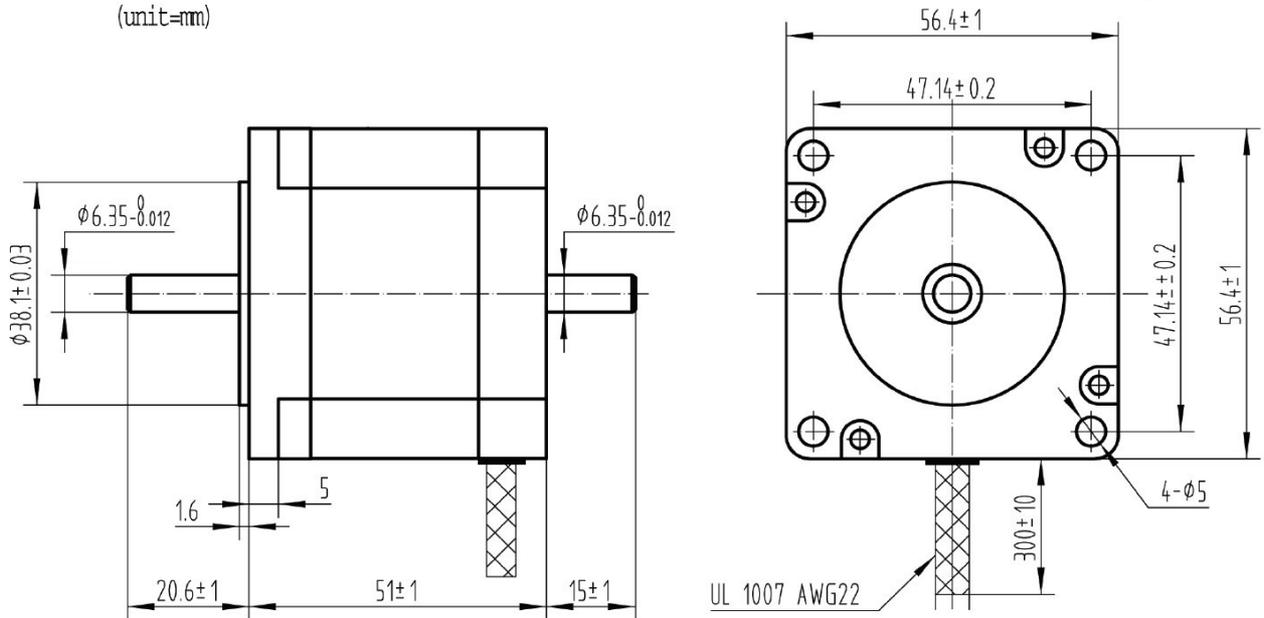
Yellow wire is to be connected to blue wire (and nothing else), we recommended using isolation tape. Orange wire is to be connected to brown wire (and nothing else), we recommended using isolation tape.

The remaining 4 wires are to be connected each to a screw terminal post on cobra board. We recommend using screwdriver while the screw terminal is detached from board, not to transmit mechanical twist force to cobra board. Only after checking wires are secured properly and no short-circuit is there by mistake, one can connect to unpowered cobra board.

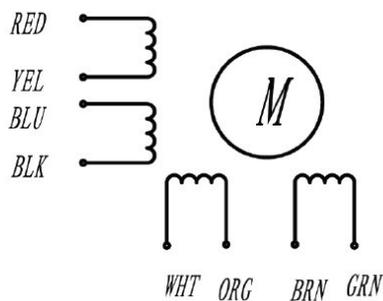
General specifications	
Step Angle (°)	1.8
Temperature Rise (°C)	80 Max (rated current, 2 phase on)
Ambient Temperature (°C)	-20~+50
Number of Phase	2
Insulation Resistance (MΩ)	100 Min (500VDC)
Insulation Class	Class B
Max.radial force (N)	75 (20mm from the flange)
Max.axial force (N)	15

PHASE	STEP ANGLE	CONNECTION STYLE	CURRENT	RESISTANCE	INDUCTANCE	HOLDING TORQUE	ROTOR INERTIA	WEIGHT
	DEG/STEP		A	ohms	mH	N.m	gcm ²	Kg
4	1.8°	Parallel	1.4	3.3	8.2	1	275	0.65
		Series	0.7	13.2	32.8			
		Unipolar	1.0	6.6	8.2	0.7		

● Dimensions:
(unit=mm)



