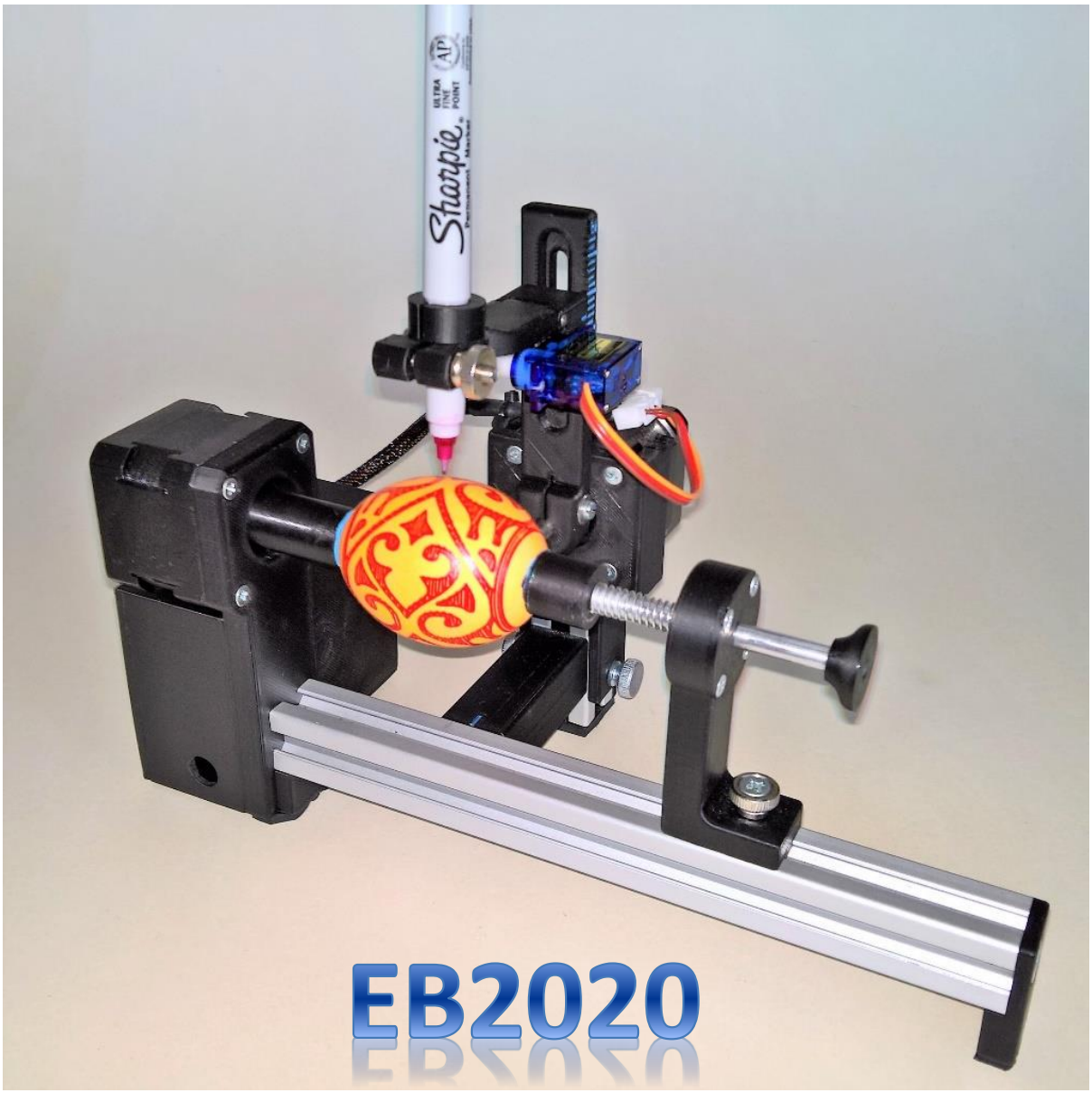


Assembly Instructions

Rev1 – 2023-01-29

Inhalt

Assembly: Mechanics

Materials required:

- Purchased and printed parts and some special tools as described in 'EB2020 BOM.pdf'.

Notes:

- Before producing the printed parts, check the slicer settings and adjust them if necessary so that the printed parts are printed with exact inside and outside dimensions.
- The number indicated in '( )' refers to the part number according to 'EB2020 BOM.pdf'.

1 X-rail

1.1 X-rail right

- Shorten the 20x20 aluminum profile (B05) to 200 mm. Cut an M6 thread on both sides deep enough for the M6 screws (B12).
- On the right side fix the end cap with stand (P01) with a M6 screw (B12). (The black cellular rubber is glued under all feet as an anti-slip in section 2.1).

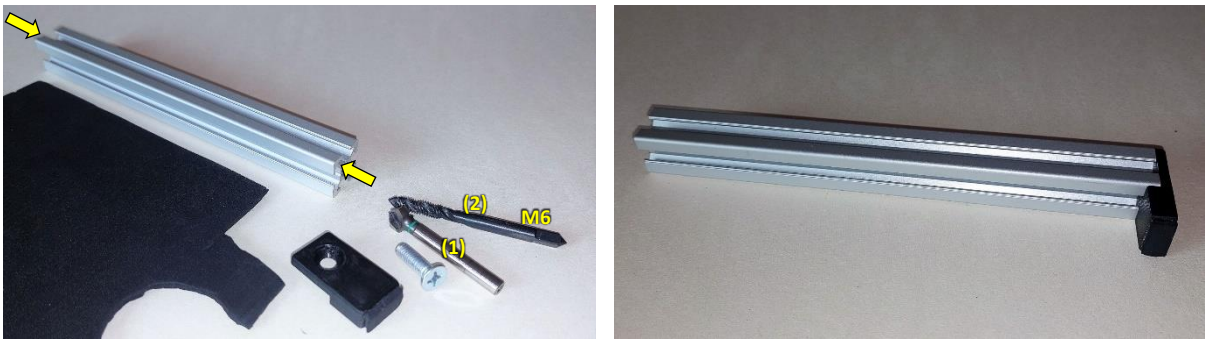


Figure 1: Assembly X-rail right

1.2 Rotation Motor Mount

- Cut two M3 threads in motor mount (P02) (they will be needed later to fasten the electronics housing).
- Fasten Nema 17 motor (B02) with 4 M3 screws (B07) to motor holder (P02).
- Clean the hole of the egg bracket left (P03) with a reamer diameter 5mm (alternatively use a drill). Glue a piece of foam rubber into the egg bracket (e.g. with superglue). Then fix the egg bracket to the motor axis with superglue. Caution: The distance between the egg bracket and the motor mounting plate should be > 20 mm (resp. > 30 mm to the motor flange). If the distance is too small, the pen may touch the motor mounting plate.
- Attach the motor mount to the X-rail (B05) using an M6 screw (B12).

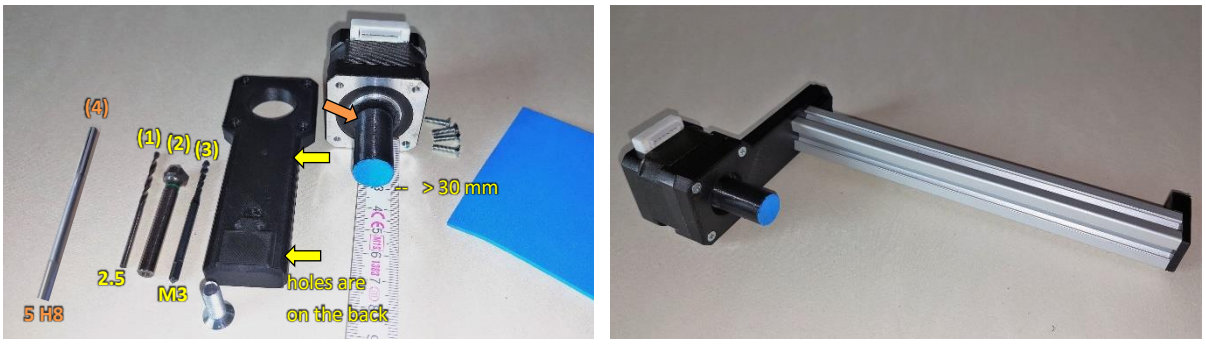


Figure 2: Assembly of X-rail motor mount

1.3 Electronics housing

- Cut M3 threads in the upper 4 holes of the electronics housing (P04) for fastening the cover. Clean the 4 holes at the bottom of the electronics housing with a 2.5mm diameter drill.
- Fasten the electronics housing to the motor mount (P02) with 2 countersunk screws (B07) shortened to M3 x 6mm, aligning it flat to the table.

