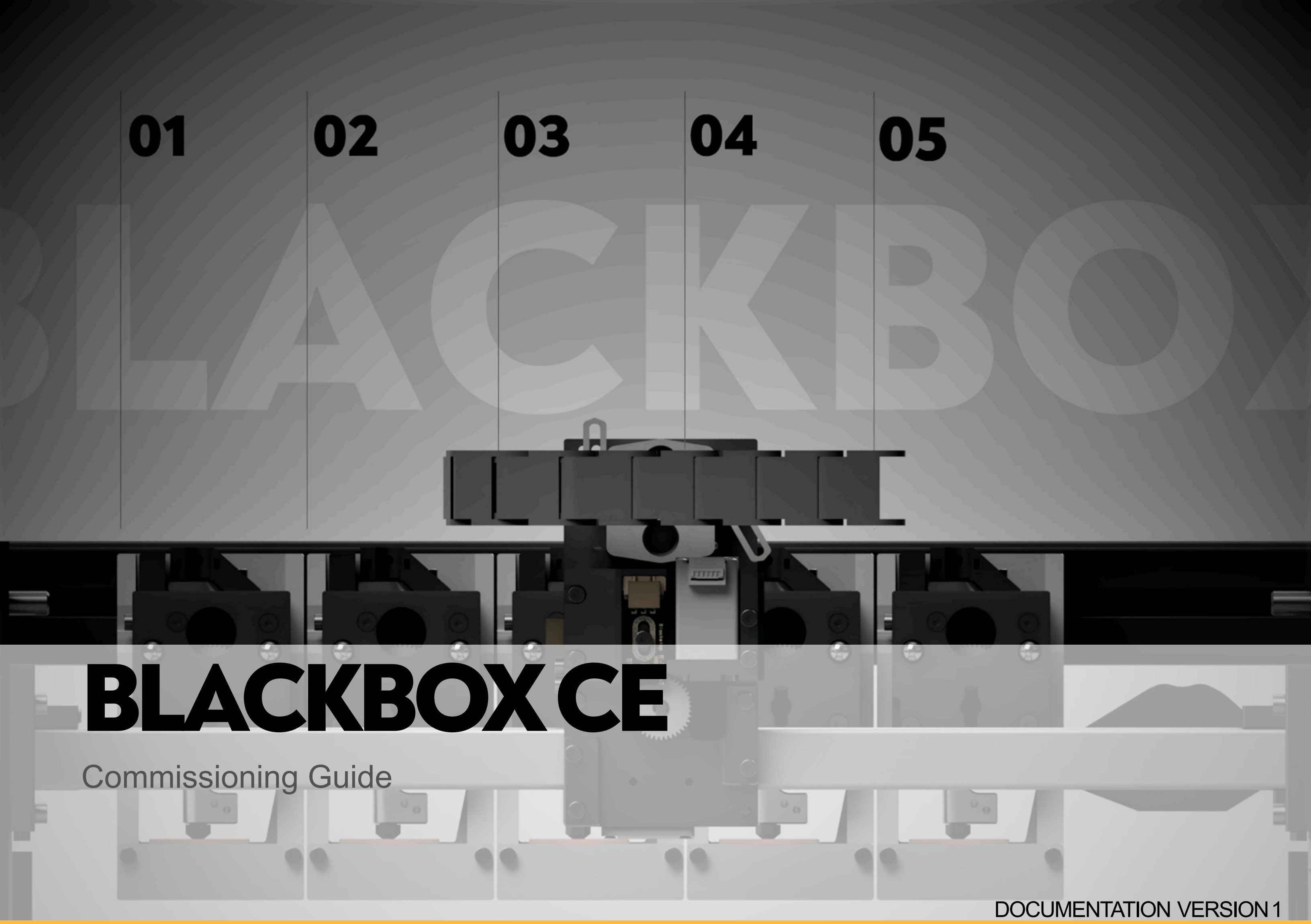


BLACKBOX CE

Commissioning Guide

DOCUMENTATION VERSION 1

Blackbox CE:

Commissioning

Change Log

Version	Notes
1	Initial Release

Before we begin:

This guide will cover both mechanical and software commissioning steps for Blackbox. It assumes you are working with the BOM recommended parts and controller.

Things you'll need:

1. **The below printed parts - These printed tools were part of previous mechanical assembly guides, so you should already have them. If not, we've gathered them here for you. These parts will be re-used as needed, so keep them somewhere handy! A Blackstack drawer, perhaps?**
2. **A fully belted, tensioned, and de-racked XY motion system. These steps were performed in the XY Motion assembly guide (#4). If you are replacing belts or components and need to repeat those steps, head there first!**
3. **A Blackbox with a Duet 3 6HC controller connected and accessible by your home network using the latest available firmware.**
4. **Your chosen method of XY offset calibration -**
    1. **TAMV running on a Raspberry Pi**
    2. **The Ember Prototypes calibration software running on your PC**

Printed Parts

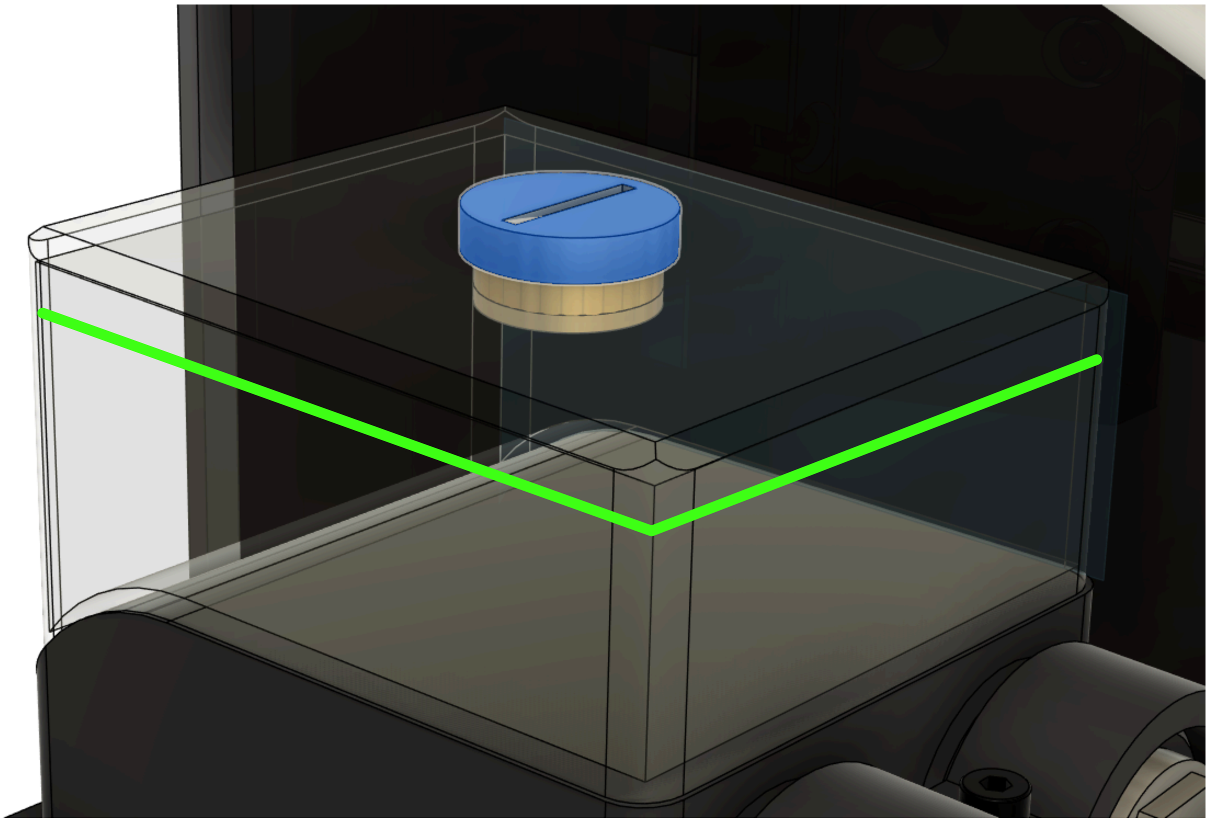
QTY	Description	Material	Ver	Link
1	Print_XY_Belt_Tensioning_Tool_Rear	PLA	1	
1	Print_XY_Belt_Tensioning_Tool_Front	PLA	1	

Tools/Supplies

QTY	Description
1	Piece of paper or feeler gauge for Z offset confirmation

Step 1: Water Cooling Fill + Bleed + Leak Test

Remove the fill plug from the water reservoir and pour in distilled water until the fluid level is around the green line below.



Leave the plug out for now, as multiple top ups will be needed as the system fills and purges air

IMPORTANT: Before applying power to the water pump, be sure that the Grey wire is being fed 12V power! Most pumps re-purposed from PC water cooling use-cases do NOT have reverse polarity protection!

For first-starts place some towels into the machine underneath the tool head for good measure. The only high-concern leak points are the tool head hose fittings and the inside of all 4 coupler joints. Otherwise the fittings are external of the machine and electronics.

If your machine is fully wired, powering on the machine will result in water pump activation.

Continue to top up the water level as the cooling system purges air in exchange for water.

The bleed process happens automatically, and can take a few minutes for the pump to quiet and all air to be purged.

DO NOT RUN THE PUMP DRY!