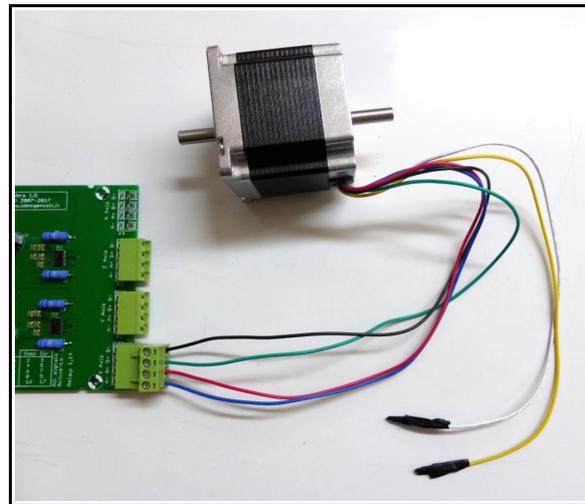
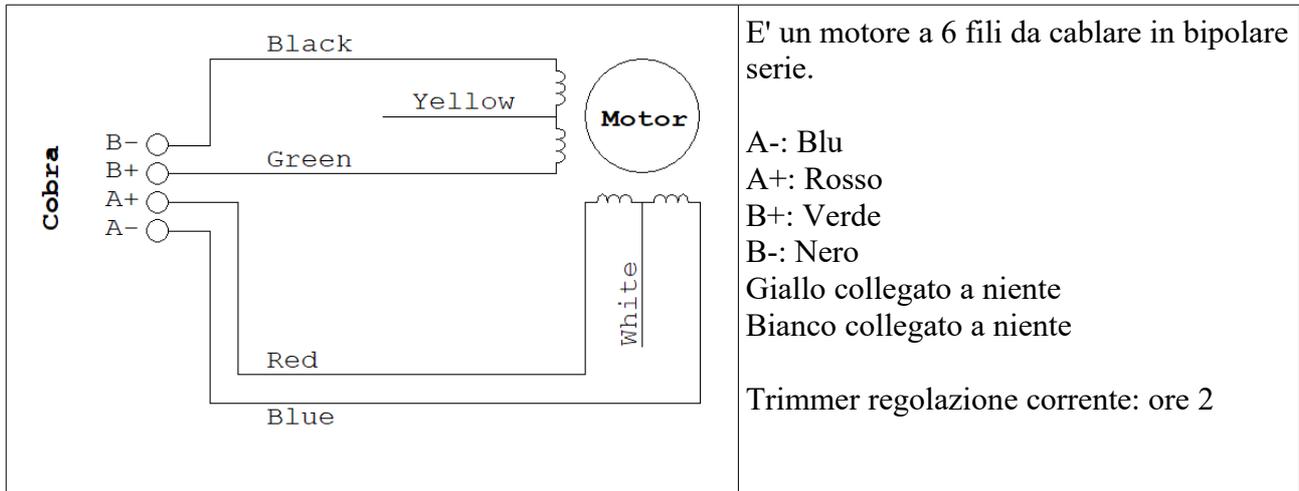
● Wiring Diagram :



Electrical datasheet and mechanical dimensions of 1,0Nm SY57SHT51-1008B stepper motor

Motor 23HS6620B

It's a 6 wires stepper motor, retention torque 0.9Nm. It's a 2.0A stepper motor when driven in unipolar (we don't use this driving technique with cobra board). Cobra board uses bipolar-series, so current figure must be divided by square root of 2. $2.0 / 1.4 = 1.4A$. Therefore current setting trimmer goes to 2 o'clock hours.

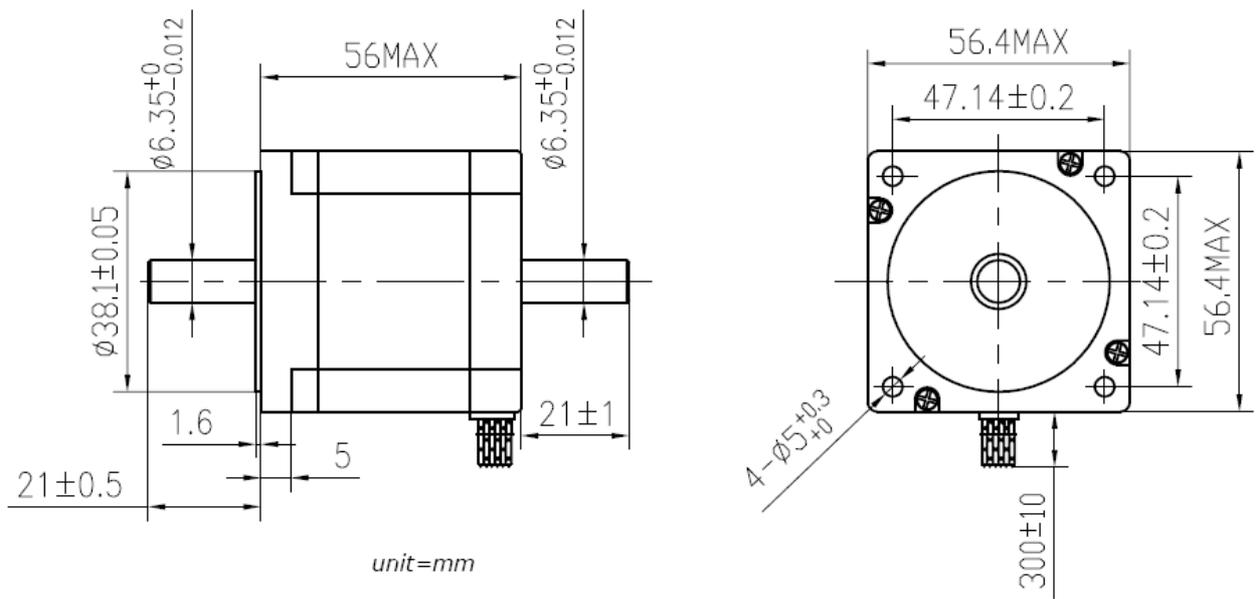


Stepper motor 23HS6620B connected to Cobra board

Yellow wire must not be connected. Therefore isolate it with electrical tape.
White wire must not be connected. Therefore isolate it with electrical tape.

