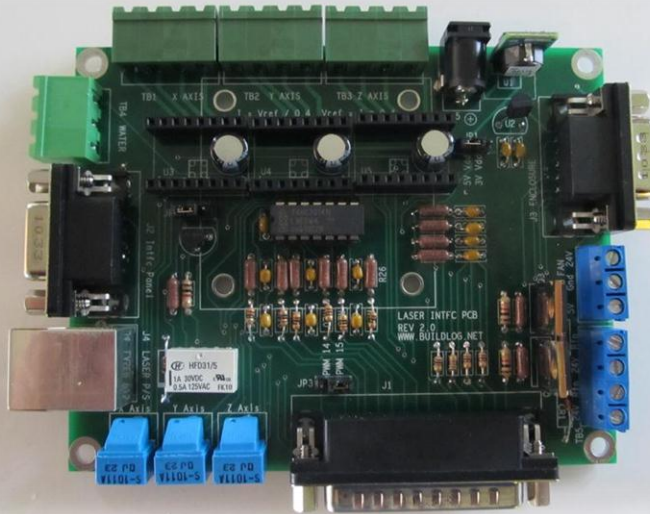


Buildlog.net Interface/Laser Driver PCB

User Guide Rev 3.3 (Doc Number A40003 Rev 4)



Safety & Disclaimers

This laser interface/driver board is design for experienced technicians only. The schematic should be studied to see if it will safely work in your system before installing or using the board. Improper use in a laser or other machine could cause personal injury or damage expensive equipment.

No circuit can be truly fail-safe. Even with properly connected interlocks and safety switches, there is always the chance for unintended firing of the laser or motion of the motors.

The user is the sole person responsible for the safety of the system. If at any time you are concerned about the suitability of this circuit for safe operation you can return it for a refund.

Unless otherwise specified in the document, no connections should be made to this board or jumpers changed while the board is powered. Remove power and wait for the voltage to reach 0 before making changes.

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Purpose

The purpose of this board is to simplify the electronics of the 2.x laser cutter. All of the subsystems wire to this board and all the complex interconnections are done on the board. The board also includes slots for 3 Pololu stepper motor drivers. These can either be the A4983 or A4988 motor drivers. Other stepper motor drivers can be used with simple wiring changes to the board.

Beyond laser cutters, this could be used as a general purpose low power stepper CNC controller. It has three axis control with limit switches and the relays could be used to control spindles and coolant devices.

Features

1. Sockets for standard Pololu and Step Stick stepper drivers.
2. Rotary switch selectable stepper resolution.
3. 3.3V and 5V supplies on board (selectable for controller compatibility)
4. Pull up resistors for all limit switches
5. Several electrical noise control features.
6. Mounting hole pattern and power take off for standard 5V or 24V fan
7. (2) 24V Digitally controlled external relay drivers (typ. exhaust, assist air)
8. Onboard relay to allow switching between Pot and PWM power control.
9. PWM source selectable between Pin 14 and 15.
10. Motor enable/disable control (logic direction high/low selectable)

Assembly

If assembly is required...Use the Bill Of Materials (BOM) section near the end of this document to determine the parts. Here are some tips to make assembly easier.

