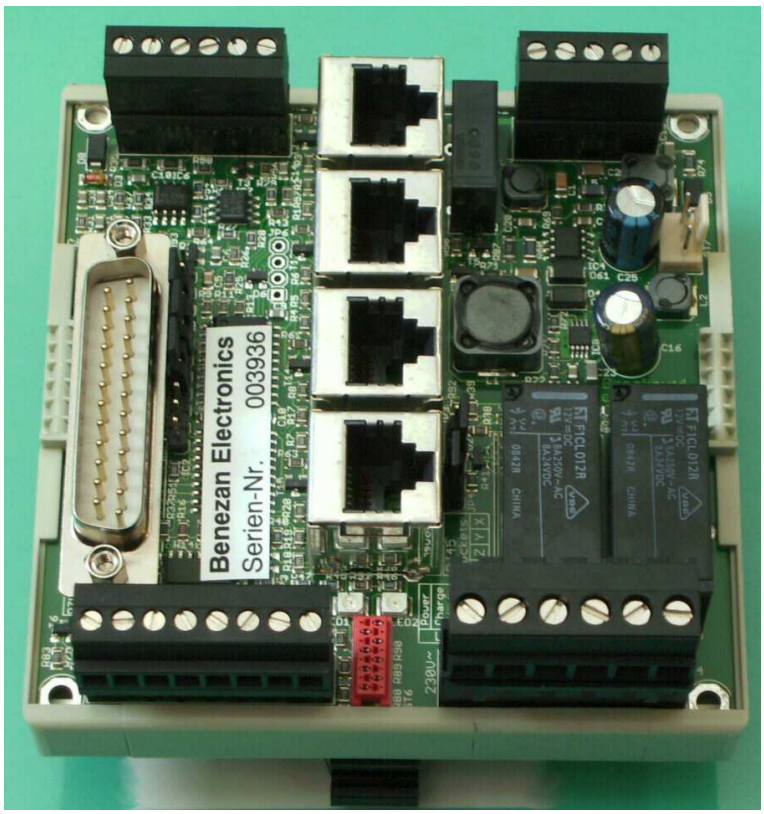
Mini Breakout-Board

CNC Interface for LPT Port

Installation Manual

Version 4



Product Brief

This breakout-board is designed to connect up to four stepper or servo drives to the parallel port of a PC. This requires the use of a CNC controller software (not included), such as like Mach3, WinPCNC, EMC² or USB-CNC. It can be set to many different configurations using jumpers. Depending on the jumper settings, additional features like control of a frequency inverter, relay outputs, Z-axis holding brake output, safety watchdog (charge pump) and limit switch inputs are available.

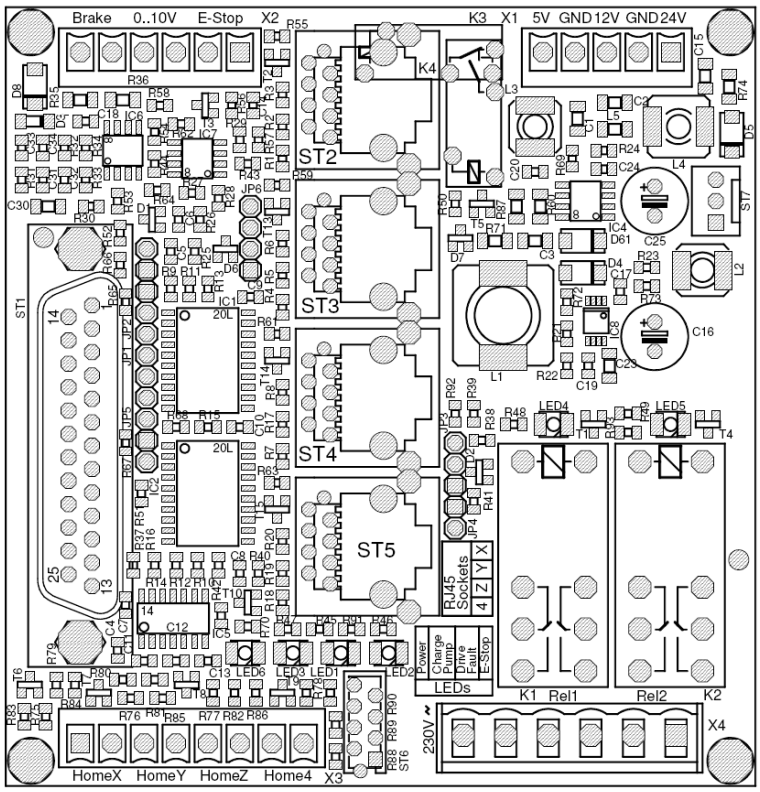
All output signals are buffered and all inputs in the machine side are designed for 24V to provide maximum noise immunity. Industrial proximity sensors can be connected directly. BEAST and UHU drives can be connected directly. Adaptors or special cables for Leadshine stepper drives and SanyoDenki Servo systems are also available. All terminals are pluggable for easy installation and maintenance.