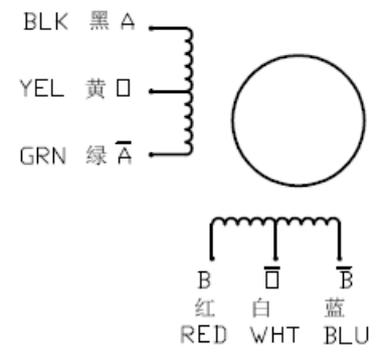
The other 4 wires go to a position on cobra's screw terminal. Work the screwdriver on the screw terminal while it is detached from cobra board. After tightening the screws and checking wires are connected correctly, with cobra UNPOWERED, connect the screw terminal to the board.

Blue wire: position A- on cobra board
Red wire: position A+ on cobra board
Green wire : position B+ on cobra board
Black wire: position B- on cobra board



SPECIFICATIONS

PHASE	相数	4 PHASE
STEP ANGLE	步距角	$1.8 \pm 5\% \text{ }^\circ / \text{STEP}$
VOLTAGE	静电压	3.6V
CURRENT	电流	2.0 A/PHASE
RESISTANCE	电阻	$1.8 \pm 10\% \text{ } \Omega / \text{PHASE}$
INDUCTANCE	电感	$2.5 \pm 20\% \text{ mH/PHASE}$
HOLDING TORQUE	静转矩	90 N.cm Min
DETENT TORQUE	定位转矩	4.0 N.cm Max
INSULATION CLASS	绝缘等级	B
LEAD STYLE	引出线规格	AWG22 UL1007
ROTOR TORQUE	转动惯量	300 g.cm^2



Electrical datasheet and mechanical dimensions of 23HS6620B Stepper Motor

Important notices

Cobra board IS NOT PROTECTED from short-circuits on motors. There must be not a short circuit between A+ and A- or between B+ and B-. We suggest checking this before connecting motor to cobra board. How? Just connect stepper motors to detached screw terminal, and don't connect screw terminal to cobra header yet. Use a multimeter to check resistance between A+ and A-, wich must be not 0 ohm, but something more, i.e. the resistance of stepper motor, e.g. 1.8ohm or 4ohm wich are typical values. If you change the wiring, e.g. put extension cables to motor leads and mix up colours, please check again with multimeter before connecting to board.

Cobra board IS NOT PROTECTED from bridged connections between the two output stages. If there are cross-linked connections or shorts between any post of A stage (A- or A+) and any post of B stage (B- or B+), it's a "bridge" and will damage board. Again, we suggest checking this with a multimeter. Connect motor to detached screw terminal, and check on it with multimeter before connecting to cobra board. There must be not continuity between A+ and B+, or between A+ and B-, or between A- and B+, or between A- and B-. Check again if you add extension cables or mix up the wiring in any way.

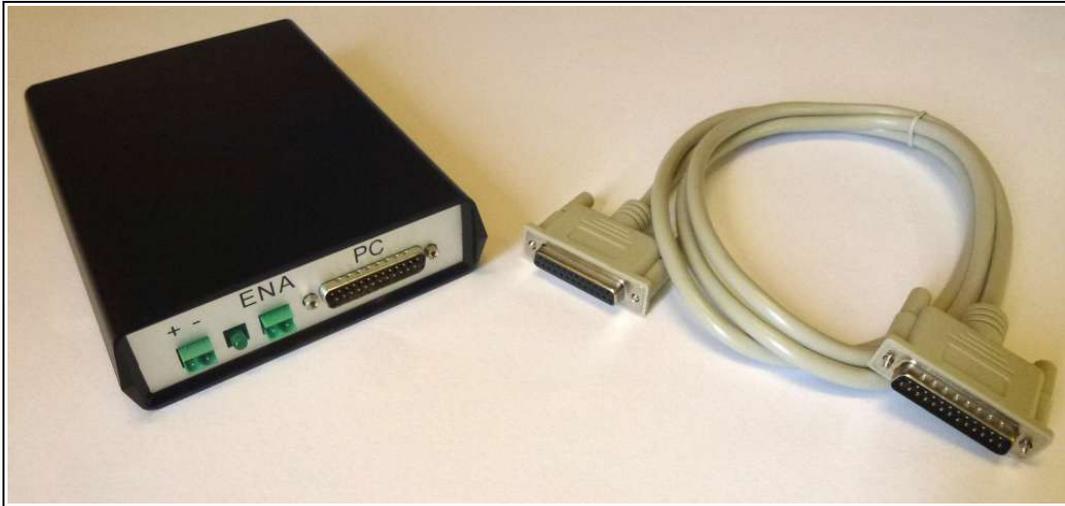
Cobra board IS NOT PROTECTED from spikes arising when connecting/disconnecting motor at powered-on board. Never connect or disconnect motors with power applied to board. Always follow this procedure: power off, wait 5 seconds, connect or disconnect, power on.

