

Why we ended up with a 10W Endurance laser system

INDEX

1. Intro and general information	2
2. First thoughts and how it began.....	2
3. The laser housing and frame	2
4. The item engineering tool	3
5. All begins with the mains 220V/110V	4
6. Power planning for a hungry machine	6
7. The initial power up.....	6
8. How to build this unit without a Raspberry Pi	8
9. Endurance air assist	9
10. The importance of proper exhaust	9
11. Z-Axis and variable laser bed design	10
12. The Endurance 10W upgrade	11
12.1. Let's talk now about the new 10W Endurance laser unit setup:	11
12.2. Installation of the Endurance system	12
13. The Raspberry Pie 3B Plus	13

1. Intro and general information

This document describes a laser cutter project for a private, nonindustrial application. All information given is the best knowledge of the author, who is an electrical engineer.

By starting writing this document we first started to supply Amazon links to the components we used, but since we use the German Amazon, we were not sure if other readers of this document could follow it. So we then listed the German description that can be used as a key search on the Internet in general to find things. As we know out of experience, that research is sometimes difficult, this could help to save time.

2. First thoughts and how it began

The original idea of laser cutting came up during Christmas, where I found on the web several beautiful LED illuminated Christmas nativity scenes that for my understanding were not possible being cut with a fretsaw or reciprocating jigsaw.

So the laser cutting project was born. Initially I was focusing on CO2 lasers and quickly ended up with the K40 machine. But the further I investigated into it, the more it was clear that the reliability and engineering layout was not what I expected. So finally I decided for an ORTUR 20W laser master 2, which I have built into a housing with some additional features. This does look today like the photo below.



We started then with 3mm birch plywood cutting and engraving and then engraved a bunch of drinking glasses and soon we found out, that the power of this machine is limited. So we upgraded it with an Endurance air assist system, added a G8 lens, which improved the situation, but was still not satisfactory. So, then finally we decided to move to a 10W Endurance laser and integrate it onto our ORTUR LM2 setup.

This is the story around it and our experiences we made.

3. The laser housing and frame

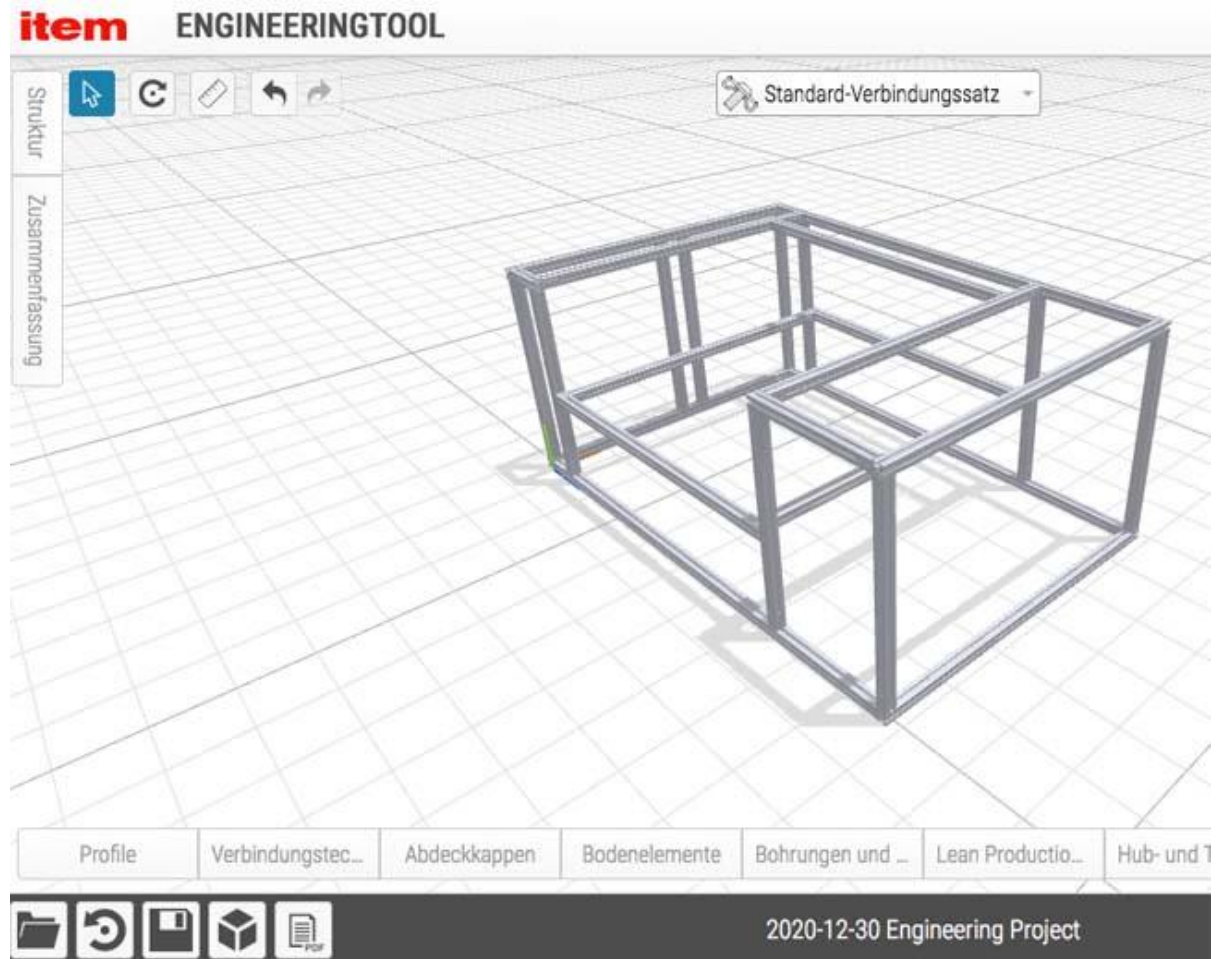
The typical Chinese units are mainly built with painted sheet steel, with a bad grounding. This does make it heavy and the enclosure is not flexible. Our thoughts was a setup of standard 2020 aluminum profiles with a combination of 8mm birch plywood, not purchased at home depot but with a wood dealer at Amazon who builds furniture. So it is a good quality and not too heavy.