1 Safety Instructions

The installation of this breakout-board should only be carried out by qualified personnel. Please read this manual thoroughly and carefully follow all instructions. Failure to do so could result in damage to mechanic or electronic components, or lead to personal injuries.

Depending on the evaluation of the machine's risk level, it may be required to install additional protection devices, such as door locks or safe halt guards. All safety circuits must be implemented purely electromechanically or with certified electronic parts that are not included with this breakout-board. Relying on software or non-certified electronic devices for critical safety functions is strongly discouraged. Both the machine manufacturer who performs the final assembly and the machine operator are responsible for fulfilling all applicable safety standards and laws.

2 Connections



Power Supply (5-way terminal X1, top right)

No.[1]	Description
1	Output voltage: 5V (150 mA max.)
2	GND: 0V
3	Output voltage: 12V (0.8 A max.)
4	GND: 0V
5	Input voltage: 24V (15-55V, 1 A max.)

1 All pins are numbered from left to right.

LPT port (SUBD25, left side)

No.	Description
1	Spindle on/off, Relay 1, PWM
2	Direction X
3	Pulse X
4	Direction Y
5	Pulse Y
6	Direction Z
7	Pulse Z
8	4th axis direction
9	4th axis pulse
10	Limit/home switch Z
11	Emergency stop
12	Y limit/home switch
13	X limit/home switch

No.	Description
14	Coolant on/off, Relay 2
15	4th axis limit/home switch
16	Watchdog, current reduction
17	PWM, current reduction
18	Signal Ground
19	
20	
21	
22	
23	
24	
25	

Auxiliary signals
(6-way terminal X2, top left)

No.	Description
1	Ground for holding brake
2	Holding brake output
3	Analogue signal GND: 0V
4	Analogue signal output: 0-10V
5	E-Stop switch input
6	E-Stop switch output: +12V

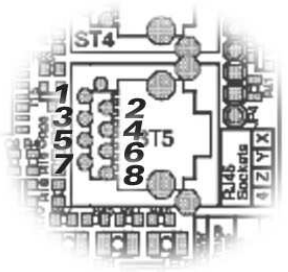
Limit/Home switch inputs
(8-way terminal X3, bottom left)

No.	Description
1	Switch or sensor power supply (+12 or +24V)
2	X axis switch or sensor input
3	Switch or sensor power supply (+12 or +24V)
4	Y axis switch or sensor input
5	Switch or sensor power supply (+12 or +24V)
6	Z axis switch or sensor input
7	Switch or sensor power supply (+12 or +24V)
8	4th axis switch or sensor input

Drive outputs
(4 x RJ45, center)

No.[1]	Description
1	Current reduction or disable
2	Signal ground
3	Pulse
4	+5V

Figure 1:



No.[1]	Description
5	Direction
6	+5V
7	Status input (low=ok, high=error)
8	Signal ground

Relay outputs

(6-way terminal X4, bottom right)

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

1 See figure 1 for Pinout.

3 Functional Description

3.1 LPT Port, PC Signals

The breakout-board is designed to be connected to the parallel port of a PC with a standard parallel printer cable (SUBD 25 pins, male to female). Please make sure that all pins are connected 1:1, especially all ground pins 18 to 25. A maximum length of 3 meters (10 feet) is recommended.

LPT signals are not galvanic isolated on the breakout-board. However, if you use BEAST, UHU or comparable drives the signals are optically isolated at the drive inputs so a second isolation is not necessary. All signals are buffered so that PCs with low signal levels (laptops usually use 3.3 instead of 5V) can also be used without problems.

The pin assignment of the LPT port is designed for use with Mach3, EMC² or WinPCNC. If you use a different software with a different pinout that cannot be changed via software settings, you will have to make a special adaptor or use a so-called patch box.

3.2 Power Supply

The breakout-board needs a power supply of 15 to 80V DC. That is why in most cases the motor supply can be shared between breakout-board and drives. However, if you need 24V for proximity switches or a holding brake, you will have to use a separate 24V supply for the board.