Step 2: Mechanical Checks

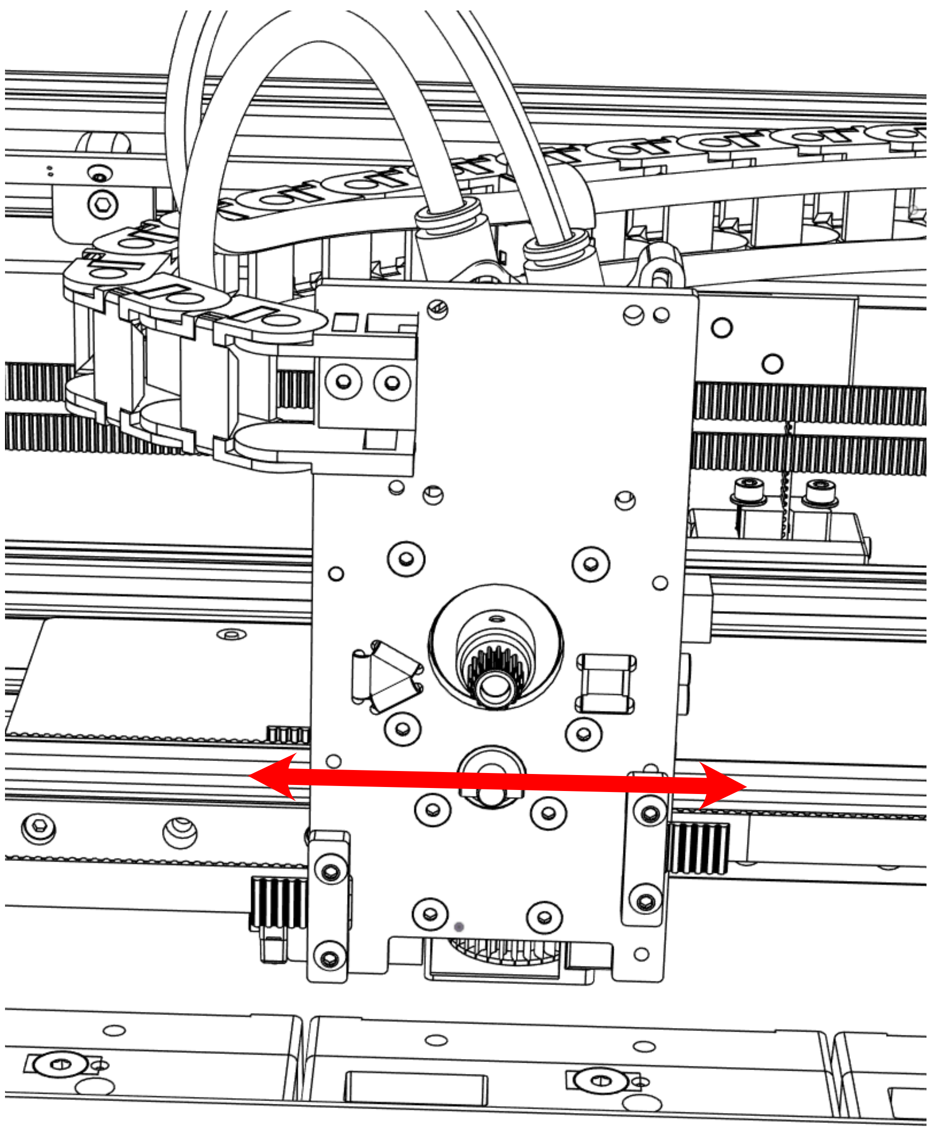
Before continuing, we need to confirm the machine has the freedom to move freely to all far corners of the printer.

Areas to pay attention to:
1. Energy chain should not bind or droop into contact with any part of the frame
2. The X and Y homing switches should be accessible by the triggers without binding
3. Water hoses and the (optional) remote tool lock cable should maintain a safe bending radius.

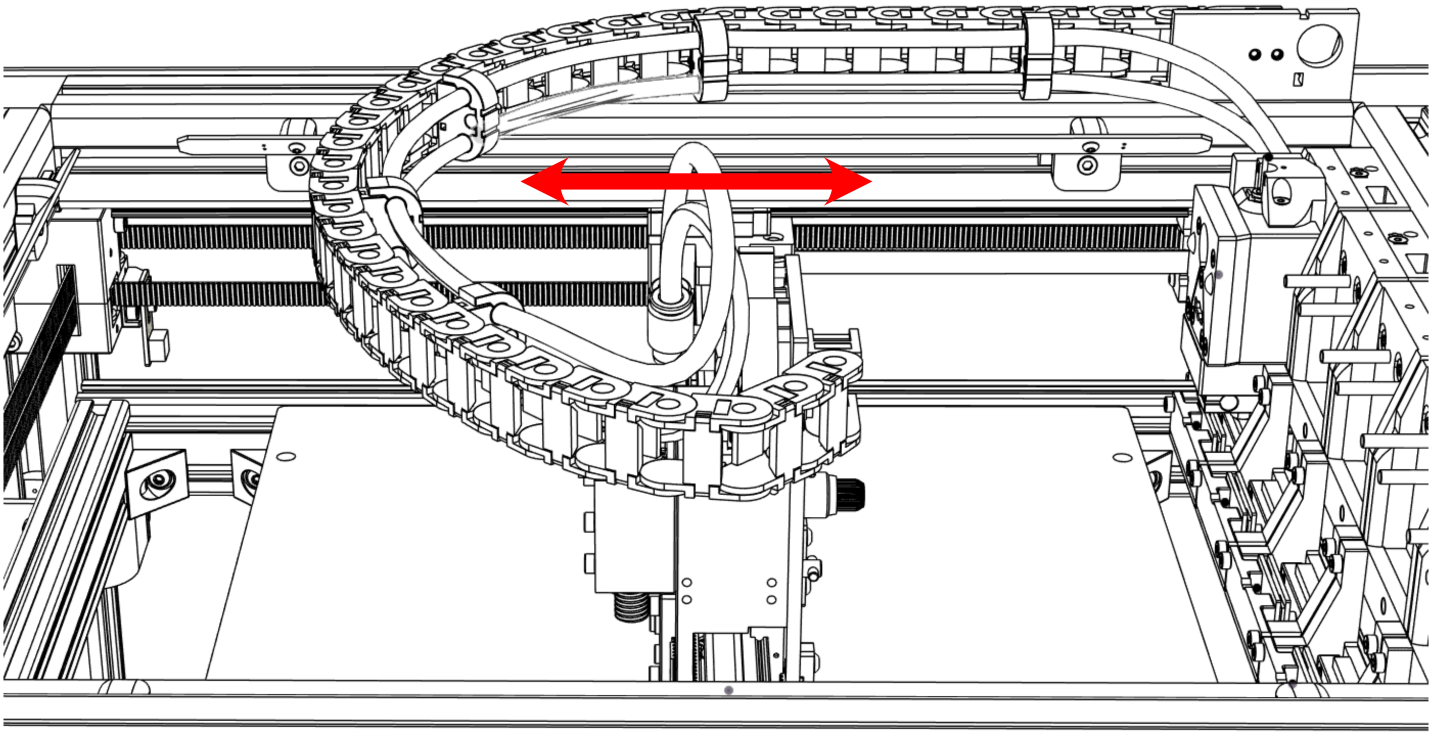
Any issues here should be addressed now, not later!

Now we will check for backlash and other motion system issues.

Apply pressure in the X+ and X- directions. Any movement of the tool head assembly should result in immediate and consistent movement of the belts, pulleys, and motor gears.



Repeat for Y- and Y+ movement.



If free play is observed, the motion system issue will need resolved before continuing.

Step 3: Motion Configuration and Homing

READ ME:

Please download and use the provided configuration from https://blackbox3d.xyz or the GitHub. This will be the starting point from which we move forward.

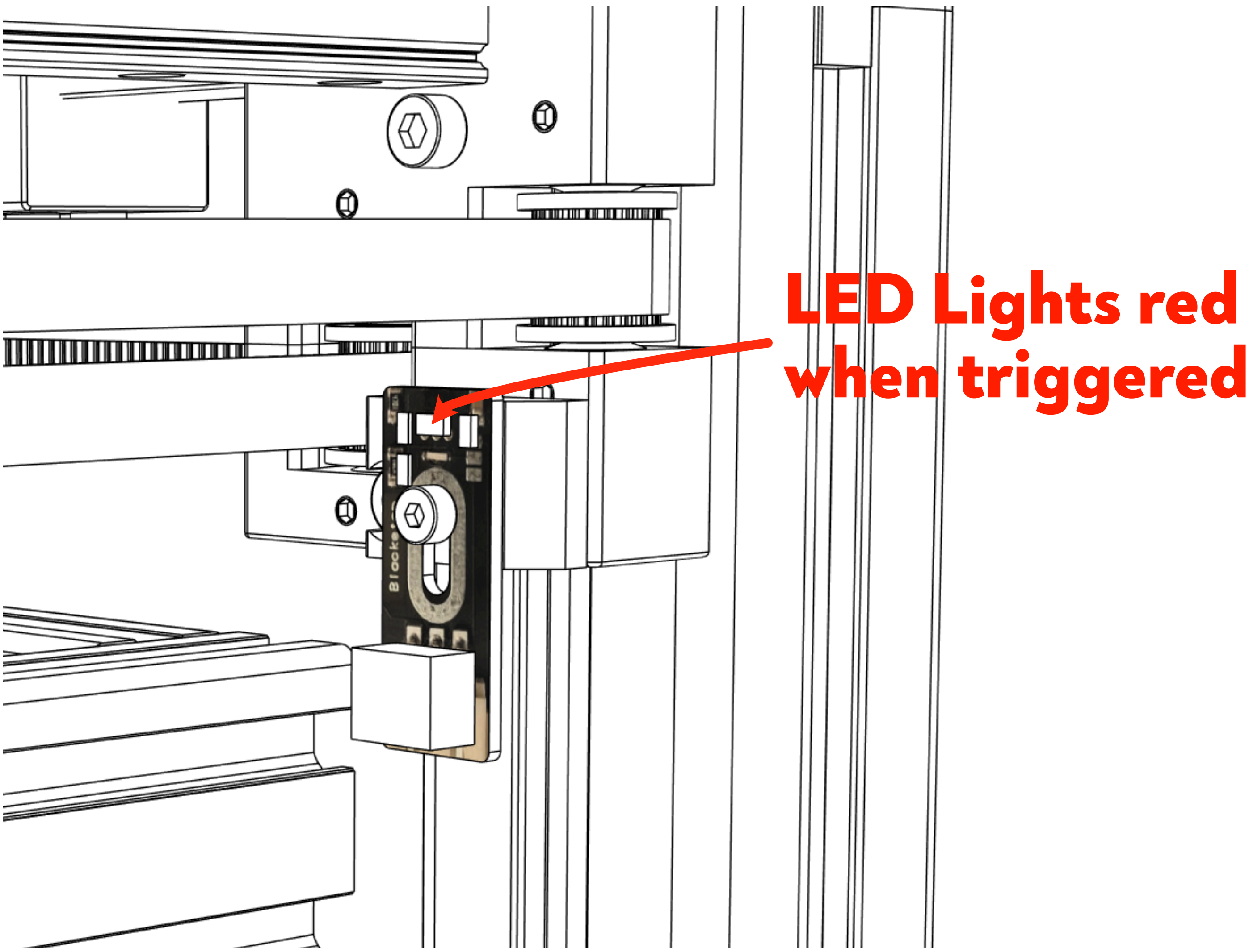
Steps marked in Blue are for those that are already configured in the files provided, and have instructions to solve them if you fail a test point along the way.

Steps marked in Red indicate that a universal approach is not possible, and that you must provide some input for things to work properly.