Now was the plan to engineer a frame based on 2020 aluminum profiles that will enclose my ORTUR frame set, air assist tubing and connection, LED illumination, enough low noise fans that can carry the smoke out of it, a Z-axis setup, so that I can at least vary the height by 15cm down and 10cm up, a regulator for the fan speed, if possible pulse width modulated (PWM), measurement for voltage, current, wattage, a big 12V power supply with at least 150watt and finally a Raspberry Pi 3Bplus with a 5" touchscreen to control all this. I didn't want to have switches, it just needed to be something a little bit sophisticated and the Raspberry Pi can easily be programmed with a language called python and has a very powerful GUI (graphical user interface) programming plugin named tkinter.

4. The item engineering tool

Since we didn't want to invest into a CAD software to develop and design the frame, we found on the internet a company dealing with standard aluminum profiles that offers an easy to use, free of charge online CAD system with their profiles. The good thing is, you can either order directly with them based on your design, or download a pdf document with all measures and details, to order somewhere else.

This is the web address: <https://www.item24.de/index.html>



On the picture on the next page, you can see the actual result. This is the status as of March 21st 2021, while we are waiting for the shipment from Endurance with the 10W laser upgrade.

For this, we have removed the side- and front-panel.

Some additional upgrades went into the machine after our first production runs. So we have kicked out the cheap Chinese fans and replaced them with ebm Pabst series 624 PWM ones, which are much more powerful and less noisy and we added a Wyze cam, which we use to monitor progress on our i-pad. You can see the cam on the left panel side, just below the hydraulic lift damper.

I will go into details in the next chapters, give you descriptions on Amazon for the different parts, will explain the electrical setup, the programming of the Raspberry Pi and last but not least the upgrade to the Endurance laser module with 10W.



This picture shows the status as per March 21st, right side panel and front panel unscrewed.

5. All begins with the mains 220V/110V

It all begins with the mains. But one thing you need to know, the main line is never clean. Voltage varies, surges and sags, as well as unwanted frequencies pollute the line and may cause an interrupt during laser operation. We use for our air assist a METABO semi-professional air compressor with a tank. If we run this machine on the same power socket as our laser, it causes by accident a stoppage of the laser program intermittent, when the compressor motor starts. On the picture above you can spot the brass made quick connector for the air intake on the left side of the housing, that runs through a 12V solenoid and then in a 6/4mm blue pressure tube.

Finally, after a bunch of research, we found a solution and this is our recommendation, even its not a cheap one, but the best for your system and the Mac, operating the laser system. We run a MacBookPro on our laser and therefore we think it was worth the investment. What we use now, is an Eaton Ellipse PRO 650 – uninterruptible power supply (UPS) 650 VA with surges protection (either 4 Schuko connectors, or 4 IEC connectors) and automated voltage control (AVR).

Amazon description:

Eaton Ellipse PRO 650 DIN - Unterbrechungsfreie Stromversorgung (USV) 650 VA mit Überspannungsschutz (4 Schuko Ausgänge) und Spannungsregelung (AVR)



Since we now run the laser and the MAC through our Eaton box, we never have had a job aborted or any issues running our device.

In case of a power outage, we also are sure that it continues the job at least for 30min.

It does support 400watts/h, whereby our system with the ORTUR 20W module, all the fans and LEDs runs at max 60watts. I didn't take the time with a stop watch, so the 30min is a rare estimation.

Nevertheless, the surges and sags protection capabilities of this device are perfect fit for our laser and computer.



The mains entry point into the housing must always be compliant to local regulations, either IEC, UL, CSA or VDE. This means it should have a two pole switch that cuts of both lines, since the plug into the mains line can be inserted in both ways.

It also must have an appropriate fuse installed 1.5A slow would be fine. If you calculate 220V and a max load of 60watts, you end up with 0.3amps, which is at 110V around 0.5amps.

For this standard socket you will find cables for all countries and power outlets.

Amazon description:

Hifi Lab Kaltgeräte Einbau-Stecker Einbau-Buchse C-14 mit Schalter Audio Kaltgeräte-Buchse Einbau Kupplung inkl. Sicherung Kaltgeräte



Inside your housing you then should run the three wires - brown for phase, blue for neutral and green/yellow for ground to a 3 pole terminal.

Before you screw it to a terminal, you can install a multi measurement device, that does measure supply voltage, current, frequency, energy consumed and power factor. The picture on the left shows the brown wire running through the measurement coil that feeds the measurement device.

In the background you can spot the 3-pole mains terminal. The black and red wire exiting the coil block are running to the measurement device, installed in the top panel.

This is the cheapest and easiest solution to gain an overview about power consumption and some basic power network data.

Some of these Chinese multimeter modules also have a backlight display, memory and an operational timer that sums up the on time of the unit.

The picture below shows how the mains, in our case 220V, get routed further in our setup. From the 3-pole terminal, it connects to a 2-pole key-switch, that again switches both wires. After that, there is a green 220V LED light that indicates that the key switch is armed.



The right red button is an emergency button that cuts of 220V power by just hitting it. Below the key switch on the left side, you can see the multimeter we use. It has a blue backlight. Various versions you can find at Amazon easily.

