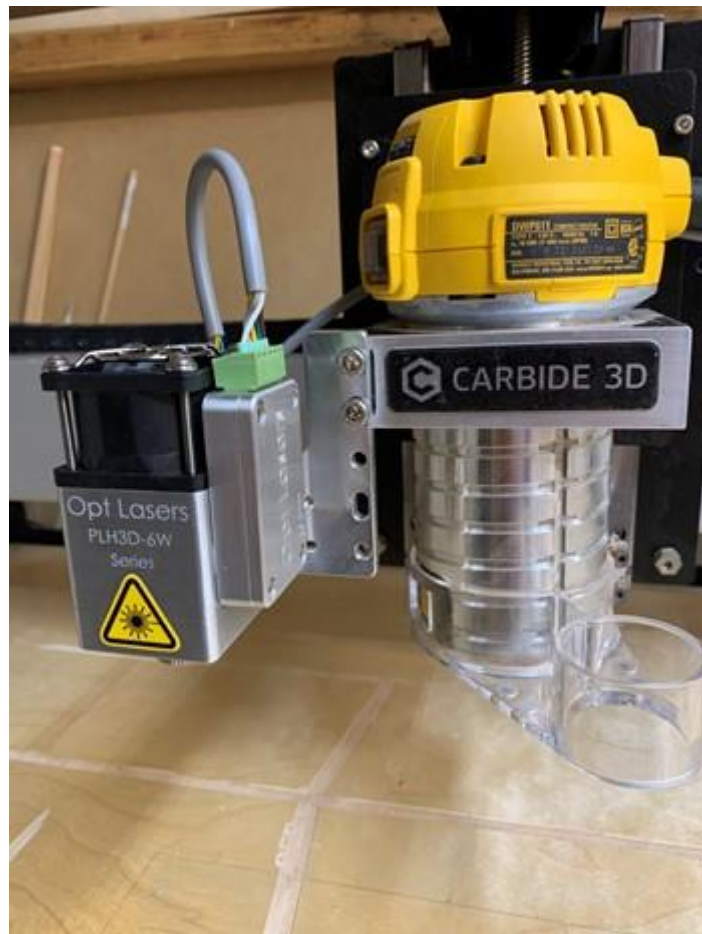


Opt Lasers GRAV

Shapeoko Laser Upgrade Setup Guide for PLH3D-6W-Series Laser Heads



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Shapeoko Laser Upgrade - Introduction

Thank you for purchasing your Shapeoko PLH3D-6W Cutting and Engraving Laser Upgrade Kit for the Shapeoko CNC.

This sub-assembly contains a high-power cutting and engraving laser with thermal protection and a professional high-speed driver. Its design ensures that the engraving laser does not require any additional cooling. The fan and airflow design make it perform as a fully customized air nozzle, protecting the lens from dirt while cooling the engraving laser. This product utilizes the PLH3D-6W driver which ensures the proper function of the engraving laser and protects the laser diode from overheating. There is an automatic thermal cutoff where at 45°C the engraving laser switches off. A turn to adjust the collimating lens allows you to easily change the focal distance of the engraving laser beam.

You can use two types of lenses with our PLH3D engraving laser heads. G2 lenses are popular because of their efficiency, but efficiency is not necessarily the most important parameter. For an engraving laser, power density is more important. G2 lenses do not provide the smallest obtainable beam at the beam waist, which can be done with most three-element lenses. Even though a three-element lens causes a bigger optical power loss, it allows you to obtain a smaller beam spot. This in turn helps to obtain a higher power density, while also giving the added benefit of a thinner cutting path.

The choice is up to a customer, since depending on the situation, it may be better to use one or the other. This engraving laser allows you to cut or engrave materials such as rubber, wood, paper, leather, plastic, card stock among other choices. With a fully analog power modulation, it is possible to engrave in shades of gray or change the output power between consecutive runs. The same effect can be achieved with a PWM signal which is fully compatible with the PLH3D driver. High power modulation (up to 100 kHz) ensures the high speed of the engraving laser, even for the most sophisticated patterns.

This engraving laser utilizes a NUBM44 450 nm diode, which is the strongest available blue laser diode on the market. We recommend using 12 V or 24 V power supply units with current capacities at 2.5 A and 1.5 A respectively. The lifetime of NUBM44 450 nm laser diode stands at 10 000 hours as given by the manufacturer.

By purchasing this product, the customer declares that he has reached the age of 18 and that he has fully read and understood the operating and safety instructions provided at <https://optlasers.com/manual/laser-head-plh3d-6w-optlasers.com.pdf>

The responsibility of use or misuse belongs to the end user. Tomorrow's System and its affiliates accept no responsibility for use or misuse by the user. If you may not be able to use this product properly, we recommend that you do not begin use or cease use immediately.

Inspect all contents of your cutting and engraving laser kit. Verify that there is no evidence of damage or wear to any components due to the shipping process.

Read the operational manuals for your Shapeoko CNC machine, the Shapeoko Laser Upgrade Setup Guide and the PLH3D-6W Series Operational Manual prior to attempting to use the system. A copy of the PLH3D-6W Series Operational Manual can be found at <https://optlasers.com/manual/laser-head-plh3d-6w-optlasers.com.pdf>.

If there are any further questions or if anything is not clear, please contact us at <https://optlasers.com/contact-us>

You should also join our supportive Opt Lasers Grav community:



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Shapeoko Laser Upgrade - Included Parts



1. LASER SAFETY GLASSES
2. LASERDOCK MAGNETIC DOCKING STATION
3. SHAPEOKO SIGNAL CABLE FOR PLH3D-CNC ADAPTER
4. 5 M ADAPTER TO LASER HEAD CABLE
5. PLH3D OPT LASERS GRAV LASER
6. MAGNETIC NOZZLE
7. PLH3D-CNC ADAPTER
8. LASER POWER SUPPLY
9. HEIGHT REFERENCE TOOL
10. SHAPEOKO CNC MOUNTING PLATE

Shapeoko Laser Upgrade - General Laser Safety



LASER RADIATION

Only a person with specialized training and appropriate laser safety knowledge can use and maintain the laser head. The laser head operator must be aware of laser radiation hazard.
While laser head is operating protection Laser Glasses designed for 190 – 540 nm (OD 7+) should be used. Make sure that all personnel in the same room worn protection glasses.
Eye exposure to the direct or diffusely reflected laser beam is a hazard. The laser head beam may cause permanent eye damage.
Skin exposure to the laser beam is a hazard. The laser beam may cause serious skin burns. Laser beam may easily burn cloth.
It is possible to get serious injury while using this product or being in the vicinity of an individual using it. Improper use of the laser head can result in injury or death.
Flammable substances exposure to the laser beam may pose fire hazard. The laser head operation in an explosive atmosphere may be dangerous. The working area must be well ventilated. During the operation laser beam may ignite gases or flammable liquids.
Before making any adjustments, changing accessories or performing maintenance, the laser should be powered off and disconnected from the power supply and CNC main board.
The laser head must be properly mounted to a rigid body such that it cannot be moved unintentionally. Unintentional move of the laser head is dangerous.
The unauthorized personnel must have no access to the system into which the laser head is integrated. The laser head must be stored out of the reach of children. Untrained persons are not allowed to operate, maintain and observe operation of the laser head.
Specular reflection materials should not be placed in front of operating lasers head. Remember, diffused reflection of the laser beam is uncontrolled and may pose hazard to eye.
Appropriate shielding should be used around the system into which the laser head is integrated. The system in which laser head is used must be equipped with key switch and safety interlock.

