IKEA Lacquer Sand Painting Table

Construction manual

7. September 2024

BINGOBRICKS

https://youtube.com/@BINGOBRICKS

Version	Alteration
8 July 2024	*Prepared for publication in MAKE 4/24.*
7. September 2024	*Chapter 9.4: Thickness of the recommended foam rubber mat increased to 3mm. Reason: The original 2mm thick mat has curled slightly over time (humidity?), which affected the quality of the sand pictures. With the new 3mm thick mat I have not been able to detect this behavior so far.*

1 Table of contents

2 Preconditions

2.1 Components of this guide

The following files and articles are considered part of this manual. You should definitely have access to these resources. Otherwise, you won't be able to recreate the project:

- File «`Materialliste.xlsx`». This Excel file lists all materials including all nuts and bolts. In this list you will also find information about the sources of supply.
- STL files of the components that you can make yourself with a 3D printer.
- The config.yaml configuration file

You can find all these and many other files in the project repository, which is referred to in the corresponding article of MAKE Magazine.

2.2 Required material

All components and materials are listed in the "`Materialliste.xlsx`" Excel file.

Before you begin, make sure that all materials are available in your environment in the specified masses and quantities. You should pay special attention to the following components:

- IKEA Lacquer Table, 90x55cm, black-brown
- LED Strips: Paulmann Entertain LED, 3m, RGB, 5V, 60 LEDs/meter, Power Jack connection, incl. Remote control
- Glass plate 6mm thickness
  Find a suitable supplier in your area who can cut a glass plate and hem the resulting cut edges . You don't need to order the jar yet. But you should be sure that you will be able to get it in due course, once you have reached chapter "10.2 - Intermezzo: Ordering the glass plate". Only then will the exact dimensions that the glass plate should have be known.

2.3 Required tools

- 3D printer with a Print room of 180x180x180 mm or e.g. Prusa Mini
- Multimeter
- Soldering iron
- Jigsaw
- Wood drill bits
- File / Sandpaper
- Allen key set
- Screwdriver
- Wrench (5mm) and 6mm)
- Side cutters larger,
- Optional: Screw clamps, Cling

2.4 Prior knowledge

The instructions assume that you have the following previous knowledge and can carry out corresponding work steps without further instructions. If you don't have this previous knowledge, I recommend that you look for and watch corresponding YouTube tutorials before starting the work:

- Woodworking: Shortening table legs with a saw; Full cut-out sawing into table top; Drilling holes in wooden panels

- Metal processing: Shortening LED profile strips with a hacksaw
- LED Strips: Shortening LED Strips; Connecting LED Strips with Connection Cable
- 3D printing with PLA or PETG filament: Prepare STL files for 3D printing with slicer software; Operating 3D Printers
- Measuring voltages with a multimeter: Setting the reference voltage on a stepper MotorDriver
- Soldering: Extending cables; Soldering cables to electronic components such as connectors; Insulating with shrink tubing or insulating tape
- Microcontrollers: Downloading and Installing a Firmware

3 Overview

All parts produced with the 3D printer are shown in red in the following illustration for better recognition.

Abbildung 1: Aussenansicht

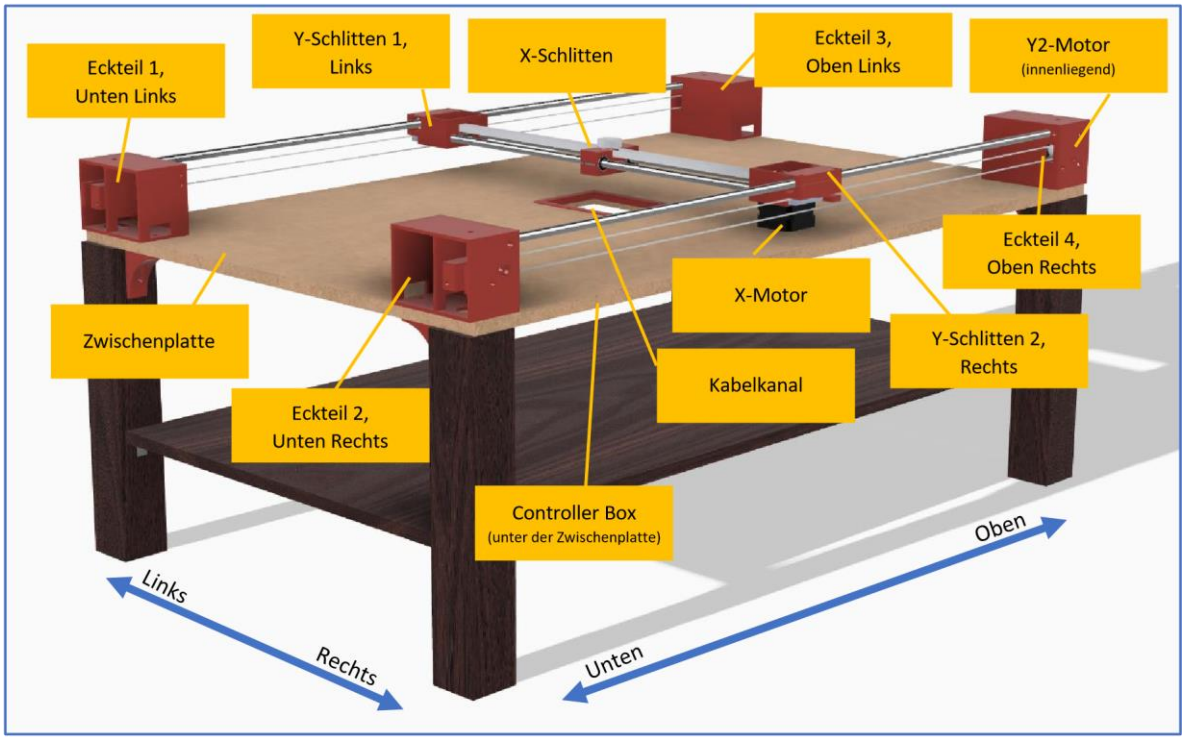


Abbildung 2: Innenansicht

4 Printing components (3D printing)

The following list shows all components to be printed. If you use the PrusaSlicer for slicing, you can directly open the provided 3MF files and benefit from preset parameters and pressure orientations.

Black filament is recommended for all visible components. This guide uses from

Reasons for displaying non-visible components red filament. Blue filament was used for the pressure of the tools. Of course, all components can be printed with black filament throughout. In total, approx. 1.2kg of PLA or PETG filament is required. The printing time is about 50h in total (Printed with a Prusa MK4 with input shaper).

The following printing instructions must be followed when printing the components:

- The layer height can be found in the table below.
- If the alignment of the components on the print bed is correct, all components can be printed without supports.
- A standard nozzle of 0.4mm diameter can be used for printing.

Number	Component Name	Color	Layer Height	Print note
1	Controller Box-Boden.stl	Black	0.3mm	
1	Controller Box-Rahmen.stl	Black	0.3mm	
1	Drilling Template Cover.stl	Blue	0.3mm	
1	Drilling Template Floor Plate.stl	Blue	0.3mm	
1	Drilling TemplateRulerFull-Cutting.stl	Blue	0.3mm	
2	Kabelkanal.stl	Red	0.3mm	
4	bracing.stl	Black	0.3mm	
1	Corner part 1-BottomLinks.stl	Red	0.3mm	1)
1	Corner part 2-BottomRight.stl	Red	0.3mm	1)
1	Corner part 3-TopLeft.stl	Red	0.3mm	1)
1	Corner part 4-TopRight.stl	Red	0.3mm	1)
2	StopCylinder Rod.stl	Red	0.3mm	
4	Table leg cover.stl	Black	0.3mm	
1	Y-Slide 1-Links.stl	Red	0.15mm	
1	Y-Carriage 2-Right.stl	Red	0.15mm	
2	Y-Carriage Clamp.stl	Red	0.15mm	
1	X-Schlitten.stl	Red	0.3mm	
1	X-Carriage Clamp.stl	Red	0.3mm	
12	LED Profile HolderStandard.stl	Black	0.15mm	
2	LED Profile HolderCornerShort1.stl	Black	0.15mm	
2	LED Profile HolderCornerShort2.stl	Black	0.15mm	
2	LED Profile HolderCornerLong1.stl	Black	0.15mm	
2	LED Profile HolderCornerLang2.stl	Black	0.15mm	
2	LED ProfileAperture CornerShort1.stl	Black	0.3mm	2)
2	LED ProfileAperture CornerShort2.stl	Black	0.3mm	2)
2	LED ProfileBezel-CornerLong1.stl	Black	0.3mm	2)
2	LED ProfileBezel-CornerLang2.stl	Black	0.3mm	2)
2	Cable Clip.stl	Black	0.15mm	

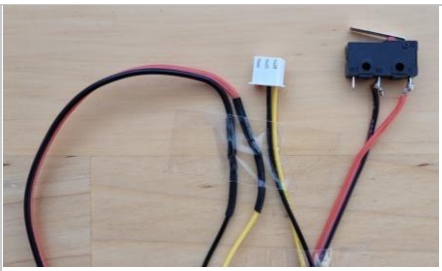
Printing notes:

1) *The corner parts should be printed with 3 perimeters, as they have to carry a relatively high weight.*

2) *The LED profile panels should be printed upright. For better adhesion to the print bed, it is recommended to print a border ("brim").*

5 Preparing electronics

5.1 Soldering components



Number	Component
2	Limit Switches, ZW12-B
2	JST XH connector with cable, 3 pin, 10cm
2	2-Pin Cable, AWG22, approx. 80 cm long
	Heat Shrink Tubing

1. Cut the red wire of the JST XH connector cable with the side cutters.
2. Extend the other two wires (yellow and black) of the JST XH connector with the 2-pin cable to a total of about 90 cm: black to black, yellow to red. Insulate with heat shrink tubing.
3. At the other end of the cable, solder the limit switch: red/yellow on C connector, black on NO connector.

Prepare another piece of this component in the same way so that you end up with two identical limit switches.

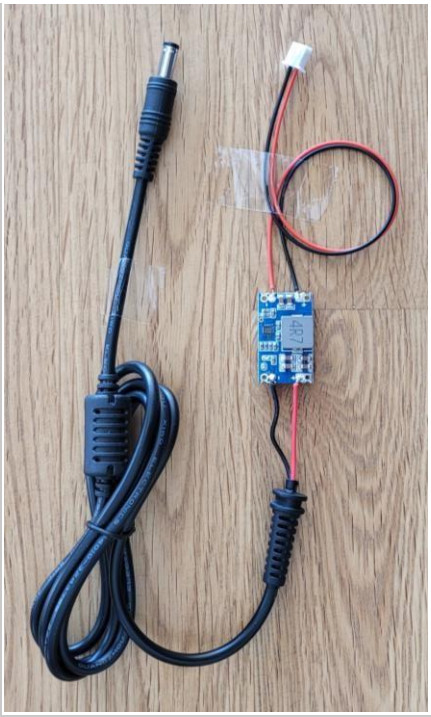
Number	Component
1	Rocker Rocker KCD1-101 Toggle Switch
1	2-pin cable, AWG22, approx. 10 cm long

1. Solder the 2-pin cable to the toggle switch (pole irrelevant).
2. Tin the other open end of the cable, so that it can later be tightened well in the screw terminal.

Number	Component
1	Momentary Push Button, R13-507
1	JST XH Cable with Connector, 2 pin, 10cm

1. Solder the push button to the cable of the two-pin JST XH connector (polarity irrelevant).

Number	Component
1	StepDown Converter 5V, Mini560
1	JST XH Connector with Cable, 2 pin, 10cm
1	DC Power Jack Cable, male, 5.5x2.5mm, length approx. 1 meter

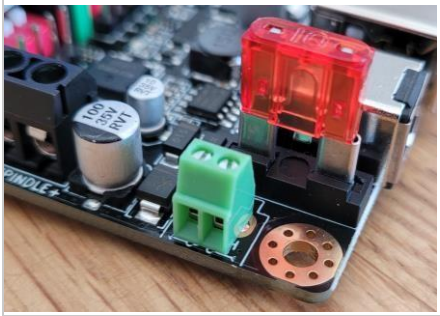


1. Solder the cable of the JST connector to the input of the StepDown Converter, using the internal connectors.
   Be sure to note polarity: Black vein at I red vein at IN-.

   Note: It is unusual for the black wire to represent the positive pole and the red wire to represent the negative pole. but the JST XH connector can only be plugged in in one direction of the board, the black wire to plus and the red wire to minus depends on this W.