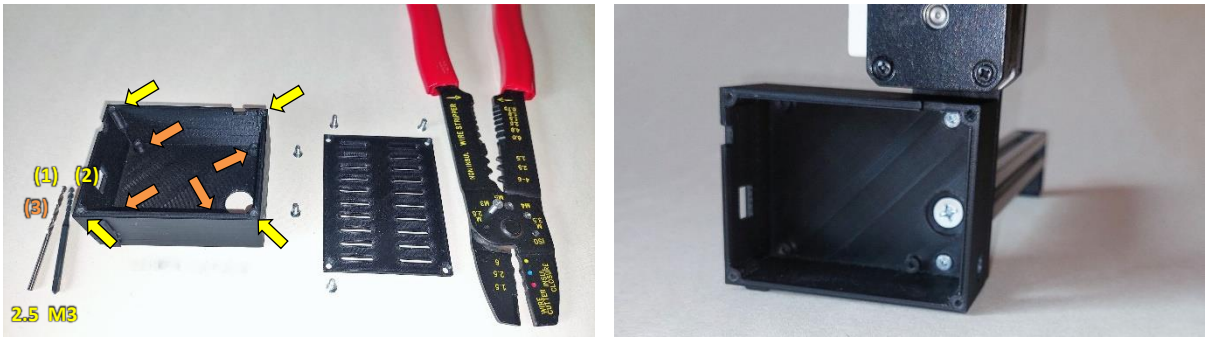


Figure 3: Assembly of X-rail electronics housing

The CNC-Shield is only installed after all work has been completed (wiring, setting the motor current, installing the firmware). For this proceed as follows:

- Slightly screw the CNC-Shield with 4 M3x4mm screws (B06) into the electronics housing.
- Fasten the cover (P05) with 4 countersunk screws (B07) shortened to M3x8mm.

1.4 Tailstock

- Cut four M3 threads in the tailstock (P06).
- Check whether the tailstock cap (P07) fits on the 6mm aluminum rod (B18). If necessary, enlarge the hole using a 6mm reamer (do not use a 6mm drill if possible).
- Shorten 4 M3 countersunk screws (B07) to 8mm.
- Press the bearing (B17) into the tailstock (should jam slightly) and fix the cover cap with the shortened M3 countersunk screws (tighten carefully).

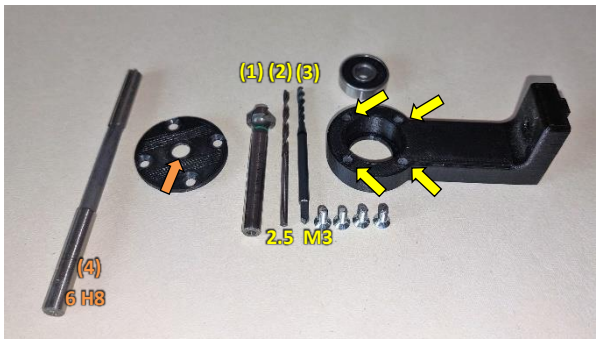


Figure 4: Mounting the tailstock bearing

For the axis with the right egg bracket:

- 1.4.5: Shorten the aluminum round rod (B18) to 70 mm. Cut a M6 thread about 6mm deep on both sides. Remove burrs so that the rod can be pushed through the bearing.
- Cut a M6 thread in the hole of the right egg bracket (P03). Glue a piece of foam rubber (e.g. with superglue) into the egg bracket.

- Then slide the spring (B19) onto the rod and screw on the egg bracket. Slide the rod from the left through the bearing of the tailstock (cover cap of the bearing is on the right).
- Slightly chamfer the holes of the knob (P08) from both sides (e.g. with a 90° countersink) and cut an M6 thread. Then screw the knob onto the right end of the rod.

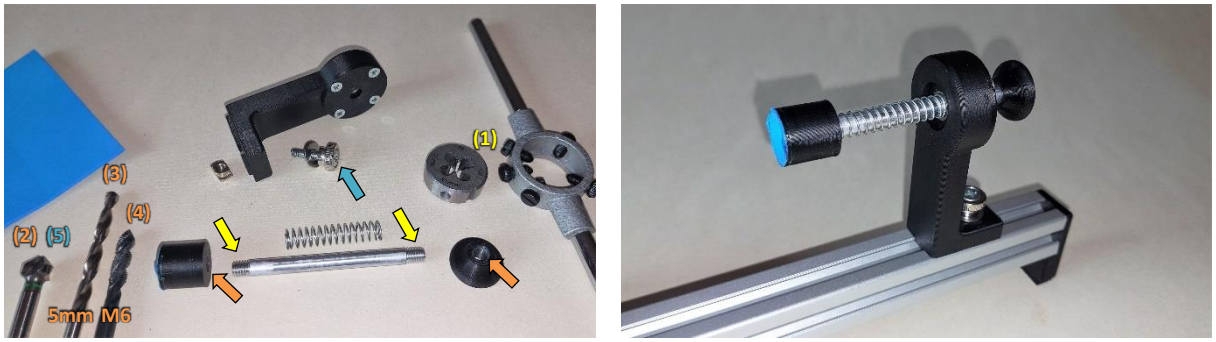


Figure 5: Tailstock assembly

Mounting to X-rail

- 1.4.9: Combine an M4 countersunk screw (B10) and a knurled thumb nut (B22) to form a knurled thumb screw with 13 mm thread length. To do this, countersink the knurled nut strongly from behind with a 90° countersink so that the head of the screw is even with the nut (alternatively, use an M4x16 knurled thumb screw (B25)).
- Insert the knurled thumb screw with washer (B14) into the hole of the tailstock and screw on a hammer nut M4 (B23) from below.
- Place the tailstock on the X-rail and screw in place. In doing so, the hammer nut should rotate 90° in the groove of the profile.

2 Pen Motor Assembly

2.1 Y/Z Axis

- 2.1.1: For the Z-axis, shorten the aluminum profile (B05) to 35 mm.
- Push the Z-cap (P10) on the Z-axis and carefully transfer the hole to the Z-axis with a 4mm diameter drill (spot drill). Then remove the Z-cap and drill through with drill diameter 4.5mm.
- Push the Y-arm (P09) and the Z-cap (P10) onto the Z-axis so that the bore of the Y-arm, profile and Z-cap are in line.
- 2.1.4: Shorten M4 threaded rod (B20) to 93 mm.
- Attach an M4 hammer nut (B23) to one side of the threaded rod using superglue.
- Insert the threaded rod into the Y-arm; use an M4 washer on the side of the Z-cap and screw on the knurled thumb nut (B22, a large knurled thumb nut according to DIN 466 with a diameter of 16 mm and a depth of 10 mm is recommended).
- Place the entire assembly on the X-rod (to the rear) and fasten it. Check that the hammer nut rotates into the groove of the profile.
- 2.1.8: Place the cover (P11) on the top of the Z-axis (the two recesses must be on the right and left, i.e. crosswise to the Y-axis) and fasten it with an M3 countersunk screw (B07) shortened to 8mm.