The 220V mains feed at the end via two 220V relays two switched power supplies. One for 12V and 150watts power output, the other one 24V and 150watts power output. The 12V supply in addition feeds a 12V to 5V module that powers the Raspberry Pi 3B Plus.

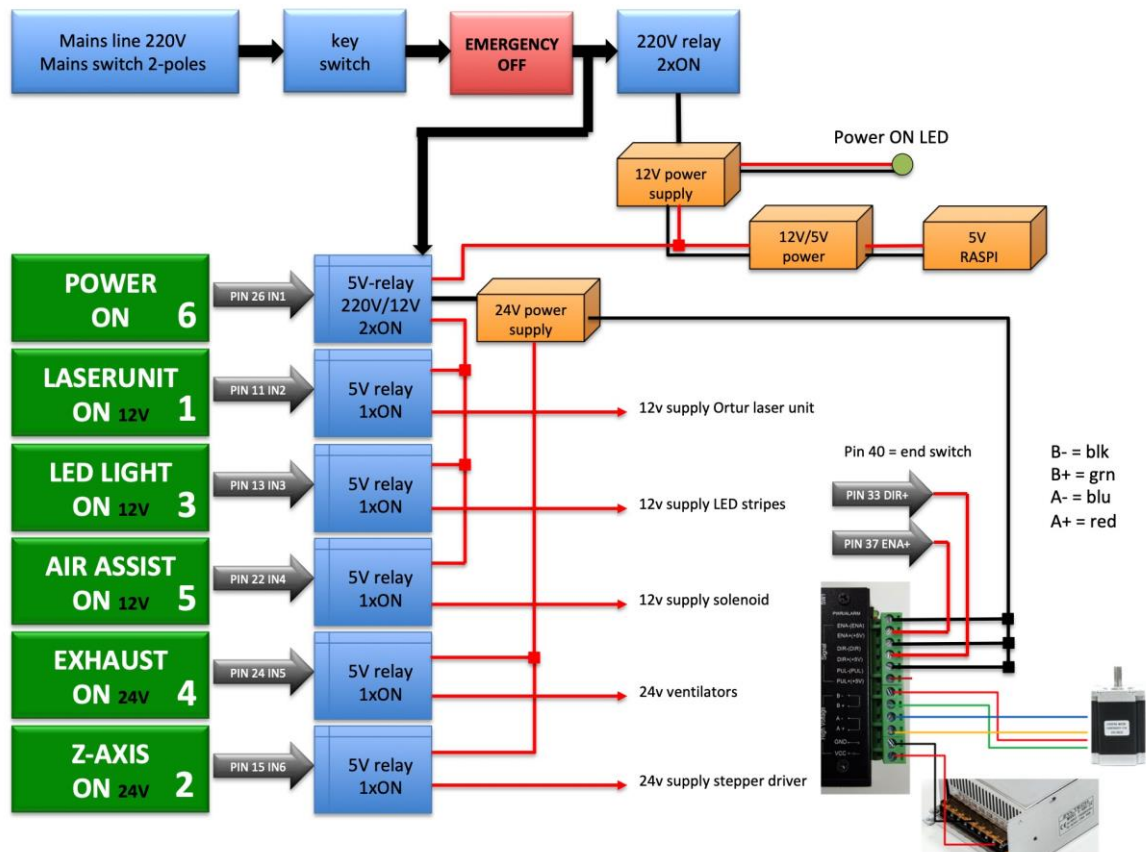
Amazon description multimeter:

LANDUM AC 100A 6in1 Digitaler Energie-Energiemonitor Spannung Strom KWh Wattmeter Tester AC 80~260 V 110 V 220 V mit Split CT

6. Power planning for a hungry machine

Power management in such a device is essential to prevent surges and sags in the machine. Every relay, like the one for the air assist, has a huge starting current, which may cause your supply voltage to drop. Therefore a switched power supply is always the best to plan for.

We use the 12V for the laser, the 5V converter for the Raspberry Pi, for LED lights and the air assist solenoid. All fans, fan controller and the Z-axis stepper with the stepper controller and PWM device are connected to the 24V supply. I'll in details explain how this is setup. This unit can be built with switches or a GUI (graphical user interface) programmed with a Raspberry Pi. Both will work. I'll explain both versions, even I run the microcomputer one. But let me explain now the wiring diagram you see below, which includes the Z-axis in the lower right corner.



7. The initial power up

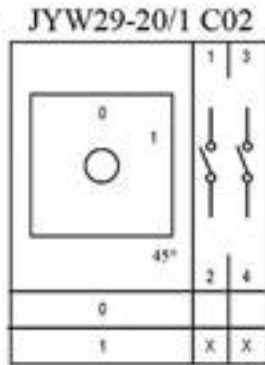


We run from top to bottom on the wiring diagram. We start at top left with the 220V power inlet and the power switch. Then follow the 220V solid black line, through the key switch, the emergency OFF switch, to a 220V relay.

This relay supplies the 12V switched power supply with 220V and leads the power to a contact to POWER ON relay 6. When relay 6 POWER ON is activated, this does supply the 24V power supply with energy. In addition the 12V feed the green power ON LED and the 12V to 5V converter and the RASPI (Raspberry Pi).

The RASPI starts booting up, which takes about 15sec and launches automatically the GUI (graphical user interface) with all buttons as seen in the picture above. Instead of the green touch buttons on the screen, you may install simple ON/OFF switches. I'll describe this in details later.

Parts used on the 220V side, 12V supply, 24V supply and 12V to 5V converter:



Amazon description for key switch:

Schlüsselschalter, Drehschalter, Nockenschalter, Hauptschalter, 5 Modelle zum Auswählen (JYW29-20/1 C02 Schalter)

This key switch is the CO2 model, which does switch both lines, phase and neutral. I'm always a friend of double security, since you may remember that we have already a two line breaker in the power inlet.