2. Solder the two free cables of the power jack cable to the output of the StepDown Converter.
   Be sure to pay attention to polarity: Red wire at Out+, black wire at Out-

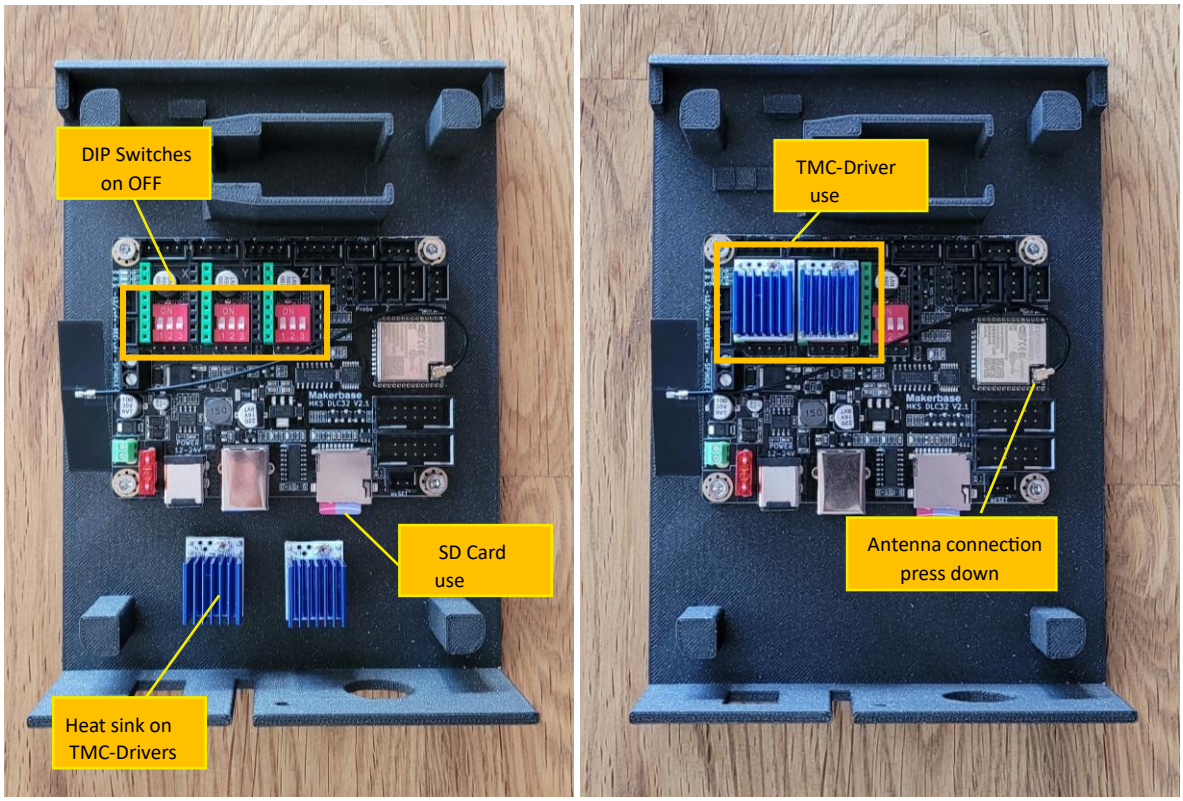
Number	Component
1	Makerbase MKS DLC32, ESP32 WIFI Board V2.1
1	2 Pin Screw Terminal, 2.54 PCB



1. Spread the pins of the terminal slightly with pliers so that the terminal fits into the drill holes of the board.
2. Solder the terminal to the "Switch" connector of the board.
   Note the orientation: Point the cable connection outwards!

5.2 Prepare a makerbase board

Number	Component
1	Makerbase MKS DLC32, ESP32 WIFI Board V2.1
2	TMC2208 Drivers and Heatsinks
1	SD Memory Card, 16 GB
1	`Controller Box-Boden.stl`
4	Metal screws M3x6



The following activities are to be performed with the Makerbase MKS DLC32 board:

1. Insert the SD card into the card slot.
2. Set all red and white DIP switches down to "OFF" (1/8 step).
3. Glue the heat sinks to the chips of the TMC2208 driver modules. Make sure that the heat sinks do not cause a short circuit at the solder joints.
4. Plug in one TMC2208 driver each to the slots for the X and Y motors.

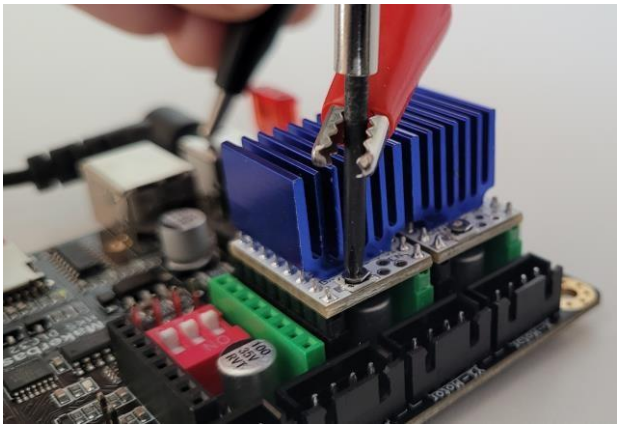
   Be sure to observe the correct polarity:
   The screw of the potentiometer must be according to the picture above!

   The slot for the Z-motor can be left free. We only need two TMC drivers.

5. Check that the antenna is firmly seated.
6. Insert the board into the 3D printed component `Controller Box-Boden.stl` and screw it in place (4 metal screws M3x6).

5.3 Setting Maximum Current/Reference Voltage

Number	Component
1	Makerbase MKS DLC32, ESP32 WIFI Board V2.1 inkl. TMC2208-Treiber
1	Plug-in Power Supply, 12V, 3A, 36W, Power Jack 5.5 x 2.1mm



1. Connect the board to the power supply via the PowerJack socket. Power supply. The LEDs on the board should now light up.
2. With the help of a multimeter, the reference voltages on the two TMC2208 drivers. (This is the tension between the adjusting screw and the ground.)
3. Use the potentiometer on the TMC2208 drivers to set the reference voltage with a screwdriver so that it is 0.5 volts each.
4. Disconnect the board from the power supply: Unplug the power supply.

Hints:

- *The reference voltage of 0.5 volts only applies if you use exactly those NEMA17 motors in combination with TMC2208 drivers that are recommended in the bill of materials.*
- *When handling a multimeter and screwdriver, make sure that you do not cause short circuits. You could destroy drivers and controllers!*
- *Never plug a stepper driver into the board when the board is energized.*
- *Never connect a stepper motor to the board when the board is energized.*

5.4 Preparing LED Strips

Number	Component
1	LED Strip, Paulmann Entertain LED, 3m, RGB, 5V, 60 LEDs/meter, incl. remote control
4	LED connector, 4 pin, 10mm, double

1. Plug the connection cable with the IR sensor for the remote control into the LED strip. Pay attention to the correct polarity!

2. Cut the LED strip into the following sections.
   Start with the first strip where you plugged in the connection cable.
   1. A strip of 2-4 cm (1-2 LEDs, plus connection cable with the IR sensor)
   2. Two strips of 37cm each
   3. Two strips of 70cm each

Of course, you may only separate the strips at the cut lines provided for this purpose!

3. Connect all five strips to the four LED connectors in the following order:
   2-4cm strip with connection cable -> connector -> 37cm strip -> connector -> 70cm Strip -> Connector -> 37cm Strip -> Connector -> 70cm Strip

We don't need the 5V power supply of the Paulmann Entertain LED kit. You can use it for another exciting project.

6 Install firmware

6.1 Install USB driver CH340

Before you can install the firmware on the board, you need to make sure that the board is accessible via the serial port via COM port. A USB CH340 driver is required for this. If you have worked with controllers (e.g. Arduino) before, you will almost certainly have already installed this driver.

1. Connect the board to the PC using the USB cable.
2. Connect the board to the power supply via the PowerJack socket and supply power to the power supply.

Now check the Windows Device Manager to see if the board has been assigned a COM port (COM3 in this example):

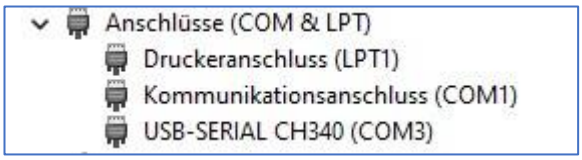


Figure 3: USB CH340 port in Device Manager

3. If the board has **not** been assigned a COM port, you will now have to take care of installing the CH340 driver. Search the web for instructions on how to download and install the CH340 driver. I can recommend the Sparkfun Electronics website: https://learn.sparkfun.com/tutorials/how-to-install-ch340-drivers/all

6.2 Installing FluidNC V3.7.8

The firmware «FluidNC» is an open-source firmware for CNC systems, which has been optimized for the ESP32 controller. FluidNC is the successor to the well-known GRBL_ESP32.

YouTube SCAN ME

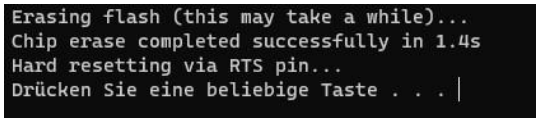
To clarify, watch the video tutorial on how to install FluidNC on the BINGOBRICKS channel.

Install version 3.7.8 as follows:

1. Download the firmware «FluidNC» version 3.7.8:
   https://github.com/bdring/FluidNC/releases/download/v3.7.8/fluidnc-v3.7.8-win64.zip

2. Unzip the downloaded ZIP file.

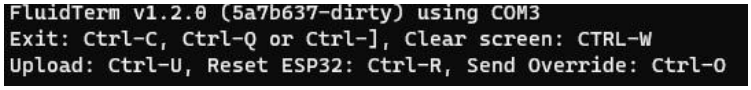
3. Delete the factory-installed firmware from Makerbase. To do this, run the following file, which can be found in the unzipped ZIP archive:
   `fluidnc-v3.7.8-win64\erase.bat`



   You may need to perform this step as an administrator.
   If Windows prevents the files from running with a warning message "The computer has been protected by Windows", then click on "More information" and then confirm with "Run anyway".

4. Then install the new firmware on the board. To do this, run the following file: `fluidnc-v3.7.8-win64\install-wifi.bat`

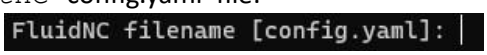
5. Select the COM port to which the board is connected via USB (see chapter "6.1 - Installing the USB driver CH340")
   In this example, enter «1» for «COM3»



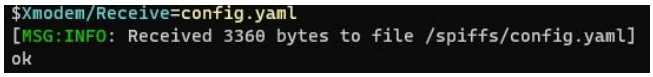
6. Now an additional file for the web interface has to be uploaded. `Press Ctrl-U` and select the following file in the file selection window that appears: `fluidnc v3.7.8-win64\wifi\index.html.gz`

   The selection must be confirmed with `ENTER` . This will begin the upload of the file.

7. We now upload a ready-made YAML configuration file for our sand painting table. It contains all the presets and parameters to make the sand painting table work properly. You can find the file in the MAKE project repository of the instructions. `Press Ctrl-U` and upload `the` config.yaml file:



   The selection must be confirmed with `ENTER` . This will begin the upload of the file.

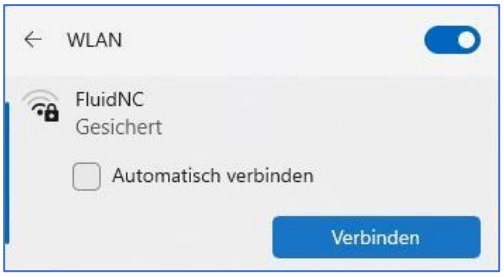


8. This means that FluidNC version 3.7.8 is installed on the board. We end the dialog with `Ctrl-Q` and then press any key.

```
Exited by ^Q
Drücken Sie eine beliebige Taste . . .
```

9. The board is now accessible via Wifi. To do this, connect the Windows PC to the "FluidNC" Wi-Fi.

   The password for the connection is "12345678".



10. Afterwards, a web browser can be used to connect to the board via the address http://fluidnc.local .
    We don't need the USB connection anymore for the time being. Therefore, the USB cable can now be disconnected.

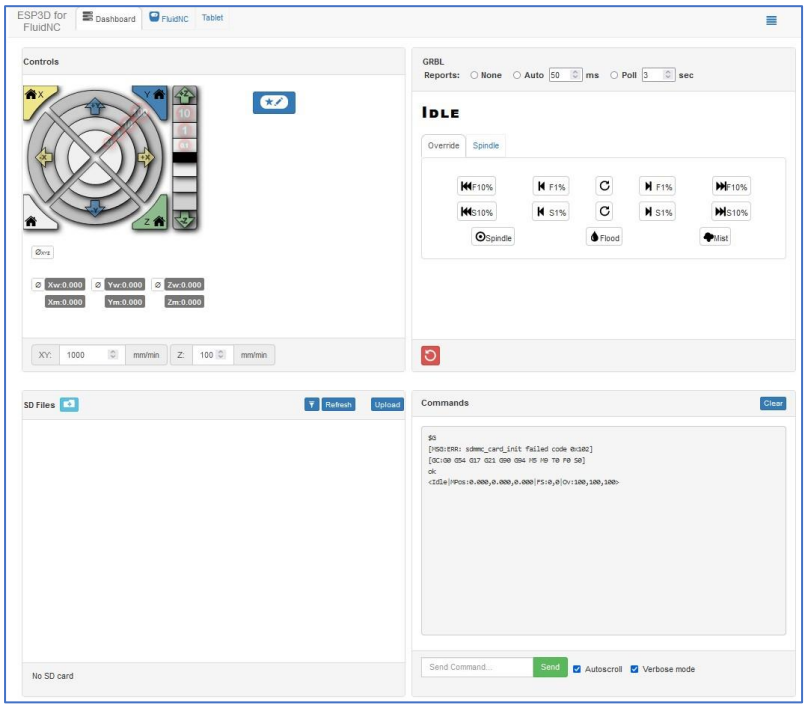
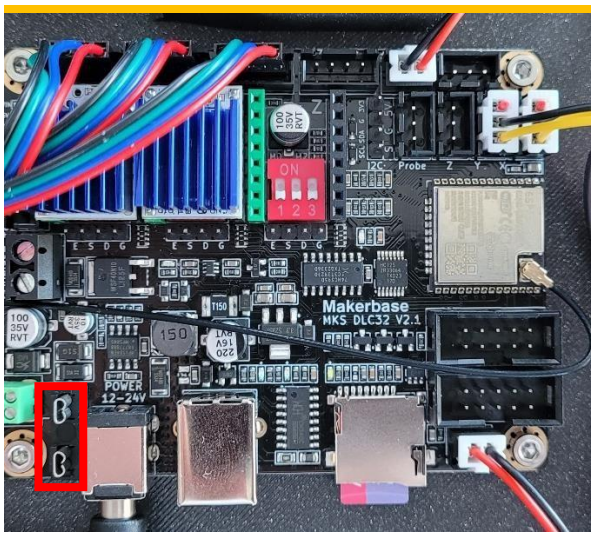


Figure 4: Web interface of FluidNC

7 Testing the electronics

7.1 Connecting the electronic components

Before you continue: Disconnect the board's power supply and remove the USB cable!