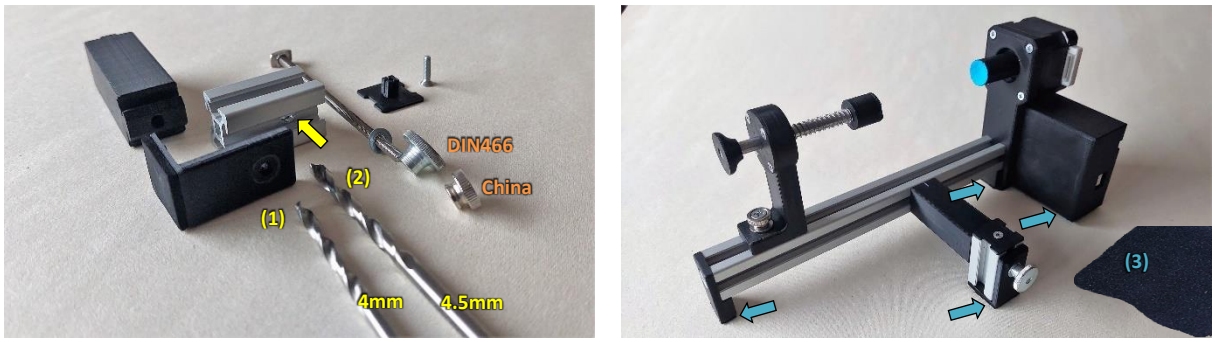


Figure 6: Assembly of the Y/Z axis and anti-slip protection

Finally, glue a piece of foam rubber or cellular rubber under the 3 stands (P01, P02, P10) and the electronics housing (P04) as anti-slip protection.

2.2 Pen Motor Mount

- Check whether the pen motor mount (P12) can be pushed onto a piece of aluminum profile (B05) (rework if necessary).
- Shorten the axis of the motor (B02) to 15 mm (measured from the screw mounting surface).
- Shorten 4 M3 countersunk screws (B07) to 8mm and use them to fasten the motor to the mount.
- Combine two M4x16 countersunk screws (B09) with knurled nuts (B22) to form knurled thumb screws with 8 mm thread length (alternatively use M4x16 knurled thumb screw (B25) and shorten).
- Slide the pen motor assembly from above into the aluminum profile of the Z-axis. Insert a hammer nut on each side and slide it under the mount on each side and fasten it with the knurled thumb screws.

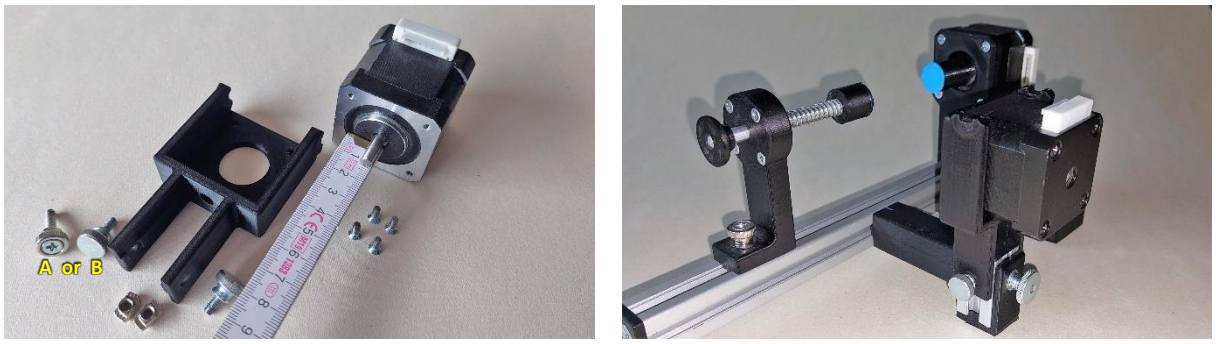


Figure 7: Assembly of Pen Motor Mount

3 Pen Arm Assembly

3.1 Arm for radius

- On the arm (P13), mark the indentations of the scale for the radius setting with light color.
- Insert an M3 nut (B15) into the arm (P13).
- Loosely screw in an M3 x 20 screw (B08) with washer (B13) from the other side.
- Slide the arm onto the motor axis so that the flat side is about 1mm away from the motor mount (arm should be even with the motor axis) and tighten it firmly.

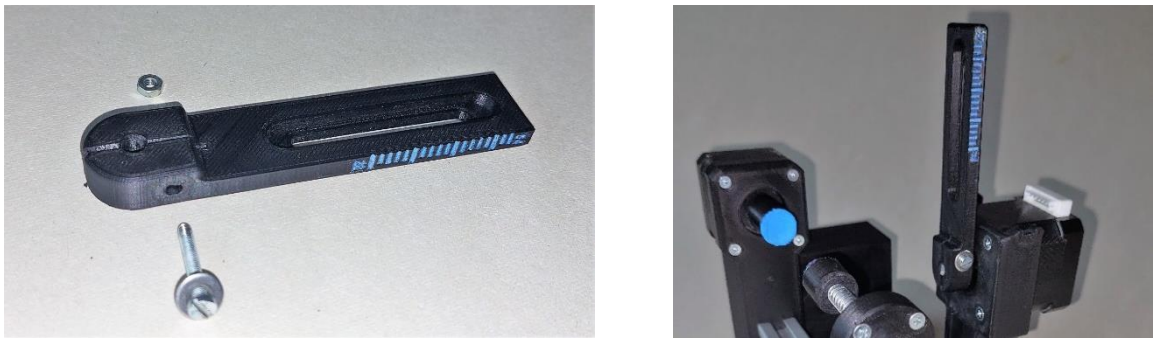


Figure 8: Assembly of the arm

3.2 Stiftarm Gelenk

- Remove the printing support from the pen arm joint (P14) and grind the surface smooth, if necessary. Check whether the component fits into the groove of the arm (P13) and can be moved without too much play. If necessary, rework the part or print again with adjusted printing parameters.
- Highlight the indentation of the marking for the radius adjustment with light color.
- Use a 3 mm H8 reamer to ream the hole for the joint so that the 3 mm cylindrical pin (B24) can easily slide through.

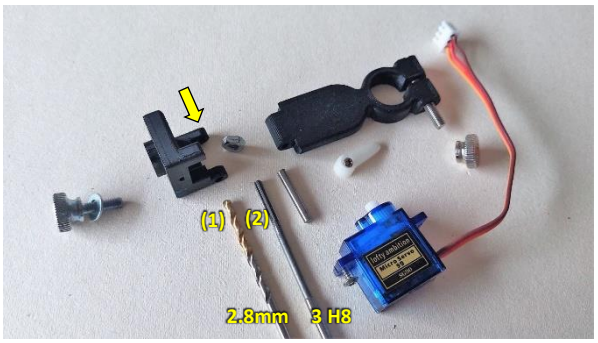


Figure 9: Preparation of the pencil arm joint. Note: The servo (B04) is mounted after the lever has been adjusted (see section 7.2).

3.3 Pen Arm

- Cut an M4 thread in the 3.3 mm hole (front of collet) of the pin arm (P15).
- Screw in M4x25 Allen screw (B11) (tighten only slightly) and fix with superglue.
- Screw on a knurled thumb nut (B22) on the other side.
- For the joint, ream the hole of the pin arm (P15) with a 3 mm H8 reamer so that the 3 mm cylinder pin (B24) can easily be pushed through.
- Connect pin arm and joint (P14) with the 3x20mm cylinder pin (B24). The pin arm should move up and down very easily and not jam. The joint should have no noticeable play, as this would have a negative effect on the quality of the drawing.