Amazon description for emergency switch:

LDIY Metal Emergency Stop Button Switch 16mm 5A/5-250VAC 3Pin Power Off Round Self-locking Waterproof Mushroom Head Switch One Open and One Closed Red 1PCS



My wife has chosen this one, from a design point of view. It is red alloyed aluminum with a nice engrave.

- installation diameter: 16mm;
- switch combination: 1NO 1NC.
- protection level: IP65, IK08.
- switch capacity: 5A / 250VAC (can also be used on 110V).
- operation modus: Push-Lock-turn type;



Amazon description for switched power supply:

Schaltnetzteil / Netzteil 150W 12V 12,5A ; MeanWell, RS-150-12

- Industrial power supply MeanWell RS-150-12
- power: 150W,
- output voltage: 12V (11,4...13,2VDC),
- output current: 12,5A
- input voltage: 88...264VAC, efficiency: 83%
- length: 199mm, width: 98mm, height: 38mm

This unit is available also for 24V.

When you want to operate your laser cutter unit with a Raspberry Pi, then you need 5V supply with enough current. This one delivers strong 5amps and can be fed through the 12V or 24V supply.

If you just operate with switches, then you don't need this 5V supply or the Raspberry Pi with its 8ch relay board. Details will be explained later in this document.



Amazon description:

JZK® 24V/ 12V bis 5V 5A Power Buck Modul DC-DC Step Down Netzteil Konverter Board mit LED

8. How to build this unit without a Raspberry Pi

This unit can be built easily without the Raspberry Pi, the touch screen and the 8ch relay board. Let's have a look on the schematics. On the left side, you see green squares, which correspond with the touch screen buttons.

Let's take the first one on the top. It says "POWER ON". The "6" means, it is relay number 6 on the Raspberry relay interface card. The grey arrow says pin 26, which is the pin on the Raspberry IO interface, controlled by the software. You don't need to care about this when using switches.

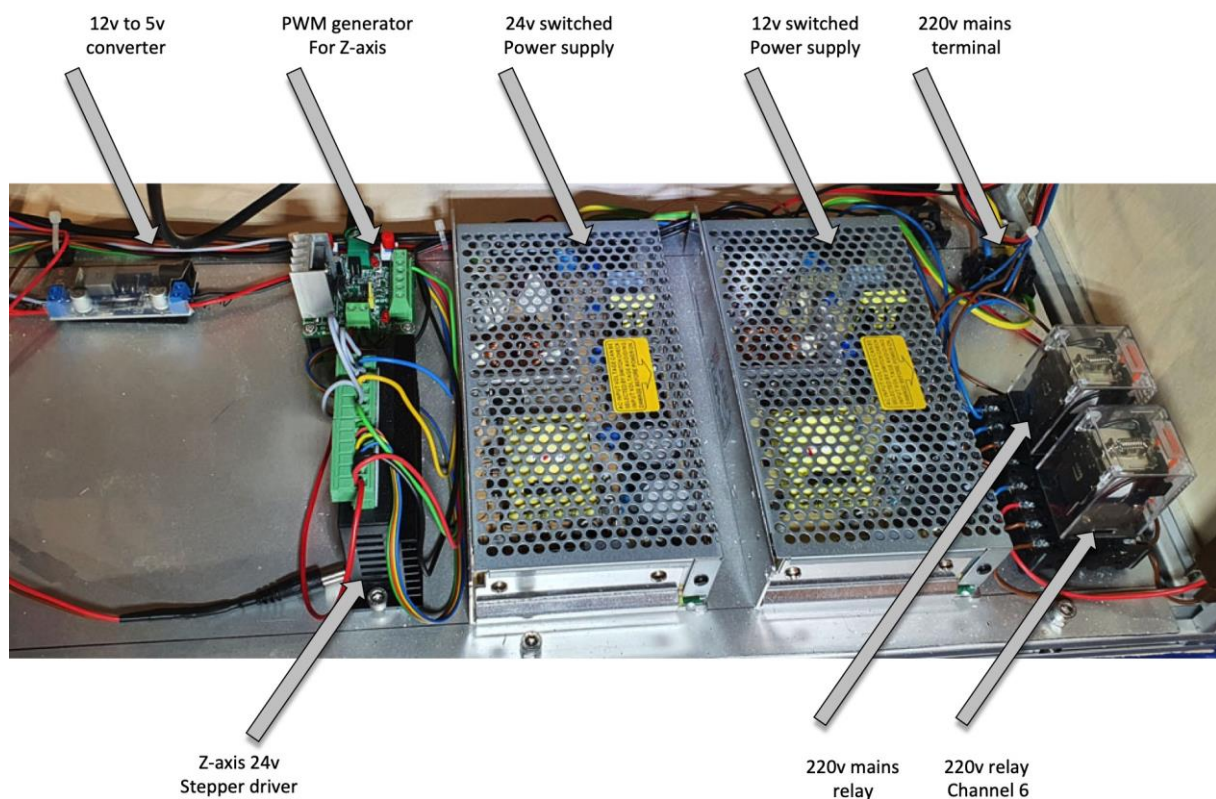
The 5V relay on the 8ch relay interface has one channel. When number 6 is activated, it will switch on ch1 220V to the 24V power supply and on ch2 enable 12V to the LASER UNIT relay 1, LED LIGHT 3 and AIR ASSIST 5. Those relays won't be activated, just supplied with 12V energy for switching.