- Be sure to double check the sex of the 9 pin connectors, because either sex will fit in either location.
- I find it easiest to assemble the shortest parts first because they can be inserted and the board flipped over and placed on a table.
- The parts in the pink, gray or mylar bags are static sensitive. Use a wrist strap or ground yourself when handling these.
- Note the orientation of the U1. The large inductor goes away from the edge of the board.
- The jumper headers are sensitive to heat and the pins can melt free of the plastic if you apply to much heat. Sometimes installing the jumper on the pins you solder can help hold it in place.
- A Pololu Driver PCB can be used to hold the mating connectors properly aligned while soldering.
- I use a little dab of super glue to hold the terminal blocks in place while soldering. This makes it easier to solder them straight. Be sure no glue flows onto the solder pads.
- Many parts are polarized other otherwise orientation sensitive.
 - The diodes must be installed with the line on the part oriented with the line on the PCB.
 - The large capacitors have a minus sign printed on the device. The negative side of the capacitor goes towards the middle of the PCB.
 - The Schmitt trigger must be oriented with pin 1 towards the end with the notch in the silkscreen.
 - The MOSFETs, transistor, relay, power supplies and resistor array are also orientation sensitive.
 - The resistor array (RP1) is bussed, meaning all the resistors share a common pin. This pin (pin 1) must be placed correctly. It goes towards the edge of the PCB. The silkscreen outline of the part rounds it off on the pin 1 end and the solder pad is square on pin1. The part is poorly marked, but the text starts at the pin 1 end. Pin 1 to any other pin will measure 10k. Any other pin to pin will measure 20k.

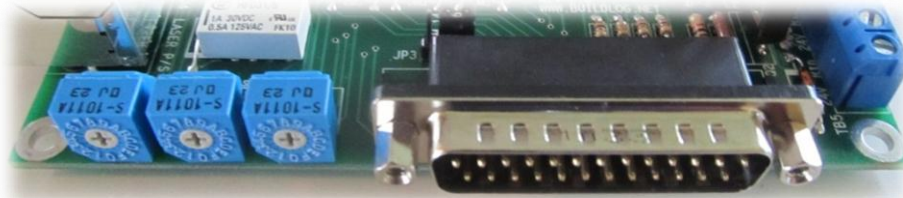
Electrical Noise.

The stepper drivers can react to pulses of 1uS and possibly less. This makes them sensitive to electrical noise. There are multiple features on the board to reduce noise susceptibility, but lasers are a very noisy environment. The laser tube and tube power can create enough noise that the drivers can assume a step pulse has arrived and step the motors. Common sense layout of the electronics can reduce the noise getting to the board and prevent any problems. Below are some guidelines you should follow. The Laser Driver PCB has been tested with most of the items below deliberately violated and still performed adequately, but some people may have different results.

- Place the tube power supply as close to the tube and as far away from the any other electrical items.
- A metal barrier between the tube power supply and other electronics will help. Steel is better than aluminum.
- Make sure the laser power supply is well grounded.
- Minimize the length of the tube positive lead and to not run it near any other wiring.
- Wrap the tube ground wire around the positive lead wherever possible. Be sure keep the ground wire at least 3" from the tube positive terminal.

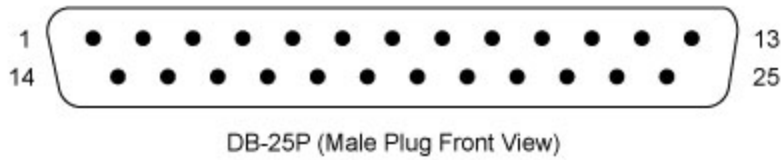
- Keep the 24V power supply lead as short as possible. Consider using a coaxial cable with the center conductor being positive.
- Use a shielded cable for the laser power supply control cable. Ground the shield at one end only.
- Twist together any wires that are not shielded.

J1 Control Connector

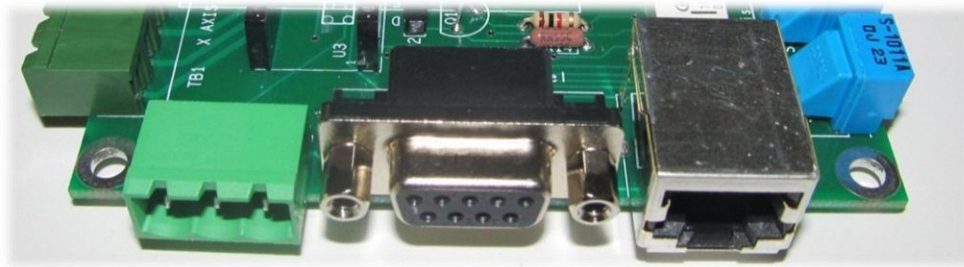


J1 is connects to the laser controller. This controller can be a PC with Mach3 or EMC2 type software or it can be a dedicated microcontroller based laser controller