Beware of small COPPER TINY-WIRES. Copper leads are built up of several small tiny-wires, please make sure none of these is protruding from a screw terminal post, shorting with adjacent screw terminal posts.

NO PARALLELIZED MOTORS. We suggest NOT connecting two motors in series or parallel to one output stage. If you have two motors on same axis, e.g. a gantry machines with two motors on X, we suggest purchasing a 4 axis board, and use A axis as second X axis. The link between X and A will be done in software, not hardware.

PC connection cable

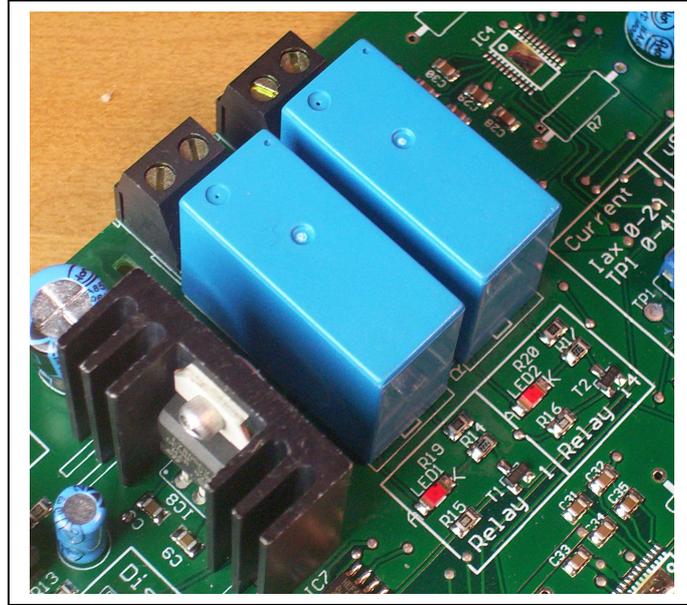
A PC connection cable is included in the scope of delivery of cobra board. It uses subd25 connectors, male on one side, and female on the other side. They only connect in a way, so you can't miss it or do a wrong connection.



PC connection cable: subd25 male-female.

Relays

Cobra board has two relay outputs for controlling on/off loads. The relay normally open contact switch is electrically connected to a two-way screw terminal. It is therefore possible to control any power supply voltage loads, since there is no electrical connection between the relay controlled contact switch and the remainder of cobra board electric circuit. Please note that mains voltage is LETHAL. Cobra relays are rated for mains voltage, but we recommend using an extra servo-relay (not provided) to control your loads, and the relay inside cobra to control the coil of the servo-relay, thus including an extra isolation stage and increasing safeness.



The two relay outputs, whose normally open contact switch is routed to screw terminals, is isolated with isolation millings on PCB. Two red leds signal when each relay is on.

The relay on the left on picture is called Relay 1 (and Relay 1 is stated on board screen printing). This is typically configured for spindle on/off control. The other relay, on the right on picture, is called Relay 14 (and Relay 14 is stated on board screen printing). This is usually configured for an auxiliary function. In mach3 this is typically called flood. You may connect a refrigeration or lubrication system for milling bit and workpiece, or a lighting for work area, a vacuum cleaner getting reed of debris, and so on...

Enable

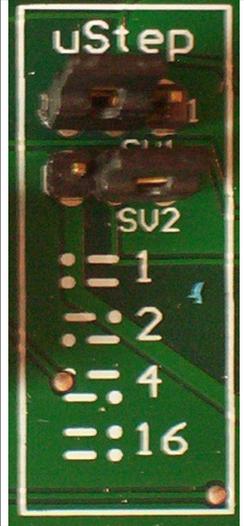
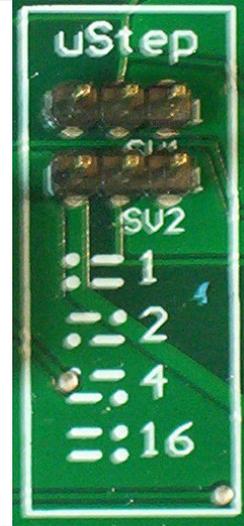
On the left on board (on the front for boxed version) there is a two ways scren terminals marked ENABLE on board screen printing (ENA on aluminium front panel screen printing for boxed version). For basic/common use of cobra board, just leave this unconnected. If you wish or need to, you may connect a normally-open switch to this input. When the switch closes, the output stage of board, driving stepper motors, will get disabled, and power removed, so motors are free to turn. This is useful to momentary reverting to manual control a CNC automated machine.