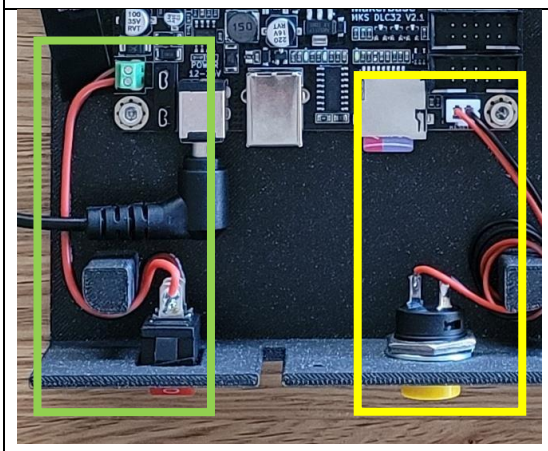


Remove the red fuse on the Makerbase board.

Plug the two limit switches into port X and Y.

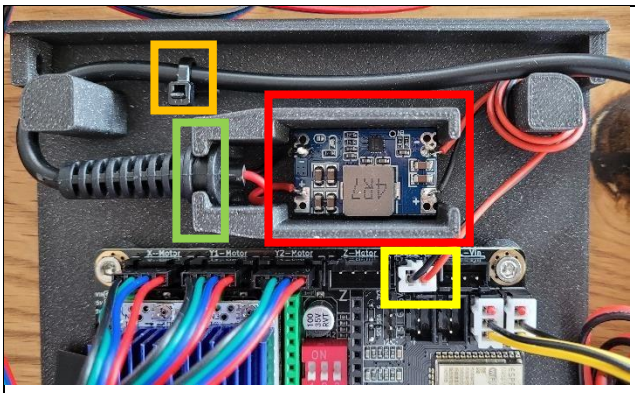
Plug the three motor cables with the Dupont connectors to the X-Motor, Y1Motor, and Y2-Motor connectors. **Pay attention to the polarity: The red wires must be connected to the right pin of the connections!**

Connect the other ends (JST XH connectors) of the cables to the motors.



Insert the toggle switch into the opening provided and screw the two ends of the cable into the screw terminal tightly.

Screw the MomentaryPush button into the provided opening and plug the JST XH connector into the RESET connector.



Plug the cable with the soldered StepDown Converter to the connector 12/24V

Lege den StepDown-Converter to the opening.

Press the thick cable end of the DC Power Jack cable into the groove provided.

Run the DC Power Jack cable around the cable diverter and then secure the cable with a cable tie.

It has a small recess where the cable rests for the cable tie to pass through.

Then connect the LED strips to the DC Power Jack cable (see next figure).

Tip: For the following test, attach a small clamp or some adhesive tape to the axles of the motors so that you can better see the direction of rotation of the motors during the function test.

Overall, the board should now look like this with all the components plugged in.

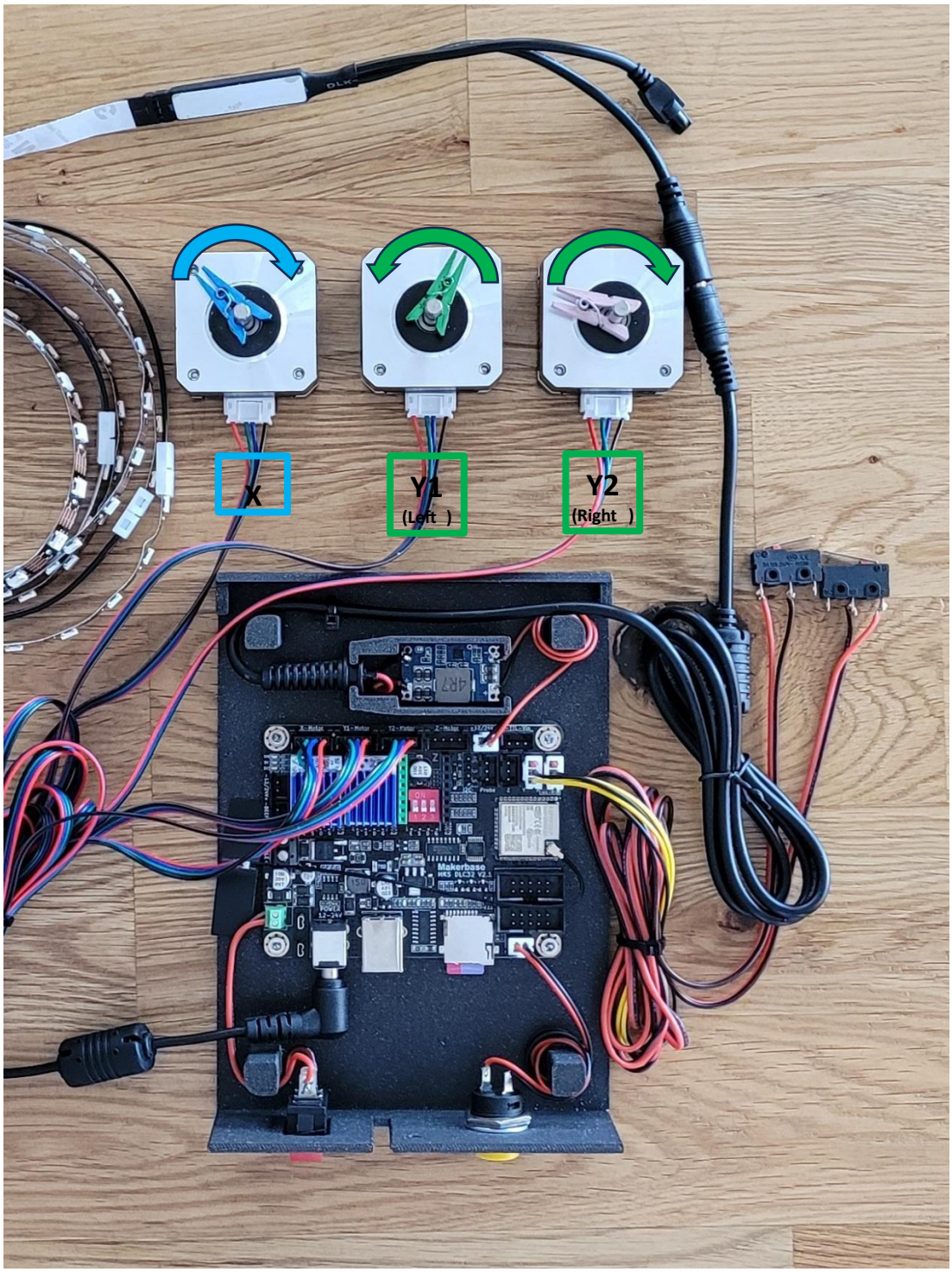


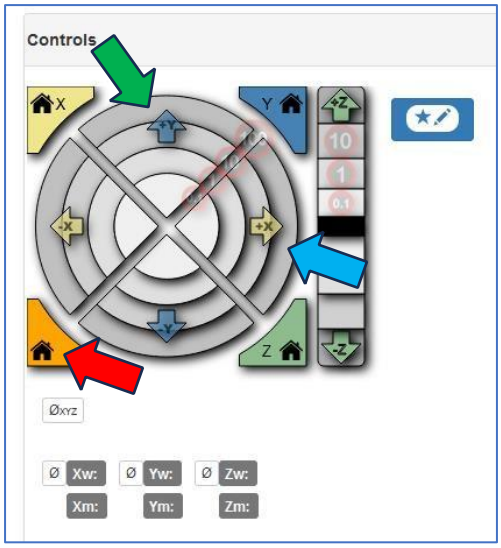
Illustration5:Overview of electronic components

1. Now you can turn on the power supply to the board:
   Plug in the PowerJack cable of the power supply and switch on the on/off switch.

2. You can then connect to the WiFi "FluidNC" and access the board with a web browser via the address *http://fluidnc.local* (see chapter "6.2 - Installing FluidNC V3.7.8").

7.2 Test the electronics and firmware settings.

To clarify, watch the video tutorial on how to test the electronic components on the BINGOBRICKS channel.



Test of the motor direction of rotation

Click on the rightmost ring. The XMotor should rotate clockwise for a few seconds (see Figure 5).

Click on the top outer ring. The Y1 engine should be counterclockwise for a few seconds, but the Y2 engine should be in the Rotate clockwise (see Figure 5).

If the direction of rotation of the motors is not correct, you have almost certainly plugged in the motor cable the wrong way. Also make sure that you `have loaded the config.yaml` file on the firmware that is available in the project file repository.

Test of the limit switches

Click the Home icon. All three engines should turn. Then briefly press both limit switches at the same time. All engines should now stop.

After pressing the limit switches, the motors perform a stop and immediately afterwards two slower changes of direction. FluidNC will then issue an alarm no. 9 and will no longer respond to inputs. Never mind!

Test of LED Strips

Press the On switch on the remote control of the LED strips: The entire 2 meter long LED strip should be lit.

Test des Reset-Buttons

Press the reset button (Momentary Push button). The board should perform a reset. You can tell by the fact that the small red LED in the middle of the board goes out briefly and lights up again immediately afterwards.

Test des On/Off-Kippschalters

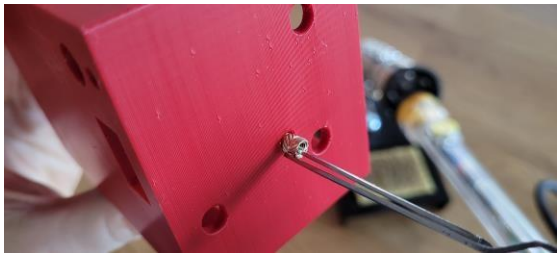
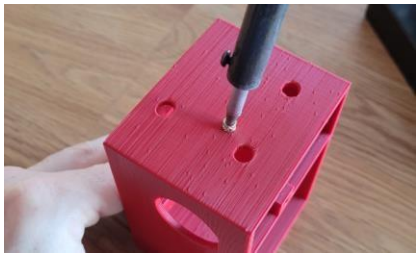
If you set the toggle switch to Off, the power supply to the board should be disconnected and all LED lights on the board and those of the LED strips should turn off.

8 Preparing components

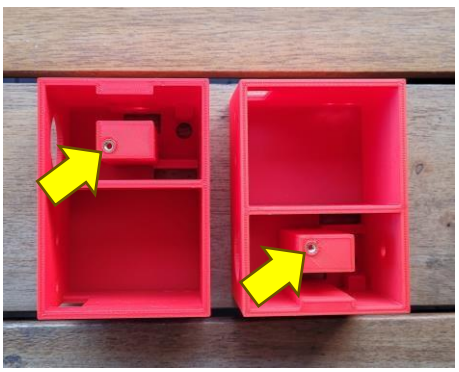
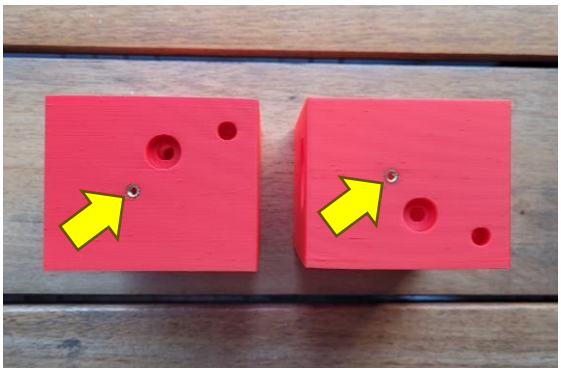
8.1 Melting Thread Inserts

Number	Component
31	Threaded inserts, M3xL5xOD4.5

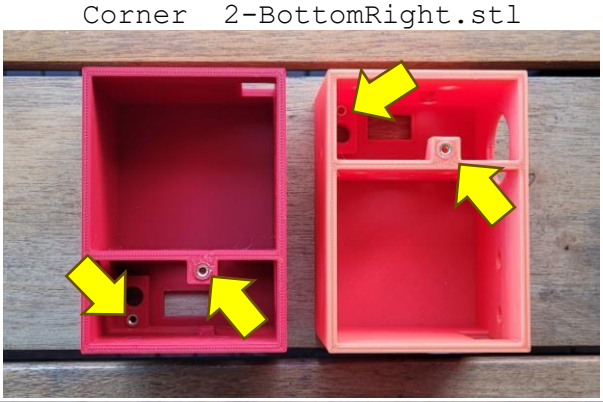
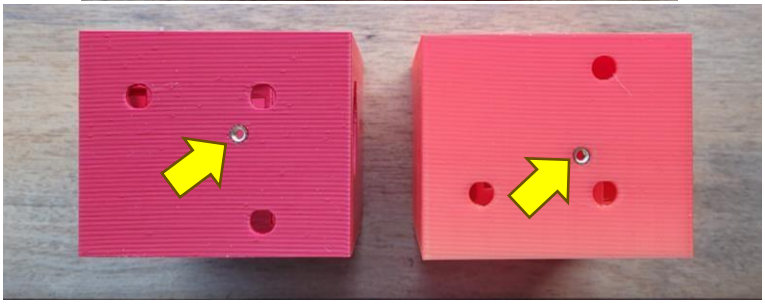
The threaded inserts are best melted into the 3D printed components with a soldering iron. To do this, first place the thread insert on the opening. Then carefully push the insert completely into the opening with the hot soldering iron.