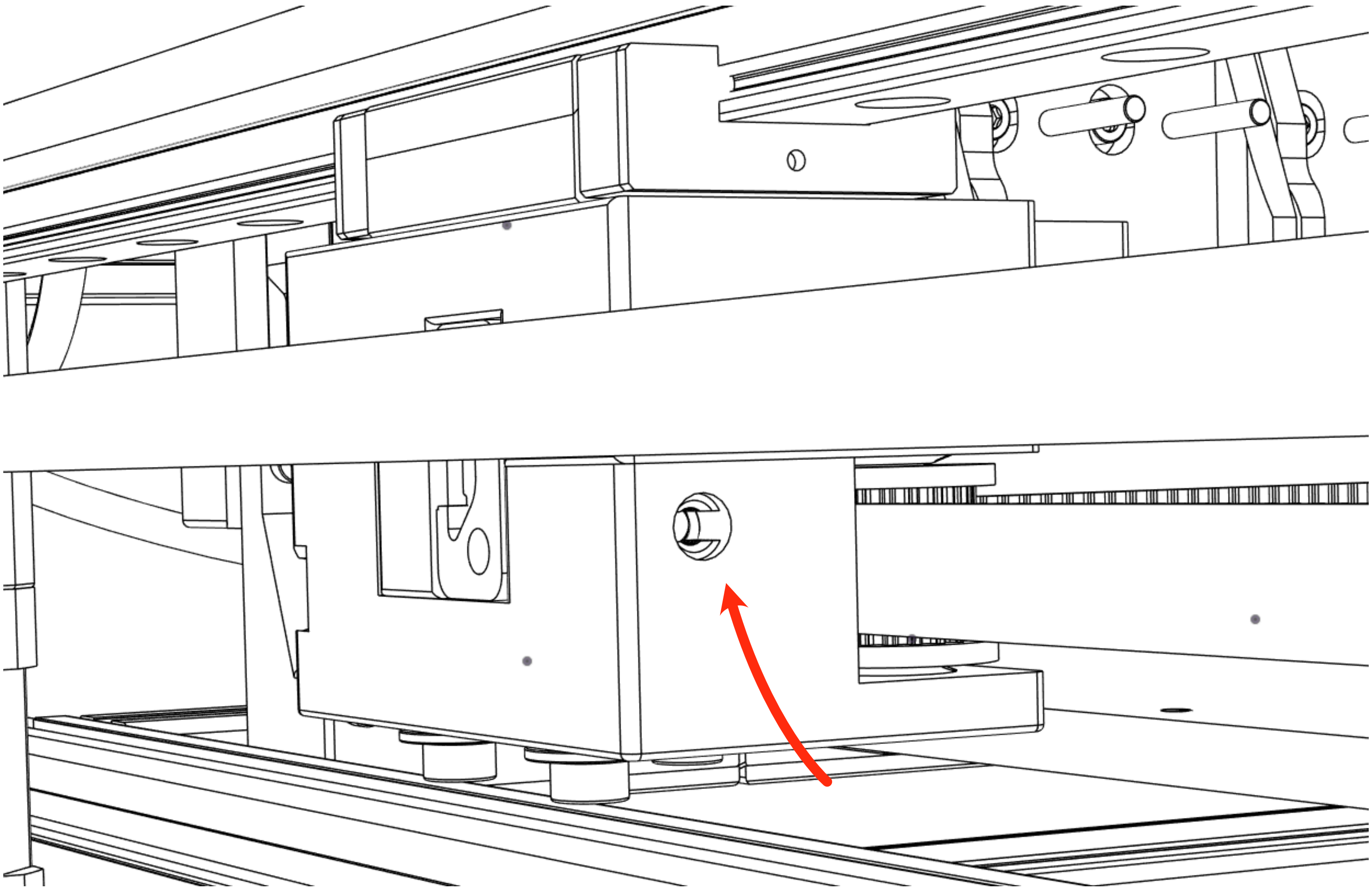
Adjusting End Stops (X, Y, A)

We first need to confirm that our end stop are adjusted properly.

Manually move the gantry in the Y- direction until the LED trigger light on the Y end stop is illuminated. Confirm that the gantry is unobstructed at all points previous to this position.

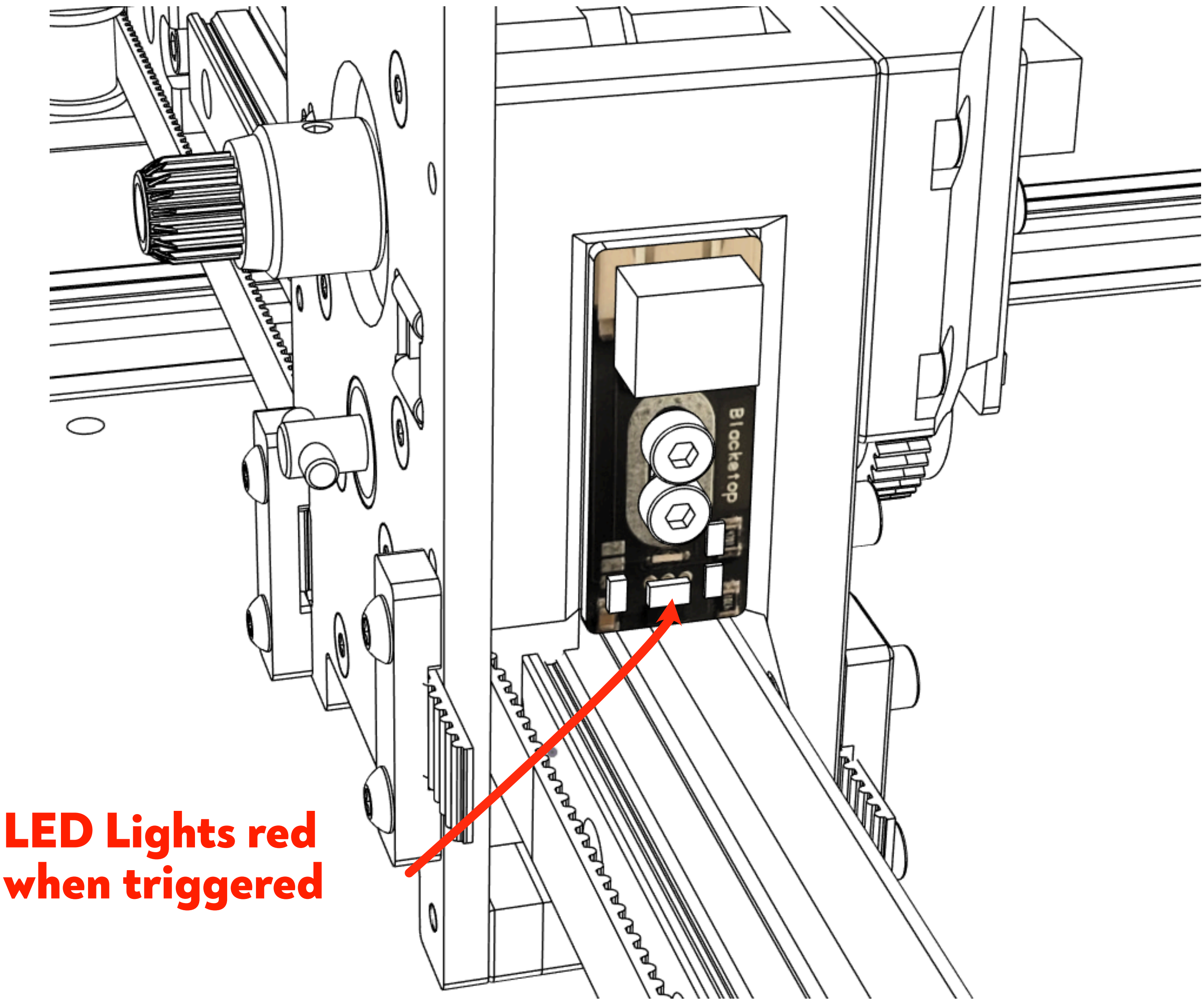


Adjust the end stop trigger inward (deeper) slowly while checking often that the end stop DOES trigger AND there is no contact between the gantry and any other part of the machine. A fully seated trigger with no additional adjustment is okay.

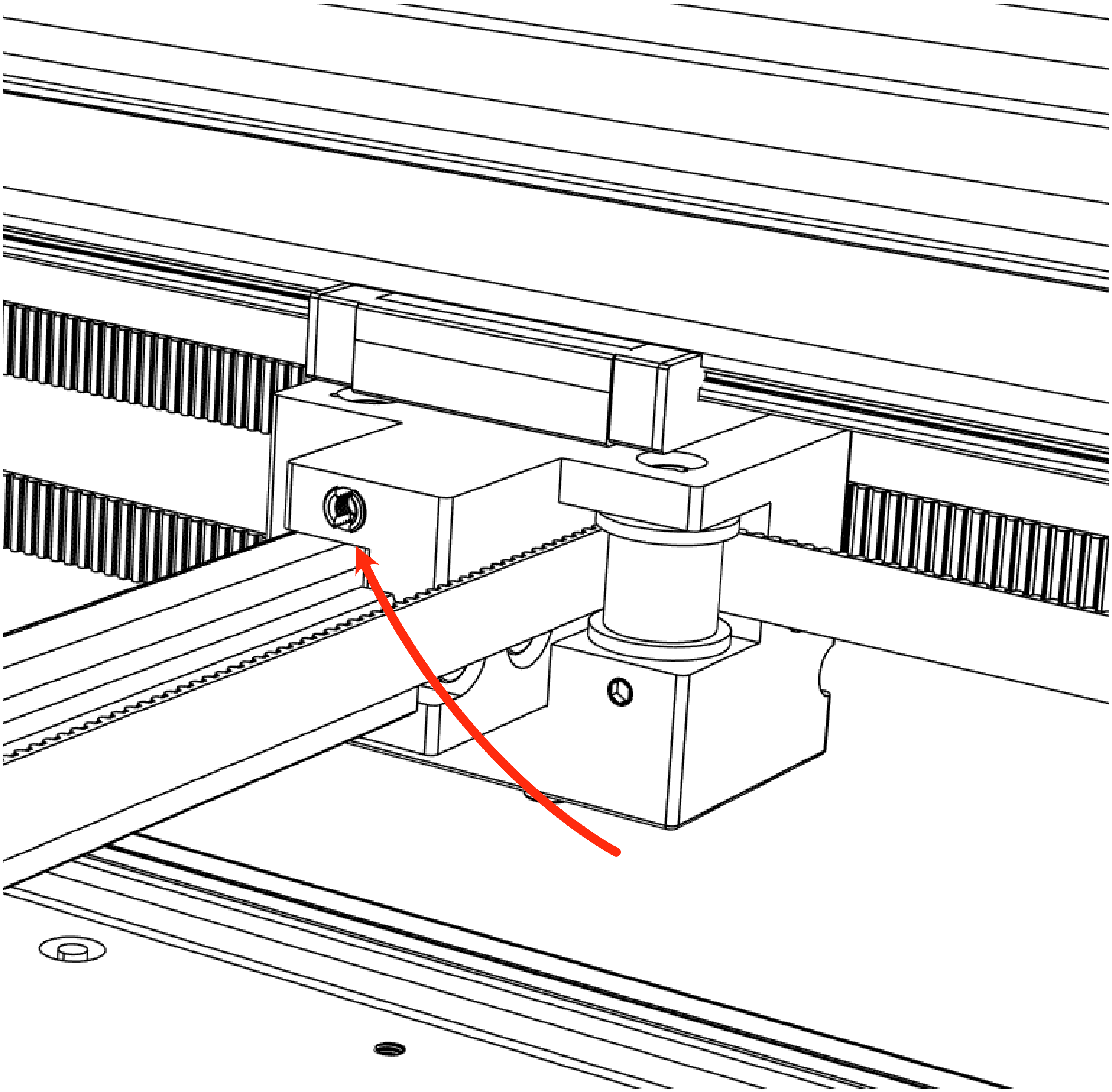


TEST POINT: The Y Axis End Stop Trigger is threaded in as far as it will go while also maintaining a triggered Y end stop switch and no contact between the gantry and fixed parts of the machine.