J1 (Control input connector)	
Pin #	Function (goes to)
1	Output 1 (Relay Driver 1)
2	X Step
3	X Dir
4	Y Step
5	Y Dir
6	Z Step
7	Z Dir
8	Output 8 (Relay Driver 2)
9	
10	X Limit Switch Input (J3-6)
11	Y Limit Switch Input (J3-8)
12	Z Limit Switch Input (J3-1)
13	Input 13 (J3-2)
14	PWM 14
15	PWM 15
16	Motor Enable Output
17	Laser On
18-25	Ground

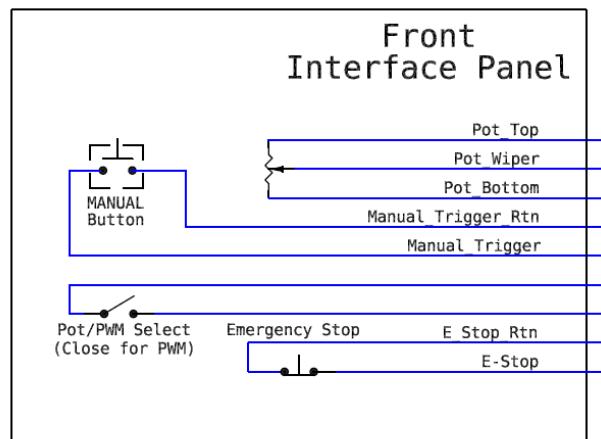


J2 Interface Panel Connector

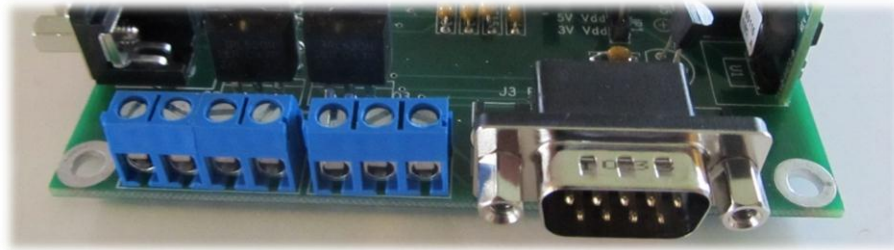


This connector groups the feature typically found on the front panel of the laser. These include the emergency off switch, the power control potentiometer (Pot), the manual trigger button and the Pot/PWM selection switch.

Pin Number	Function
1	Pot Top (+5V Laser)
2	Pot Wiper (Laser P/S Power Input)
3	Pot Bottom (Gnd)
4	Manual Trigger Return
5	Manual Trigger (Close to fire laser)
6	Pot/PWM Switch (Open = Pot, Closed to +5V = PWM)
7	+5V
8	E-Stop Return
9	E-Stop (Open = E-Stop Condition)

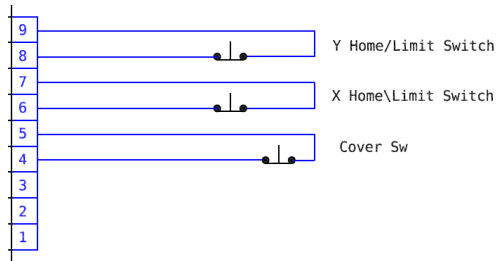


J3 Enclosure Connector

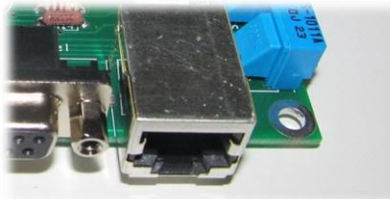


Limit switches should be normally (non-limit condition) closed to ground. The board has built in 10K pull up resistors to Vdd. When a limit is hit, the switch should open and the controller will see a logic high. Input 13 can be used for any unspecified input to the controller. It also has a pull up resistor.