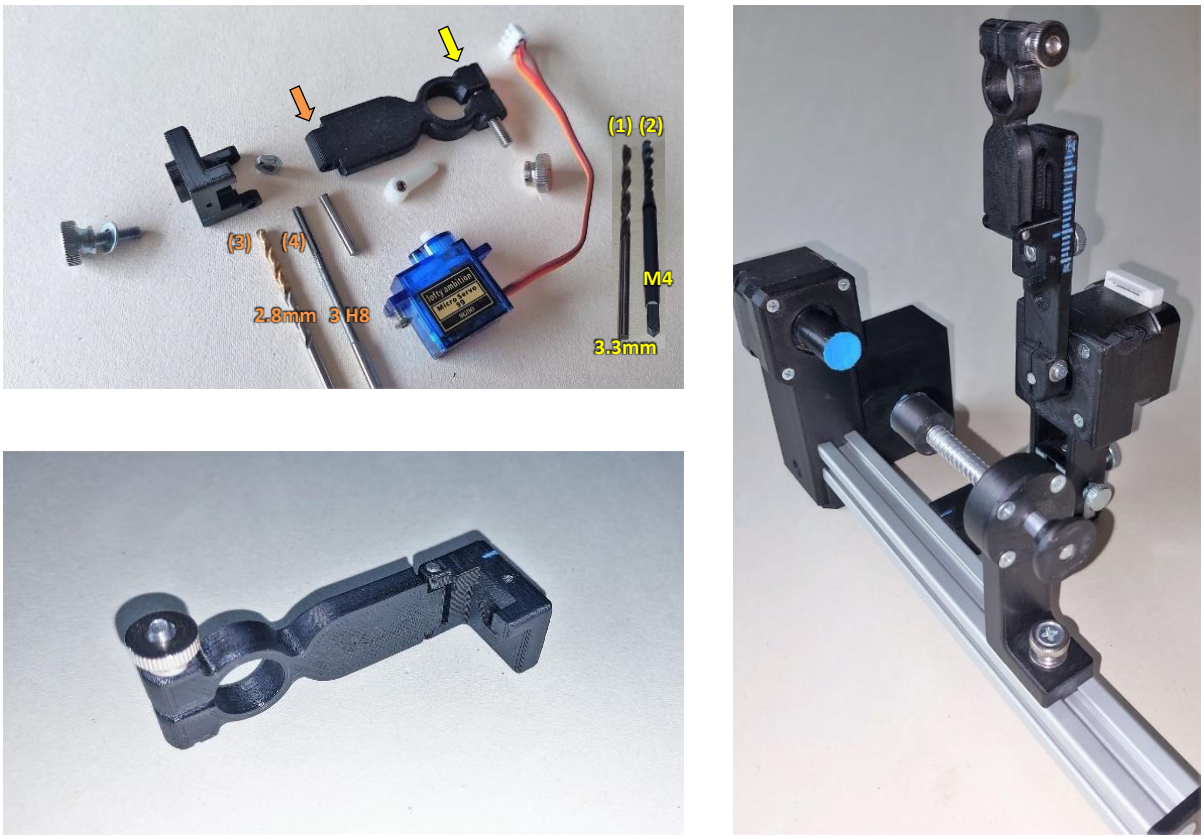


Figure 10: Assembly of the pen arm joint

- Combine an M4 countersunk screw (B10) with a knurled thumb nut (B22) to form a knurled thumb screw with 13 mm thread length.
- Press an M4 nut (B16) into the pin arm joint (should clamp slightly).
- Then attach the assembly to the arm (P13) with the knurled thumb screw and washer (B14)).

Assembly: Electronics

4 PCBs

4.1 Correction of CNC Shield V4+

The PCB contains a design flaw that causes the MS1-MS3 jumpers to not be able to set the microstepping of the A4988 step sticks. MS1-MS3 are always low regardless of the jumper configuration, which causes the A4988 to operate in full step mode.

However, the EB2020 requires 1/16 microstep mode, which is turned on by setting MS1-MS3 high. We achieve this with the following patch:

- All jumpers of positions MS1-MS3 must be removed (danger of short circuit!).
- On the back side solder the wire bridges as shown. This sets the pins MS1, MS2 and MS3 of the A4988 stepper driver to 'High' and activates the 1/16 step mode.
- Set the jumper at position 'Mot-V0T-Sel'. This will drive the motors with the 12V voltage from the power supply.

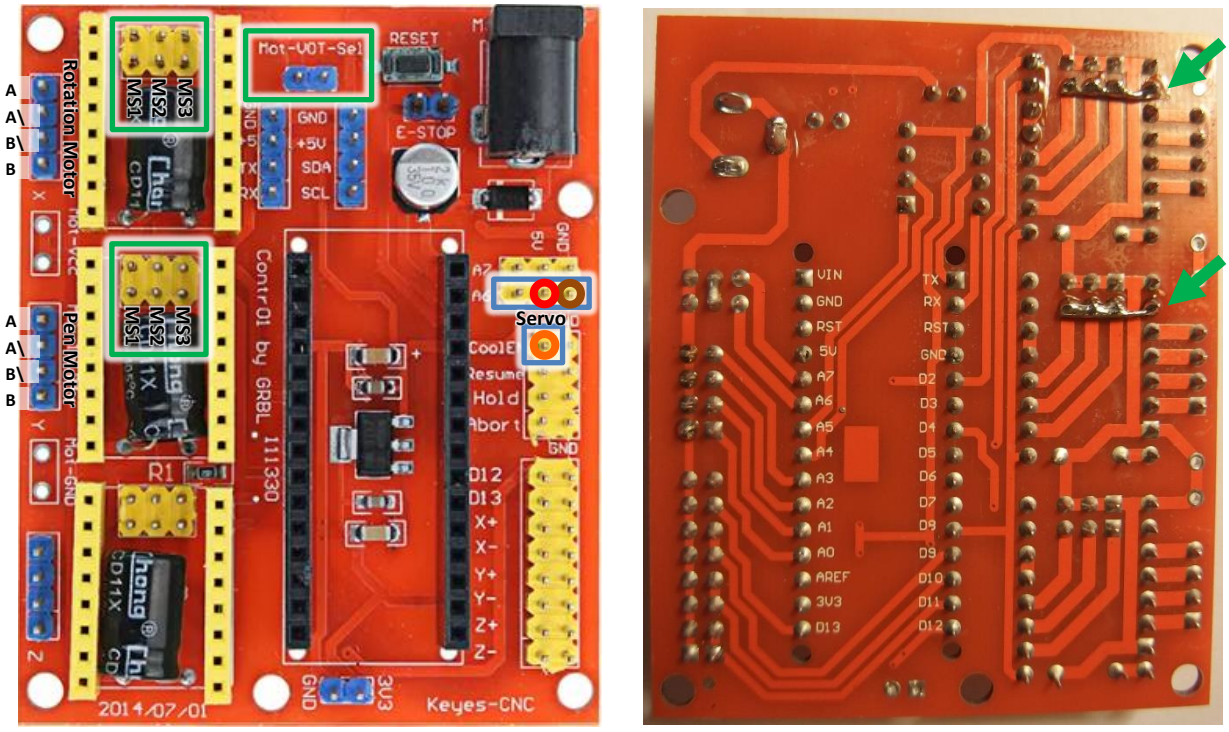


Figure 11: CNC Shield V4+ (a) Jumper and pin assignment of EB2020, jumper MS1-3 must be removed, 'Mot-V0T-Sel' must be set. (b) Solder wire bridges to enable the 1/16 microstepping of the A4988 StepSticks.

4.2 Disable Auto-Reset of the Arduino Nano

The Arduino resets itself every time a connection is established. This interferes with the function of the 'Eggbot Control' Inkscape plugin.

- To disable the auto-reset, desolder the capacitor as shown in Figure 12.