Manually move the gantry in the X- direction until the LED trigger light on the X end stop is illuminated. Confirm that the gantry is unobstructed at all points previous to this position.



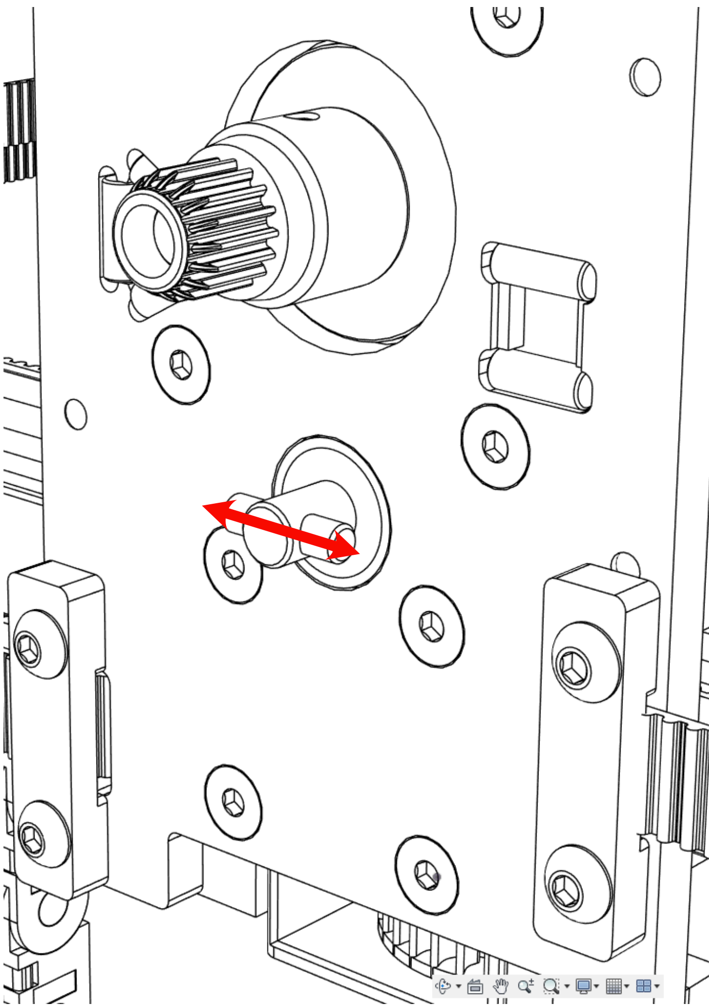
Adjust the end stop trigger inward (deeper) slowly while checking often that the end stop DOES trigger AND there is no contact between the gantry and any other part of the machine. A fully seated trigger with no additional adjustment is okay.

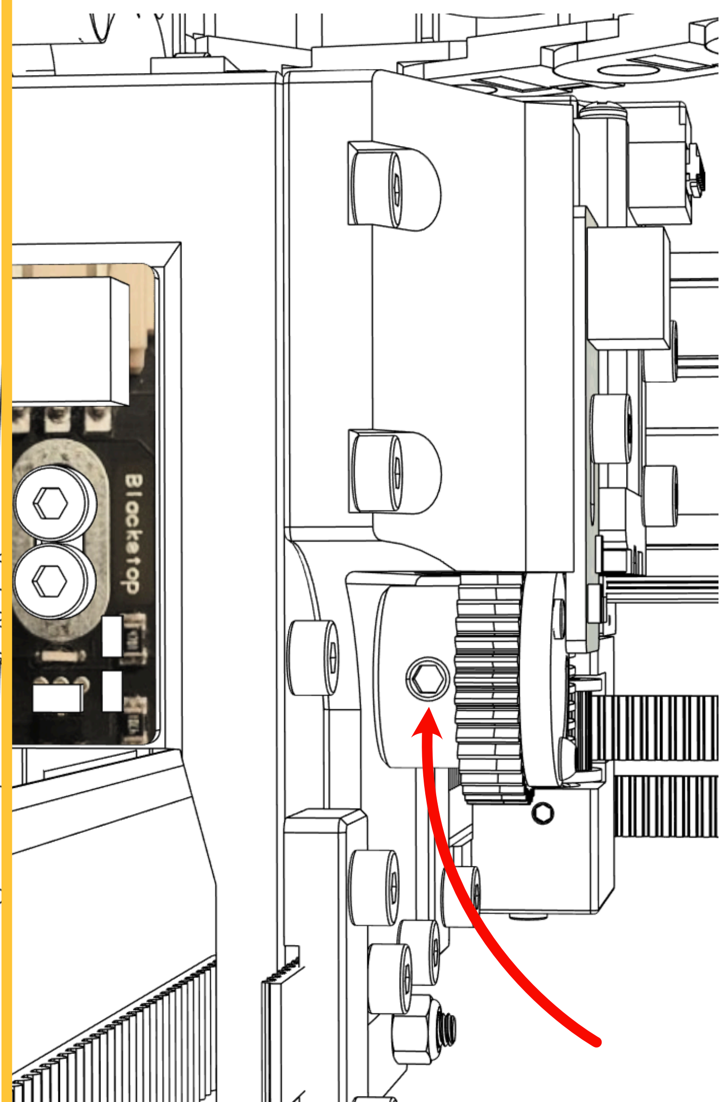


TEST POINT: **The X Axis End Stop Trigger is threaded in as far as it will go while also maintaining a triggered X end stop switch and no contact between the gantry and fixed parts of the machine.**

Blackbox uses an additional end stop for the A Axis (Tool Lock) that is triggered when the T-Lock is in the open position - horizontal. To begin adjusting this end stop we need to start with the mechanical position of multiple components.