Microstep

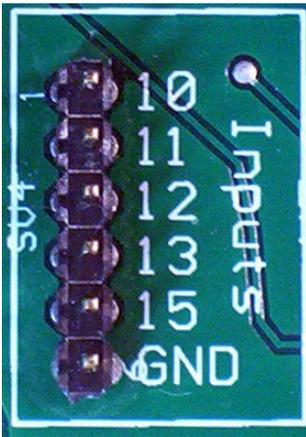
Centrally on board, there are two configuration jumpers that let you choose desired setting for microstep. Microstep is a driving technique that lets you increase the number of steps per revolution of your stepper motor, increasing smoothness and accuracy. Please refer to this table for microstep setting:

Microstep setting	Microstep per revolution on a typical 200 step per revolution stepper motor
1:1 full step, microstep disabled	200
1:2 half step	400
1:4 quarter step, default and recommended	800
1:16 maximum microstep setting	3200

On board screen printing, just below jumpers, find a small table with graphical symbols showing where to put the jumpers to choose the desired microstep setting. When no jumpers at all are inserted, board defaults to 1:4 (quarter step). However, we recommend leaving jumpers in all the times, not to loose them.

				
microstep 1:1 <i>(full step)</i>	microstep 1:2 <i>(half step)</i>	microstep 1:4 <i>(quarter step, suggested and default)</i>	microstep 1:4 <i>(quarter step, suggested and default)</i>	microstep 1:16

Digital inputs



The board routes printer port digital inputs to a 6 ways 0.100" spaced pin-headers connector. There are 5 pins for each of the 5 digital inputs and a sixth pin for reference ground. Please note that printer port GND reference is in common with cobra board GND reference, and with negative power supply. Find the pin number assignment next to each pin on board screen printing. Pin-header are normally pulled high to +5V (or slight less) from printer port internal circuitry. Pull them low with a switch to GND or the NPN transistor of an optocoupler to have them toggle digital state.

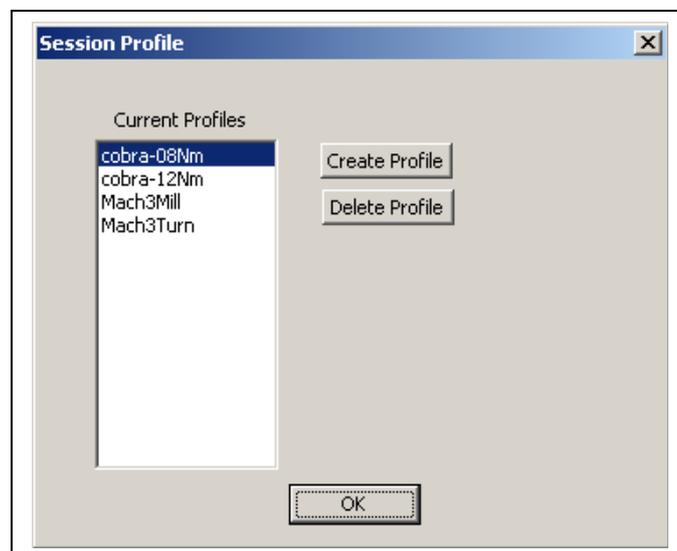
Please refer to mach3 (or your control software) to gather informations on how to configure and use these digital inputs for various functionalities, such as limit or homing switches, software emergency stop, PLC handshake, automated tool change, torch height control for plasma cutters, touch probe, spindle speed sensing, manual pulse generators, and so on...

Control software installation and use

The board is compatible with almost all cnc control software for PC. Just to mention a few: TurboCNC for DOS, KellyCam for Windows 98, CeNeCe, foamworks, galaad, cncplayer, ninos, emc2. We suggest using Mach3, for which we prepared a ready-made config file, that will ease the set-up process for your machine. Mach3 is free for personal or commercial use and will run – in base version – up to 1000 lines (older releases; 500 newer releases) of ISO/Gcode toolpath lines. You'll need to purchase license if you want to run longer toolpaths or wishes to give money to the programmers of such a good piece of software. Download software and configuration file from <http://www.ideegeniali.it/cobra>

Once you save software installer on your hard disk, just double click on it and follow instructions to complete installation process. Please reboot your PC when asked. Other software may work without reboot, mach3 won't, you really need to reboot when asked. Mach3 is installed in c:\mach3 folder. Please copy to this folder also the ready-made config files, they are distributed as a .zip archive, you'll have to extract the .xml and .set files from inside the .zip archive, and copy the .xml and .set file into c:\mach3 folder on hard drive.