Responsibility of use or misuse belongs to the end user. Tomorrow's System and its affiliates accept no responsibility for use or misuse by the user. If you may not be able to use this product properly, we recommend that you do not begin use or cease use immediately.

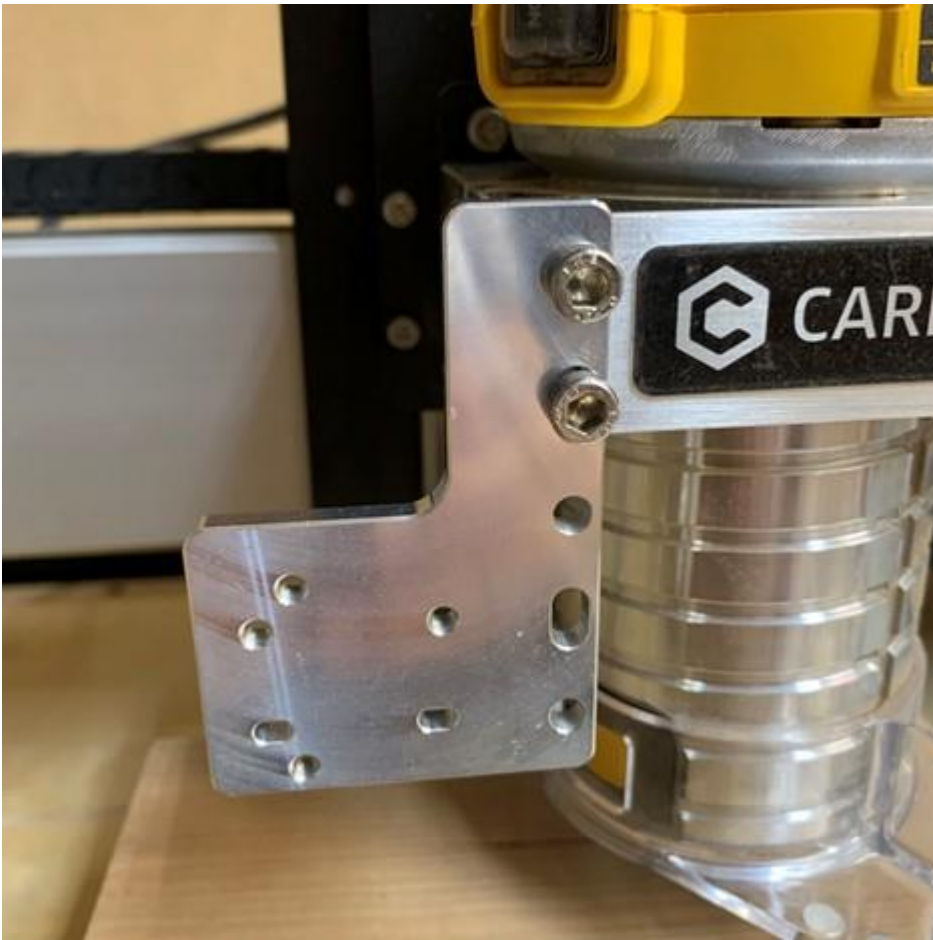
Shapeoko Laser Upgrade - Mounting Instructions



1. Install the Opt Lasers PLH3D-6W Series Shapeoko Mounting Plate and the Magnetic Docking Station onto the Shapeoko Spindle Mount.

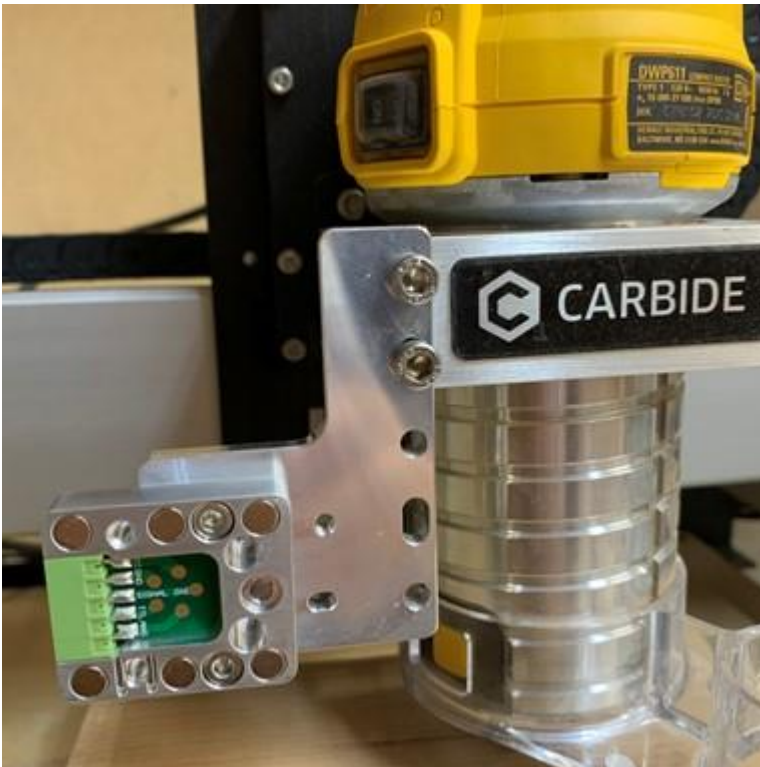


2. To install the Mounting Plate on the Spindle Mount start by removing the two M5x55 mm screws. Next, mount the plate with the included M5x65 screws.