Place a total of 31 thread inserts in the following 3D printed components:

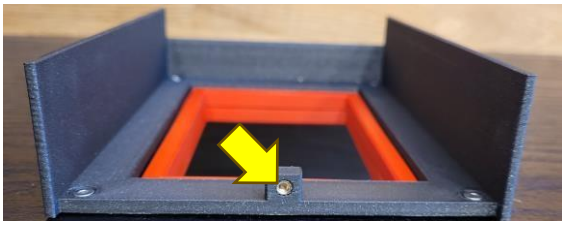



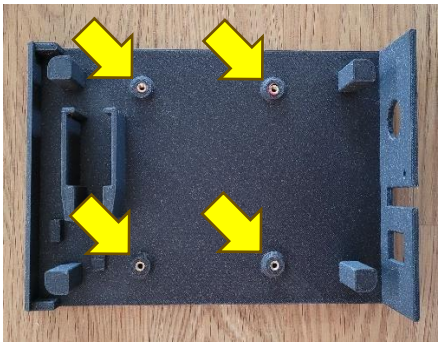
Corner part UntenLinks.stl
Corner 2-BottomRight.stl

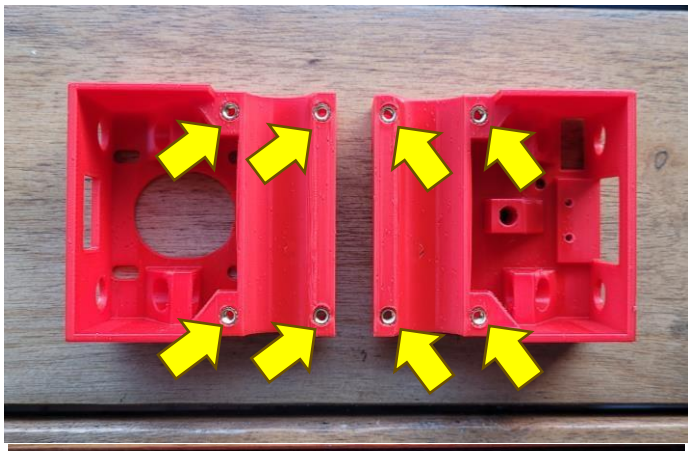
Corner part 3-TopLeft.stl

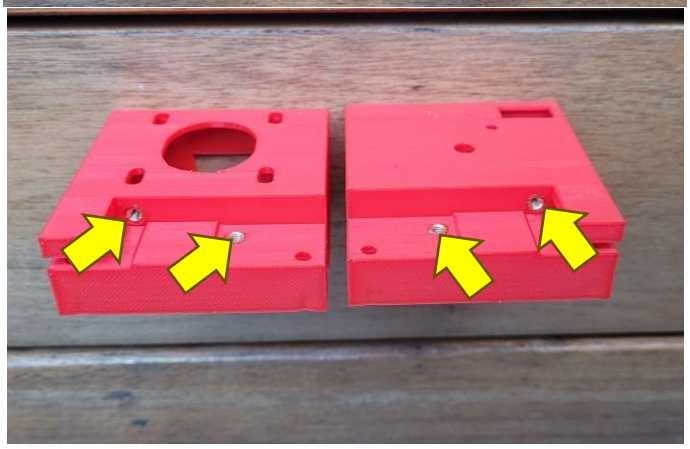
Corner part 4-TopRight.stl



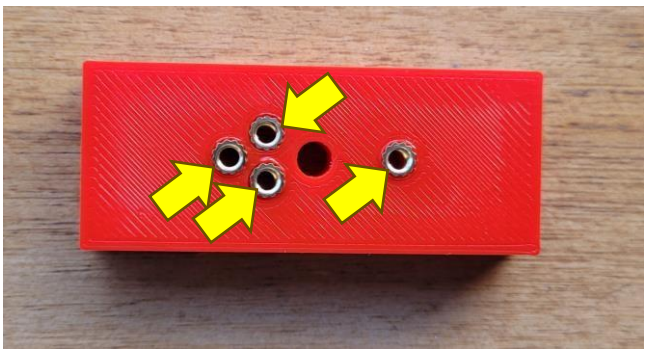


Controller Box-Soil .stl





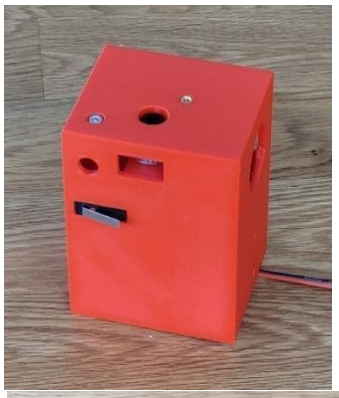
A-Slide 1 -Links.stl
A-Sled 2 -Rechts.stl
Controller Box-Rahmen.stl



X-Sleigh -Klemme.stl

8.2 Further preparations

Before you begin, you should disconnect the cables for the motors, the cables for the limit switches, and the LED strips from the Makerbase controller board.



Corner part 1-BottomLinks.stl

Number	Component
1	Corner part 1-BottomLinks.stl
1	GT 2 Idler (from the GT2 Kit)
1	Metal screws, M5x25, ultra flat head
1	Metal screws, M3x10
2	Metal screws, M2.5x10
1	Limit Switch, ZW12-B

- The GT2 Idler with the M5 screw in the
schr • The outside.
This M3x10 screw into the component
Line screw *later serves as a stop of the left*
- The *Y*
Limi *arstange.*
daf in chapter "5.1 - Soldering
Heb components"
t switch with the two M2.5 screws
or the intended opening, screw so that
the switch protrudes outwards.

Heb **Test the Limit Switch**: If you set the
- That protruding lever of the switch to a
flat surface, it should trigger. If this
does not happen, the
el **very little** to the outside.
Cable of the Limit Switch through the
opening
the Lead struts outwards.

Componen
:
ien.
-
ode into
the
hat the
n on
witches in

Number	Component
1	Corner part 2-BottomRight.stl
1	GT 2 Idler (from the GT2 Kit)
1	Metal screws, M5x25, ultra flat head
1	Metal screws, M3x10

-

Corner part 2-BottomRight.stl

- Screw the GT2 Idler into the component with t M5 screw.
- Screw the M3x10 screw into the component. *T will later serve as a stop for the right Y linear b*

Corner part 3-TopLeft.stl

Number	Component
1	Corner part 3-TopLeft.stl
1	GT 2 Pulley
1	Stepper Motor NEMA17, Pancake 17HS4023
3	Metal screws, M3x6

- The GT2 Pulley on the NEMA17 Step Set the motor so that the lower Ran Pulleys is 10mm away from the motor.
- Screw the pulley with the two grub screws in the pulley.
- Place the NEMA17 stepper motor in the Ec and align it so that the on for the cables points outwards. Screw the three M3x6 screws in place.
- Connect the motor cable to the motor, lead the cable through the side opening on the outside.

Number	Component
1	Corner part 4-TopRight.stl
1	GT 2 Pulley

Corner part 4-TopRight.stl

1	Stepper Motor NEMA17, Pancake 17HS4023
3	Metal screws, M3x6

•Place the GT2 Pulley on the NEMA17 S
Motor so that the bottom edge of the P
10mm away from the

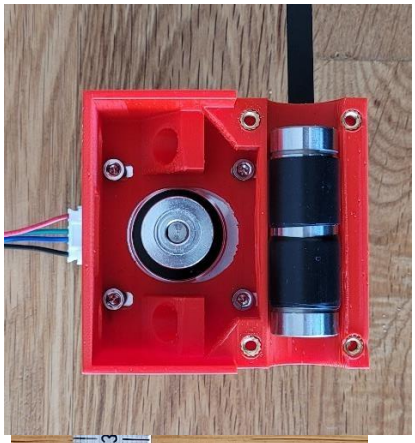
•Screw the pulley with the two grub screws
in the

•Place the NEMA17 Stepper Motor in the
section and align it so that the connector
cables is facing outwards. Screw the motor i
with three M3x6 s

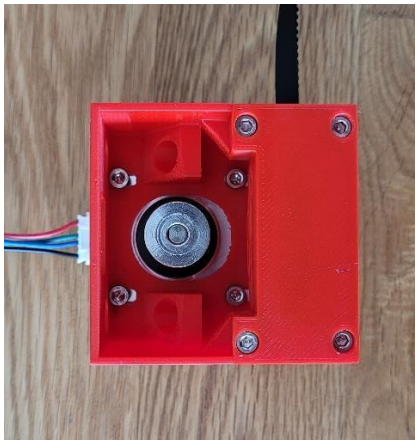
•Connect the motor cable to the motor and le
cable outwards through the side op

Number Component	
1	Y-Carriage 2-Right.stl
1	GT 2 Pulley
1	Stepper Motor NEMA17, Pancake 17HS4023
4	Metal screws, M3x6
1	Y-Carriage Clamp.stl
1	Linearlager 8mm, LM8LUU
	Insulating tape
4	Metal screws, M3x10
1	GT2 Aluminum Clamps
1	GT2 Timing Belt, 190cm
2	Metal screws, M3x10

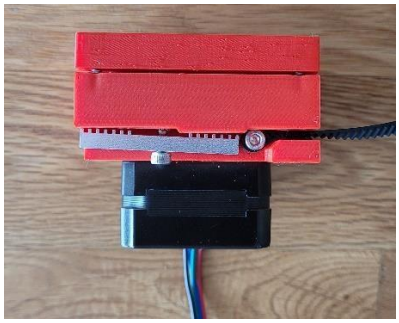
x10-



- Place the GT2 Pulley on the NEMA17 Stepper Motor so that the bottom edg the Pulley is 7mm away from the motc
- Screw the pulley with the two grub scr sitting in the pulley.
- Place the NEMA17 Stepper Motor in tl component and align it so that the connector for the cable is as shown. Sc the motor in place with four M3x6 scr
- Connect the motor cable to the motor
- The LM8LUU linear bearing 2x with 4 v of insulating tape each (total diameter of linear bearing and insulating tape = 16mm) and place in t socket of the corner part.
- The `Clamp Y-Carriage Clamp.` on the linear bearing and screw it on v four M3 screws.
- Prepare a 190cm long piece of GT2 tim belt.
- Wrap one end of the timing belt aroun M3x10 screw (teeth of the timing belt the inside).
- Screw the M3x10 screw into the Y-carr and insert the timing belt through the Lead the notch outwards. The end of the timing belt must not protrude beyond the part.
- Loosely screw on the GT2 aluminium c with an M3x10 screw.



Y-Carriage 2-Right.stl;
Y-Carriage Clamp.stl



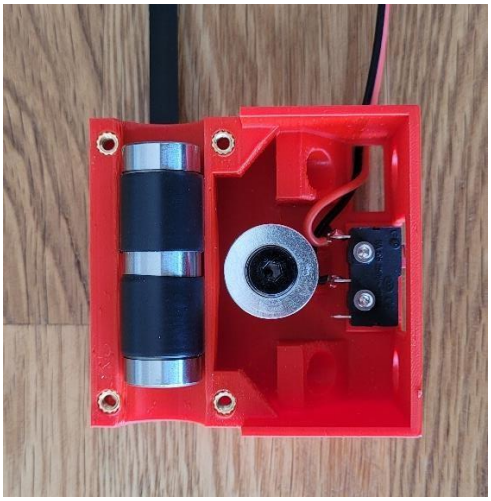
Number Component	
1	Y-Slide 1-Links.stl
1	GT 2 Idler
1	Metal screws, M5x25, ultra flat head
1	Washer 5x15mm
2	Metal screws, M2.5x10
1	Limit Switch, ZW12-B
1	Y-Carriage Clamp.stl
1	Linearlager 8mm, LM8LUU
	Insulating tape
4	Metal screws, M3x10
1	GT2 Aluminum Clamp
2	Metal screws, M3x10
1	GT2 Timing Belt, 190cm

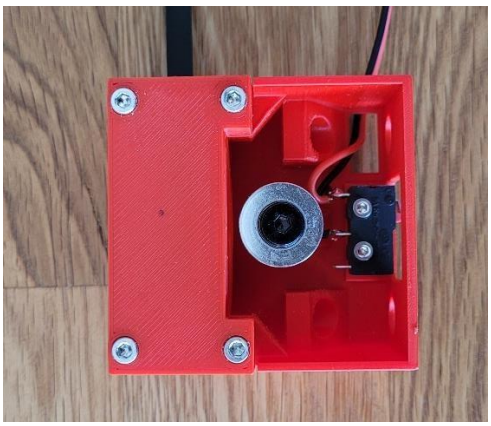
ared

o that the

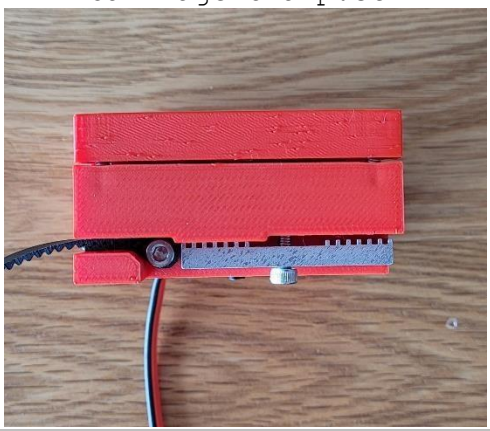
on

-





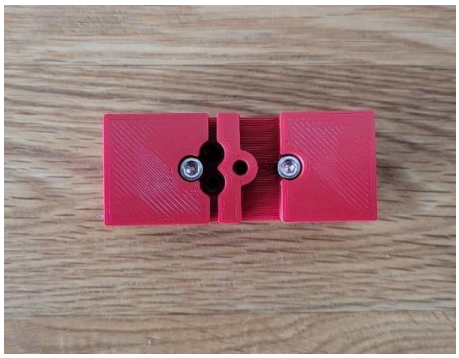
Y-Slide 1-Links.stl; Y-Carriage Clamp.stl

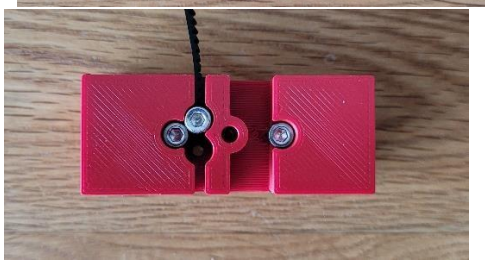


- Screw the GT2 Idler into the Y-slide with t M5 screw and a washer.
- The one described in chapter "5.1 - Solde components"
  Limit Switch with the two M2.5 screws int provided opening screw lever of the switch protrudes outwards.
- Insert the Limit Switch cable through the opening to the outside.
- The LM8LUU Linear Bearing 2x with 4 wra each
  Insulating tape (total diameter of linear bearing and insulating tape = 16mm) and in the socket of the corner part.
- Set the clamp `Y-slide clamp.stl` t linear bearing and screw it on with four M3x10 screws.