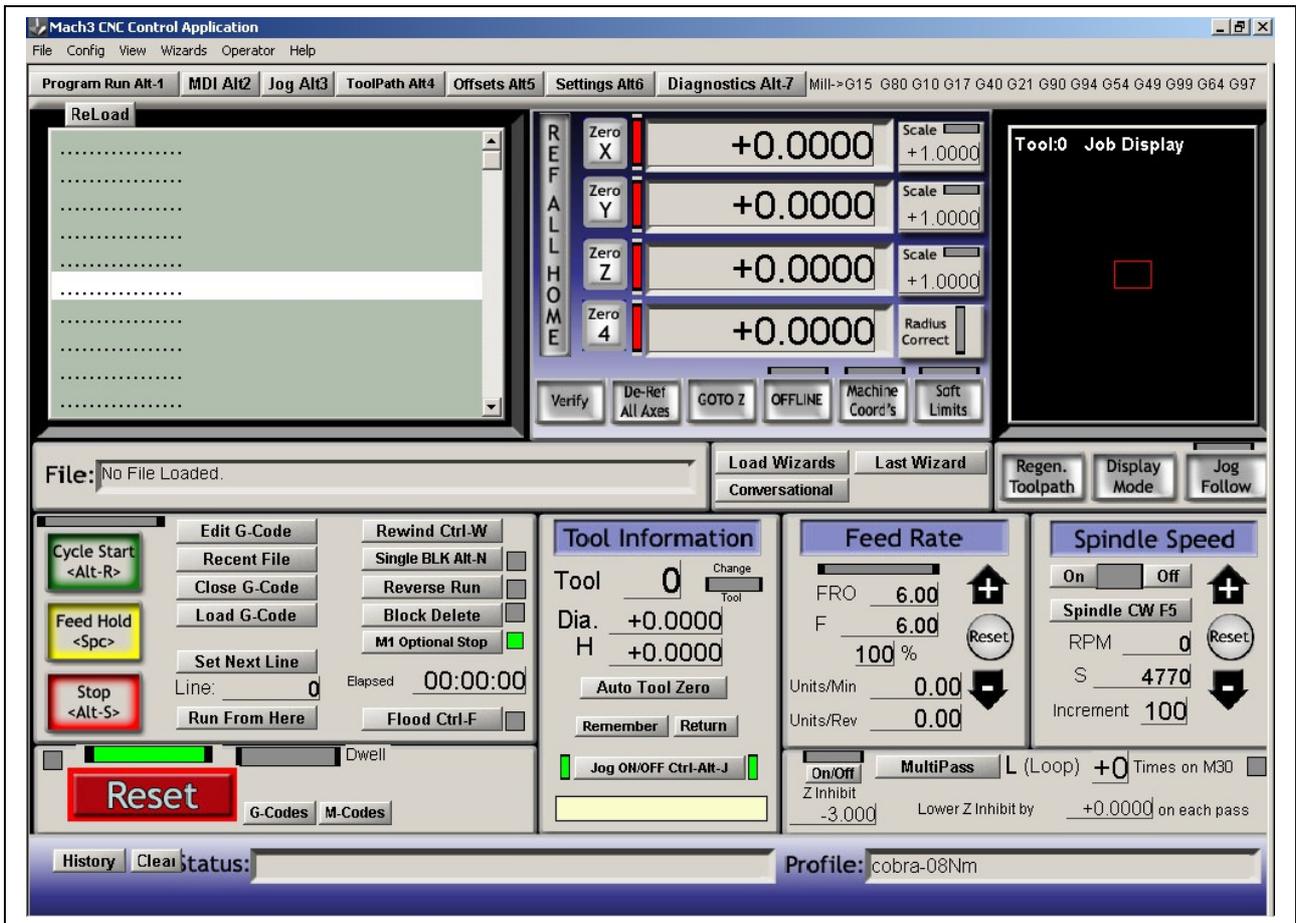
When you start mach3, you'll be presented a list of found config files. You'll find default mach3mill and mach3turn profiles (profiles are set of configuration parameters in mach3 lingo) and the ones you just copied, please choose cobra-12Nm which is the one you're going to use.



Choosing a config file (or profile in mach3 lingo) among the ones present in c:\mach3 folder

Once choosing a profile, you'll go to main mach3 screen. This may leave disoriented at beginning, because there are many controls on screen, but once you learn using, you'll end up happy for having

all you need present on screen. Please don't connect cobra board yet, take a moment to get the feel of mach3 screen controls and understand how they work.



Main screen of mach3. Lower right corner will show currently loaded profile.

Reset

The most important element on mach3 screen is the giant red button marked RESET, lower left corner, with the steady green or red/green led above it. When machine is online, led is steady green, and machine will operate at your commands. When led is green/red flashing, mach3 is offline, and machine won't operate. By clicking on reset, you may toggle between online and offline status.

Sometimes machine will go offline without clicking on reset: when a limit switch is hit, or a software emergency stop event is fired by some operations. You'll have to click reset to have the machine online again. Sometimes it won't go online, and write a error message in the Status: line on the bottom of the screen. Read to message to understand why mach3 refuses to go into oline status.

Flood and Spindle On/Off

The easiest command to learn is to switch the flood on or off by hitting CTRL+F on keyboard, or clicking on Flood button on screen. This will toggle relay 14 on board on or off. A yellow led is provided on mach3 screen telling you whether relay 14 (flood) is on or off. Spindle control is similar: you have ON and OFF buttons to switch it on and off. You'll notice on-screen leds, and the relay 1 toggling on board. Flood can be switched on or off in any moment. Spindle will only change status after completion of any motor movements in progress.

Jogging

When jogging is active (this conditions is signalled by a green led on screen, just besides of Jon on/off button), you may use the four arrow keys on keyboard to manually move X (left and right) and Y (up and down) axes, and the PgUp PgDown keys to manually move the Z axis. Movements will default to slow for higher accuracy. If you want rapid movements, just hold down SHIFT key while hitting arrow keys or PgUp PgDown. Hit TAB keys to get a screen where you can set the slow jog rate as a % of maximum available speed.

DRO

DRO (Digital Read Out) is a complicate name for a simple indication: any section on screen with numbers on it is a DRO. The 4 most important DRO's are those giving actual coordinates of the X Y Z A axes. These coordinates are expressed in mm (or inches). And not in motor steps or other complicate things. Typically X=0 Y=0 is on a work piece vertex or other reference point on work piece. Z=0 typically denotes the height when the working tool tip meets the top surface of work material. With this assignment, Z>0 is above the workpiece, in air “cutting air” in CNC lingo. Z<0 is inside the piece “cutting material” in CNC lingo. Therefore Z=-0.3 is the height to carve 0.3mm deep inside the material. Z=-4 is the height to completely cut out a 3mm thick material, also cutting 1mm inside the disposable material below the work piece.