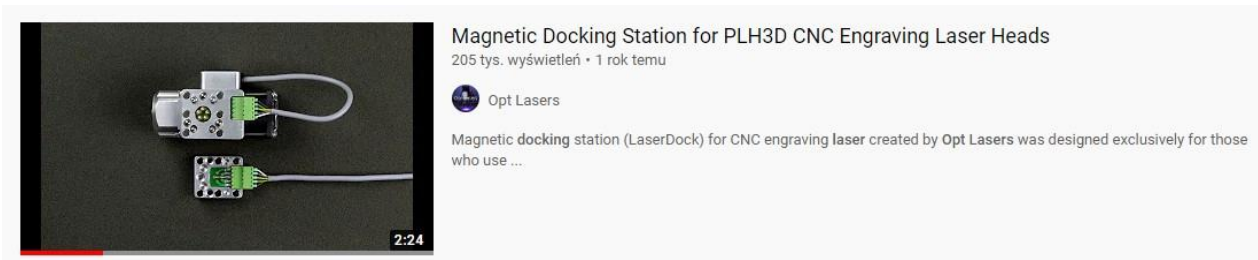


3. Attach the female part of the magnetic docking station for the cutting laser (the Opt Lasers Grav LaserDock) onto the plate by installing the two hex screws.



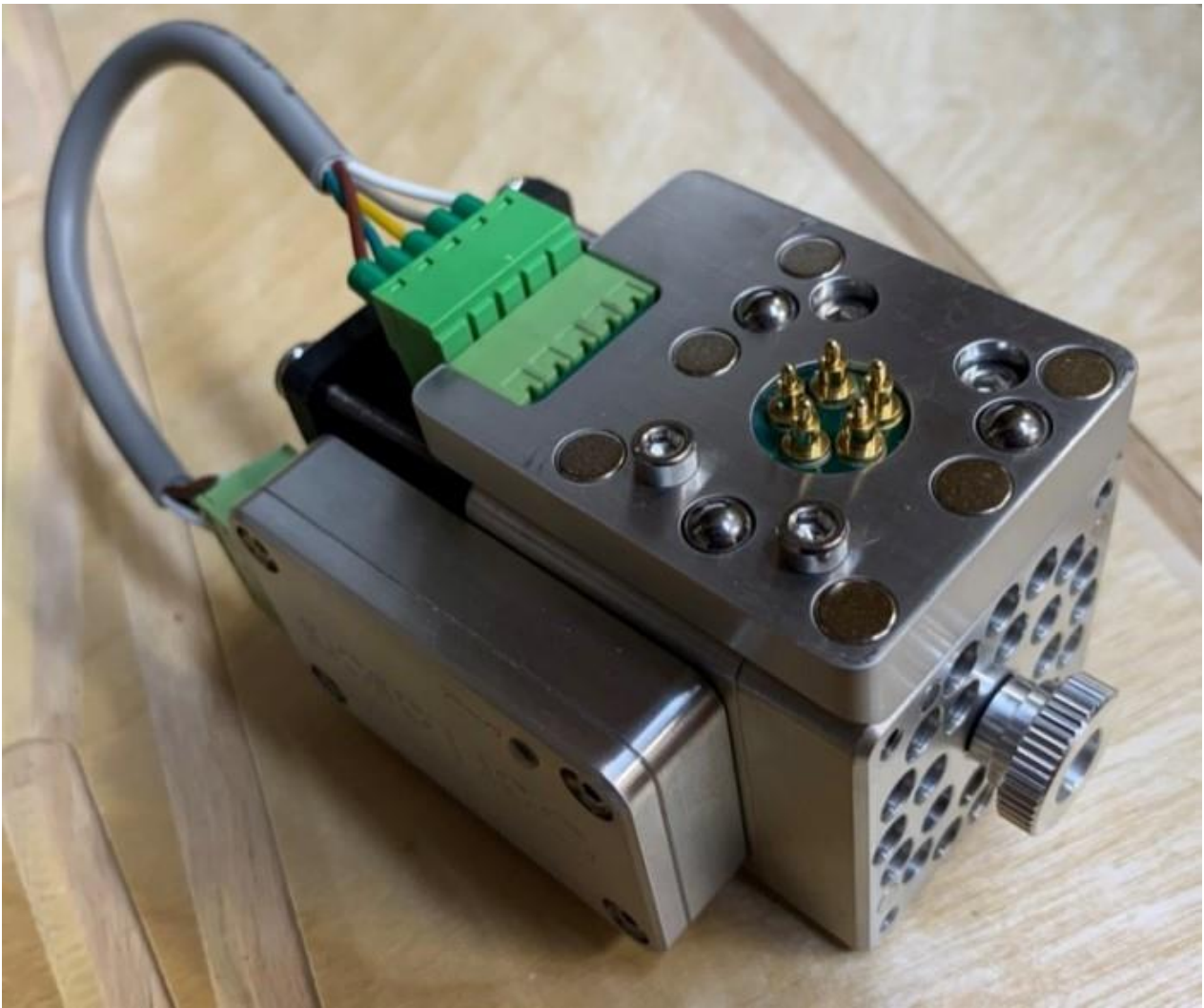


A detailed video instruction can be found on Youtube:



4. Don't forget to subscribe to our Youtube channel for exciting first-hand news and video guides.

5. Install the male part of the docking station onto the laser module. Be sure to check screw lengths when installing.



6. Attach Opt Lasers Grav cutting laser by simply aligning the magnets. It will fit securely.



7. When not in use, laser head should be removed. The docking station can then be covered with the provided cover.

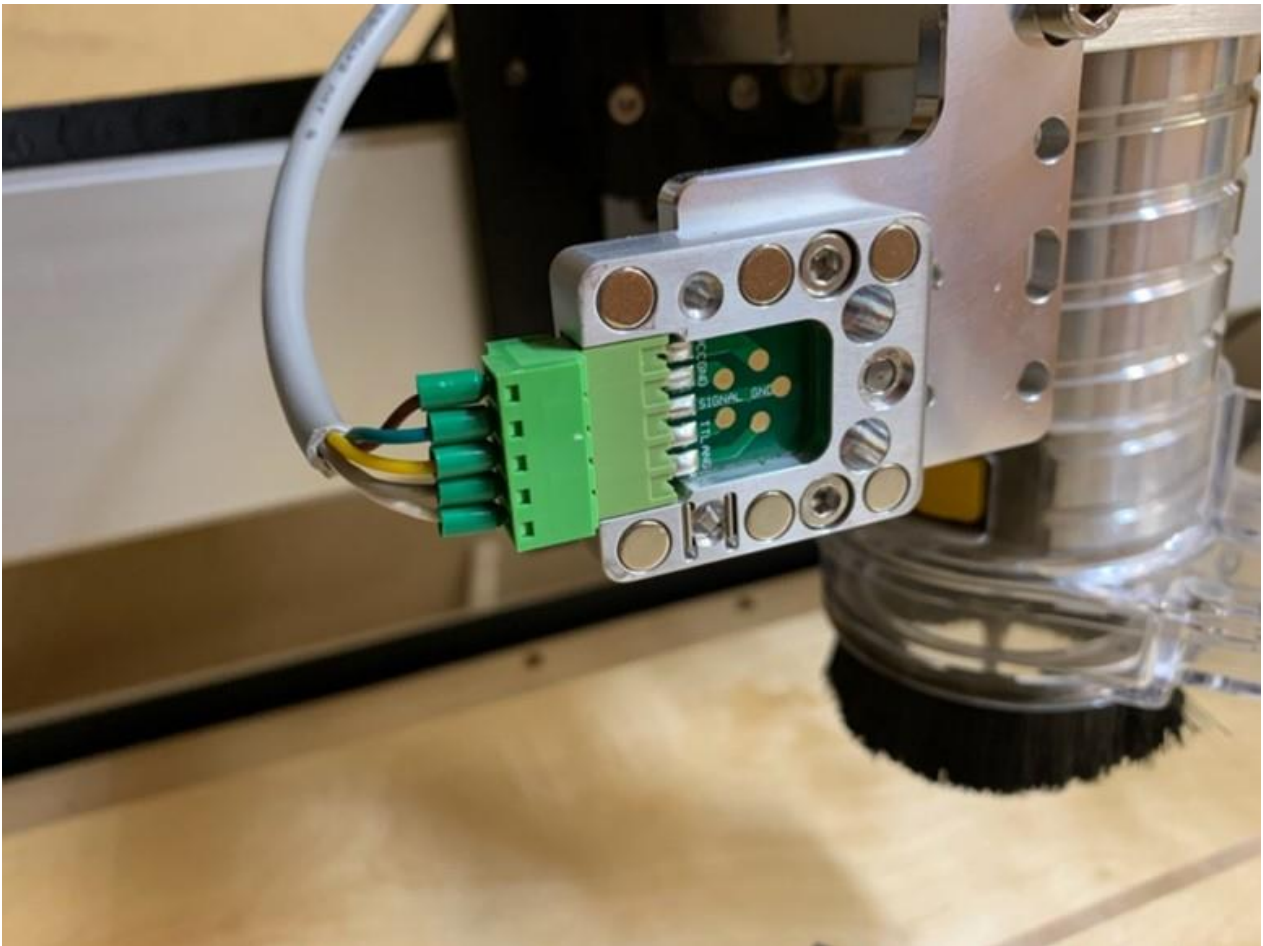


Shapeoko Laser Upgrade - Wiring Setup

1. Unpack the Opt Lasers PLH3D-CNC Adapter.



2. Plug one end of the 5 M Adapter to Laser Head Cable to the female part of the LaserDock.



3. Run the cable behind the spindle and attach it to the spindle cable with cable ties. You can then either secure it along the x-axis drag chain with zip ties or route the cable into the x-axis drag chain. Routing the cable into the x-axis drag chain can be achieved with a flat-bladed screwdriver. Feed the other end of the 5 M Cable through the end of the drag chain and out the left side of the machine. At this point you can attach it to the bundle of cables with a cable tie.







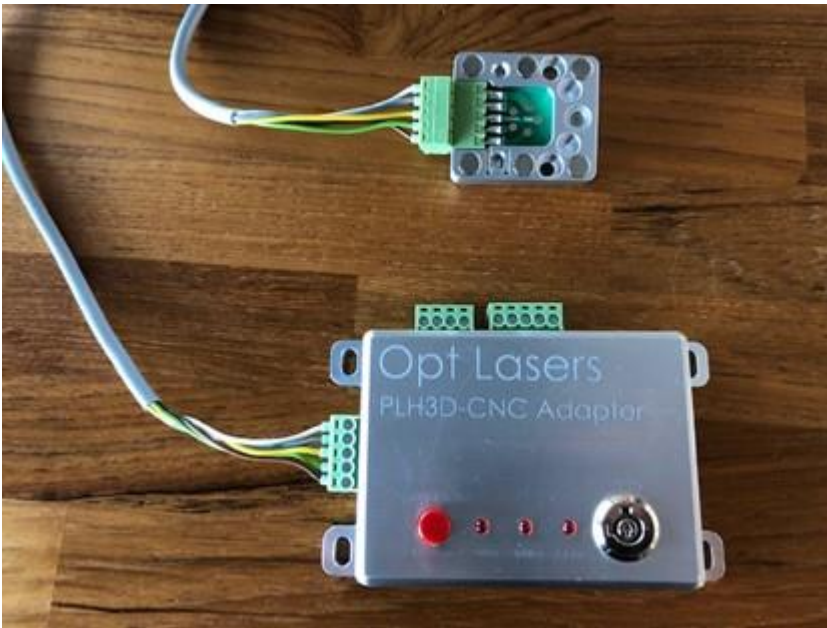
4. When connecting the 5 M Cable to the LaserDock, be sure to double check the colored wires are properly aligned. They should mirror one another once plugged in.

- 2.
- 3.



5. Find a suitable place to mount the PLH3D-CNC Adapter and connect the other end of the 5 M Laser Head Cable to the left side of the PLH3D-CNC Adapter.





6. Attach the green connector to the right side of the PLH3D-CNC Adapter.



7. Connect the 2 core wire Adapter inputs to the spindle outputs on your

Carbide3D printed circuit board. The Brown wire should go into the top center pin indicated below (PWM). The White wire needs to be connected to top right pin depicted below (GND).



1.

8. Put on your Laser Safety Glasses. Ensure nothing unintended is left in the path of your laser. Ensure that the Adapter is off.

9. Insert the power cord into the PLH3D-CNC Adapter and plug the opposite end into your outlet.

Shapeoko Laser Upgrade - About PLH3D-CNC Adapter

The PLH3D-CNC Adapter serves as a versatile interface and safety unit connected between a CNC machine and a high-performance PLH3D cutting laser head.

Many types of CNC machines (including 3D printers) available on the market, with different control voltage standards and levels available, may be used to control the PLH3D cutting and engraving laser. The PLH3D-CNC Adapter converts all these signals to the standard compatible with the PLH3D cutting laser.

The key function of the PLH3D-CNC Adapter is to “arm” and “disarm” the laser head. Arming means turning the head power supply on; the armed head is then able to generate a laser beam. Disarming (turning the head power supply off) brings the laser head to a safe state where generating a laser beam is completely impossible.

Key features of the PLH3D-CNC Adapter:

- Key-lock for preventing use by unauthorized personnel;
- Safe start;
- Mode button - can be used for arming/disarming, laser pulse test, and configuration enable settings;
- Status LEDs - power on, armed, laser working, and setting of Enable Modes;
- Connectors: PLH3D laser head, control, extensions, and external switches;
- Power connector;
- External desktop low-noise power supply;
- Machined aluminum quality enclosure;
- Optional PLH3D laser cables and signal cables dedicated to a CNC machine or controller type;
- Optional external key-lock, stop button, and sensors;
- Compatible with PLH3D laser heads;
- Can be configured for matching with the majority of CNC machines and 3D printers.