- Prepare a 190cm long piece of GT2 timing belt.
- Wrap one end of the timing belt around t M3x10 screw (teeth of the timing belt on inside).
- Screw the M3x10 screw into the Y-carriag and guide the timing belt outwards throu the notch. The end of the timing belt mus not protrude beyond the part.
- Loosely screw on the GT2 aluminium clam with an M3x10 screw.

Number	Component
1	X-Carriage Clamp.stl
1	X-Schlitten.stl
2	Linearlager 8mm, LM8LUU
2	Metal screws, M3x20
	Insulating tape
1	GT2 Timing Belt, 120cm
1	Metal screw, M3x20





`X-Carriage Clamp.stl;`
`X-Schlitten.stl`

- The two LM8UU linear bearings each wrap 1x insulating tape.
- Place the bearings in the socket of the X-Schlitte clamp.
- Put the X-slide on the clamp, attach two M3x20 screws slightly

Attention:
Screw the clamp only so tightly that it fits well, but the parts do not bend!

- At one end of the timing belt, a Loop with the teeth inwards b Screw an M3x20 screw through the loop and the timing belt, while the timing belt is guided outwards.
  Screw the screw flush to the component surface. It must not be prominent
- Pinch off any excess small end of the tooth with the side cutters.

`bracing.stl`

Number Component	
4	`bracing.stl`
8	Metal screws, M5x25, external hexagon

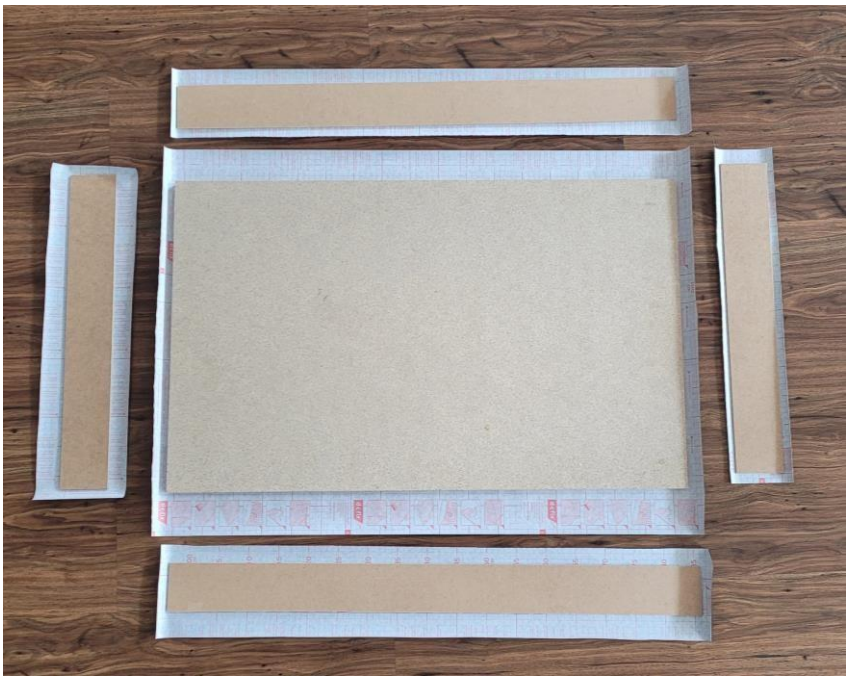
- Place two M5 screws in each of the four struts.
  Tip:
  With an M5 nut on the opposite side, t screws can be pulled in/screwed into t holes well.

9 Wood and metal processing

9.1 The foil plea

Number	Component
1	Particleboard, 884x544x12mm, raw
2	Wood panels, MDF, 80x550x3mm, raw
2	Wood panels, MDF, 80x893x3mm, raw
1	Klebefolie d-c-fix, Blackwood, 67.5x200 cm

1. Cut the d-c-fix adhesive film into the following pieces:
   - For the chipboard: 1 piece à 100cm x 67.5cm
   - For the long MDF wood panels: 2 pieces of 100cm x 12cm each
   - For the short MDF wood panels: 2 pieces à 60cm x 12cm



2. Cover the chipboard and all MDF boards with the adhesive foil on one side: cut out corners. Fold the overlapping pieces over the edges. Use a spatula or cloth to smooth out the foil.

9.2 Prepare intermediate plate

Number	Component
1	Particleboard, 884x544x12mm, raw
2	Kabelkanal.stl
1	Controller Box-Rahmen.stl
4	Wood screws, 3x12, countersunk head

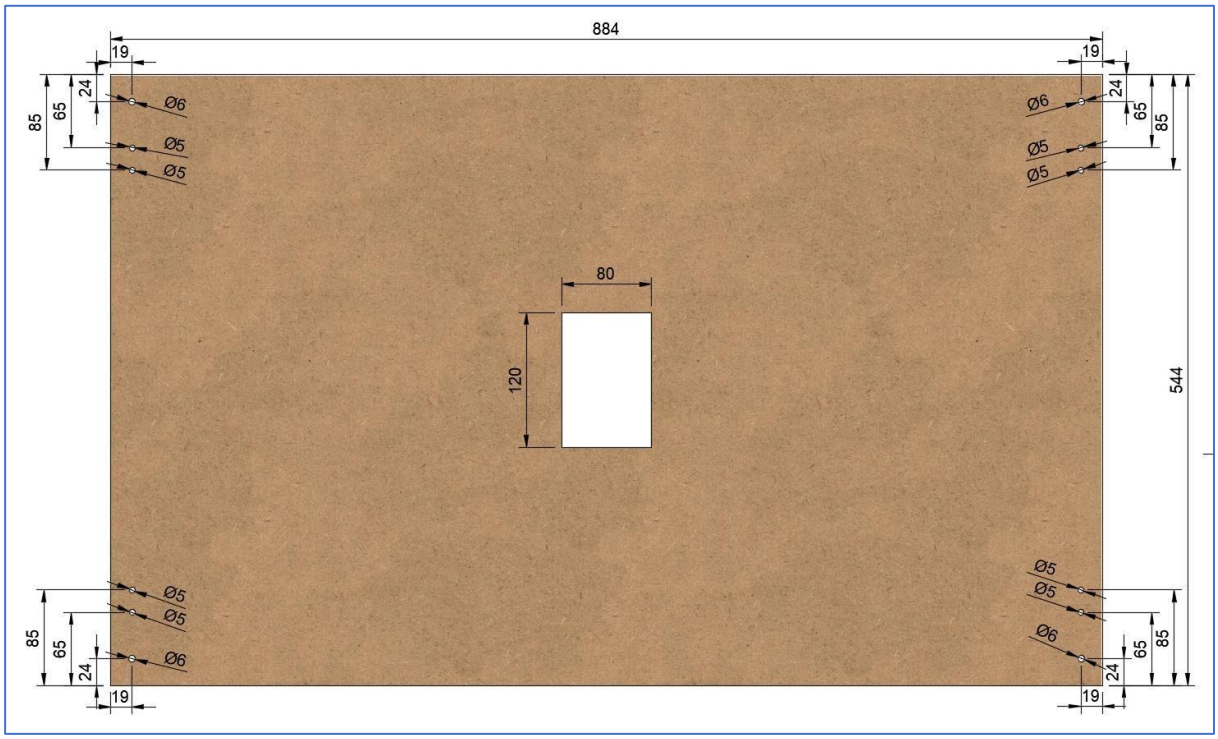
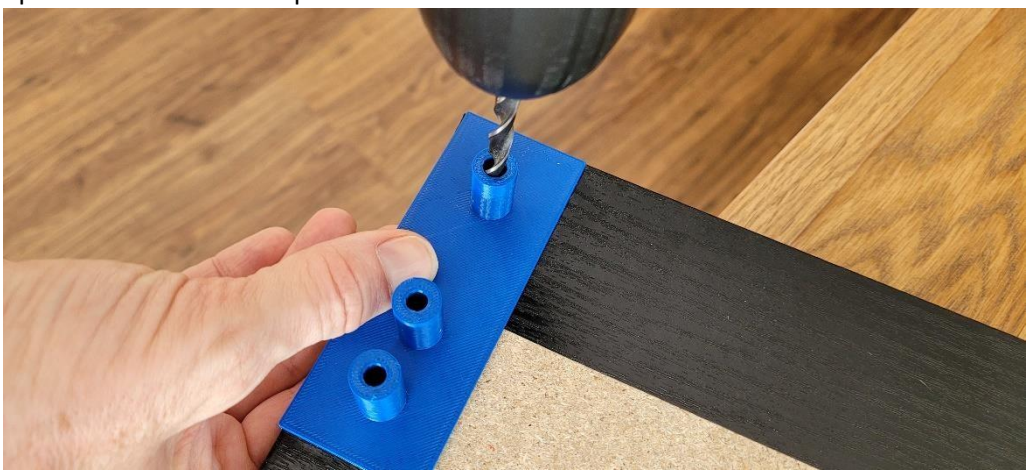


Figure 6: Locations of the holes and the cable duct in the intermediate plate.

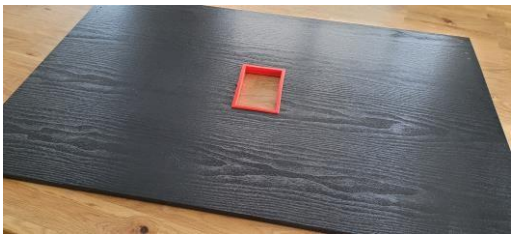
1. Drill four holes with a diameter of 6mm and eight holes with a diameter of 5mm in the positions shown in the plate.



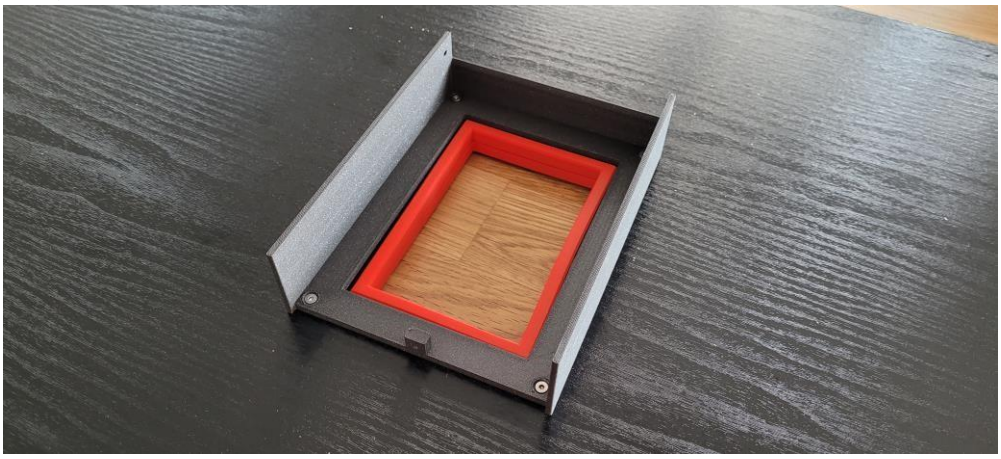
To make it easier for you to drill the holes in the correct positions, you can use the 3D Printed Tool `Drilling Template Intermediate Plate.stl` *use. Set up the Stencil exactly at the edges of the chipboard, then you can drill directly through the recesses of the drilling template and thus automatically have the holes in the right place.*

2. Approximately in the middle of the plate, use the jigsaw to saw out a full cut-out with the dimensions 80x120mm. Note the orientation of the cutout according to Figure 6.

3. Place the two 3D printed components `Kabelkanal.stl` in the recess of the intermediate plate. One on the raw side, the other on the foil side. If the parts don't hold on their own, glue the parts in.

4. Place the 3D printed component `Controller Box-Frame.stl` around the glued-in cable duct **on the foil side** of the plate. Screw it tight (wood screws, 3x12mm, countersunk head).



9.3 Prepare the cover

Number	Component
2	Wood panels, MDF, 80x550x3mm
2	Wooden panels, MDF, 80x893x3mm

1. Create two holes with a diameter of 5mm per MDF wood panel. Place the holes according to the illustrations below.

Note the different lateral distances:
30mm for the shorter ones and 25mm for the longer ones.