If an axis moves backwards than what you expect, go to menu config, ports and pins, motor output, and change the V in X (or the X in V) for the colum DirLowActive for the axis. I.e. if you have Z with positive number going down, and negative going up, change the V in X (or X in V) for DirLowActive for Z axis. If you end up with mirrored engravings, just mirror X or Y axis by changing the DirLowActive for one of the two (don't mirror both of them, or you'll end up with 180° rotated drawing, but still mirrored).

While X Y Z are somewhat standardized, A B C can mean lot of standard – or weird – things on your machine. A B C could be expressed in mm, if they're linear axes, or in degrees, if they're

rotative. They could also have strange measuring units, if you have a tool changer carousel connected to A axis, it could go from 1 to 5 representing which carousel position it's rotated to...

Gcode

For some works, you may actually do the job by just using manual jogging and choosing a suitable speed. But to unleash CNC power, you'll have to run toolpaths (I.e. a sequence of movements commands) written in the so-called ISO/Gcode standard. These files are just plain ASCII text files, you may edit them with Windows notepad, but have a .tap or .gc or .cnc (or any) extension instead of .txt. Yet they may still be opened and edited with notepad or any other text editor. The most simple – and most used – commands are:

G0 – Rapid movements (please note it's Golf-Zero not Golf-Oscar)

G1 – Movement at current set feed rate

M3 – Spindle ON

M5 – Spindle OFF

M8 – Flood ON

M9 – Flood OFF

M30 – End of toolpath

F – Set feed rate (the speed for movements)

These commands are inserted – one per line – in a text file. Load them in mach3 by clicking on LOAD GCODE button. Once it is loaded, you may execute the toolpath by clicking on CYCLE START (green button), stop it by clicking on STOP (red button) or pause it by clicking on PAUSE (yellow button). A going on automated cycle can also be stopped by clicking on RESET or closing a software emergency stop switch. An ongoing toolpath program cycle can also be aborted by hitting a limit switch or other hardware or software events that will bring the machine offline.

MDI

You may execute Gcode commands without editing a text file, but just by inputting them one after the other from keyboard in MDI (Manual Data Input). Just hit ENTER on keyboard, input the command (that will appear on the yellow bar just below the Jog section on screen), then ENTER again to execute it. Insert another command, or hit ENTER without inserting commands to exit the MDI modality. It is important to exit MDI modality once you're finished, because many functions of mach3 (including JOG) won't work while you're still on MDI modality. Just try this: insert M3 M5 M8 M9 to toggle the relay1 and relay14 on and off. Or launch a movement command, like G0 x1 y1 z2, and once it's executed, g1 f80 x0 y0 z0.

Gcode example

Let's see an example gcode toolpath: we're about to mill a 1cm side square, along with one of the two diagonals. Before launching this toolpath, zero your machine on the upper surface of material (jog there with PgUp and PgDown, then click on Zero Z). Zero X and Zero Y as well (by clicking on ZeroX and ZeroY buttons), the program will start from there.

G0 Z2	Rapid movement to Z=2 (X=?, Y=?) – High in the sky, cutting air
M3	Spindle ON
G0 X0 Y0	Rapid movement to X=0, Y=0 (Z=2) – going to a vertex
G1 Z0 F100	Movement at feedrate 100 to Z=0 (X=0, Y=0) – Contact with material
G1 Z-0.2 F50	Movement at feedrate 50 to Z=-.2 (X=0, Y=0) – Inside material
G1 X10	Movement at feedrate 50 to X=10 (Y=0, Z=-0.2) – First side
G1 Y10	Movement at feedrate 50 to Y=10 (X=10, Z=-0.2) – Second side
G1 X0	Movement at feedrate 50 to X=0 (Y=10, Z=-0.2) – Third side
G1 Y0	Movement at feedrate 50 to Y=0 (X=0, Z=-0.2) – Fourth side
G1 X10 Y10	Movement at feedrate 50 to X=10 Y=10 (Z=-0.2) – Diagonal
G1 Z2 F100	Movement at feedrate 100 a Z=2 (X=0, Y=0) – Exiting material
M5	Spindle OFF
M30	End of toolpath

All coordinates are expressed in mm (or inches). Feedrate are expressed in mm/min (or inches/min). The rapid movements (G0) operate at maximum allotted machine speed. Slow movements (G1) will take place at latest set feedrate (F). The actual feedrate is shown on screen. You may insert all of X Y Z coordinates, or just one or a few of them, when you're moving along a single or just two axis, but the remainder axes just stay in the position they had before. The movements are linear in 3D, mach3 will interpolate along axis. If you state 6 axis X Y Z A B C, mach3 will interpolate all of them all together in a 6-dimension space.

Configuring throw per revolution for your machine axes

Configuring microstep

To send to stepper motor control board the correct number of step pulses to obtain the user requested advancing in mm (or inches), mach3 needs to know how long an axis travels for a complete rotation of motor.