Built-in safety mechanisms prevent misuse and unexpected behavior in case of an emergency. The key switch protects the engraving and cutting laser head from being armed by children and unauthorized people. Arming the cutting laser head is always done manually by the user, by pressing a button. Special circuitry prevents arming during an internal electrical malfunction. The cutting laser head is automatically disarmed in case of an emergency: loss of the mains supply (grid power), PSU failure, breakage, or disconnection of the laser head cable. After disarming, the system remains in a safe state and rearming always requires the user to press the button.

Additional safety mechanisms can be incorporated into the system by adding up to two external switches (e.g. limit switch, key switch, or e-stop). There is also an additional extension connector for future needs.

Additional feature are industry-standard screw connectors. A dedicated, low-noise desktop power supply unit assures compatibility and reliability as well as eliminates problems caused by using third-party power supplies. The general status (power on, arming, laser working) may be inspected at a glance by looking at the three LEDs.



1	LASER HEAD TERMINAL BLOCK
2	EXTERNAL SWITCH TERMINAL BLOCK
3	EXTENSIONS CONNECTOR
4	POWER SUPPLY CONNECTOR
5	CONTROL TERMINAL BLOCK
6	MODE BUTTON
7	LED STATUS INDICATOR
8	KEY SWITCH

1. LASER HEAD TERMINAL BLOCK.

Attach the laser head cable here.

2. EXTERNAL SWITCH TERMINAL BLOCK

Up to two external switches (e.g. limit switch, key switch, e-stop) that arm/disarm the laser head can be connected to the PLH3D-CNC Adapter. When not using a switch, replace it with a jumper wire. Opening any external switch disarms the laser head immediately. Then, even if the switch has been closed again, the system will stay disarmed. The mode button must be pressed to rearm the laser head.

3. EXTENSIONS TERMINAL BLOCK Intended for future use.

4. POWER SUPPLY CONNECTOR

Plug in an external 15-24V DC power supply here. We strongly recommend using a dedicated power supply unit exclusively for the PLH3D-CNC Adapter.

5. CONTROL TERMINAL BLOCK

Controlling inputs and outputs are attached here.

6. MODE BUTTON

- a. Pressing the mode button once will arm the engraving and cutting laser head. Doing so will cause the ARMED LED indicator to light up showing the cutting laser head is in the armed state; the fan in the laser head starts to work as well. To disarm the laser head press and release the button again.
- b. A test laser pulse can be generated in the armed state by pressing and holding the mode button for at least 1.5 seconds. An approximately one-second-long pulse at 100% power is then issued on the laser head control line. The LASER LED lights up confirming the appearance of the pulse. A single pulse will be generated even if the button is held for longer.
- c. Holding the mode button while turning the power on activates the configuration mode where the “enable option” may be viewed and/or changed. Details can be found in the section For Advanced Users.

7. LED STATUS INDICATORS



- The POWER LED shows the presence of power and also signals supply errors.
- The ARMED LED shows the arming state and also signals both disarming by an external switch and disconnecting the cutting laser head.



- The LASER LED shows the presence of the cutting laser head controlling signal (a steady one or a pulse-like). Note that controlling the cutting laser head is disabled in the disarmed state.



- In configuration mode, the LEDs show the current “enable option”. Refer to section For Advanced Users.

8. KEY SWITCH

Turn the key switch clockwise to the upper position to switch the PLH3D-CNC Adapter on. Turn the key switch counter-clockwise to the left position to switch the PLH3D-CNC Adapter off.

Further information can be found in ***Product User Manuals/PLH3D-CNC Adapter - User Manuals***

Shapeoko Laser Upgrade - PLH3D-CNC Adapter Settings

Specific CNC machines issue special “disable/enable” signals for turning the cutting laser beam off and on. The PLH3D-CNC Adapter can be set in such a way that the engraving and cutting laser beam is enabled only for certain states on two Enable inputs and disabled in other cases. A total of 12 distinct combinations of states (called “Enable Options”) may be selected. This allows the PLH3D-CNC Adapter to connect with virtually any machine. Disabling affects the controlling signal only and does not cause disarming of the cutting laser head.

The table below shows the appropriate settings of the “Enable Options” for a choice of widely used machines.

The PLH3D-CNC Adapter is shipped with the Enable Options already matching the user’s machine.

In any case, it is worth double-checking to confirm that the befitting software is loaded before operating the cutting laser head.

Machine	Enable options		
X-Carve	0	○ ○ ● POWER ARMED LASER	ENABLE1=any ENABLE2=any
Stepcraft (with UC100 Ethernet Controller and UCCNC)	11	● ○ ● POWER ARMED LASER	ENABLE1=TOGGLING ENABLE2=HIGH
Shapeoko	0	○ ○ ● POWER ARMED LASER	ENABLE1=any

			ENABLE2=any
Z-Morph	7	○ ○ ● POWER ARMED LASER	ENABLE1=LOW ENABLE2=HIGH
WorkBee/i2R CNC (and other CNC Machines) with Duet Controller	2	○ ● ● POWER ARMED LASER	ENABLE1=HIGH ENABLE2=any
WorkBee (and other CNC machines) with CNC xPro Controller	0	○ ○ ● POWER ARMED LASER	ENABLE1=any ENABLE2=any
Avid CNC (and other CNC machines) with SmoothStepper Controller	0	○ ○ ● POWER ARMED LASER	ENABLE1=any ENABLE2=any
LEAD, WorkBee, Acro System (and other CNC machines) with BlackBox Motion Control System	0	○ ○ ● POWER ARMED LASER	ENABLE1=any ENABLE2=any
<i>Most cases not covered above</i>	0	○ ○ ● POWER ARMED LASER	ENABLE1=any ENABLE2=any

NOTES:**1. LED SYMBOLS:**

- LED is off
- LED is lit
- LED is flashing

2. ANY means:
 - lack of connection or any voltage in the 0 - 24 V range.
3. LOW means:
 - either a DC voltage from 0 to +0.8 V,
 - or a connection to GROUND through a 0 ... 1 kΩ resistance.
4. HIGH means:
 - a connection to a DC voltage from +3 V to +24 V directly or through a 0 ... 1 kΩ resistance.
5. TOGGING means:
 - LOW-to-HIGH or HIGH-to-LOW transitions, 200 ms or less apart.

THE CORRECT MODE CONFIGURATION FOR **YOUR I2R CNC IS OPTION 2:**

How to Check Enable Option in PLH3D-CNC Adapter

Note: After turning the key switch On, the current Enable Option setting will be displayed with indication LEDs for a second. Applicable for PLH3D-CNC adapter sold after 20-July-2020. For older version of PLH3D-CNC Adapter please follow the instruction below.

- A. Turn the key switch OFF.
- B. Press and hold the mode button.