In the case of fans, relays, or other external devices, you can use internal voltage regulators. At terminal X1 there are 5V and 12V outputs available. There is also a 3-pin socket for standard 12V fans near the X1 terminal. The 5V and 12V outputs are short-circuit proof. However, please note that shorting can lead to temporary malfunctions of the board as these voltages are also used internally.

3.3 Drive Outputs

The motor drives can be connected to the RJ45 sockets with standard network patch cables. BEAST stepper drives and UHU servo controllers can be connected directly. For Leadshine stepper drives and servo systems from SanyoDenki there are special adaptors available.

Please note that one of the signals is a status input to the breakout-board where an open connection means fault (broken cable or drive problem). So if one or more axes are unused, the corresponding socket has to be occupied with a “dummy” connector with a jumper wire between pin number 7 and pin number 8. An exception is the 4th axis, which can be disabled with a jumper at header pins 15 and 16 (see section 4 below).

BEAST Stepper Drives

BEAST stepper drives can be connected directly with standard network cables (make sure NOT to use an X-cable). The following features are available:

1. The current reduction signal can be configured for LPT pin 16 or 17 (see jumper settings, section 4).
2. The automatic current reduction of each drive can be used (activate DIP switch no 3 of the drives).
3. No current reduction selected (no jumper at header 8, DIP 3 off).

UHU Servo Drives

There is a special version of the UHU servo drive from Benezan Electronics (“SMD-UHU”) that has the same form factor as the BEAST drives. We recommended to use this version instead of older versions with Euro-sized PCB (160 x 100 mm) because it is much easier to connect.

It is important to disable the current reduction signal because it uses the same pins as the emergency stop input of the UHU. Also make sure

that the error output of the UHUs are configured as normally closed (see UHU installation manual, section 5.1). If UHU and BEAST drives are to be mixed, then it is recommended to either disable the current reduction (and to use automatic current reduction if required) or to cut off the E-Stop input signal (pin number 1) at the UHUs.

3.4 Relay Outputs

The two relay outputs at terminal X4 can be used to switch either 230 VAC or 24 VDC loads (not both). The relay contacts can take up to 8A non-inductive load current or up to 1 kW inductive loads (motors). Higher loads have to be switched with an external contactor. Inductive loads (motors, transformers or pneumatic or hydraulic solenoids) should be equipped with a surge suppressor to avoid arcing and EMI problems.

To switch 24 VDC loads, connect the DC supply to terminals X4 pins 1 and 2 instead of the 230 VAC supply. Be sure not to mix low and high voltages at terminal X4 because the insulation distance between the contacts is not sufficient (however, 230 VAC between X4 and other terminals is safe).

Relay no. 1 can be controlled with LPT pin no. 1 or with the PWM comparator (PWM>10%). Relay no. 2 is always controlled with LPT in no. 14. The state of the relays is displayed with a yellow LED for each. We recommended using the watchdog (charge pump) if possible. Otherwise the relays could be switching unexpectedly while booting the PC or when the LPT cable is disconnected.

3.5 Home or Limit Switch Inputs

At terminal X3 up to four switches or sensors can be connected. If you do not need a home switch for the 4th axis, you can also use this input for a tool length measurement switch or probe.

It is possible to use mechanical switches or industrial proximity sensors of PNP type. If you use proximity sensors you have to use a 24 VDC supply for the breakout-board and set jumper 12-13. Industrial sensors normally have three wires, one brown, one blue, and one black. Connect the brown wire to terminal X3 pins 1, 3, 5, or 7; connect the black wire to terminal pins 2, 4, 6, or 8. The blue one has to be tied to ground at the power supply.

If you use mechanical switches, the board can be powered with any DC supply from 15 to 80V if jumper 12-13 is set. Never set jumper 12-13 if the supply voltage is above 30V because this could damage the switches or sensors (the breakout-board itself is protected against 80V).

The inputs are inverting, which means the corresponding LPT signal is low when the switch input is high (switch closed). You can use both normally-open or normally-closed switches. The polarity can be selected via software setup. All inputs have noise filters and Schmitt triggers so that no EMI problems should arise even with unshielded cables.