You may now replace the green touch screen boxes by 2 channel ON switches, or use 12V relays and switch them with a 1channel switch each. I love relays, they are more reliable, therefore I would recommend a single channel switch with a 12V LED and 12v relay with 2xON. That's it, as easy as this.

Now let's have a look on the picture below, which shows the electrical installation on the bottom of the right hand side inside the housing. We start in the right corner with the 3-pole 220V terminal. From here the cable goes up to the key switch and emergency switch and coming down again to the 220v mains relay.

This does switch on the 12v power supply and in daisy chain the 12v to 5v converter. The 24v power supply is switched on with channel 6, activated by the 220v relay named channel 6. This relay does also supply all 12v switches with 12v.

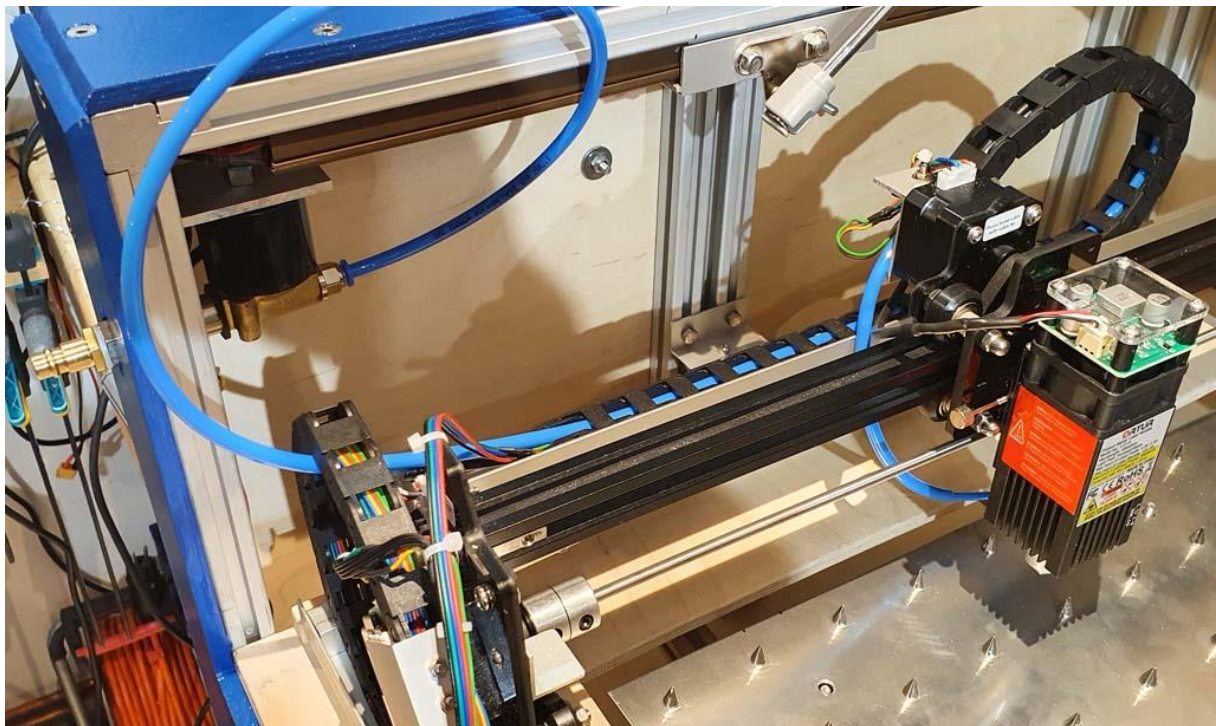
The PWM generator does drive the Z-axis stepper driver.



9. Endurance air assist

Why air assist? An air assist nozzle that is blowing in parallel to the laser beam does enforce cutting capability. We found out that a 3mm birch plywood without air assist support requires on the ORTUR 20W machine at least 5 cuts at a speed of 150mm/min. With air assist a maximum of 3. In addition, the both sides of the cut didn't get too much burned.

By testing we found out, that we need at least 1.5bar. Below, it won't work too well and would not show the effect we expect. Above 2bar, there is no significant more effort seen on the material. The way we set it up is the following. We use standard pressure air connector for pressure tubes, which we have installed in the left side of our housing. This brass element is directly screwed into a 12V ¼" solenoid, whereby on the other end, a 6mm quick connector is screwed in. This allows us to run a 6/4mm blue pressure tube, which is reduced just 10cm before the nozzle with a blue 4/2mm tube. The blue tube is good for around corners and doesn't get bent, so you always have a proper airflow. Details you see in the picture below, still feeding the ORTUR© 20W head.



10. The importance of proper exhaust



Air flow in a laser engraving/cutting environment does not look too complicated in the first view I thought. But talking to experts around my area where I live told me a different story.

The Innograv GmbH, located in D-27299 Langwedel - Daverden, www.innograv.com is a professional supplier for any kind of engraving and cutting material. We purchased from them the CerMark sprays, one for METAL LASER marking and one for BLACK CERAMIC AND GLAS marking. We also got a bunch of Acrylic samples, which are colored sandwiches in different thicknesses. Here the surface temperature plays a big role.

Too much air flow will cause glass to crack or the Acrylic surface look like a sand paper. This is the reason why we have a path through ventilation that can be air flow regulated.

To make this happen, we have 4 x 60x60mm cheap two wire fans installed in the front and 4 x very high quality 60x60mm ebm Pabst 624/2H3P series four wire installed in the rear. The ebm Pabst ones have besides plus and minus a tachometer signal and a PWM (pulse width modulated) control input. They can be controlled between 4,000rpm to 10,000rpm.

Cutting in a room is only possible, when I hook an exhaust adaptor over the four rear fans, but most of the time I operate on my veranda at the rear side of our house. Below I list the two PWM control units for 2-wire and three/four wire fans. All eight fans run on 24volts.