Pin Number	Function
1	Z Limit (close to ground when not at limit)
2	Input 13 (Connects to Pin 13 on J1 connector)
3	Gnd
4	Cover Switch Return
5	Cover Switch (Part of safety loop)
6	X Limit (close to ground when not at limit)
7	Gnd
8	Y Limit (close to ground when not at limit)
9	Gnd



J4 Laser Power Supply Connection



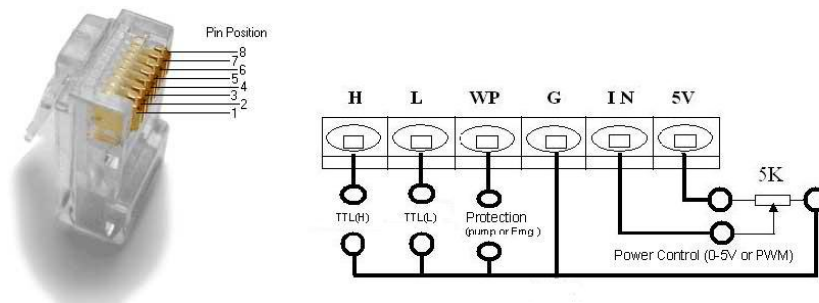
A Shielded RJ45 connector was chosen for this circuit, because it is a simple, low cost shielded connector. Pre-wired mating cables are also cheap and easy to find.

Ideally you should use a cable with a metal covering on the connector. This connects the shielded to ground. Get CAT 7 if you can. This has multiple levels of shielding and has the best quality and largest conductors. The internal wires have a standardized color coding that is listed in the table below. If you buy a cable that has connectors pre-installed at each end you may want to verify the colors by beeping out the wires to the pins. The unused wires should be cut short and prevented from contacting other circuits. Be careful, some wire colors especially the white/brown and white/orange and the white/blue and white/green ones are easy to mix up.

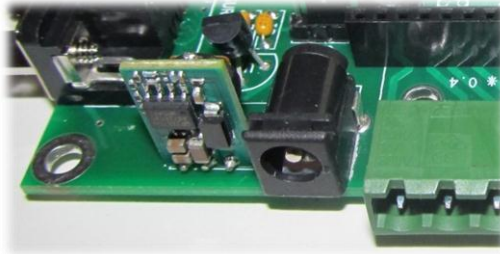
Many laser power supply connectors look similar to the drawing below. The pinout in the table shows the connections for that. You may need to adjust if your p/s is different.

Note: Do not connect the +5V on the laser power supply to the +5 from the PCB. They are two separate power supplies.

Pin Number	Wire color	Laser P/S connection
1	Orange/White	(H or TH) Enable High
2	Orange	(G) Ground
3	Green/White	(IN) Input
4	Blue	Not connected (Ground)
5	Blue/White	(WP) Water Pump
6	Green	(L or TL) Enable Low
7	Brown/White	Not connected (Ground)
8	Brown	(5V) +5V (From Laser P/S)



J5 Power connector



This connector is for the 24V input power of the board. The center pin is positive and the outer ring is ground. Double check the voltage before applying. Reverse voltage will destroy many parts on the board. Use a twisted pair of 18-22 AWG wires or coaxial shielded cable for this. The connector is rated for 5 amps continuous current. The mating connector is a standard 2.5mm x 5.5mm power connector.