3.6 Emergency Stop

The breakout-board has several different circuits to warn the PC of a problem and to bring the machine to a halt:

1. An E-Stop switch (mushroom shaped button) must be connected to terminal X1 pins 5 and 6. If the contact is open, the relay outputs are automatically forced to off. The E-Stop state is signaled with a red LED labeled “E-Stop”, and is communicated to the PC via LPT pin no. 11.
2. If one or more motor drives signal a fault or if they are powered down or disconnected, the LED labeled “Drive fault” is lit and LPT pin no. 11 is also asserted.
3. In both cases (E-Stop switch or Drive fault), the holding brake relay is opened. This engages the brake (if installed) and can prevent a heavy Z axis from moving downward.
4. In case of a power outage, LPT pin no. 11 is asserted to avoid unwanted “blind” running of the PC software.
5. If the watchdog is enabled (jumper 1-2 open), the relay and step signals are only enabled when the charge pump signal is valid (toggling at > 10 kHz).

3.7 Watchdog (Charge Pump)

When the LPT port cable is not connected, when the PC is booting or whenever the PC CNC software is not running properly, port signals appear as undefined. Some software protection key (“dongle”) drivers even

generate frequent pulses. This could lead to unwanted and probably dangerous movements of the machine. The watchdog circuit can be used to avoid this.

The CNC software has to generate a so called charge pump signal that toggles with a frequency of at least 10 kHz (Mach3 uses 12 kHz, for example). Whenever this signal stops toggling (when the software is not running or has problems), all relay and step pulse outputs are disabled. Short interruptions (up to two missing pulses or 200µs) do not disable the outputs. The state of the watchdog is displayed with a green LED labeled "Charge pump".

If your controller software does not support a charge pump or toggle signal, then the watchdog has to be disabled by setting jumper 1-2. **Important:** The watchdog is not a certified safety feature. If the software should crash for any reason, it is highly probable but not guaranteed that the charge pump signal will stop toggling. Therefore all critical safety devices to protect the machine operator from injury must be implemented independent of the PC software.

3.8 Spindle Speed Output

The analogue 0-10V output of the breakout-board can be used to control a variable frequency spindle drive (VFD). The output voltage is proportional to the duty cycle of a PWM signal at pin no. 1 or 17 of the LPT port. 0V corresponds to 0% PWM and 10V to 100% (PWM = pulse width modulation). The frequency of the PWM signal (called PWM base frequency in Mach3) should be 45 Hz or higher. This gives a resolution of 10 bits at 45 kHz kernel speed.

If you wanted to use all the features of the breakout-board at the same time, e.g. current reduction, PWM and both relays, you would normally run out of pins. To get around this, relay no. 1 (normally used as spindle start/stop) can be controlled via the PWM signal instead of a separate pin. If jumper 3-4 is set, relay 1 will be switched on whenever the PWM signal has a duty cycle >10%. In most cases, the speed range below 10% is not used, anyway, so the minimum pulse width can be set to 10%.

3.9 Holding Brake

If a low friction ball screw is used together with servo motors for a heavy vertical axis, it is often required to install a mechanical brake to prevent the axis from moving down when the motor is not powered. Brakes are available in combination with servo motors or as separate units. For low cost applications that do not need much torque, a spring biased solenoid would also do. Electromechanical brakes and solenoids are usually operated with 24 VDC and are released when power is applied and engaged when power is off.

The breakout-board has a relay output at terminal X2 which is powered whenever the board is powered, the watchdog signal is present (or disabled) and there is no drive fault or E-Stop condition. The output has an internal free wheeling diode so inductive loads of up to 5A can be switched directly. It is recommended to use a power supply of the same voltage (usually 24V) as the brake is rated for. If you power the breakout-board from a higher voltage, an external relay must be used to avoid damage to the brake.

3.10 External LEDs

The status of the breakout-board is displayed with six on-board LEDs. However, sometimes it is desirable to have the status visible from the outside of a cabinet. For this reason, it is possible to connect additional LEDs via a ribbon cable to a small connector between terminals X3 and X8. A ready-to-use PCB with LEDs and ribbon cable can be purchased from Benezan Electronics.

4 Configuration

It is possible to set up the breakout-board for different software and different applications via jumpers. On the board there are two rows of header pins, one with 11 pins next to the SUBD25 connector and one with 5 pins between the RJ45 sockets and the relays. The pins are numbered from top to bottom.