Amazon description:

DC 6-60 V 12 V 24 V 36 V 48 V 30 A PWM DC Motor Drehzahlregler (PWM) Geschwindigkeit Einstellbare Stufenlose Regler, Motor Drehzahlregler mit Start-Stopp-Schalter

This is the PWM controller for the 2-wire front fans. Since they cannot be controlled through a dedicated PWM input, the controller can run from 40% to 100%. Below 40%, the fans just cut off.

This is the DC-Pulsweitenmodulator K8004 from Velleman, which is available as a kit, easy to solder together. It's not on Amazon, so you need to look for the stuff on ebay.

The unit is able to handle up to 6.5amps at 35volts and has a full set of adjustments for low speed limit, high speed level and PWM frequency.

You don't need to connect the tachometer wire, so any 3-wire fan would be fine. This is a great controller with a huge performance.



11. Z-Axis and variable laser bed design

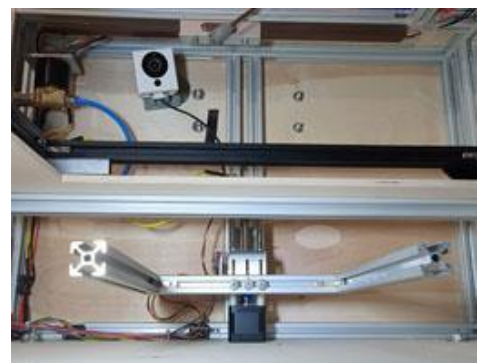


When using an ORTUR roller to engrave water glasses, or thick material, you need enough variability in your laser bed setup. This chapter describes the Z-axis control and the variable laser bed design.

Also this setup can be controlled with switches. One switch for Z-axis power-on that will enable 24V supply on the boards, one switch for up/down and one switch for the enable signal.

The picture on the right shows the Z-axis module installed on the left wall of the housing. On the top left you see the intake solenoid for the air assist, a bit to the right the Wyze cam and then two 2020 vertical profiles. These two profiles serve as installation pole for the Z-axis linear unit and is solid enough. These profiles are also used to form the fork carriage for the laser bed.

The ENA (enable) signal on the stepper motor driver starts and stops the Z-axis stepper motor. The DIR (direction) signal lets move the unit up and down. Since I have installed the Raspberry



Pi, I have installed two end switches, that are connected to an I/O that stops the controller. If you use switches to control the Z-axis unit manually, end-switches are not required.

Amazon description:

Wisamic Mini 60MM CNC Z achse Lineareinheit Slide Motion DIY 3 Axis Graviermaschine

12.The Endurance 10W upgrade

This setup explained so far, does serve together with Lightburn© perfectly our requirements. The 20watts laser unit from ORTUR© is ok, but from a power point of view not exactly what we expected. We know that the installed components for this project are not the cheapest ones, but the main goal was best comfort and fun building this project.



Since we have already purchased the Endurance air assist and G8 lens from Endurance, we discussed with George also the best setup how to replace the ORTUR© 20W laser module.

Some ORTUR 20W unit benchmarks for our decision:

Engraving on glass without CerMark but with Acrylic mate black nail paint was 150mm/min at 100%.

Engraving on glass with CerMark 500mm/min at 80%.

Cutting on 3mm birch plywood was 150mm/min at 100% 6 cuts without air assist and 3-4 cuts when using it.

Engraving a photo on a drinking glass took at least 4-8hrs.

This was the basis for our decision, swapping out the ORTUR© laser head for an ENDURANCE© unit.

When you plan this, you need to start thinking about your controller connection first. So it all starts with the connection to the ORTUR© motherboard. I used a three-wire Multiplex servo cable male/female, which I cut in the middle and installed the male one as shown here. You only need ground and PWM, but I also soldered the 12V one. So PWM yellow, ground black and 12v red. Make sure that you use an appropriate electronic controlled soldering station. This servo cable has a solid connector and the thickness of the wires fit onto the solder points of the motherboard.

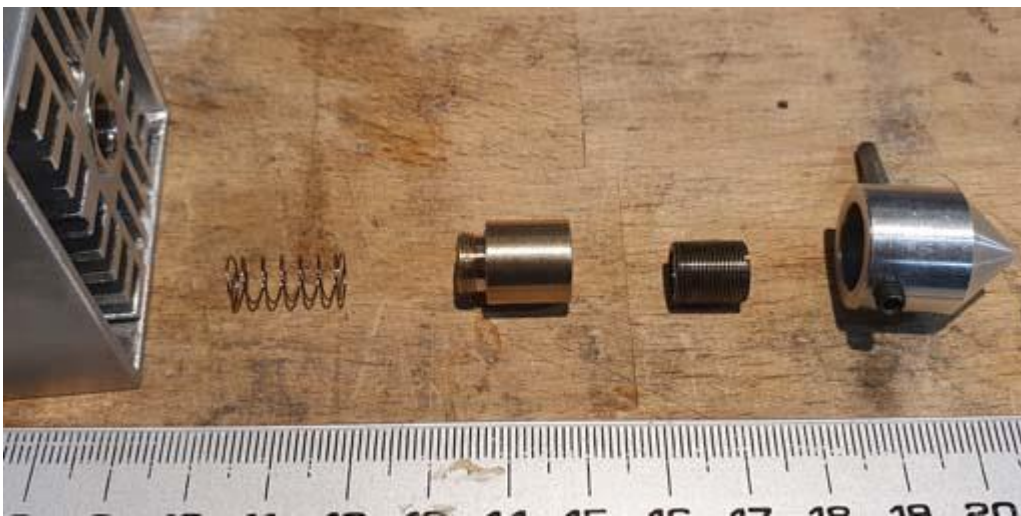
12.1. Let's talk now about the new 10W Endurance laser unit setup:



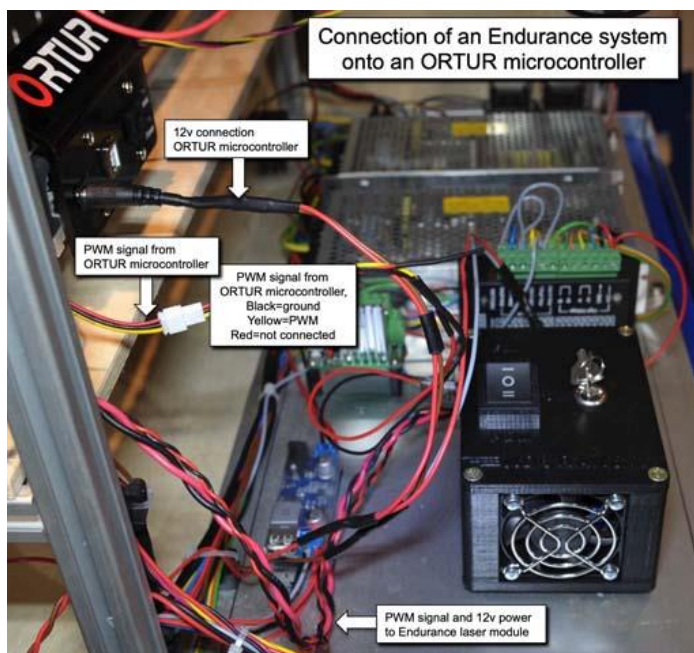
We have lined up two rows of parts. The upper row shows the two washers and the standard lens shipped with the unit. Only the big spacer/washer in the lower row was also installed when we received the unit and is needed for the G8 lens.

So from left to right, we start with the spring, then the G8 lens just 3 turns screwed into the big spacer/washer. Followed by the air assist upper deck, which is completely screwed onto the lens. Take care to install the lens the correct way. The two incisions must be installed outward, away from the laser diode. Then fasten the extension tube over the upper deck, pushed in completely. The push in the lower extension completely and fasten is with the two screws. At last, push in the nozzle completely. The whole G8 lens setup has, when this installation is finished, from the heat sink to the tip of the nozzle 75mm and 95mm – 120mm focal length.

This was not satisfactory, since this distance will use up lots of height in our housing. We were looking for a focal length of 20mm – 50mm with the G8 and so finally, we used the setup, shown below. We screwed the G8 lens 100% into the brass extension, always the two incisions out, away from the laser diode. The spring, followed by the brass extension and on top the air nozzle. That's it. The whole G8 setup has a total length of 20mm and a focal length of 25mm – 35mm.



12.2. Installation of the Endurance system



To connect the Endurance system into an ORTUR system is straightforward. You start with the PWM and ground wire from the microcontroller board and connect this to the PWM input of the Endurance controller. Then you plug in the 12V power.

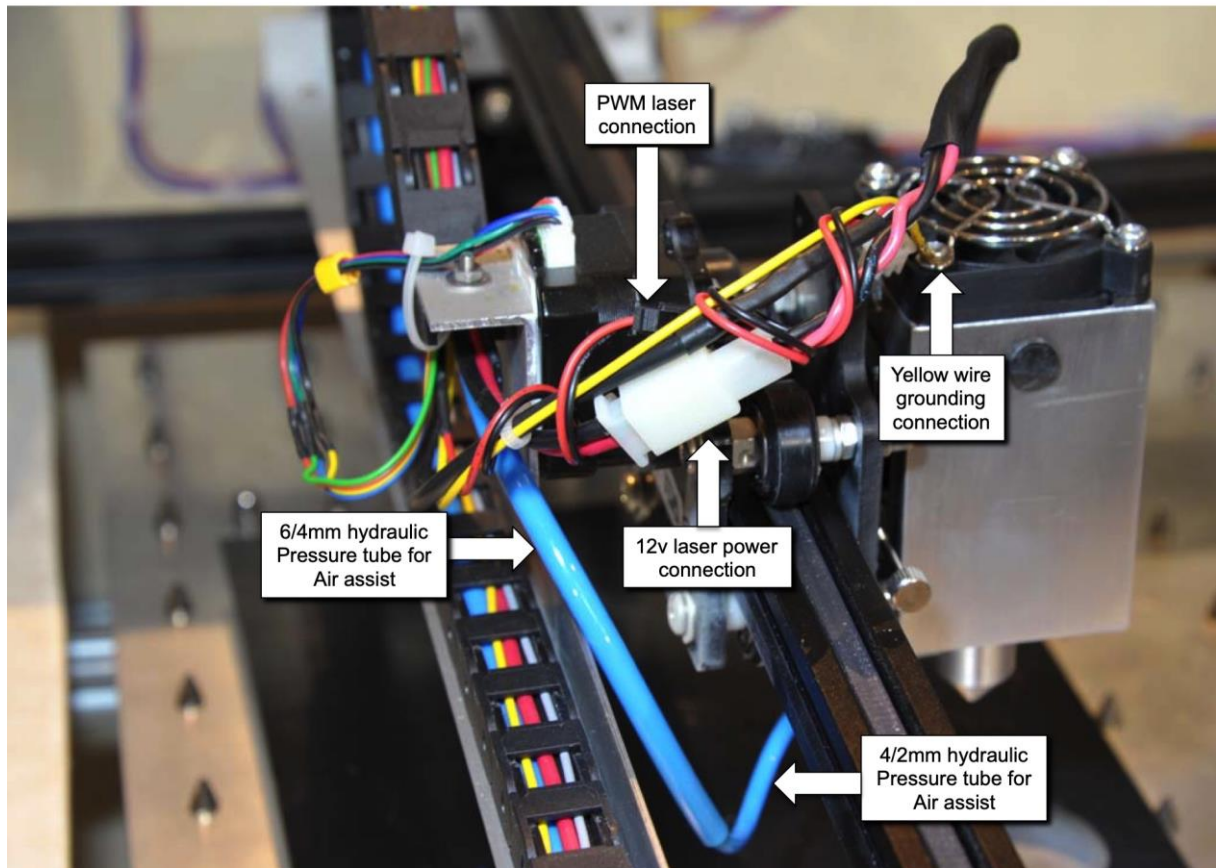
There are two twisted pair red/black wires from the Endurance controller box to the laser head. The thick wires are the 12V supplies; the thin wires the PWM signal.