C. Turn the key switch ON while holding the aforementioned button.



D. Wait approximately one second until any LED is lit and release the button.



E. LEDs will show a combination corresponding to the current setting. Do not press Mode button again.

F. To quit without saving, wait for five seconds until Power LED is lit or turn the switch key off.

How to Set Enable Option in PLH3D-CNC Adapter

I. Turn the key switch OFF.

II. Press and hold the mode button.



III. Turn the key switch ON while holding the aforementioned button.

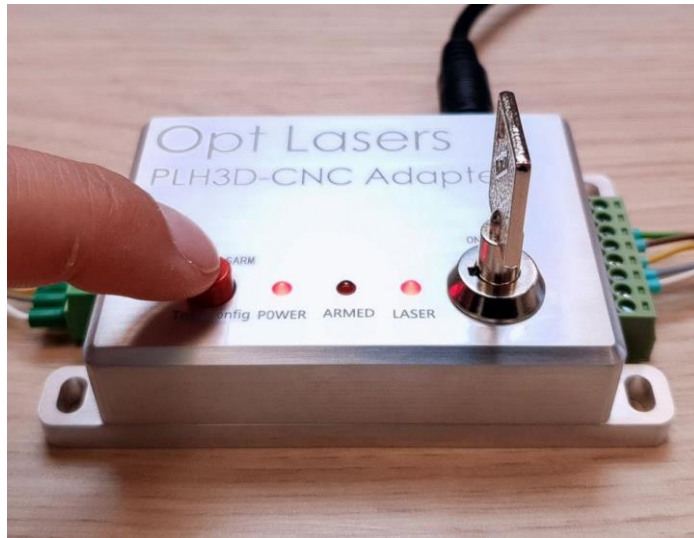


IV. Wait approximately one second until any LED is lit and release the button.



V. LEDs will show a combination corresponding to the current setting.

VI. To step to the next setting, press the mode button once. Keep pressing the mode button till you find the settings that you wish to be set.



VII. To save the current setting, wait five seconds with the button released. To quit without saving, turn the key switch off before five seconds elapse.

The chosen setting is kept in non-volatile memory and remains unchanged during power-off.

Shapeoko Laser Upgrade - Laser Pulse Test

Conduct a pulse test and verify if the cutting laser powers on and fires.

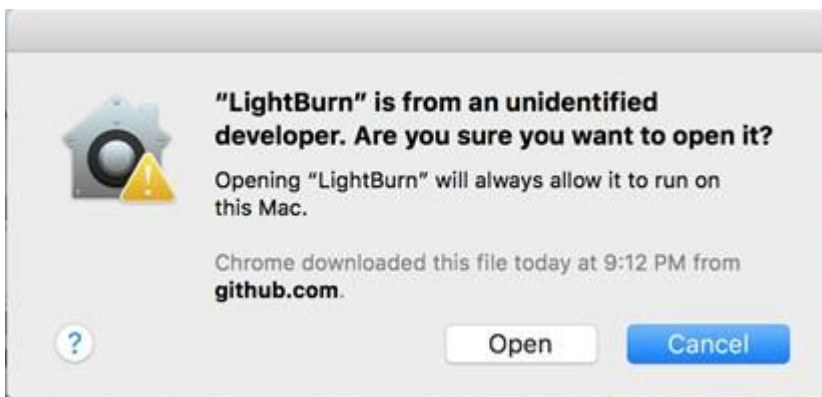
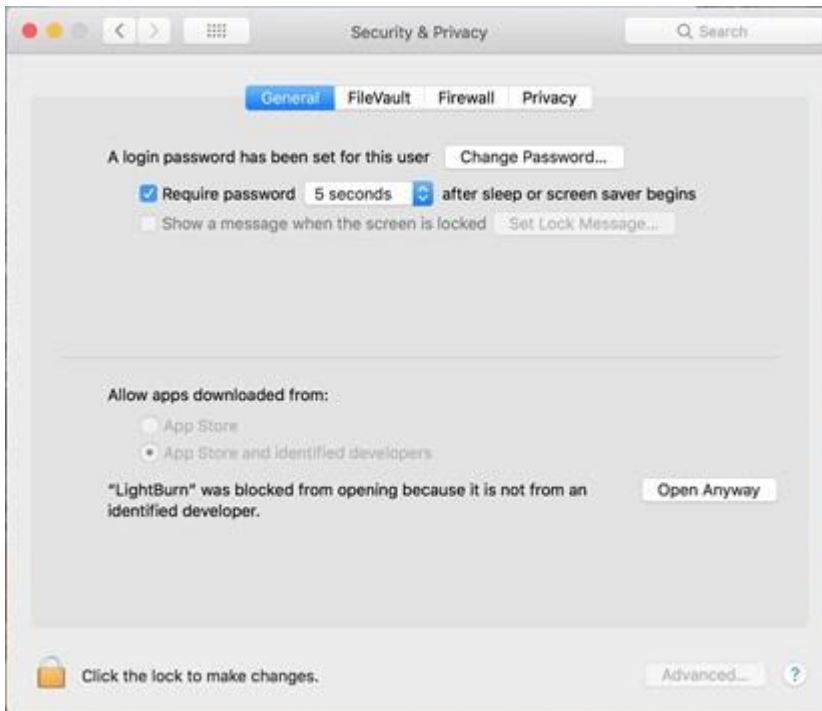
- 1. Put your laser safety glasses on. Place a piece of scrap material under your engraving and cutting laser.*
- 2. Turn the key to the on position.*
- 3. Push the red (mode) button to arm the device.*
- 4. Hold the red button down 1.5 seconds. The cutting laser will power on and fire a laser pulse for a brief moment. It should leave a burn mark.*

You've now confirmed your cutting laser is working properly.

Shapeoko Laser Upgrade - Lightburn Configuration

Lightburn is the recommended software to use with Shapeoko for laser engraving and cutting applications. Alternative options include GRBL and other laser software suitable for more advanced users.

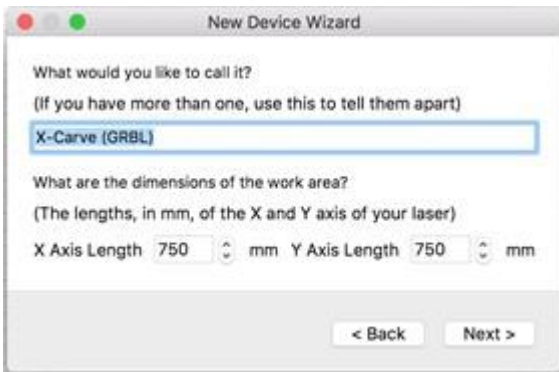
1. Download and install Lightburn. The license can be bought at <https://optlasersgrav.com/cnc-software/cnc-laser-software-lightburn>
2. Launch Lightburn. MacOS users may need to go to  > System Preferences > Security and Privacy > General, then click "Open Anyway" and "Open".