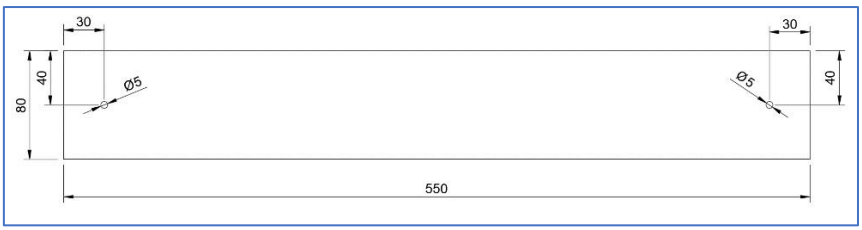


Figure 7: Size and positions of the holes in the two smaller MDF boards

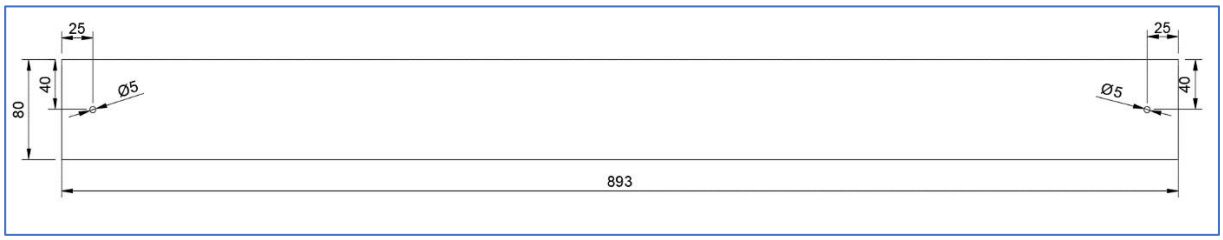


Figure 8: Size and positions of the holes in the two larger MDF panels

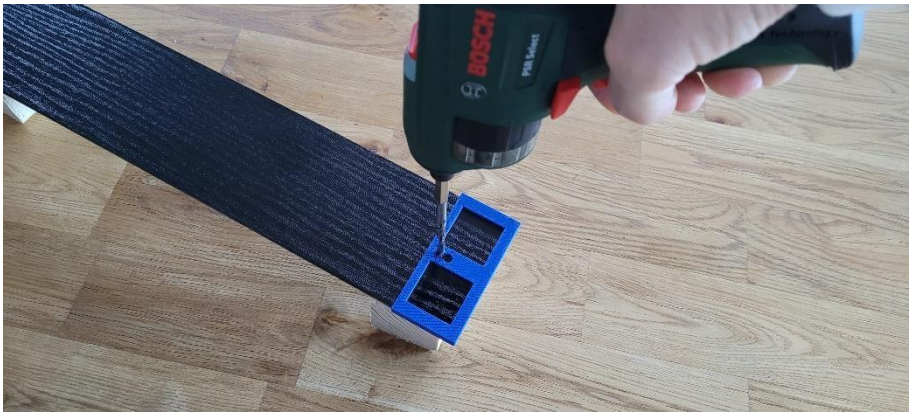


Figure 9: Attaching Drill Holes with the Drilling Template

To make it easier for you to drill the holes in the correct positions, you can use the 3D printed tool `Drilling Template Cover.stl` *. Align the template exactly with the edges of the MDF boards, then you can drill directly through the recesses of the drilling template and thus automatically have the holes in the right place.*

9.4 Editing the table top

YouTube SCAN ME

To clarify, watch the video tutorial on how to create a full clip on the BINGOBRICKS channel.

2. Unpack the large tabletop of the IKEA Lacquer coffee table and put the other parts aside for the time being.

Number	Component
1	IKEA Lacquer, coffee table, 90x55, black-brown

3. Use the jigsaw to saw a full cut-out with the dimensions 770mm x 420mm into the upper wall of the tabletop.

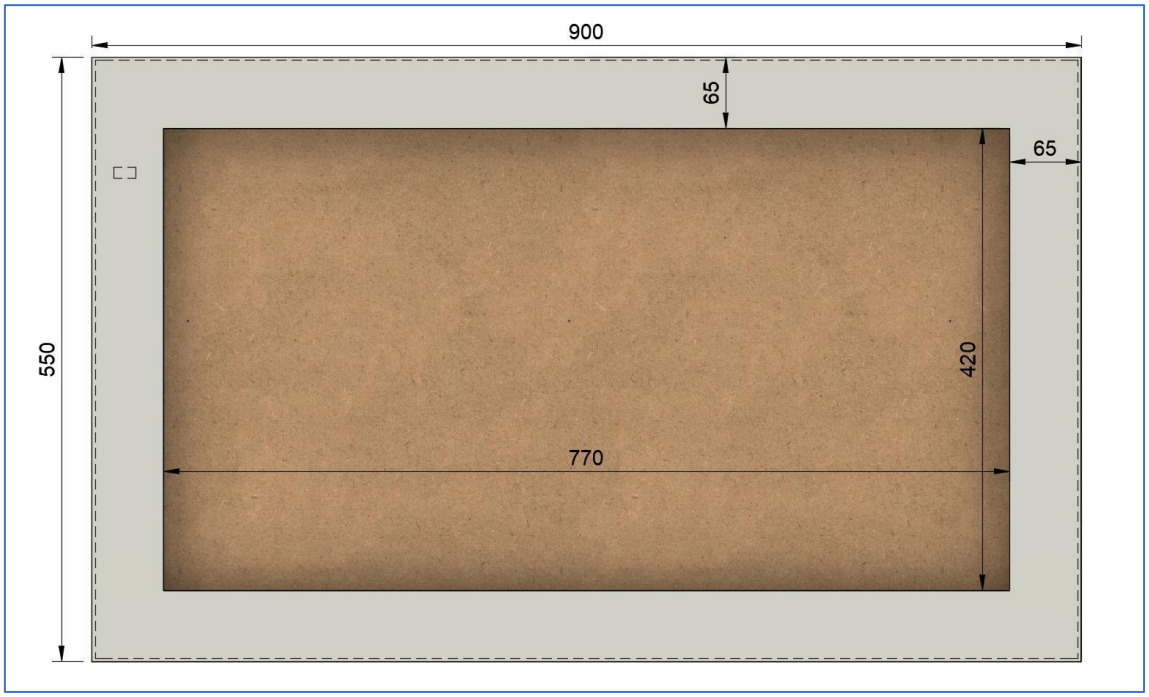
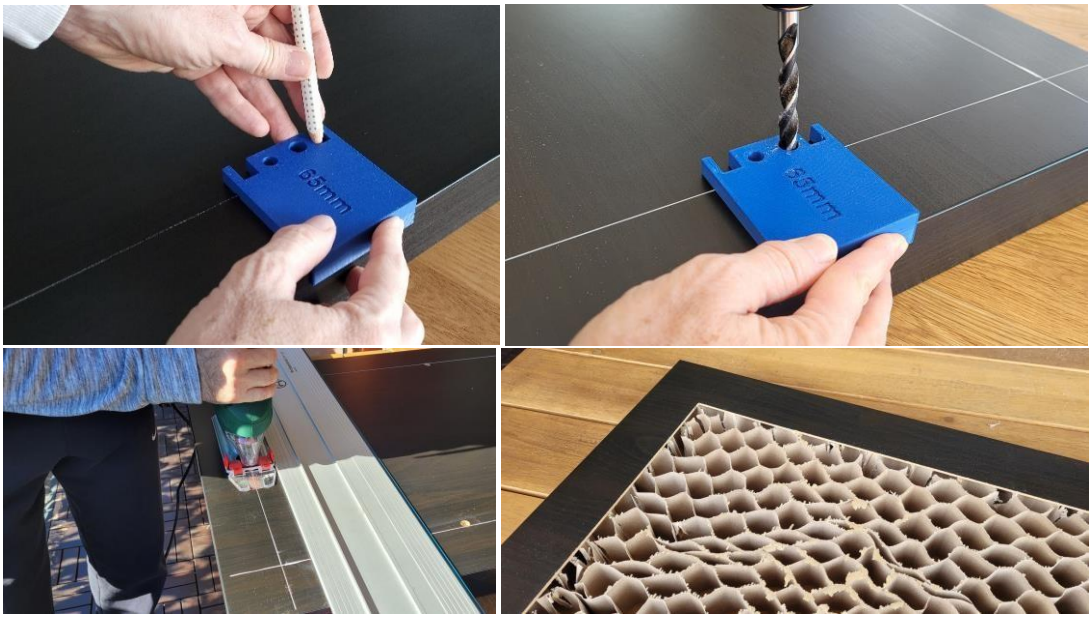


Figure 10: Full cut-out in the ceiling wall of the tabletop (view: above)

The cut-out must correspond to the specified size to the millimetre, be absolutely right-angled and lie exactly in the middle of the tabletop. See also the explanations in chapter "10.2 - Intermezzo: Ordering the glass plate".



In order to facilitate the marking of the cutting line and to remove the holes for the insertion of the
jigsaw, you can use the 3D printed tool
`Drilling TemplateRulerFull-Cutting.stl` *use.*

4. Remove the cardboard honeycomb pattern that appears in the tabletop.

Figure 11: Damaged cut edge and repair with d-c-fix adhesive film

If the IKEA table was damaged when sawing out the full cutout, you can use the Save the table at a suitable time with the residual material of the d-c-fix adhesive film from chapter "9.1 - Attaching foils". To do this, tape the entire cut surface of the full cutout with the adhesive foil so that there is a nice 5mm wide frame around the cutout.

5. Sand the bottom of the table a little with coarse sandpaper so that no cardboard scraps stick to the bottom and the floor is as free as possible of unevenness. A few flat glue residues may remain, they will not bother you.

6. Turn the tabletop over so that the bottom wall of the tabletop is facing up. Saw or drill a hole with the approximate dimensions of 20x10mm in the base wall of the tabletop at the position indicated in the illustration.

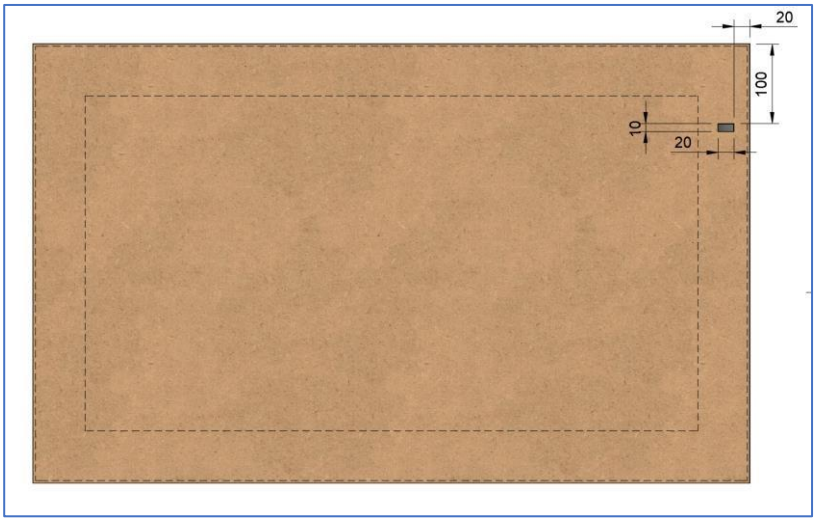


Illustration12: Cable grommet for LED -Cable

The LED cable will later pass through this recess. The size and shape of the recess is not so important, as long as the connector of the LED strip fits through it. However, the position of the hole is important, as the LED cable can later only be led through this gap of 10mm past all other parts into the technical substructure.

7. Lay out the squared timbers (rectangular strips) and glue.

Number	Component
2	Squared timber, spruce, 44x44x670mm
2	Squared timber, spruce, 44x44x330mm

8. Glue the four squared timbers into the tabletop to the respective inner outer walls according to the following illustration.

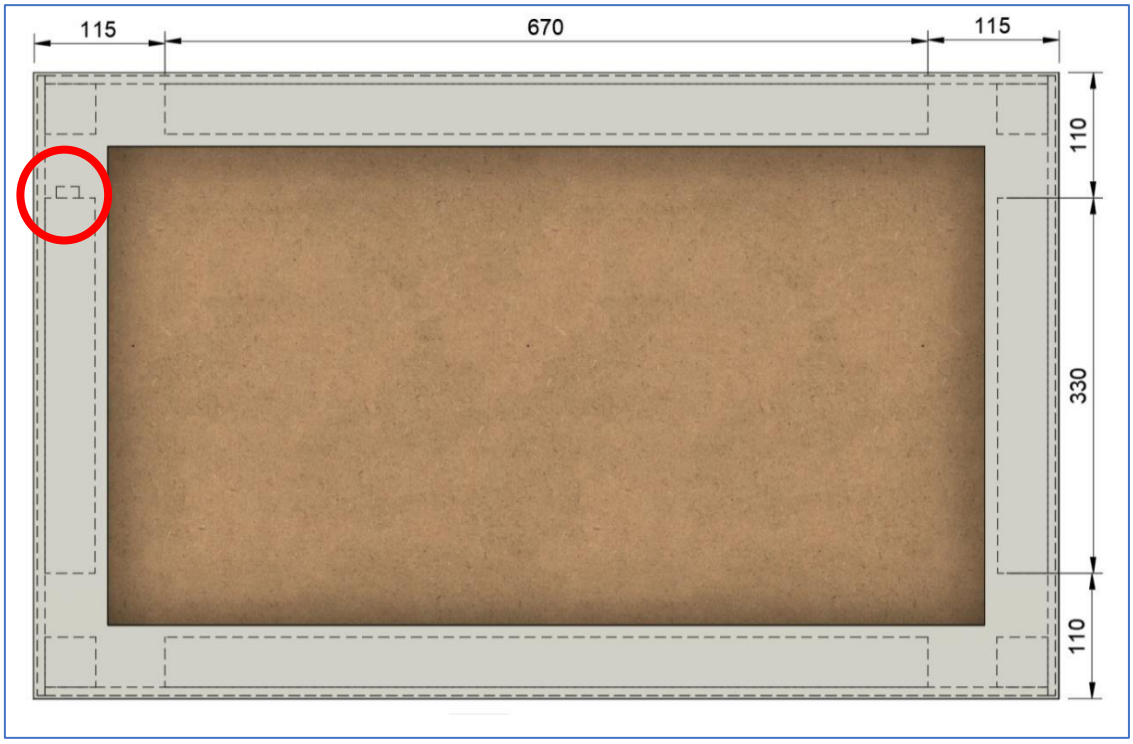


Figure 13: Position of the rectangular strips.
The cable duct, marked here by the red circle, must remain free!