Since we run these cables through our cable chain supply, we have added two connectors before the cables enter the cable chain and two connectors near the laser head, that enables us to remove it for maintenance or lens exchange.

To ensure proper function you may use for the PWM signal a tiny connector, but for the 12v power supply this connector should be able to carry at least 3amps. This does also apply to the cables. The 12v power supply cable should have at least 0.5sqmm.

To still ensure also the operation with the ORTUR® laser head, we have left this cable and connector installed on the system and have pulled 4 additional wires for the ENDURANCE® laser head. This does include the yellow grounding wire, screwed onto the ventilator grid screw.

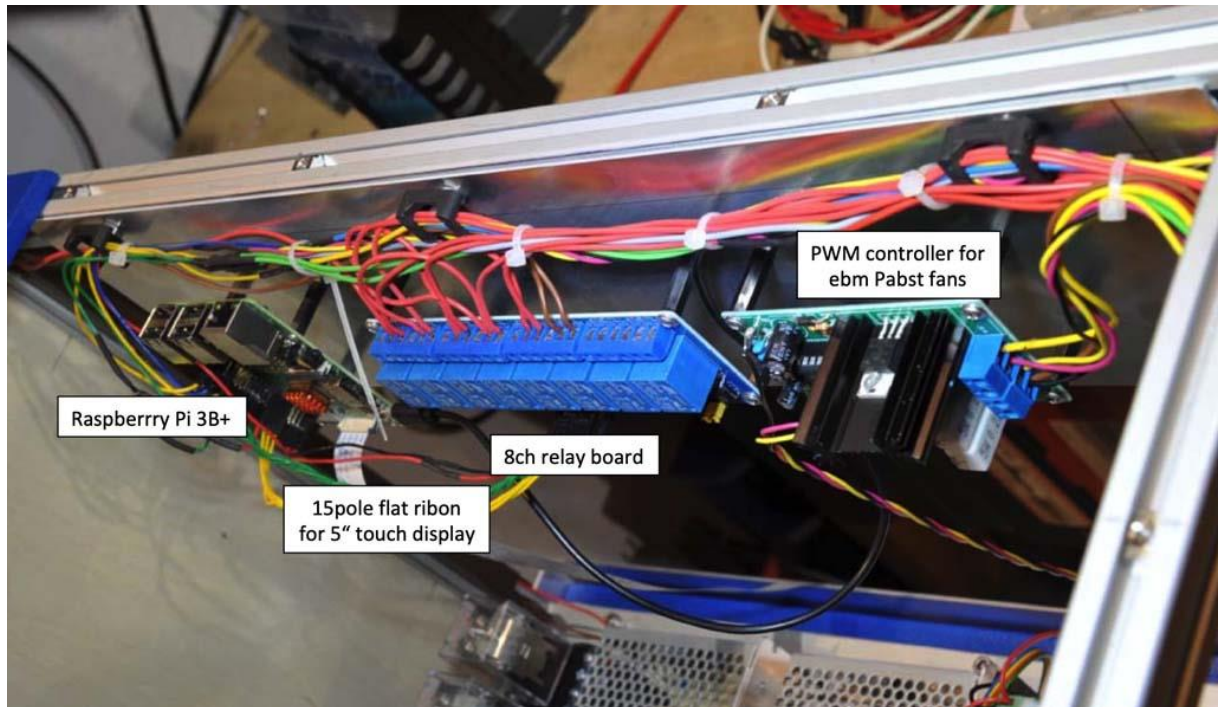
The picture below shows the connection setup with connectors, screwed onto the ORTUR mechanical Z-axis attachment. For this, I have drilled two 2.4mm holes in the heat sink and in made 3mm threads. So I was able to screw it on. Since this is somehow like a Band-Aid solution, I'll exchange this soon for a printed solution.



13.The Raspberry Pie 3B Plus

Python is a very easy to understand programming language and with the Tkinter module you can easily create powerful graphic application. You touch a button, which activates a relay. That's mainly it. The python file must be stored in a specific directory and an autoexec file installed on the Raspi. We do not publish the program and autoexec files. If you would like to have a copy, then ask for it on e-mail dietrich.pals@googlemail.com !

The Raspberry Pi installation with its components does fit on the right top 2020 rail, as you can see on the next picture. From left to right the picture shows the Raspberry Pi with a 32Gb SD card that holds the operating system and the program to run the touch screen and the relay board. The 8ch relay interface, which easily can be connected onto the I/O of the Pi and a 5" touch display, connected via the DSI interface.



If you decide to build the version with switches, or the Raspberry one, its up to you. For us it's a very handy machine. And if you check page 4 carefully, you see at sits on a table with rubber wheels, which we have built afterwards. It does make transportation easier.

Thanks to my wife, who does support all this and Jonas, an engineer as I am who supported with 3D printing.

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