3. The first time that you launch Lightburn you will be prompted to setup your cutting and engraving laser device. See Lightburn's documentation for additional information (available at [GitHub -> LightBurnSoftware -> Documentation](#)). Select GRBL.



4. Next, select "Serial/USB". Input the name of your device, for example "Opt Lasers Grav engraving laser" or "Shapeoko (GRBL)".



Important: There are certain programs that can lock Lightburn out of laser control, which can cause a sudden stop of operation or issues with installation. This shows up as Lightburn not being able to find your cnc laser (can't connect). If you run other software, like RDWorks, Easel, Carbide Create, Carbide Motion, AutoLaser, LaserCAD, etc, make sure that software is not running when you run LightBurn.

5. Input the x-axis length and y-axis length. This sets up the maximum distance that can be travelled by the cutting and engraving laser in the x axis and y axis. You can find the suitable working dimensions at Carbide3D Support web page. Examples:

- Shapeoko 3: [X-Axis = 16"], [Y-Axis = 16"]
- Shapeoko XL: [X-Axis = 16"], [Y-Axis = 33"]
- Shapeoko XXL: [X-Axis = 32"], [Y-Axis = 33"]

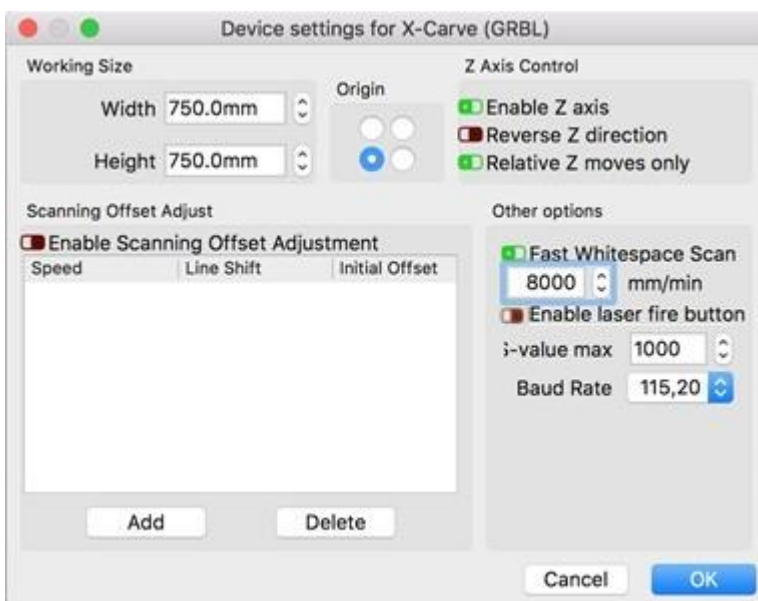
6. You can reference your GRBL settings by sending \$\$ to view your maximum distance. Set the origin of your Opt Lasers Grav cutting and engraving laser to Front Left.



7. Now review your chosen settings and click Finished. Make your new device the default and click OK.

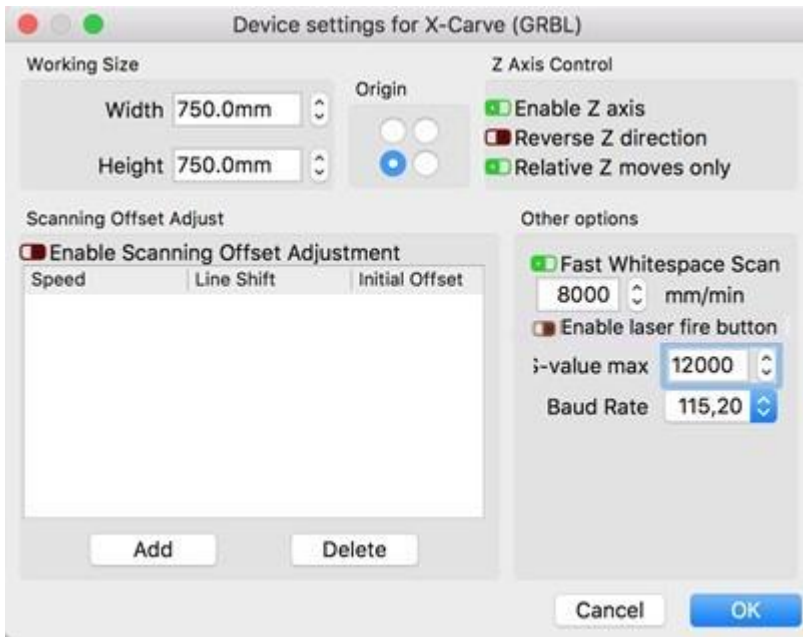


8. The settings depicted below are likely to give you the best performance of your Opt Lasers Grav cutting and engraving laser. For GRBL v1.1f, v0.9c and newer, you can access them by going to Lightburn > Edit > Device Settings.



- G-Value Max: 1000 (GRBL: \$30 = 1000)
- Enable Z-axis
- Relative Z moves only
- Fast Whitespace Scan: 8000 mm/min
- Enable Laser Fire Button OFF - this button is only meant to be used to help with calibration and to show the user where the laser beam is currently pointing. It is important that it is kept off in other cases.

9. For GRBL v0.9j and older, the GRBL setting \$30 (Maximum Spindle Speed / RPM) can't be altered. This version of the GRBL also doesn't provide the option to change the set Spindle PWM range. In some cases, for example when your spindle is controlled by this value, this value can be set in the Lightburn CNC software.



- G-Value Max: 12000
- Enable Z-Axis
- Fast Whitespace Scan 8000 mm/min
- Enable Laser Fire Button OFF - this button is only meant to be used to help with calibration and to show the user where the laser beam is currently pointing. It is important that it is kept off in other cases.

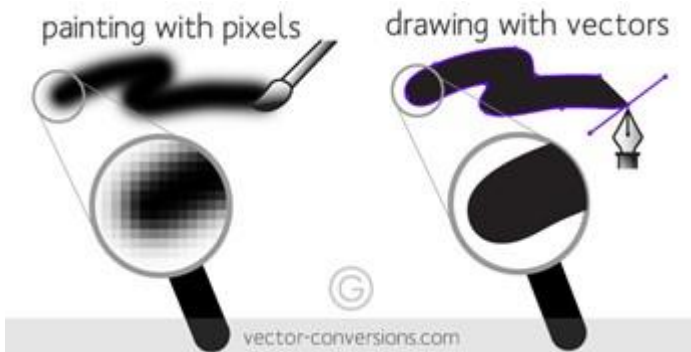
Cutting and Engraving Laser Operations

10. Lightburn has the ability to perform multiple types of cutting and engraving laser operations (See Lightburn documentation for additional details). These operations can be performed with raster images (raster engraving) and vector images (vector engraving).