The squared timbers should be glued approximately in the middle of the respective sides of the table. A few millimeters more to the left or right are tolerable. However, make sure that the squared timber does not cover the recess for the LED cable! (see circles in illustrations)

Illustration14: Recess for LED cable

9. Have the two foam rubber mats ready.

Number	Component
2	Foam rubber mats, 25x100cm, 3mm thickness, white or black
	Strong thin tape, e.g. gaffer tape

10. Cut a piece of the two foam rubber mats with the dimensions 790x220mm.
    Glue the mats together with strong tape (e.g. gaffer tape) so that this results in a mat with the dimensions 790 x 440mm.

Place the mat in the inner floor wall and make sure that everything is nice and flat. *The mat is used to dampen scratching noises from the sand.*

Figure 15: Covering the floor with foam rubber mat for noise insulation

9.5 Preparing table legs

Number	Component
	Table legs, metal struts and screws from the IKEA LACQUER set
4	`Table leg cover.stl`

1. Use the saw to shorten the four table legs of the LACK table to 310mm.

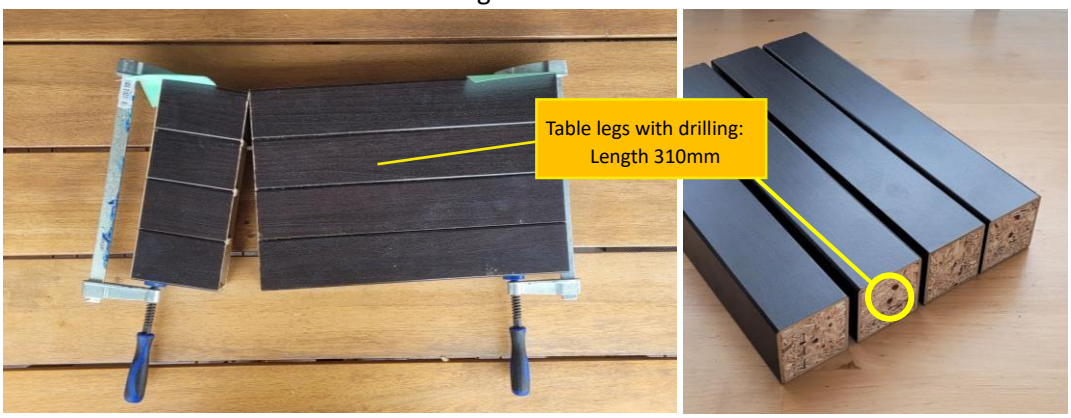


Illustration16: Shorten table legs

One side of each table leg has a hole, the other side has none Drilling. You absolutely have to shorten the table leg so that ***the part with Drilling*** *has a length of 310mm.*

2. Screw the four original IKEA metal struts into the table legs using the IKEA template. Use the original screws from the LACK package for this.

Illustration17: IKEA metal struts screw on

3. Glue a 3D printed component `Table Leg Cover.stl` into the open ends of each table legs.

Figure 18: Cover the table leg opening with a printed component.

If the table legs are of different lengths, the table will wobble later. In this case, you could adjust the file `Table Leg Cover.step` with a 3D CAD program and adjust the different lengths of the table legs again.

9.6 Shorten LED profile strips

Number	Component
1	LED Profile LP7, 2 meters

1. Saw the LED profile with the hacksaw into four parts: 2x 670mm and 2x 330mm.

2. Deburr the resulting edges on the cut surfaces with a metal file.

10 Assembly

10.1 Montage der LED-Profile

Number	Component
12	`LED Profile HolderStandard.stl`
2	`LED Profile HolderCornerShort1.stl`
2	`LED Profile HolderCornerShort2.stl`
2	`LED Profile HolderCornerLong1.stl`
2	`LED Profile HolderCornerLang2.stl`
20	Wood screws, 3x12, countersunk head

1. Use the 3x12 wood screws to screw all the LED profile holders to the squared timbers glued into the table frame. All standard parts go to the sides, all corner parts to the corners of the table frame. The long corner parts go to the long side, the short corner parts to the short side of the table.

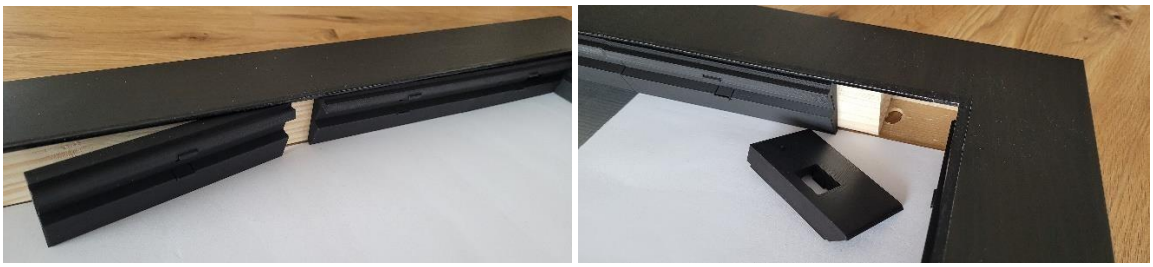


Figure 19: Screw on the LED profile strips.

First place all parts in the appropriate places before screwing them on. In particular, make sure that the two corner parts of a corner do not get in each other's way. Also make sure that there is no offset when screwing on the parts, because the groove must be at the same height for the LED profiles. Take a profile panel (`LED ProfileAperture-CornerLang1.stl`*) to align the parts with each other.*
You should not screw on the part that comes in the place of the cable grommet yet. This makes it easier for you to pull the cable through the cable grommet later.

2. Glue the four LED strips into the four LED profiles of the appropriate length. The LED strips should protrude slightly above the LED profiles so that the LED connectors can be connected. Slide the diffusers over the profiles.

3. Insert the four LED profiles into the LED profile brackets. Make sure that you insert them in the middle of each one. Stow excess cable from the LED connectors in the holes of the LED profile holders.

Once the long LED profiles are completely in the holders, they are very difficult to move or remove. So make sure that you press them into the middle of the brackets when inserting them so that the profile panels fit to the left and right of the brackets later.

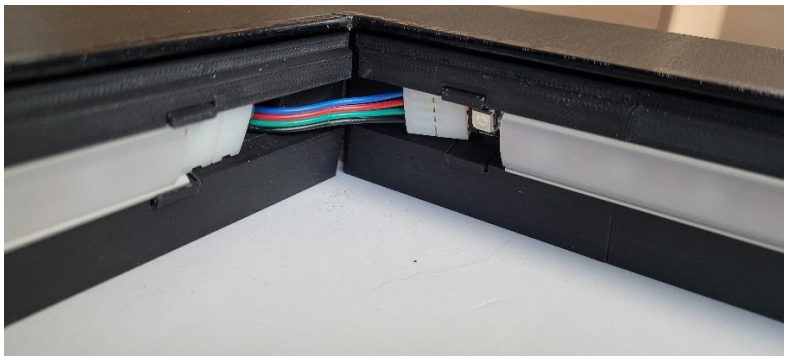


Figure 20: LED profiles used with LED connectors

Run the LED cable through the profile bracket in the corner, which is not yet attached, as well as through the hole for the cable grommet in the table. Now you can also screw on this last profile bracket.

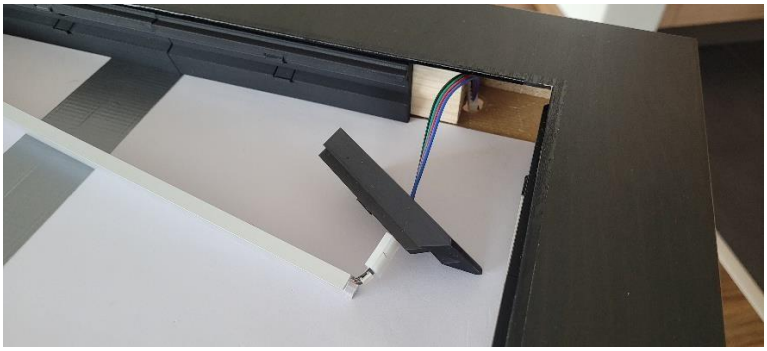


Figure 21: Passing the LED cable through the lower table wall

4. Insert the LED profile panels in the corner areas so that they cover the connecting cables.

Number	Component
2	LED ProfileAperture CornerShort1.stl
2	LED ProfileAperture CornerShort2.stl
2	LED ProfileBezel-CornerLong1.stl
2	LED ProfileBezel-CornerLang2.stl

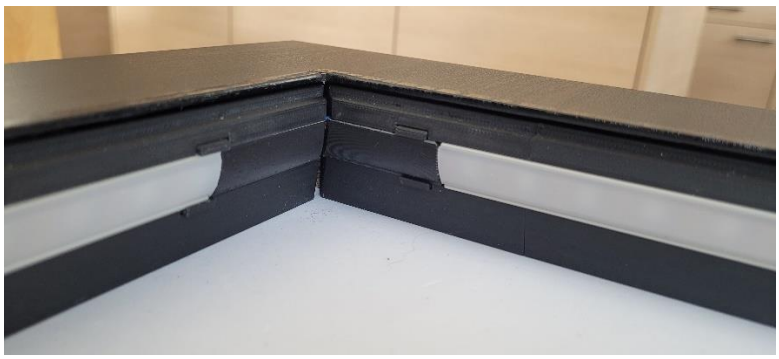


Figure 22: LED profile panels used

The panels can be easily clamped in place and do not need to be attached any further. Again, use the lengths of the profile panels as a guide: the longer ones fit the long side of the table, the shorter ones the short side. Stow excess cable in the table frame by pushing the cables through the recesses of the LED profile brackets.

10.2 Intermezzo: Ordering the glass top

Now it's time to order the customized glass top. A glass plate is guaranteed to be manufactured by your glass supplier at right angles and usually with a cutting tolerance of +/- 1 millimeter. You, however, probably won't see the full cut-out made with the jigsaw exactly at right angles and almost certainly not
with millimetre precision according to the instructions in this manual. *(If I underestimate your abilities, I apologize).* That's why you now need to find out the exact dimensions of the glass top that fits your specific table. I suggest the following procedure, which has proven itself in my case:

1. Measure the exact dimensions of the full cutout in the tabletop. Check that the lengths and widths of the full neckline are the same everywhere. If not, use the smallest measured measurement of length and width as a guide for the next steps.

2. Subtract 1mm from both lengths (length and width) to compensate for the cutting tolerance.

3. If you feel that further corrections are necessary due to an inaccurate cutout, reduce the length and width measurement by further millimeters.

4. Have a cheap wooden board (z.B. MDF board) in at least 5mm thickness cut to size by the hardware store in the calculated length and width dimensions.
   Of course, you can also saw such a plate yourself. But then you should be absolutely sure that you can cut the plate at right angles.

5. Place the wooden plate in the table top in the sense of a glass dummy. Check them for fit. Correct the order mass if necessary.

6. As soon as you are sure what dimensions the glass plate must have, you can now place the corresponding order with the glass supplier. I recommend ordering toughened safety glass (ESG) with hemmed edges .

   Don't forget to include the cutting tolerance in the measurements!

10.3 Assembly of the substructure

Now let's put the IKEA table together. Instead of the original table top, however, we use the tailor-made chipboard.

Number	Component
1	`Controller Box-Boden.stl` (with mounted electronics)
2	Metal screws, M3x10, black, ultra-flat head
1	Metal screws, M3x6
1	Particleboard, 884x544x12mm, raw
4	Metal screws, M6x50, flat head
4	Washers, M6x18x1.5
	Storage plate, metal struts and screws from the IKEA LACQUER set
4	`bracing.stl`
4	Wood screws, 3x12, countersunk head

1. Prepare the pre-assembled electronics in the bottom of the controller box for assembly:

- Disconnect all motor cables from the controller
- Disconnect all cables for the limit switches from the controller
- Disconnect the LED strips from the DC Power Jack cable
- Disconnect the power and USB cables from the controller

2. Screw the bottom of the controller box into the already mounted `Controller BoxFrame.stl` on the chipboard. To do this, place two M3x10 ultra-flat head screws as an axle in the side holes of the frame and screw them into the controller box bottom.
   The box should thus be able to be opened and closed as a flap. Close the flap of the controller box and lock it in place by screwing an M3x6 screw into the front panel.

Figure 23: Assembly of the Controller Box

3. Attach the four table legs to the chipboard. Use the four M6x50 screws with the M6x18 washers. Rotate the table legs so that the metal struts of the table legs are facing inwards so that they can support the IKEA shelf in the next step.

4. Now place the original IKEA storage plate on the metal struts and screw them firmly with the original IKEA screws.

5. Insert the 3D printed strut parts from below into the prepared holes of the chipboard. Screw the struts into the table legs with a 3x12 wood screw each.

10.4 Mounting the X-axis

Number	Component
1	`Y-Slide 1-Links.stl`
1	`Y-Carriage 2-Right.stl`
1	`X-Schlitten.stl`
2	Linear rods cylindrical, 8mm, 500mm
1	Metal screw, M3x20
1	Neodymium disc magnet with hole Ø25x7 mm
1	Neodymium disc magnet, Ø25x5 mm
1	Metal screw, M4x14, countersunk head

1. Insert the two 500mm long linear rods into the `Y-slide 1Links.stl`. Push the rods all the way into the component.

2. Now very carefully slide the component `X-Slide.stl` onto the two linear rods. Make sure that the component is correctly aligned according to "Figure 24": The X-motor is on the right side and the X-carriage is slid up so that the two ends of the timing belt are up.

3. Insert the `Y-slide 2-right.stl component` onto the other end of the linear rods.

4. Place the timing belt around the two pulleys and back to the X-slide.

5. Wrap the free end of the timing belt around the M3x20 screw and screw it into the XSchute. Run the timing belt through the notch while screwing the screw flush with the surface of the component.