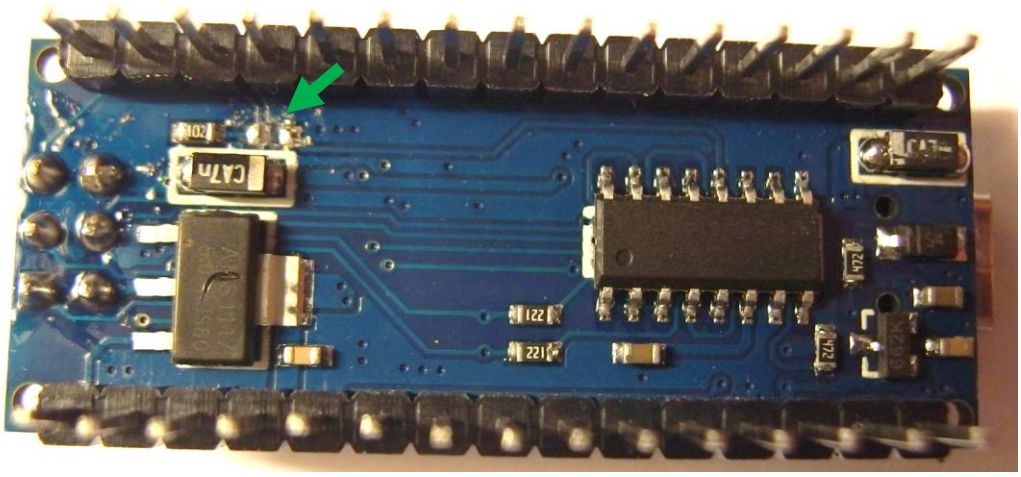


Figure 12: Deactivate the auto-reset of the Arduino Nano by desoldering the capacitor at the marked position.

4.2.1 Alternative solution

The alternative solution is to solder a 10µF capacitor between RST and GND. If you make this pluggable (e.g. with pin header and plug) the change is even reversible.

4.3 Setting the motor current

4.3.1 A4988 StepSticks

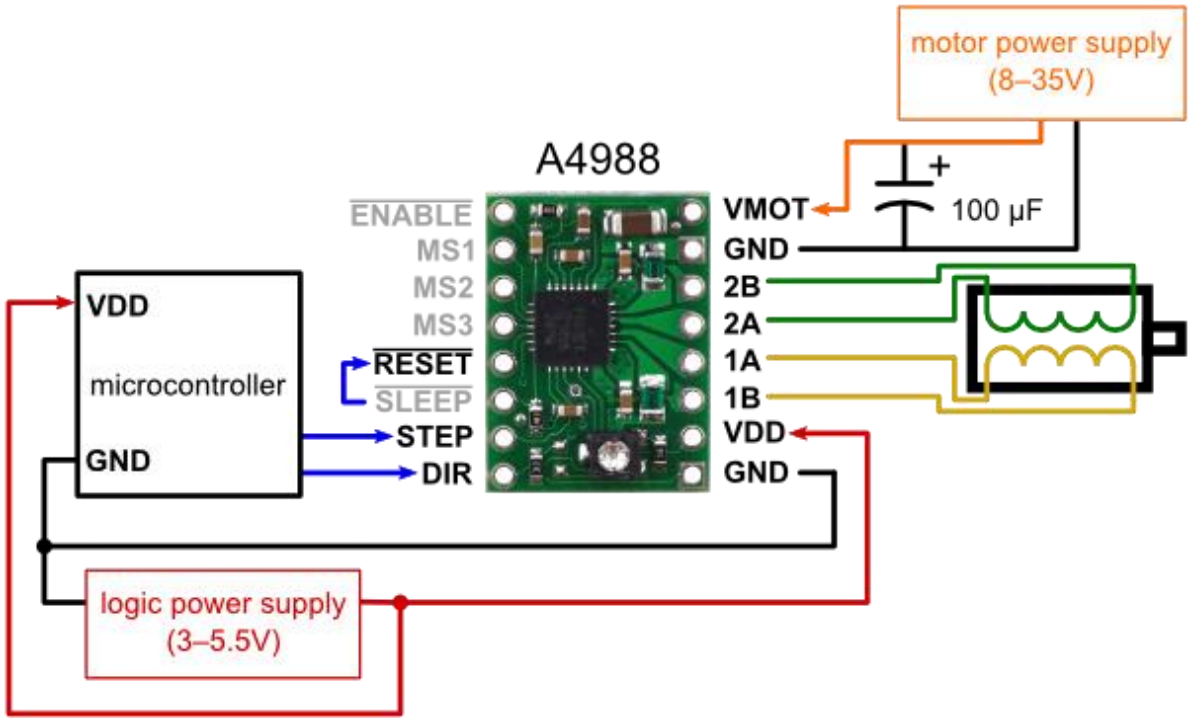


Figure 13: Typical wiring of the A4988 StepStick (Source: https://www.pololu.com/product/1182)

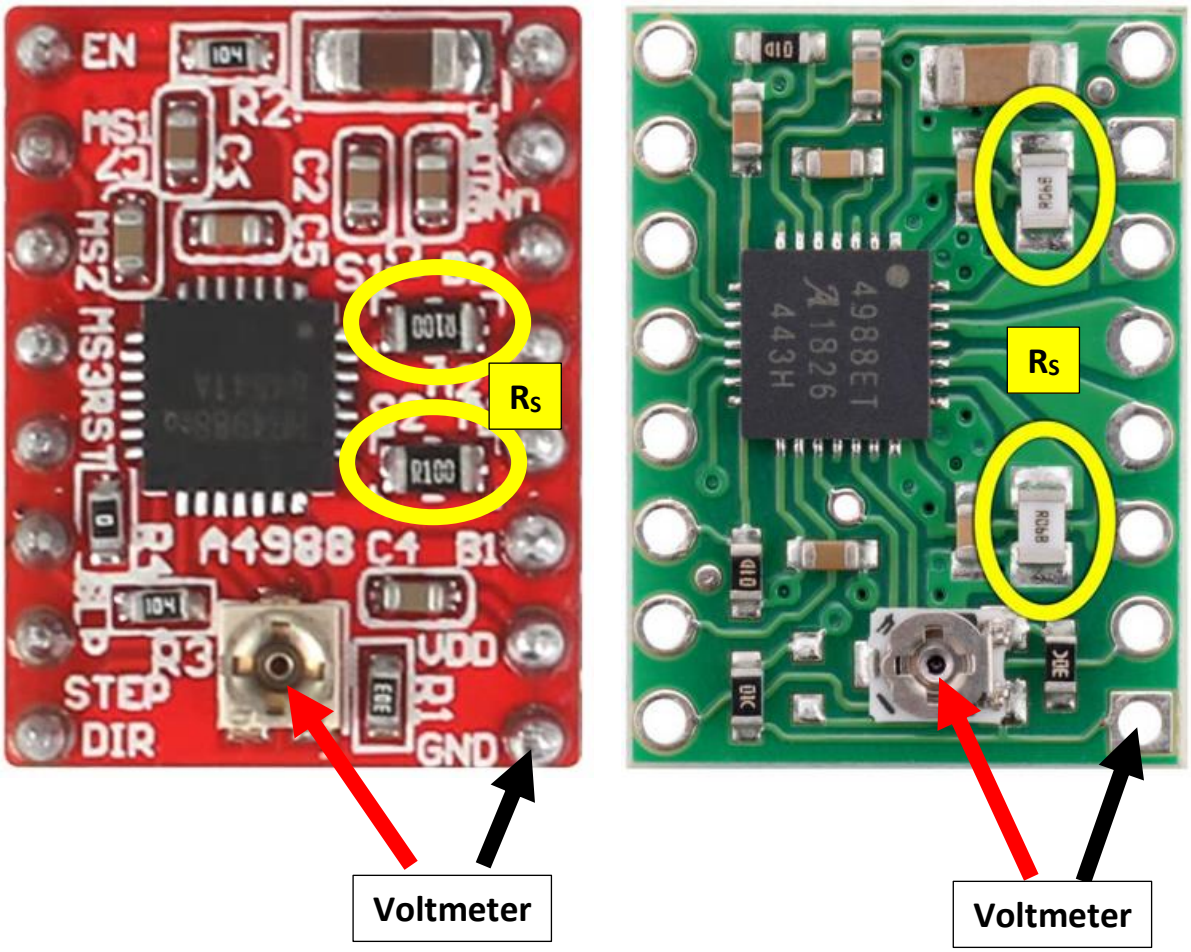


Figure 14: Variants of the A4988 StepSticks

There are variants of the A4988 StepStick stepper motor driver boards with different current sense resistors (Rs). While the original Pololu A4988 stepper motor driver boards use 0.05 Ohm or 0.068 Ohm in newer versions, Chinese variants of the A4988 normally use 0.1 Ohm. The different resistors have the following labels:

- 0,05 Ohm - R050
- 0,065 Ohm - R068
- 0,1 Ohm - R100
- 0,2 Ohm - R200

To set the reference voltage (V_{REF}), connect the 12V power supply to the CNC Shield, then clamp an alligator clip (red) to the screwdriver and use the negative tip of the voltmeter on the GND pin to set the voltage, as shown schematically in Figure 14. The voltage to be set results from the maximum motor current of the stepper motor used according to the following formula:

$$V_{REF} = 8 \cdot R_S \cdot I_{MAX}$$

With a 1.2 A stepper motor and RS=0.1 Ohm, V_{REF} = 0,96 V would have to be set. If the motor gets too hot during operation, simply set a slightly lower value.

4.3.2 TMC2209

Alternatively to the A4988 StepSticks the 'Silent StepStick' TMC2209 can be used. The driver is almost pin compatible (see https://wiki.fysetc.com/Silent2209/#pin-functions). The pins between STEP and MS2 must be unused - be careful - the pinout is slightly different depending on the version of the StepStick. With version 3.0 and 3.1 it is sufficient to cut the pins marked TX and RX.

Attention: Pay attention to the orientation when plugging in. On the TMC2209 the potentiometer is on the other side!

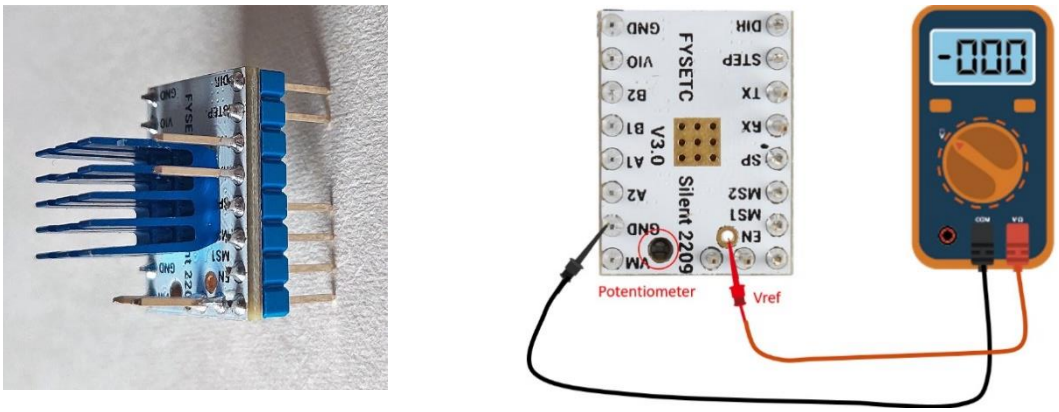


Figure 15: (a) TMC2209 V3.0; (b) Setting the motor current (source: https://wiki.fysetc.com/Silent2209/).

On the TMC2208, the motor current is set according to the following formula:

$$V_{REF} = I_{MAX}$$

5 Cables

5.1 Rotation motor

- Shorten the cable to the rotation motor and provide it with a Dupont connector for connection to the CNC shield (for the pin assignment of the motor on the CNC shield, see Figure 11(a)).
  Use the multimeter to find the 2 phases of the motor and connect them to A, A\ or B, B\.
  It doesn't matter which phase is connected to A and B and also the order within a pair doesn’t matter. The order only determines the direction of rotation which can be adjusted by a software setting (see section 7.5).

5.2 Pen motor and servo

- Shorten the servo cable to about 150 mm and fasten the connector. The cut connector is used for connection to the CNC shield; remove the orange wire from the connector.
- Shorten a 4-pin cable to the stepper motor (do not cut the connector on the stepper motor) to 250 mm.
  Prepare a 3 pin, 250 mm long cable to connect the servo. On the left side the cut part of the servo cable can be used (remove the connector housing). On the right side attach a 3 pin female connector.
- Cut 2 pieces of heat shrink tubing D 6.4 mm L 15mm.
- Cut off a piece of D 4mm (4-6mm) fabric tubing 160mm.

- Push the cables through the heat shrink tubing on the right, then the fabric tubing as well as the second heat shrink tubing. Then slide the pieces of heat shrink over the fabric tubing; do not shrink yet! Then attach the dupont connectors:
    - Stepper motor, 4-pin: A, A\, B\, B (s.a. Figure 11(a) – Pen Motor)
    - Servo, 3-pin: braun, rot, >not connected<
    - Servo, 1-pin: orange
- Adjust cable lengths and check on EB2020, then shrink and attach a cable tie as strain relief.
- Fasten cable to pen motor mount (P12) with a cable tie.