No	Description	Reference
1	Watchdog disable	JP2
2	(open = watchdog active, closed = disabled)	
3	PWM>10%, analogue out >1V →	JP1
4	→ Relay 1	
5	LPT pin 1 →	
6	→ PWM signal	
7	LPT pin 17 →	
8	→ Current reduction	
9	LPT pin 16 →	
10	Enable signal instead of current reduction	
11		

JP1 is used to select between possible input sources, for example 5-6 or 6-7 selects the source of the PWM signal between either pin 1 or pin 17 of the LPT port. This way, conflicts (connecting two outputs together) can be avoided.[2]

No.	Description	Reference
12	sensor supply 24V →	JP3
13	→ power supply for sensors at X3	
14	sensor supply 12V →	
15	status signal for 4th axis disable	JP4
16	(open = 4th axis used, closed = not used)	

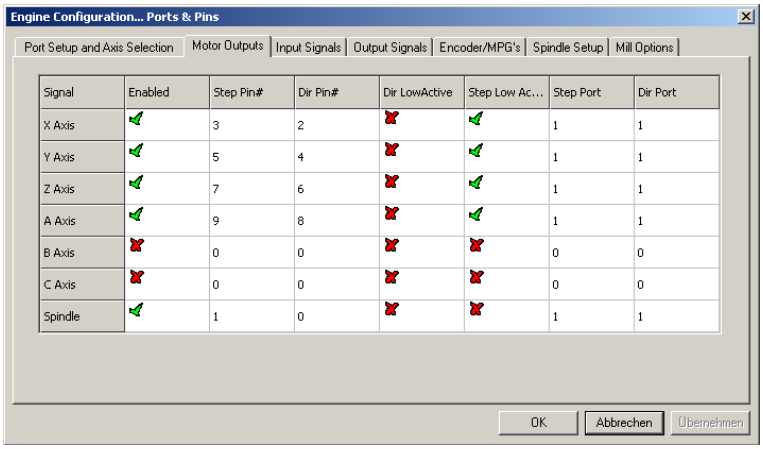
Important: If the power supply at terminal X1 pin 5 is greater than 30V, then JP3 **must not** be set to 24V mode (jumper 12-13 set). Otherwise proximity sensors could be damaged.

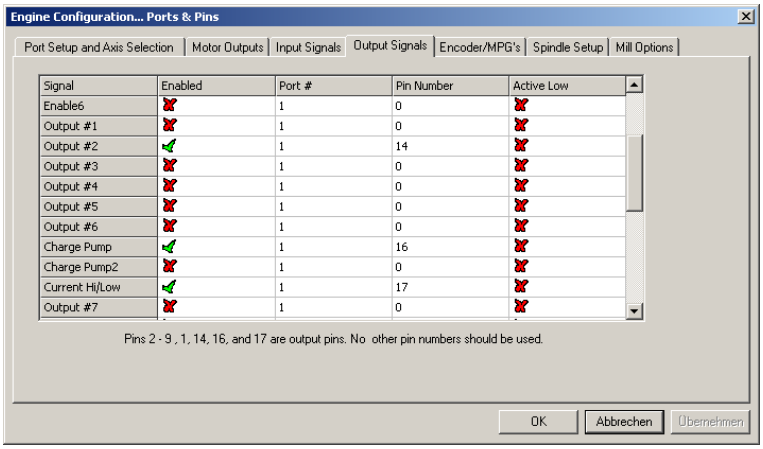
Recommended Jumper Settings

- Stepper motors, no VFD speed control: 4-5, 7-8.
  Relay 1 controlled by LPT pin 1, no PWM, current reduction by pin 17, watchdog signal at pin 16.
- Stepper motors with VFD and analogue output: 3-4, 5-6, 7-8.
  Relay 1 on if PWM>10%, PWM at pin 1, current reduction pin 17, watchdog pin 16.
- Servo drives and VFD: 4-5, 6-7.
  Relay 1 at pin 1, PWM at pin 17, no current reduction, watchdog pin 16.
- Special mode for Leadshine stepper drives: 4-5, 6-7, 10-11.
  Relay 1 at pin 1, PWM at pin 17, enable signal instead of current reduction, watchdog pin 16.

2 Exception: If jumper 10-11 is closed, pin 8 must not be used at the same time

Mach3 Example Configuration





The screen shots on the left show the standard configuration for stepper motors and VFD (jumpers set to 3-4, 5-6, 7-8). Additional settings:

- XHome pin 13.
- YHome pin 12.
- ZHome pin 10.
- AHome or probe pin 15.
- Relay control:
  M3 and M4 → Output#1.
  M7 and M8 → Output#2.
- Motor control:
  √ Use spindle motor output.
  √ PWM control.
  PWM base freq. = 45.
  Minimum PWM = 10%.