   Make sure that the timing belt is properly tensioned. The timing belt must not be too loose. Otherwise, you can loosen the four screws of the X-motor, push the motor slightly outwards to tighten the timing belt, and then fix the position of the XMotor again.

6. Check that the X-carriage can be easily moved along the entire length of the X-axis.

7. Check the correct alignment of all components again using "Figure 24". Place the X axis in front of you so that the X motor is on the right. The ends of the timing belt (yellow arrow) must be up.

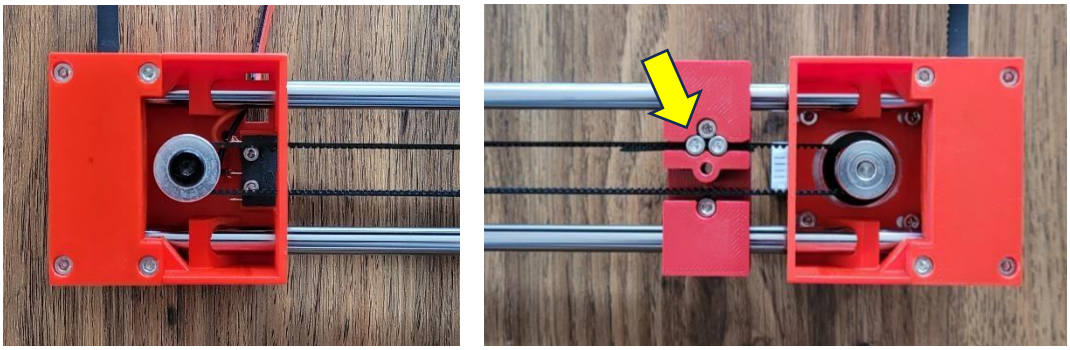


Illustration24: Orientation of the X-Slide

8. Cut off the excess end of the timing belt with the side cutters.

9. Screw the disc magnet onto the X-slide with the help of the M4x14 screw. Place the second disc magnet on top of the first.

The magnets attract each other very strongly. Don't let the magnets jump on each other!

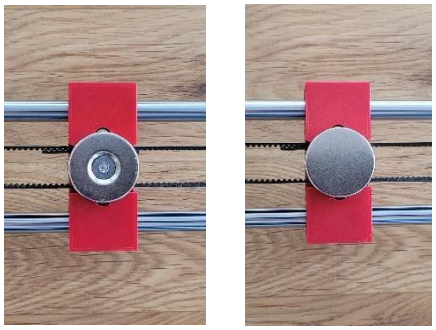


Figure 25: X-slide equipped with magnet

10.5 Montage Y-Achse

Number	Component
	`All four 3D printed corner parts (bottom, top, left, right)`
8	Hexagon Nuts, M5
8	Washers M5x15x1
	(X-axis from previous step)
2	Linear rods cylindrical, 8mm, 800mm
2	`StopCylinder Rod.stl`
2	Metal screws, M3x10

1. Slide the printed corner parts onto the screws of the struts in the respective corners of the intermediate plate. For the correct placement of the corner pieces, refer to "Figure 2: Interior view" at the beginning of this guide.

2. Screw the corner pieces to the struts by tightening them with M5 nuts incl. M5x15 washers.

When screwing the corner parts into place, make sure that they are not at an angle, but nicely aligned parallel to the intermediate plate.

3. Insert one of the 800mm long linear rods into the round opening of the component `corner part 3TopLeft.` Push the rod through the component about to the middle.

4. Insert the other 800mm long linear rod into the round opening of the component `corner part 4TopRight.` Push the rod through the component about to the middle.

5. Carefully **guide the two linear rods** through the linear bearings of the X-axis.

Pay attention to the orientation of the X-axis according to "Figure 2: Interior view" at the beginning of this guide! The X-axis motor must be on the right Y-axis.

6. Push the two 800mm long linear rods into the openings of the two opposite corner parts until they stop (screw).

7. Attach the printed component with an M3x10 screw `Cylinder rod.stl` at the end of the linear rod on component `corner part 3-ObenLinks.stl`

Figure 26: Y-axis lock on the upper left corner part

8. Attach the printed component with an M3x10 screw
   `StopCylinder rod.stl` at the end of the linear rod on component `corner part 4TopRight.stl`

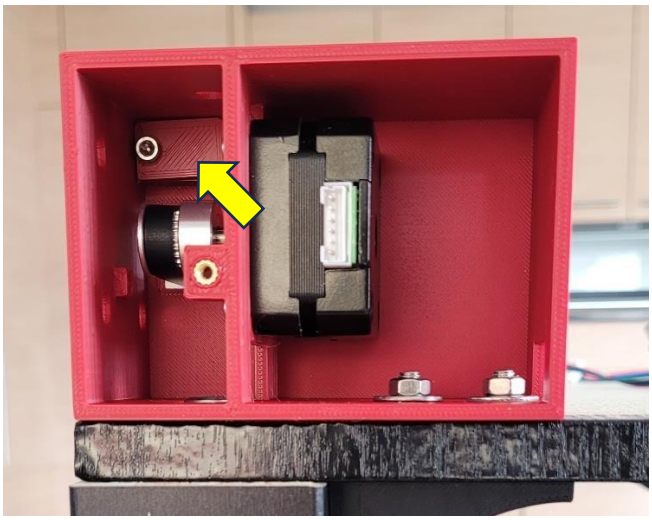


Illustration27: Locking Y -Axis on the corner top right

The two long linear rods of the Y-axes should thus be firmly locked and can no longer be moved.

9. Run the right timing belt of the Y-axis over the pulley of the Y-motor and over the opposite idler back to the Y-slide. Before you can pinch the timing belt, you need to shorten the timing belt to the appropriate length with a side cutter. Then clamp the timing belt and clamp it into the aluminum clamp while tightening the screw of the clamp.

Figure 28: Timing belt attached with aluminum clamp

10. Repeat the previous step with the Y-axis left timing belt.
    Make sure that both timing belts of the Y-axis are sufficiently tensioned.

10.6 Laying the cables

Number	Component
2	`Kabelclips.stl`
2	Wood screws, 3x12, countersunk head

1. Connect all cables except the LED strip to the controller according to the instructions in chapter "7.1 - Connecting the electronic components". Run the cables through the cable channel of the intermediate plate.

Make sure the engines are connected and polarized correctly:
Y1 engine is on the left, Y2 engine is on the right according to "Figure 2: Interior view". Polarity of the connector according to the illustration in chapter "7.1 - Connecting the electronic components"

2. Run the DC Power Jack cable for the LED strips through the cable duct up onto the intermediate plate. Connect the IR receiver of the LED strip to the DC Power Jack cable. *You will only be able to connect the LED strip later, when the tabletop is attached.*

3. Move the IR receiver of the LED strip sideways over the short side of the table under the intermediate plate. Attach the IR receiver with two `cable clips.stl` and 3x12 wood screws.

Figure 29: Mounting the LED IR Receiver with Cable Clips

4. You also have to run the power supply cable for the controller outwards over the short side of the table. You lead this cable to the socket via a table leg. You can attach the cable to the table leg with cable ties or Velcro.

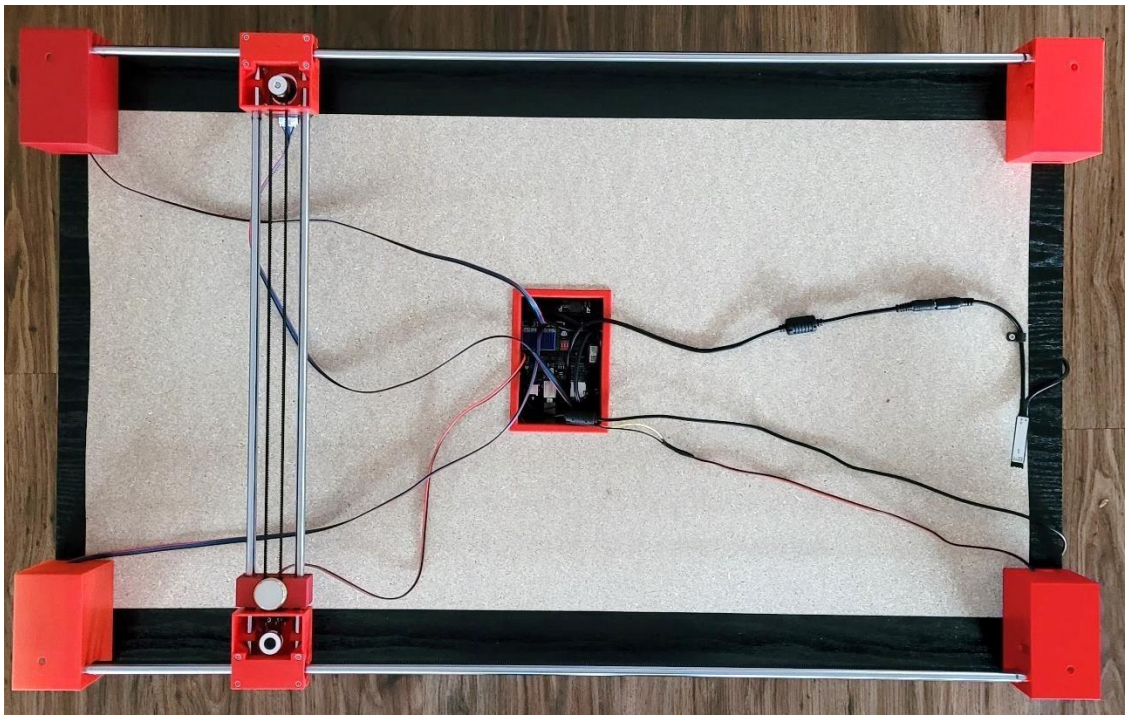


Figure 30: Routing of the cables

10.7 Final assembly

Number	Component
4	Threaded screws, M6x50, hexagon socket
4	Hexagon Nuts, M6
4	Washers, M6x18x1.5
2	Wood panels, MDF, 80x550x3mm
2	Wooden panels, MDF, 80x893x3mm
8	Metal screws, M3x10, black, ultra-flat head
8	Washers, M3x10, black

1. Use an Allen wrench to screw the set screws into the holes pre-drilled by IKEA at the corners below the tabletop. Allow about 1 cm of the threaded pin to protrude.

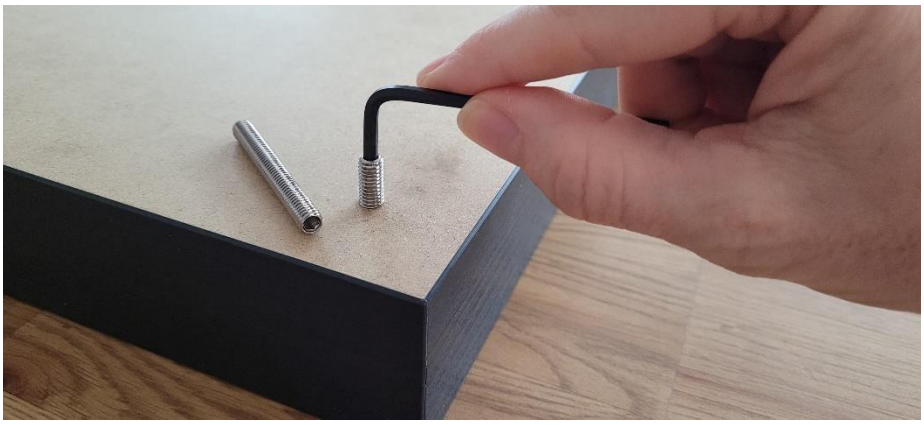


Figure 31: Screwing in the threaded screws with an Allen key

2. Place the tabletop on the four corner pieces. Pass the four threaded screws through the corresponding openings of the corner parts.

3. Screw the tabletop to the corner pieces with four M6 nuts and matching washers.

4. Now connect the LED cable of the tabletop to the DC Power Jack cable provided in accordance with chapter "7.1 - Connecting the electronic components".

5. Screw the four MDF wood panels to the sides of the corner pieces with the help of black M3x10 screws and corresponding black washers.

Figure 32: Fully assembled table

11 Final Test and Deployment

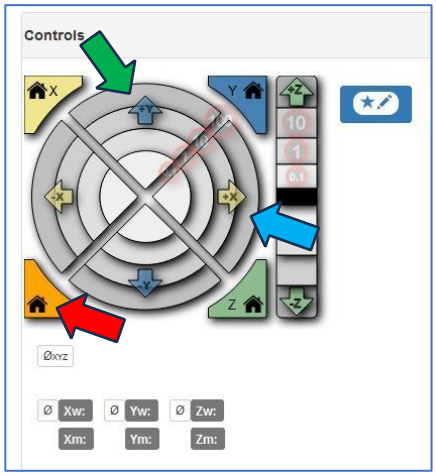
1. Connect the sand painting table to the power supply.

2. Turn on the controller with the on/off toggle switch.

3. Test the LED lighting.

4. Place the ball in the table where the magnet is underneath so that the ball is caught by the magnet.
   I recommend that you do the first function test without sand filling.

5. Connect your smartphone, tablet or PC to the WiFi «FluidNC»:



For the following directions, follow "Figure 2: Interior view".

Perform a homing.
The ball should move to the bottom left corner.

Click on the rightmost ring (X-axis).
The ball should move to the right.

Click on the top outer ring (Y-axis).
The ball should move upwards.

Did it all work out? Then you can now carry out the last two steps to get started:

6. Fill the table with fine-grained sand and spread it evenly.
   If the ball loses contact with the magnet on its way through the sand, reduce the amount of sand.

7. Cover the table with the glass top.
   The suction cup listed in the material list helps you to insert or remove the glass plate.