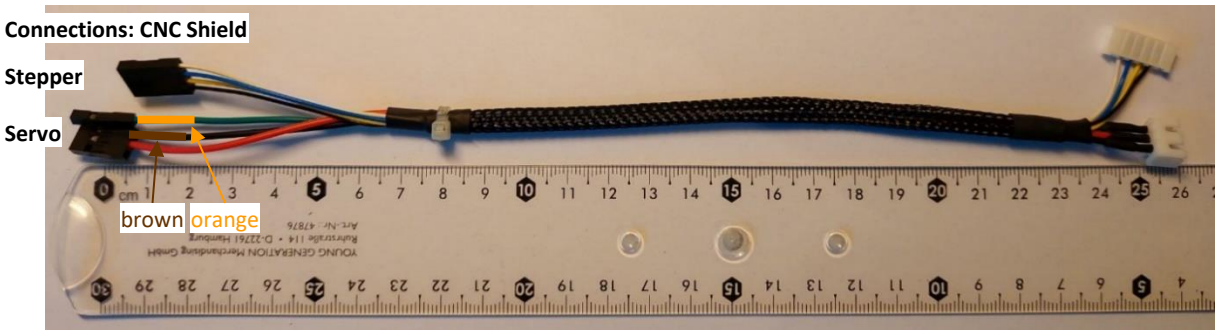


Figure 16: Cable for pen motor and servo

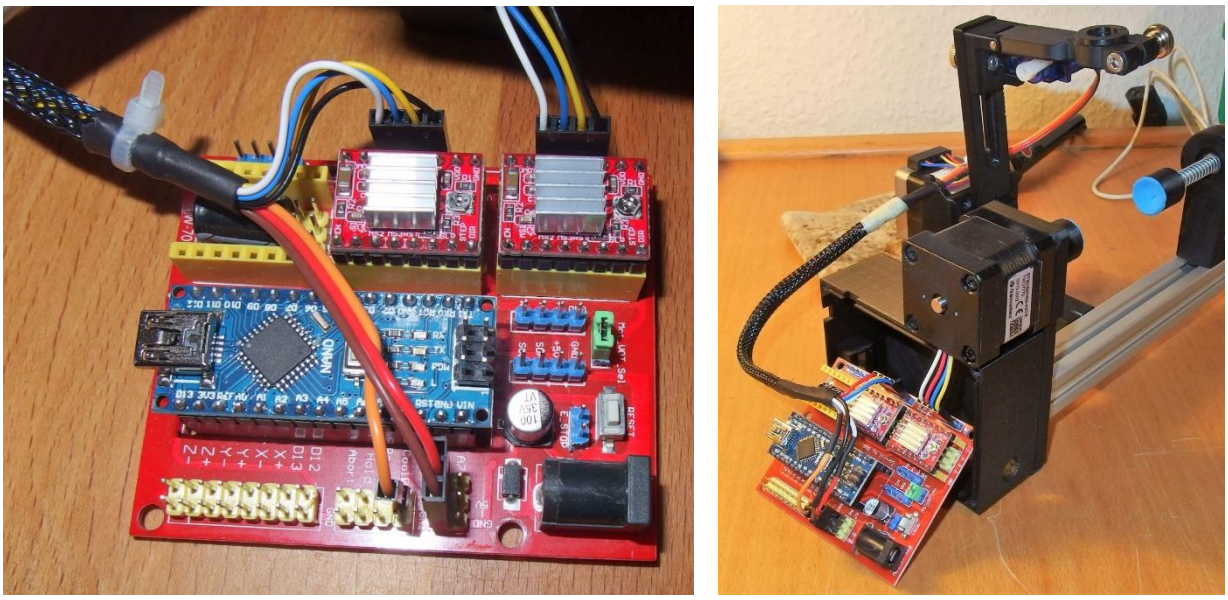


Figure 17: (a) Connections on the CNC Shield and (b) Wiring

5.3 Pause / Continue Extension [optional]

From version V2.05 on, the EggDuino firmware contains an extension to briefly pause and resume the drawing process. This is useful if e.g. the acrylic pen does not want to draw anymore.

Connect a push button (normally open) against ground to CNC.Resume (corresponds to pin A2 on the Arduino).

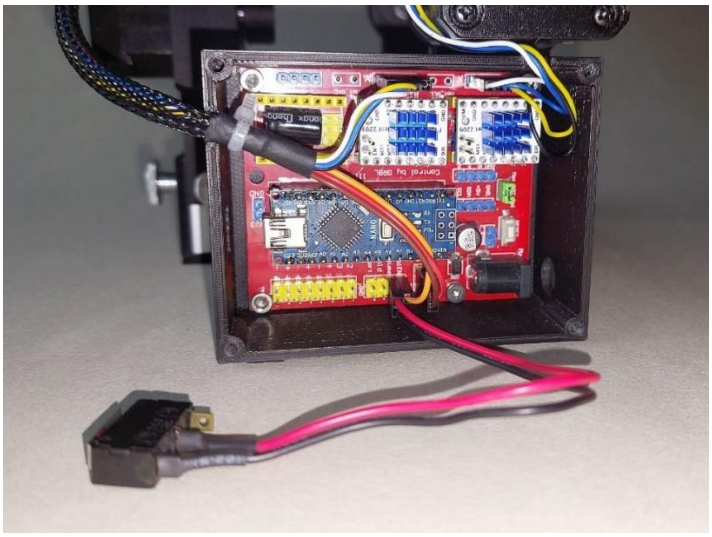


Figure 18: Prototypical wiring of the Pause/Continue function.

Software installation and commissioning

6 Software

6.1 EggDuino Firmware for Arduino Nano

The FautzMakes variant of the EggDuino firmware is derived from Papa bricole. It offers some small improvements (see History.txt).

For installation unpack the zip archive 'EggDuino(V*).7z' and then compile it either with the Arduino IDE (Board Arduino Nano) or with Visual Studio Code using PlatformIO and upload it to the Arduino Nano board. Since the auto-reset is disabled, press the reset button on the Arduino immediately after the compilation is finished to upload.

6.2 PC SW

6.2.1 Inkscape

- Install the Inkscape software (currently latest is V1.2.2, see https://inkscape.org/).

6.2.2 Eggbot extension for Inkscape

- Copy content of ‘ad-ink_370.FautzMakes*.7z‘ to:
  <inkscape installdir>\share\inkscape\extensions

  e.g.: C:\Program Files\Inkscape\share\inkscape\extensions

Alternatively, you can install the original Inkscape Extension from Evil Mad Scientist. But then additional manual changes and optimizations have to be done by yourself:

- Ad-ink (Eggbot Extension) installation
  Download the ZIP archive ‚ad-ink_*.zip’ and install it according to Evil Mad Scientist's instructions:

  https://wiki.evilmadscientist.com/Installing_software#Alternative_.28Manual.29_install_for_Windows
  (do not use a space, but an underscore '_')

- Modify the file ebb_serial.py
  <inkscape installdir>\share\inkscape\extensions\axidraw_deps\plotlink\ebb_serial.py
  Proceed as described in the following link:

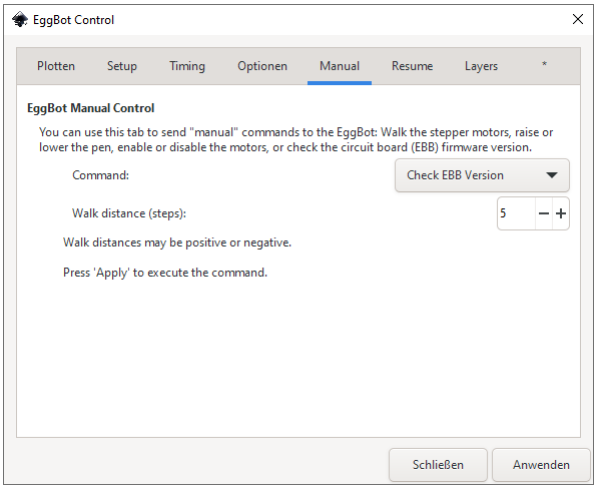
  https://github.com/papabricole/EggDuino#setup-the-inkscape-plugin

- In Eggbot.py, comment out the QueryPRGButton section (reduces pen shaking).

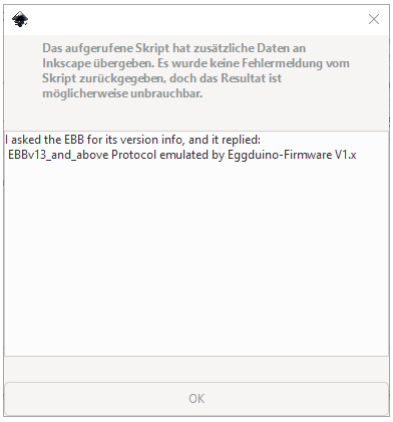
7 Initial start-up

7.1 Communication test

- Connect EB2020 with 12V power supply and connect it via USB to the PC.
- Start the EggBot Control in Inkscape via the menu 'Extensions | EggBot | EggBot Control...'.
- Select the 'Manual' tab and choose 'Check EBB Version' as command.



- If the connection works then after pressing [Apply] a message window should be displayed.

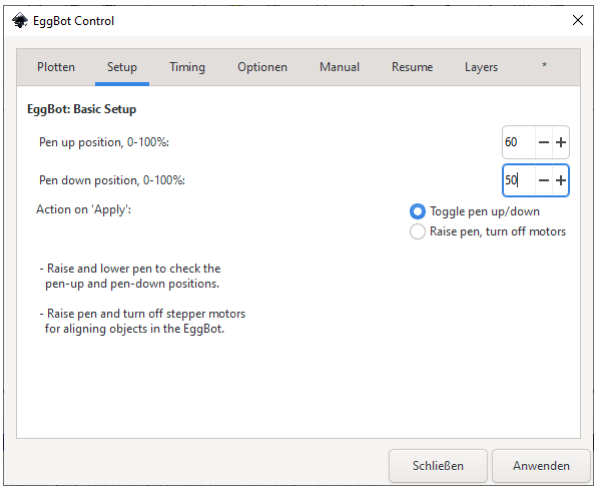


Troubleshooting:
However, if *'Failed to connect to EggBot. :('* is displayed then recheck,

- if the auto-reset has been deactivated (see section **Fehler! Verweisquelle konnte nicht gefunden werden.**)
- if the Inkscape Extension was installed correctly (see section 6.2.2)
- and if the Arduino has been programmed correctly (see section 6.1)

7.2 Adjusting the servo lever

- Set the 'Pen up position' to 60 and the 'Pen down position' to 50 with EggBot Control. Then apply 'Toggle pen up/down' so that the servo is at the 'down' position.