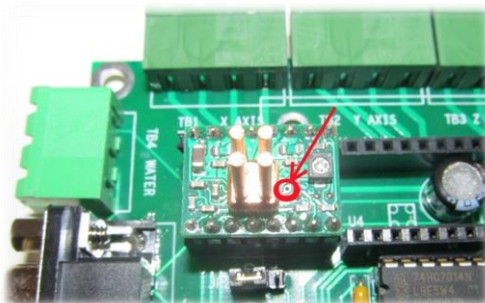
TB1, TB2, TB3 Stepper Motor Connections



Pin 1 and 2 are for one winding and pins 3 and 4 are for the other winding

The Pololu drivers must be installed in the orientation shown. Any other orientation will destroy the drivers and other circuitry. The current is set using the potentiometer on the driver board. You adjust the pot until the correct voltage is measured on the very little point shown below. The voltage is calculated using the following formula. For 1.5A you would set the voltage to 0.6V.

$$V = I * 0.4$$



Note:

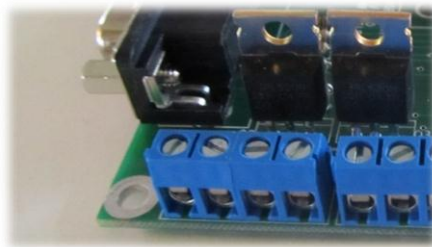
Never disconnect a stepper motor with the board powered. It will destroy the stepper drivers. Make sure the wires are securely fastened in the terminal blocks to prevent accidental disconnect. The use of heatsinks on the drivers is suggested. Heatsinks are attached with special heatsink tape.

TB4 Water Switch



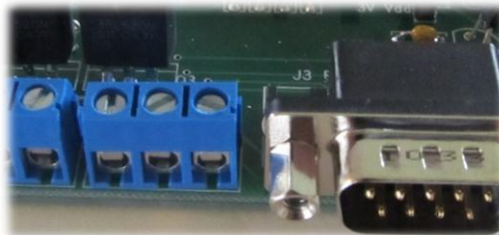
The water flow switch must complete a connection from pin 1 to pin 3 of the terminal block to complete the safety interlock circuit. 5V is provided on the terminal to power advanced water monitoring circuits.

TB5 Relay Drivers



Up to 2 external relays can be controlled power via on board MOSFETs. The MOSFETs should be able to handle just about any 24V relay coil, but be careful that the total current from the steppers and the relays does not exceed the maximum of 5A for the board. The 24V terminal is always on and the return/ground terminal is switched to ground by the MOSFETs. A logic high on pin 1 or pin 8 of the J1 25 pin control connector activates the circuit

TB8 Fan Power



This terminal block can power a 5V or 24V fan. It can also be used to power light current off board accessories. Be sure not to exceed the 5A maximum current on the 24V power connector.

Do not over tighten the fan. It just needs to be snug. If you put excessive pressure on the fan housing it may distort and cause the fan to bind. This may cause permanent damage,

S1, S2, S3 Stepper Resolution Switches.



The rotary switches control the stepper motor resolution on the Pololu A4983/A4988 driver boards. The control bit scheme follows a binary progression except for the highest resolution. The positions are decoded below. Other switch positions will result in some resolution, but probably should be avoided. Resolution can be changed while the system is powered.

Encoder Position	Resolution (bit pattern)
0	Full Steps 0,0,0
1	1/2 Step 0,0,1
2	1/4 Step 0,1,0
3	1/8 Step 0,1,1
7	1/16 Step 1,1,1

JP1 Vdd Voltage Selection Jumper

Some controller use 5V logic and some use 3.3V logic. This jumper allows you to select that voltage. The limit switch circuits use this voltage as the pull up voltage when the switches open. This voltage can damage controllers if it is not right.

JP2 Motor Disable Logic Level Selection Jumper

Some controllers use a logic high signal to enable the steppers and some use a logic low signal. This jump allows you to select that. If the behavior of this circuit is opposite of what you want, just move the jumper.

JP3 PWM Source Selection Jumper

This allows you to select the source of the PWM signal on the J1 25 pin connector. The PWM value will only reach the laser if the Pot/PWM relay is energized. See the section on the J2 front panel connector.