The tool lock should be set horizontally

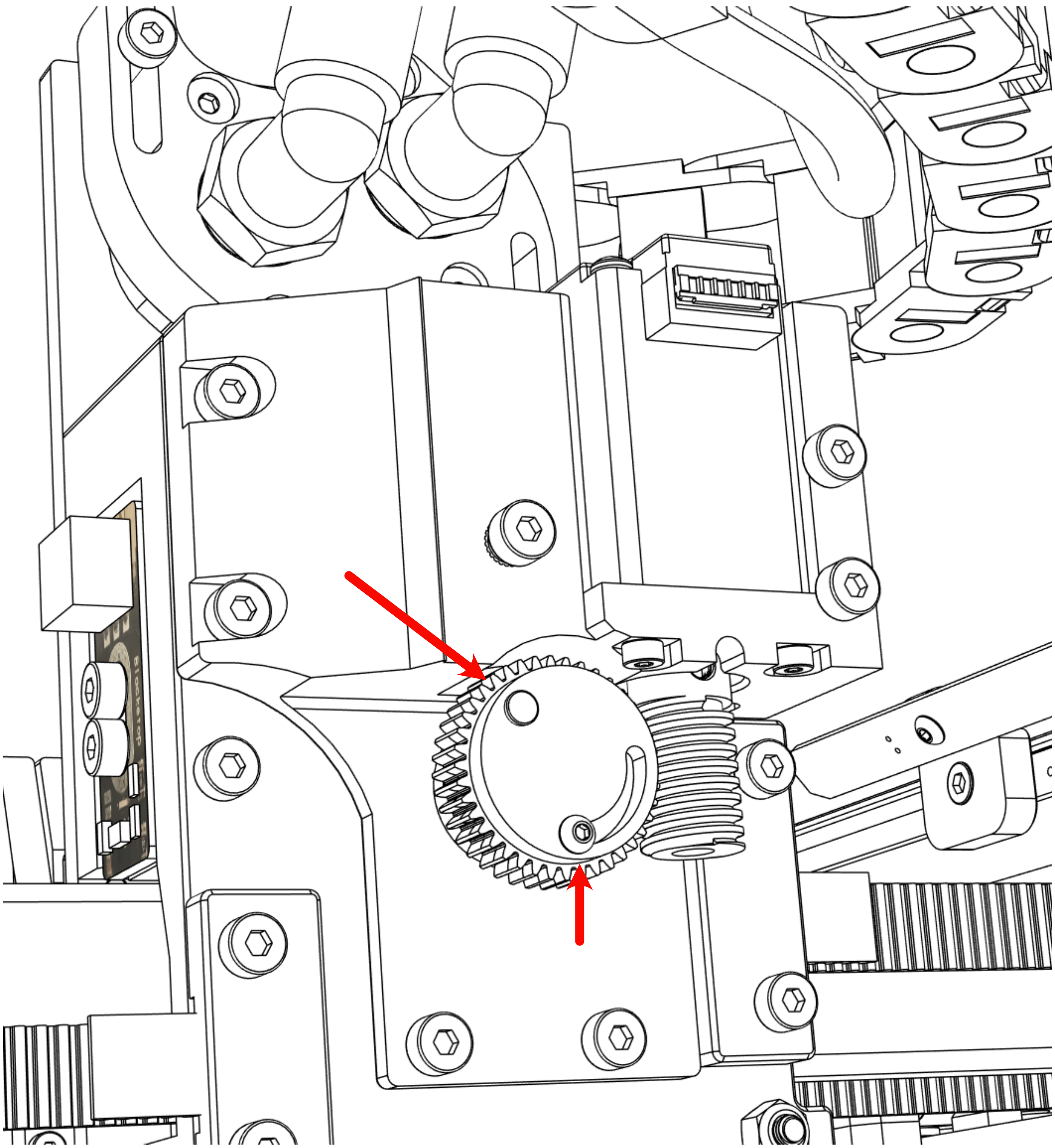




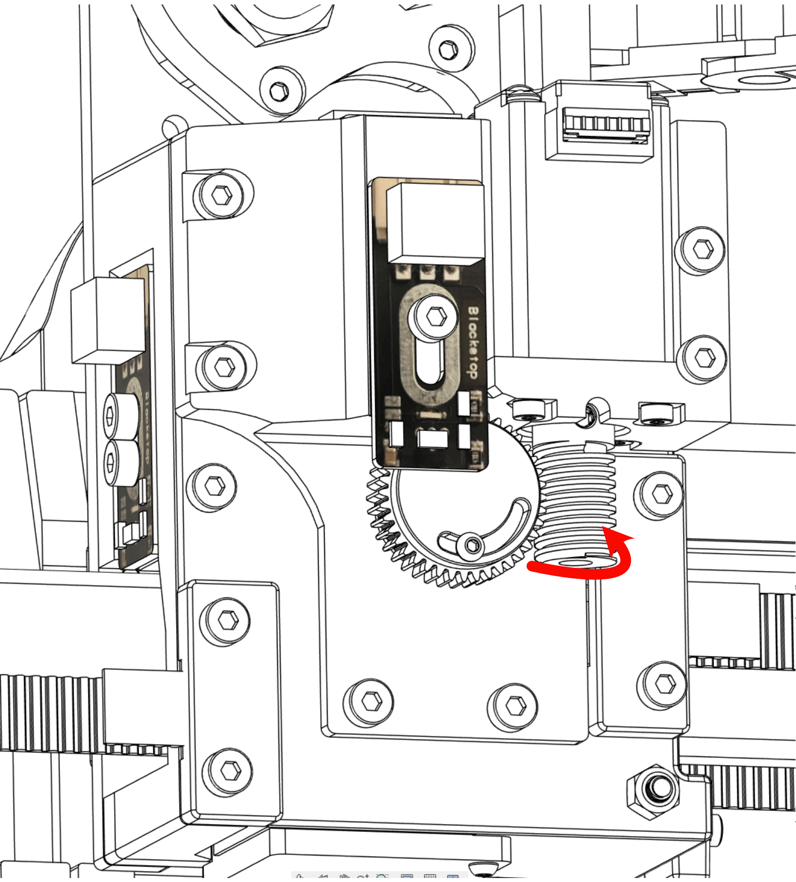
The set screw in the 40 tooth worm driven gear should be engaged with the flat surface of the t-lock, and parallel with the X-axis.

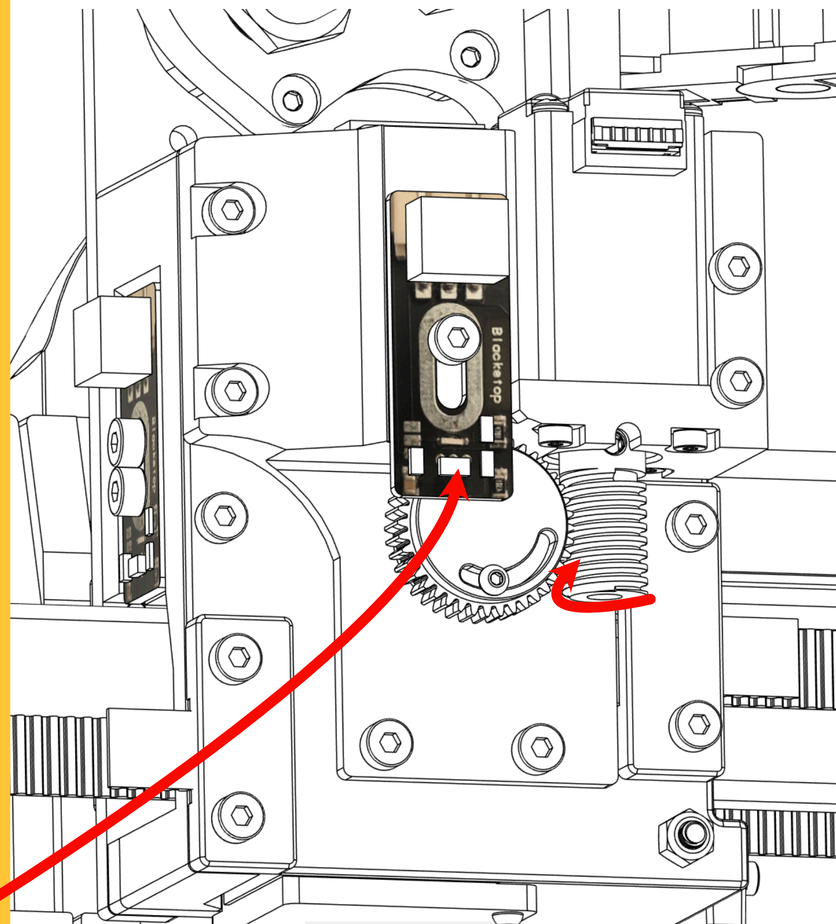
Orient the trigger plate and its magnet as shown below. The depicted position is a good place to start, but leave the adjusting screw slightly loose for final adjustment in the next steps.

Note: The below image does not show the Blackstop for a better view!



Rotate the worm drive gear counter-clockwise by hand 2-3 full rotations. This will move the T-lock itself clockwise when viewed from the front of the X-Plate





LED Lights red when triggered

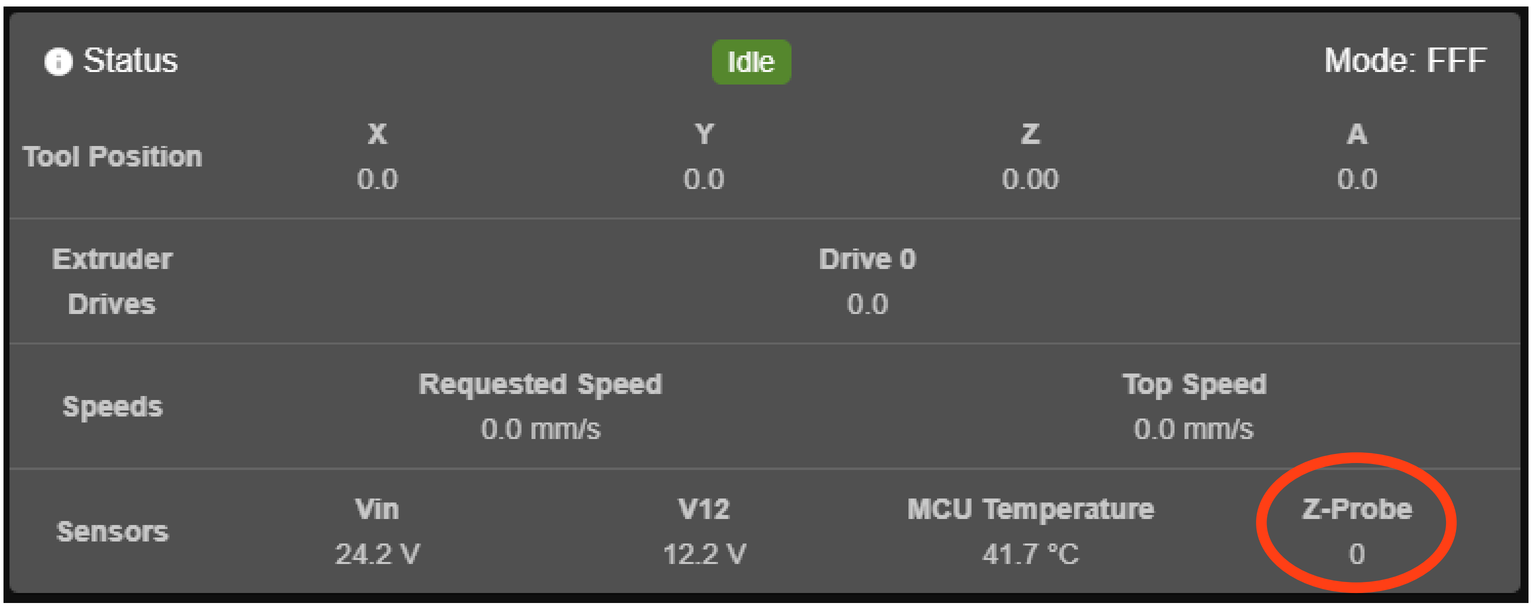
Now rotate the worm driver gear clockwise slowly until the Blackstop LED light is triggered. At this exact position the T-lock should be horizontal.

Adjustments to achieve this can be made by a combination of:

1. **The rotation of the trigger holder (Be sure to tighten the fastener when you're done!)**
2. **The vertical position of Blackstop within it's mounting slot**

TEST POINT: **The A Axis (Tool lock) should be horizontal at the moment of trigger when the worm drive gear is manually rotated clockwise (as shown above.)**

TEST POINT: The Z probe switch should read "0" in DuetWebControl when idle, and "1000" when manually depressed (triggered)