- Insert the servo lever so that the lever is approximately horizontal and fasten it. Then fasten the servo (B04) to the pin arm joint with one of the included screws.
- Now you have to find the position where the arm is exactly horizontal. To do this, change the 'Pen down position' step by step and 'Apply' until the correct position is reached.
- Note the determined position in the EB2020 Quick Start Guide in section 2.1.
- Finally, set the 'Pen up position' about 5 higher and the 'Pen down position' about 5 lower.

7.3 Motor test

Now we enable the motors:

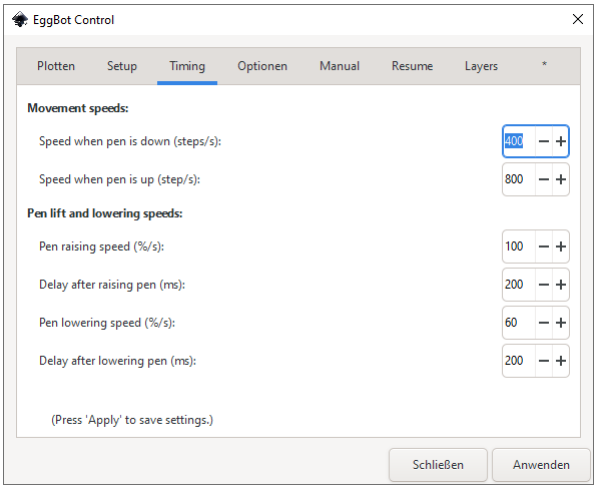
- Execute the command 'Enable Motors ' in the EggBot Control tab 'Manual'.
- Both, the motor of the rotation axis and the motor of the pen arm should hold its position. Apply force lightly in both directions to check this.

Troubleshooting:

- Check if each phase of the motor (A, B) is correctly connected to the CNC board (see Figure 11). Use the multimeter to find a pair of wires of one of the motor coils and connect it to A and A\. Check the second pair of wires and connect them to B and B\.

7.4 Motor speed

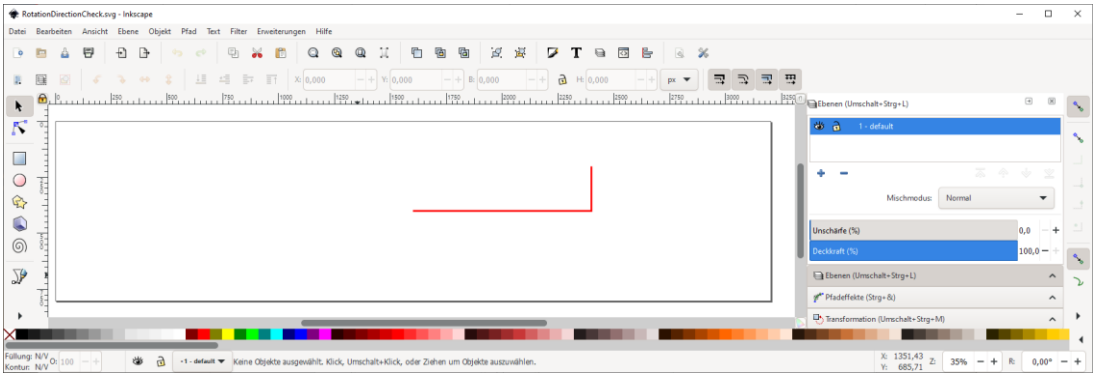
- Set the default values, e.g.:



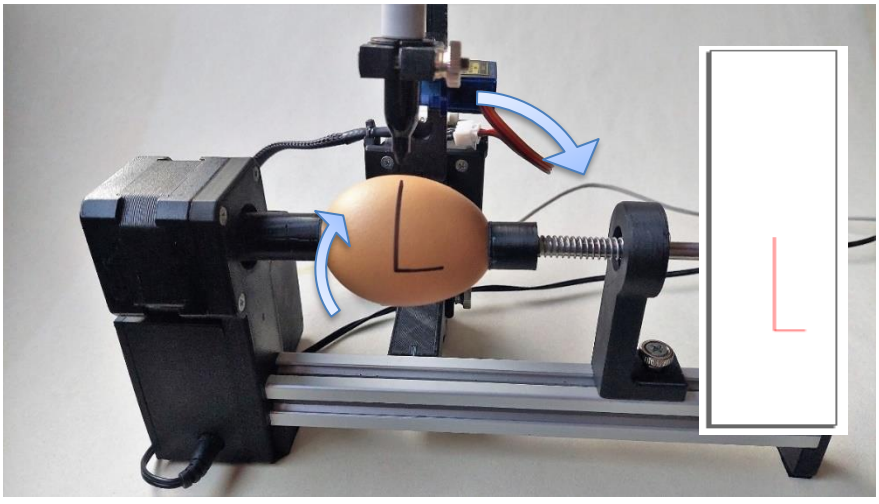
7.5 Adjust the direction of motor rotation

We adjust the rotation direction so that later the eggs are clamped to the motor with the thick end (= bottom of the drawing).

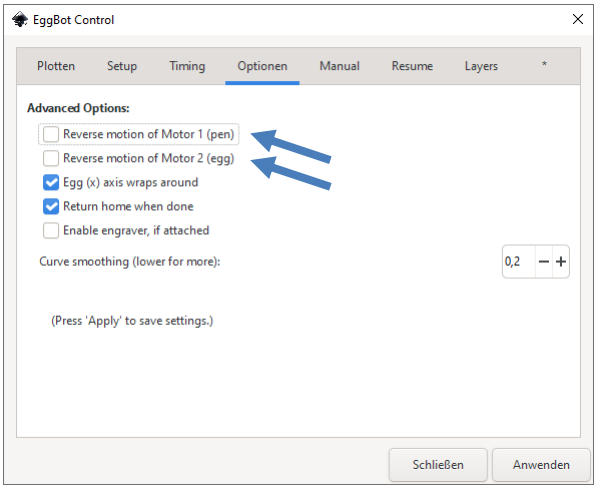
- Load the drawing 'RotationDirectionCheck.svg' with Inkscape.



- Open the EggBot Control tab 'Plot' and select 'Apply' to start plotting (no pen or egg needs to be inserted).
- Basically, the drawing is transferred to the egg rotated 90 degrees to the right. So first, the rotation motor should rotate upwards, then the pen arm should rotate to the right, so that the following picture would result when pen and egg are used:



- If necessary, change the directions of rotation of the motors. Either by
  - swapping the wires A, A\ of a motor
  - or by configuration in EggBot Control



Note:
You can also move the motors with functions of the 'Manual' tab. The rotation axis 'Egg' then moves according to the X-axis of the Inkscape drawing. However, the pen arm will move in the opposite direction to the Y-axis of the drawing.

Finally, install the CNC Shield as described in section 1.3.

8 Links

https://wiki.evilmadscientist.com/The_Original_Egg-Bot_Kit	The original EggBot
https://github.com/evil-mad/EggBot/	The directory 'example files' with the original examples may be interesting.
http://evil-mad.github.io/EggBot/ebb.html	EBB (EiBotBoard) Command Set
https://github.com/papabricole/EggDuino	Improved EggDuino Firmware