- **Cut** - Cut will trace the laser along the vector path. Depending on the power and feed rate settings, this can be used to cut through a material in single or multiple passes. Decreasing the power and/or increasing the speed can also allow you to engrave or simply mark the surface.
- **Scan** - Scan will fill the interior of a vector. It is similar to engraving a raster image.
- **Scan + Cut** - Combines the scan and cut operations. Scan is performed before the Cut. This can be used to cut out a part once the scan is complete or simply emphasize the outline of the part before moving on to the next operation.

Image Types

11. There are two primary image types that you can work with -> Vector and Raster. These image types present different ways of engraving, each with their own benefits. Choose your design and export it as a DFX or JPG/BMP.



11. Vector shapes can be created directly in LightBurn without the need to import. See the LightBurn documentation for more details:

- **Creating Vectors in LightBurn**
- **Importing External Vectors**

12. Raster Engraving works best for images with a lot of detail. Raster images have to be scanned onto the work piece. The engraving laser intensity dictates the depth or darkness of the image being output. The technique is similar to how an image scanner scans a paper into the computer. Reference the Common Cutting Parameters for a good starting place for some common materials. It is best to import high resolution images (300 dpi or higher). Additional information can be found in LightBurn documentation.

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Shapeoko Laser Upgrade - Setting the Working Distance

One of the first things you ought to do once your Shapeoko Laser Upgrade is operational, is the appropriate Working Distance calibration.

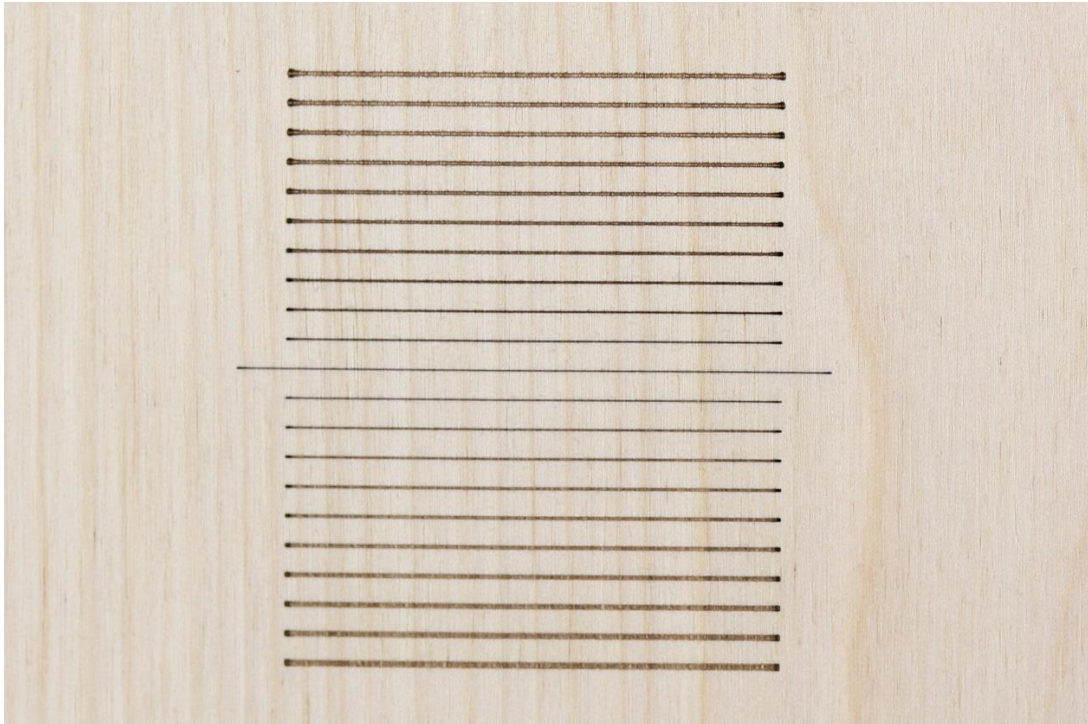
Some engraving applications may require small focus spot, i.e. high-resolution engraving, detailed engraving. PLH3D-6W Series engraving laser has adjustable focal length and exchangeable lens. This feature allows it to fulfill broad range of engraving applications. Shorter focal length of the engraving laser produces a smaller beam spot (higher power density).

You can adjust focus spot distance from the front of the engraving laser by rotating the lens clockwise or counterclockwise. Note: it is necessary to ensure that the mounted lens is sufficiently deep inside the laser head, so the lens does not move before powering on the unit.

Once you changed the position of the lens use your CNC machine to find where is the focus spot. Using the methods described above calibrate the engraving laser head's position.

- **Coarse adjustment:**
 - a. Set current position as a zero position in your CNC software.
 - b. Engrave "zero position" line on the engraving material. Hint: make this line longer compares to the next engraved line, it's going to be easier to find "zero line".

- c. Engrave (on the engraving material) 10 lines with step 1 mm in the positive direction of Z-axis and 3 mm step in X-axis.
- d. Go back to zero position.
- e. Engrave (on the engraving material) 10 lines with step 1 mm in the negative direction of Z-axis. and 3 mm step in X-axis.
- f. Inspect engraved lines, find the thinnest engraved line.
- g. Count how many lines away is the thinnest line from “zero line”, and in which direction it is placed. Let’s consider case when the thinnest line is located 5 lines from zero line and in positive direction of X-axis. In such a case calibration parameter is +5mm.
- h. In the CNC software, move “zero position” of the laser head by calibration parameter.



- **Fine adjustment:**

To obtain the highest power density, which results in the better engraving performance, we recommend making fine adjustments to the distance of the laser head and the engraving material. This adjustment should be done after performing coarse adjustment.

The process is similar to the coarse adjustment process expect steps in Z-axis, they are smaller to make adjustment precise.

- a. Set engraving laser head at a zero position, which must be calibrated by know.
- b. Engrave “zero position” line on the engraving material. Hint: make this line longer compares to the next engraved line, it’s going to be easier to find “zero line”.
- c. Engrave (on the engraving material) 10 lines with step 0.1mm in the positive direction of Z-axis and 3 mm step in X-axis. We recommend engraving lines with 50mm length, it is easier for eye to compare thickness of a line on longer range.
- d. Go back to “zero position”.
- e. Engrave (on the engraving material) 10 lines with step 0.1 mm in the negative direction of Z-axis. and 3 mm step in X-axis.
- f. Inspect engraved lines, find the thinnest engraved line.
- g. Count how many lines away is the thinnest line from “zero line”, and in which direction it is placed. Let’s consider case when the thinnest line is located 2 lines from zero line and in negative direction of X-axis. In such a case calibration parameter is -0.2 mm.

- h. In the CNC software, move “zero position” of the laser head by calibration parameter.