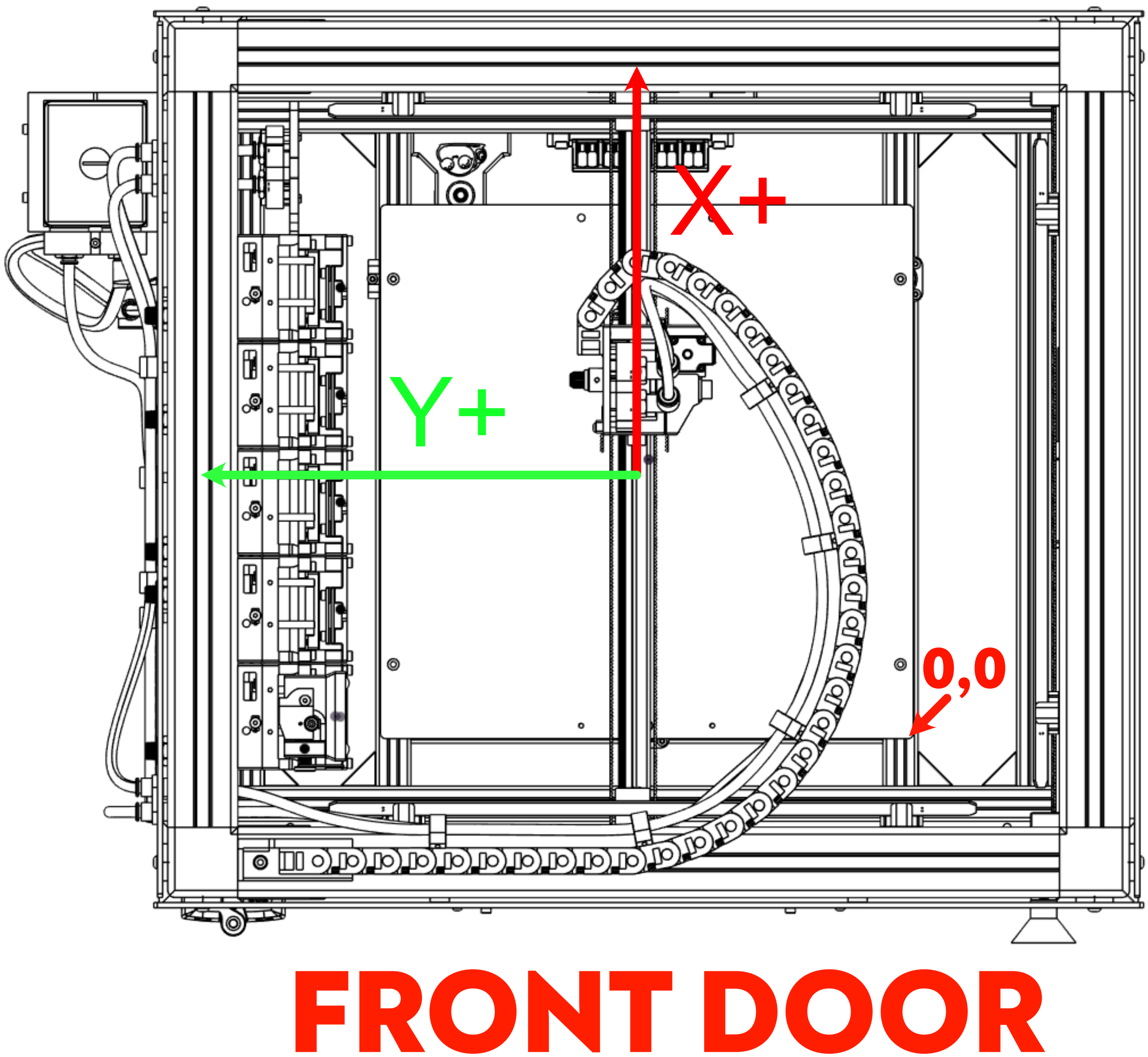


Testing Motor Movement Direction

For a CoreXY machine, RepRapFirmware assumes that the motor connected to the X motor output moves the head in the +X and +Y directions when it runs forwards, and that the Y motor moves the head in +X and -Y directions when it runs forwards.

A Note about machine coordinates:

Your viewing direction when the machine is in use is rotated from the machine coordinates. While following movement direction directives please use the image below to familiarize yourself with the origin point and work coordinate system!



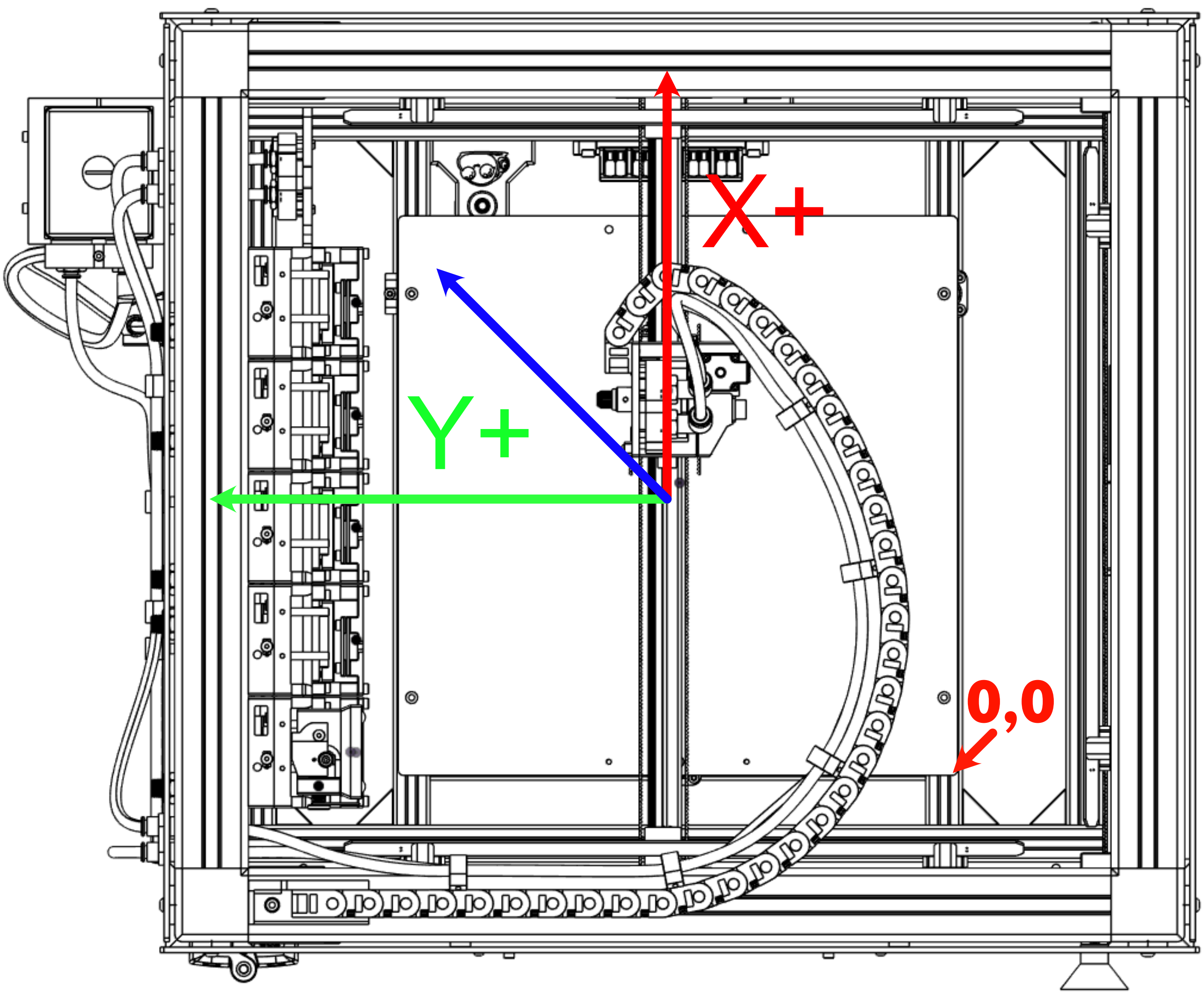
TEST POINT: **Test for the correct X motor movement by sending these commands from the console:**

G91

G1 H2 X10 F3000

If the head moves diagonally in the +X and +Y directions, all is well. If it moves in the -X and -Y directions, invert the S parameter in the M569 P0.0 command. If it moves towards +X and -Y, or towards -X and +Y, then either turn the power off and swap the X and Y motor connections, or use M584 in config.g to swap the X and Y motor drivers over.

Correct movement direction



FRONT DOOR

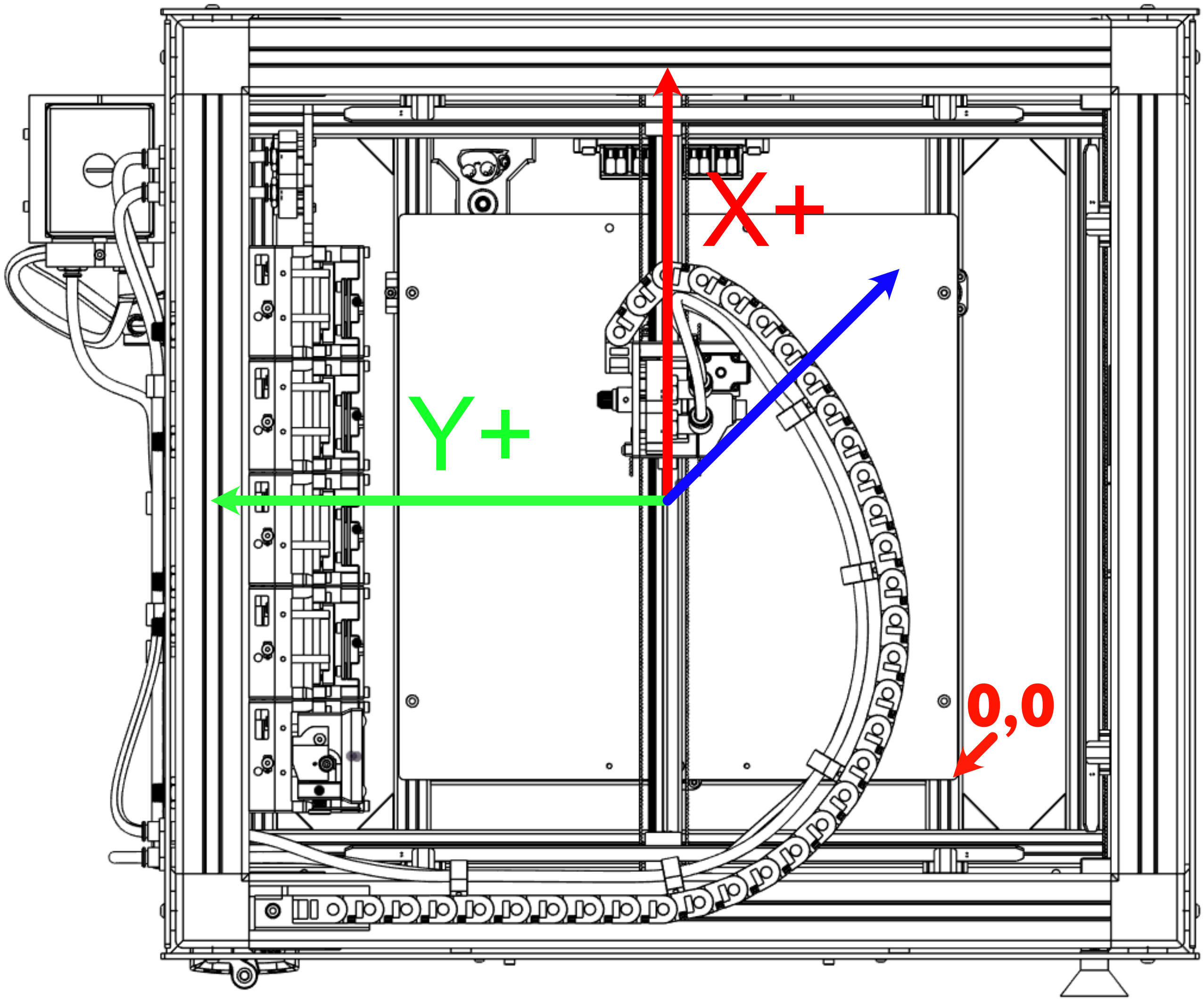
TEST POINT: When you have the X motor moving correctly, test the Y motor by sending from the console:

```
G91
G1 H2 Y10 F3000
```

If the head moves diagonally in the +X and -Y directions, all is well. If it moves in the -X and +Y directions, invert the S parameter in the M569 P0.1 command.