Bill Of Materials

Designator	Qty	Description	Part Number
C1,C2,C12-C16	7	0.1uF 50V 20% Ceramic Cap	Kemet C410C104M5U5TA7200
C3-C5	3	220uF 25V Electrolytic Cap	Panasonic ECE-A1AKA221
C6-C11	6	100pF 100V 5% Ceramic Cap	AVX SA102A101JAR
CR1-CR3	3	Diode, 1N4148	Generic
J1	1	Connector, D 25 Pin Male 90 Deg	FCI 10090097-P254VLF
J2	1	Connector, D 9 Female	
J3	1	Connector, D 9 Male	
J4	1	Connector, RJ45 Shielded	Stewart SS-6488S-A-NF
J5	1	Connector, DC Power	
JP1,JP2,JP3	3	Connector, Male Header 3pos	Generic
K1	1	Relay,	Panasonic TQ2H-5V
Q1	1	Transistor	Motorola MPS2222A
Q2,C3	2	MOSFET	Vishay IRL520
R1...R4,R10,R12,R14,R17 ,R18,R21,R22,R24,R26	13	Resistor, 10K, 1/4W	Generic
R5,R6,R7,R8	4	Resistor, 100R, 1/4W	Generic
R9,R11,R13	3	Resistor, 1K, 1/4W	Generic
R15,R16,R19,R20,R23,R25	6	Resistor 10 Ohm, 1/4W, Metal Film	Generic
RP1	1	Resistor Array 10K x 9	
S1,S2,S3	3	Hex Rotary Switch	Copal S1011
TB1,TB2,TB3,TB5	3	Terminal block 5mm x 4, Pluggable	
TB4	1	Terminal block 5mm x 4	
TB4	1	Terminal block,5mm x 3, Pluggable	
TB8	1	Terminal block 5mm x 3	
U1	1	Power Supply 5V DC/DC	Murata OKI-78SR-5/1.5-W36-C
U2	1	Power Supply 3.3V DC/DC	Microchip MCP1700-3302E/TO
U3,U4,U5	3	Stepper Driver	Pololu A4983 or A4988
U6	1	Schmitt Trigger Non-Inverting	NXP 74HC7014
Accessories Kit			
B1	1	50mm Blower, 5V	Sunon KDE0505PFV1.11.MS.A.GN
Terminal Block Plug	3	4C For stepper motors	
Terminal Block Plug	1	3C For water connection	
Power Connector	1	For 24VDC power input	CUI
Jumper	3	0.1" Jumper Cap	Generic
Standoffs	4	For blower	McMaster
Screws	4	PHMS #4-40 x 2.5	
Nuts	4	#4-40 Nylon Locking	

Troubleshooting Section

Laser will not fire. This is usually due to the safety loop being open. The water switch, emergency switch and cover switch all need to be in the closed position. Beep out terminals 3 to 4 on the laser power control terminal block with it disconnected from the laser power supply. If it does not beep, you have an open circuit.

Steppers run backwards. If you swap any two wires on the same poll you will fix this. You can often change it in software too.

Steppers do not run or lock when powered. Make sure the polls are wired correctly. If you are unsure about what wires go to what polls try shorting two stepper motor wires together on the motor. If it is harder to turn the motor, they belong to the same poll. Is the enable circuit working? Try moving the jumper on the enable circuit as a test.

Stepper Motors Step or Move by Themselves. This is likely a noise issue. Review the noise section and try to reduce the noise.. Does it still happen if laser power supply is not powered?

The motors whine when enabled. Normal

Test Procedure

Start with no jumpers or driver boards installed.

Visually check orientation of all parts.

Visual inspect all solder joints.

Apply Power to PCB and make sure it is not drawing and current.

Check 5V power supply on JP1 (connect meter common to mounting hole)

Check 3.3V Power Supply on JP1

Check interlock loop (white/blue on Ethernet cable to ground) through all switches.

Install Jp1 Jumper on 5V

Check Pot/PWM relay closing J2-Pin6 to 5V. listen for activation.

Turn off power

Install JP2 jumper on Disable and JP3 jumper on PWM 15

Plugin parallel port

Install stepper drivers

Power On

Check enable Disable

Run motor

Check relay drivers

.