The predefined setting for provided config files, is for a 200 step/revolution stepper motor, microstep 1:4 (quarter step) and 1mm/revolution of mechanical axis throw. If you machines uses a

different throw per revolution, stepper motors with a different number of steps per revolution, or a microstep setting different from recommended 1:4, you'll need to change this setting to get consistency between mm shown on screen and actual machine movement.

Mach3 needs to know, for each axes, just one datum: the number of steps needed to advance of one measure unit (a mm or an inch). Predefined setting is 800: stepper motors are 200 step/revolution. Microstep 1:4 gets 800 microstep/revolution out of 200 step/revolution. And we suppose a threaded rod with 1mm pitch per revolution transmits motion to axis. Therefore for 800 pulses sent by mach3 to cobra board, you get 1mm throw on the axis.

If you set microstep to 1:16, we need four times more pulses to achieve same movement, you'll tell mach3 $800 * 4 = 3200$ step per unit are needed for that axis. On the contrary, if you leave microstep 1:4, but your threaded rod is 4mm pitch instead of 1mm pitch, you need 4 times less pulses, $800 / 4 = 200$ step per unit. And so on.

The formula to use is this one: multiply 200 (the step/revolution of a typical stepper motor) by the microstep (e.g. 4 for microstep 1:4), then divide for the pitch of the threaded rod. Example: 200 step/rev stepper motor, 1:16 microstep, 3mm pitch threaded rod, calculate $200 * 16 / 3 = 1066.6666667$ and this is the number to input in mach3. If your mechanical system is more complicated, and you have gear reductions or pulleys, or pignon, just compensate accordingly expanding the formula adding multiplying factors for the mechanical motion trasmission stages. If you have a gear reduction, you'll need more motor turns for same throw, you'll multiply the step per unit value by the reduction factor of the gears. It's not complicated, once you understand mach3 just wants to know how many pulses has to send to get one unit (one mm typical, or one inch) advance. This “magical number” steps per unit, must be written in the dialogue windows accessible by the menu config / motor tuning. Click on A axis in axis selection, input the number, click on apply. Repeat for Y and Z (and A, B if you have these also). Click on axis name, input number, click on apply. If you don't click on apply each time, mach3 won't take the parameter change. When you're done will all axis, click OK.

Once you set step per unit, please check maximum speed as well. Maximum speed is specified in unit/min. Typical mm/min. Depending on your mechanics, you will find out what max speed your system tolerated before stalling out. Adjust also acceleration: if you have massive with high inertial mass axis, they'll need slower accelerations. If you have light weight axis, they can stand faster accelerations. You may test the parameters by clicking on apply, and using arrow keys up and down while still in the config / motor tuning screen.

Configuring other brands software

Cobra board is compatible with almost any CNC stepper motor control software for PC. Just to mention a few: Ninos, TurboCnc, KellyCam, Galaad, CeNeCe, Foamworks, CncPlayer, Master 5, Mach1, Mach2, Mach3, EMC2... any software outputting step and direction pulses on printer port, will do. We signal TurboCnc (for DOS) and EMC2 (for linux) for being totally free of charge. Mach3 (for windows) is the most popular, and we provide a ready-made config file. KellyCam is compatible with Windows 98. FoamWorks and CeNeCe are specific for hot wire foam cutting machines. Galaad and Ninos integrate a CAM software in the motor controlling software.

If you use any of these software, you must configure step and direction pins for each axis. If your software also supports relay outputs, configure those as well.

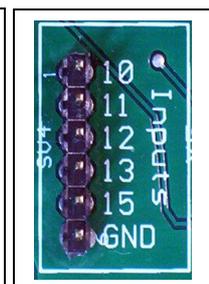
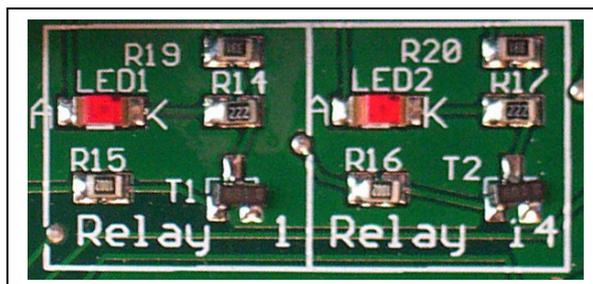
Please note step signal is active on the high-to-low transition, if you software lets you specify this parameter, make sure to specify it correctly. It will generally work even if reversed, so never mind if your software doesn't let you configure this parameter.

Output signals for axes (from PC to Board)	Step pin #	Direction pin #
X axis	2	3
Y axis	4	5
Z axis	6	7
A axis	8	9
B axis	16	17

Relay output signals (from PC to Board)	Pin #
Relay 1 (Spindle)	1
Relay 14 (Flood)	14

Input signals (from board to PC)	Pin # 10, 11, 12, 13, 15
-------------------------------------	--------------------------

	Step	Dir
X Axis	2	3
Y Axis	4	5
Z Axis	6	7
A Axis	8	9
B Axis	16	17



The pin numbers associated with each signal can be read on board screen printing

Many wishes!

Have fun with your ideegeniali cobra board powered CNC machine.