Important: make sure that you have chosen a right-hand axis system. That is, looking down on the printer the +Y direction should be 90 degrees anticlockwise from the +X direction. If instead it is 90 degrees clockwise, you have a left-hand axis system, which will give you mirror-image prints.

Correct movement direction



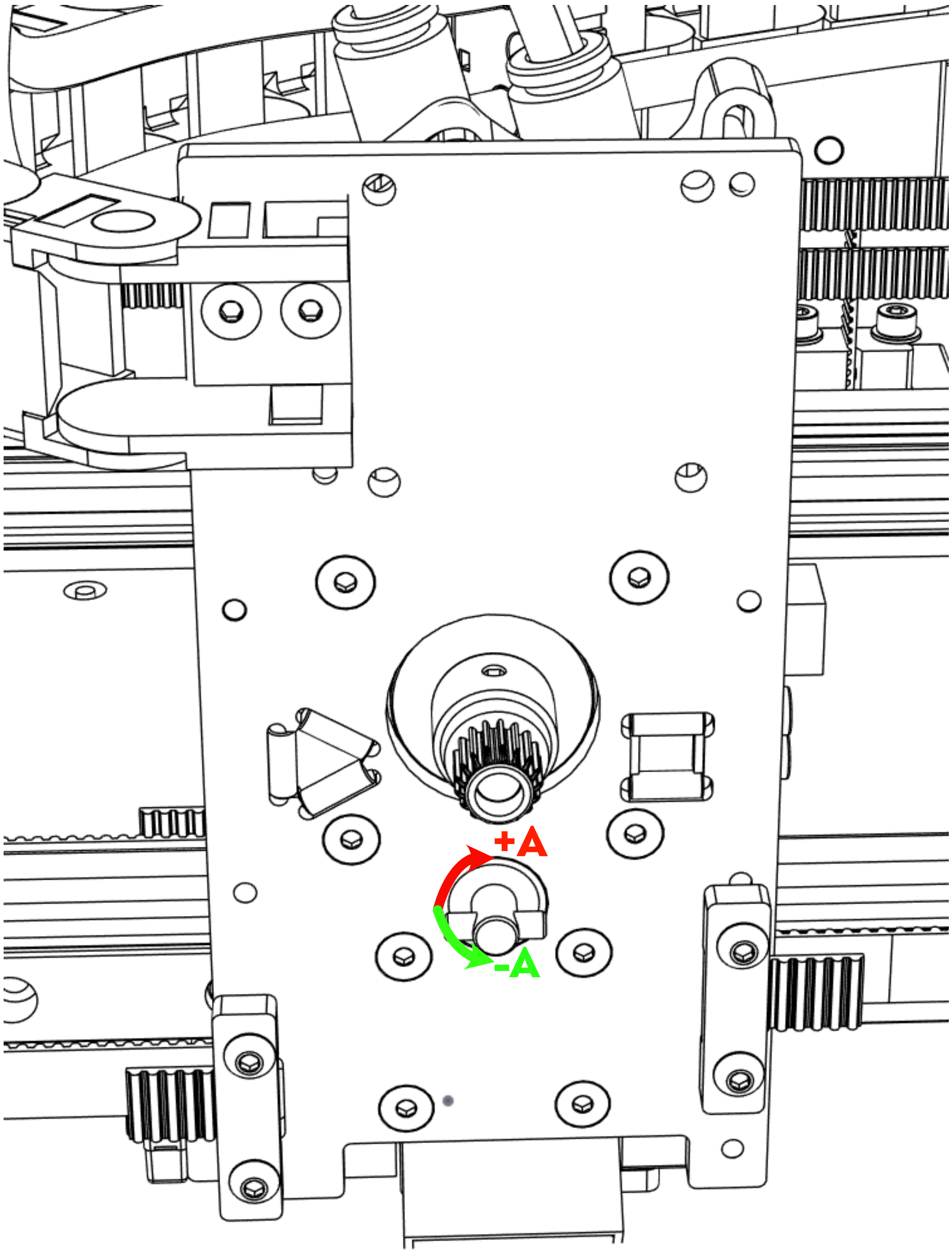
FRONT DOOR

TEST POINT: **When you have the A (Tool Lock) motor moving correctly, test the A motor by sending from the console:**

G91

G1 H2 A10 F2000

If the T-lock rotates clockwise (as viewed from the front of the X-plate shown below), all is well. If it moves in the counter-clockwise direction, invert the S parameter in the M569 P0.4 command.

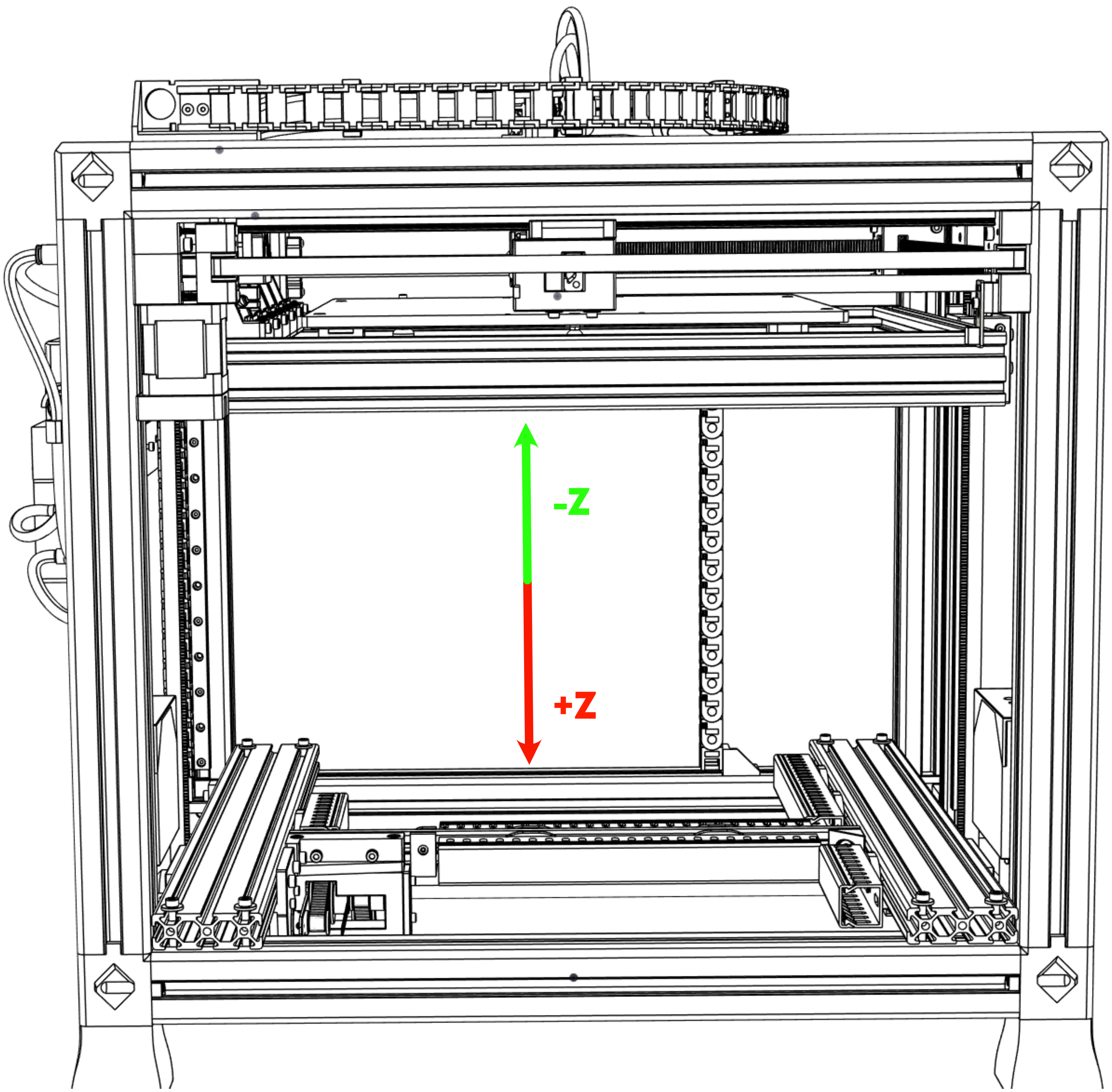


TEST POINT: **When you have the Z motor moving correctly, test the Z motor by sending from the console:**

G91

G1 H2 Z10 F3000

If the bed assembly moves downward, all is well. If it moves upward, invert the S parameter in the M569 P0.2 command.



TEST POINT: **You can now fully home the machine for the first time! Start with the bed at at least 100mm of clearance to the nozzle and the tool head near the middle of the bed. Be sure to have access to either the power switch or the emergency restart button in Duet Web Control. Here is what to expect:**

The X and Y axis move toward Xmin and Ymin (0,0) until the first of the two end stops is triggered. The remaining axis then continues until its end stop is triggered. The Gantry will then do a second slower speed homing after moving in X+ and Y+ a small distance. The Toolhead will then move to the center of the build area.

The Z axis will raise slowly until the Z probe microswitch is triggered. The bed will then drop a few mm for a second lower speed probe. The bed will then lower by 10mm

The A axis will rotate toward the "Tool Locked" direction a short distance, and then slowly approach the A axis endstop until it is triggered.