5 Specifications

5.1 Absolute Maximum Ratings

The following limit values must not be exceeded under any circumstances in order to avoid damages:

Parameter	min.	max.	Unit
Supply voltage	-100	+100	V
Storage temperature	-40	+70	°C
Operating temperature	0	+70	°C
Voltage at switch inputs	-10	+100	V
Voltage at analogue output	-0.5	+15	V
Voltage at terminal X4 relays	-	250	V_{rms}
Current at terminal X4 relays	-	8	A_{rms}
Voltage at holding brake output	-	30	V
Current at holding brake output	-	5	A_{rms}

5.2 Operating Conditions

Parameter	min.	max.	Unit
Power supply voltage (nominal 24V)	+15	+80	V
Power consumption (without external loads)	0.1	3	W
Ambient temperature	0	+50	°C
Threshold for switch inputs	4	7	V
5V output voltage	4.8	5.3	V
5V output current	0	150	mA
12V output voltage	11.5	12.5	V
12V output current	0	0,3	A
Full scale analogue output range	9.5	10.5	V
Analogue output max. non-linearity	-	1	%
Threshold frequency, watchdog off	5	10	kHz
Threshold frequency, watchdog on	10	20	kHz
Step/dir output current	-	8	mA

5.3 Dimensions

Description	Width	Length	Height	Unit
PCB dimensions without connectors and case	89	93	20	mm
Hole pattern for mounting bolts	83.5	87	-	mm
Dimensions with connectors and case	93	96	60	mm

6 First Operation and Troubleshooting

After installation and before applying power for the first time, please check the following carefully before proceeding:

- All terminals have to be located and correctly aligned in their sockets (X1 to X4).
- Supply voltage (15 to 80 VDC) must be connected to X1 pin 5 (rightmost pin), and ground to pin 4.
- If supply voltage is greater than 30V, jumper JP3 must be set to 13-14 (limit switch supply 12V).
- All RJ45 sockets (except the 4th one) must be busy, e.g. either connected to a drive or terminated with a dummy connector (jumper on pin 7-8). If the 4th axis is used, jumper 15-16 must be open. Otherwise, jumper 15-16 must be closed.
- An E-Stop button (normally closed) must be connected to terminal X2 pins 5 and 6. Only for testing purposes and without connection to an actual machine, a jumper wire can be used. Whenever connected to an actual machine, an E-stop button is obligatory.
- Please re-check if all jumper settings match the configuration of your CNC software.

Only when these preconditions are met, you can connect the cable to the PC, apply power to the board and drives, and load the CNC software. After activating the control software (for example, pressing the “Reset” button in Mach3), the state of the LED indicators should be as follows:

- Both green LEDs labeled “Power” and “Charge Pump” should be lit.
- Both red LEDs labeled “Drive Fault” and “E-Stop” must be off.
- Both Relay 1 and Relay 2 yellow LEDs should be off.

If this is not the case, please check the “Troubleshooting” section below. If everything works as expected, you can proceed to test the motor drives, relays and limit switches.

Troubleshooting

The following table lists the most frequent errors and their causes:

#	Symptom	Explanation
1	LED “Power” (left green) is dark	Power supply (Ground at pin 4 of X1, +15 to +80 VDC at pin 5, right side) is not connected or polarity is wrong.
2	LED “Charge Pump” (right green) does not light up	The PC software must provide a square wave (charge pump) signal of at least 10 kHz at pin 16 of the LPT port. If the software doesn’t support this, you must set jumper 1-2 to disable the watchdog.
3	LED “Drive Fault” (left red) is on	Not all drives are connected or at least one of them is signaling an error. If the 4th axis is not used, jumper 15-16 must be closed.
4	LED “E-Stop” (right red) is on	E-Stop button (X2 pins 5 and 6) is pushed or not connected.
5	Relays don’t work	a) Yellow LEDs are lit but relays are off: see #4. b) Yellow LEDs are dark: jumper settings or software pin configuration wrong.
6	Motors don’t turn	a) Green LED “Charge Pump” is dark: see #2. b) Pulse and dir pins swapped? (LPT pins 2, 4, 6, 8 = direction, pins 3, 5, 7, 9 = pulse).
7	VFD speed is unstable	PWM base frequency too low, min. 45 Hz.
8	No E-Stop signal change (LPT pin 11)	Pin 11 must be set to “active low” in the software, LEDs “Drive Fault” (see #3) and “E-Stop” (see #4) must be off.
9	Motors move one step at a time when “Reset” or E-Stop are pressed	Step signal polarity must be inverted.