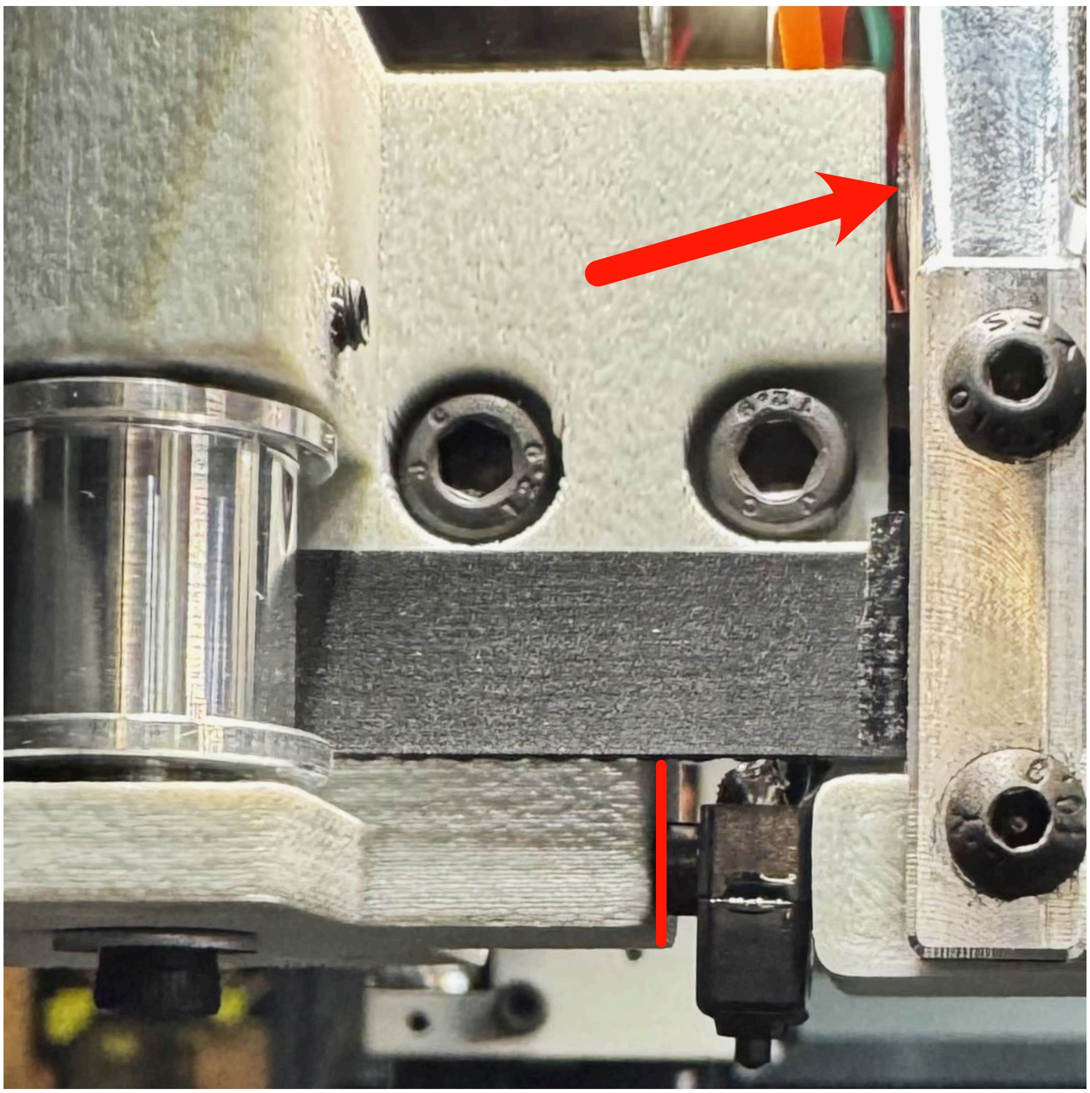
If everything goes as it should, the following X, Y, Z and A values should be shown (or similar)

TEST POINT: **For future steps we must confirm that our total X axis travel is available.**

The default value in config.g for X max is 308.5mm. Your machine should be able to reach this value without mechanical contact between the tool head and XY gantry.

Slowly jog the tool head in the X+ direction as you approach X-MAX.

See the image below for critical locations.



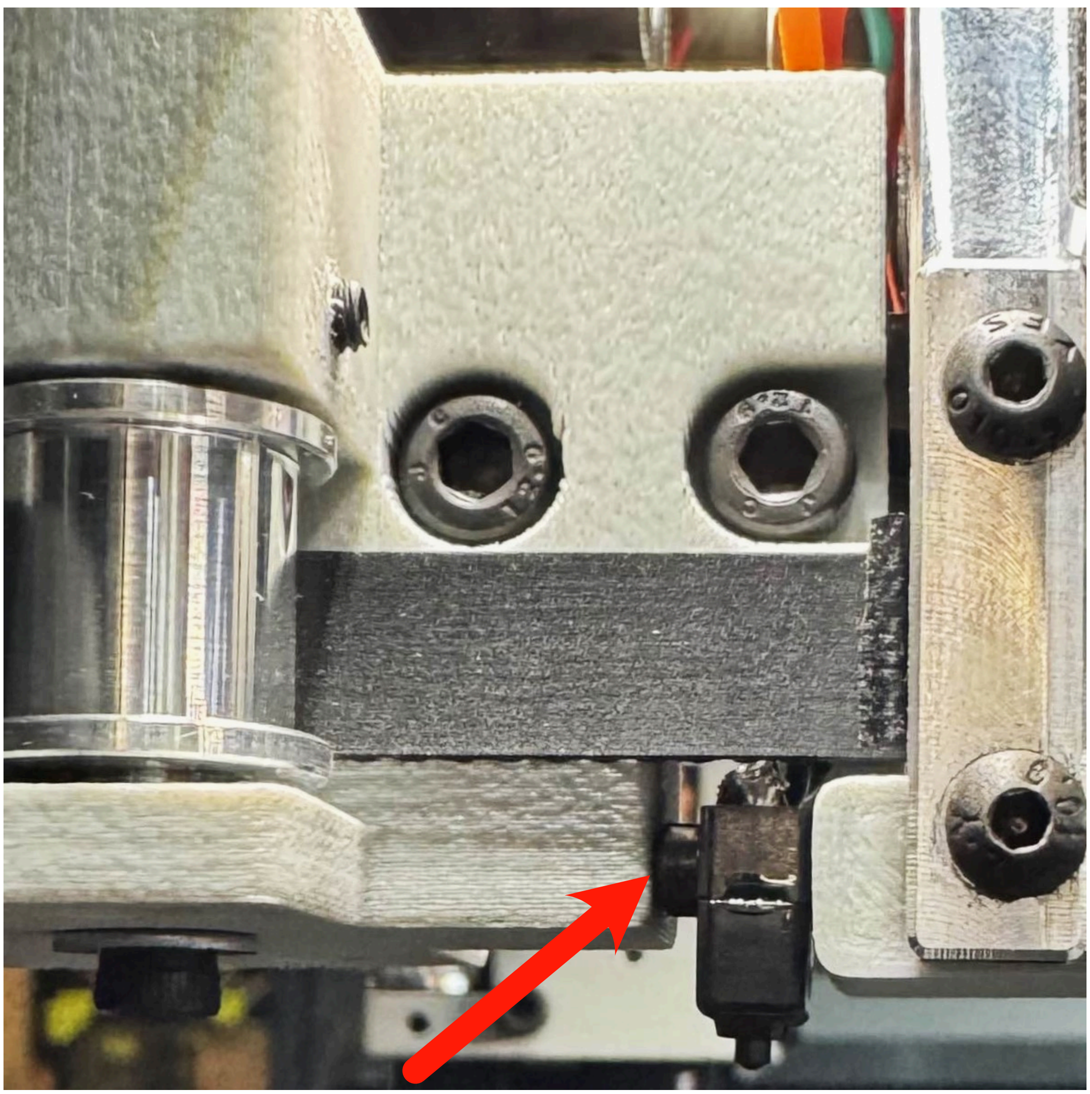
Confirm that sufficient (though minimal) gap exists between the tool head and XY gantry at an absolute position of X308.5.

X Travel Troubleshooting

ISSUE: My toolhead contacts the gantry before XMAX is reached.

This is most often caused when the threaded Blackstop hall effect trigger is not threaded far enough into the printed part on the XMIN side of the gantry. Revisit page 10 of this commissioning guide being certain that the endstop trigger is threaded as far into the printed part while still maintaining the test points.

If the issue remains - locate the point of contact and resolve as needed. Early bill of materials used socket head cap screws to retain the Z switch. Swapping to button head screws is a common solve for contact at this interface.



Finding + Teaching Tool Lock Rotation Distance

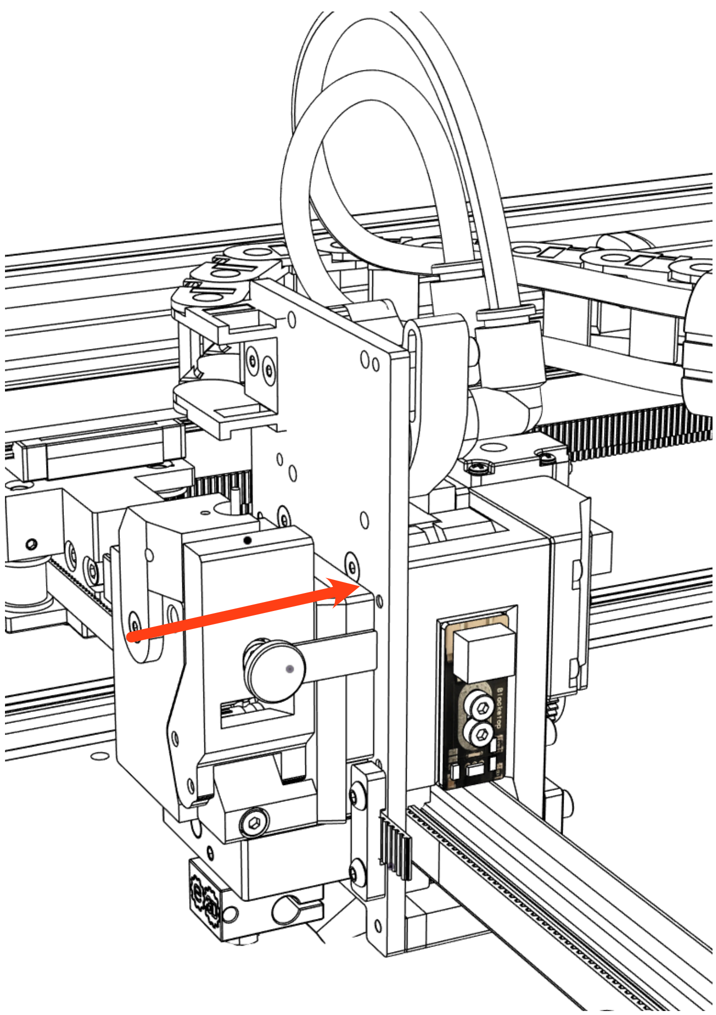
Each tool will require it's own specific rotation value required to pull the tool tightly against the kinematic mounts, without being TOO tight. Incorrect setting of this value can result in poor precision (too loose) or short wedge plate life (too tight).

Begin by placing tool 0 (the tool closest to the idle cooler's water block) onto the tool head by hand. While applying light inward pressure (direction of arrow below) jog the A axis manually in Duet Web Control by 1mm increments until the following conditions are met:

1. A typical value is somewhere between 8 and 13mm (absolute A axis position)

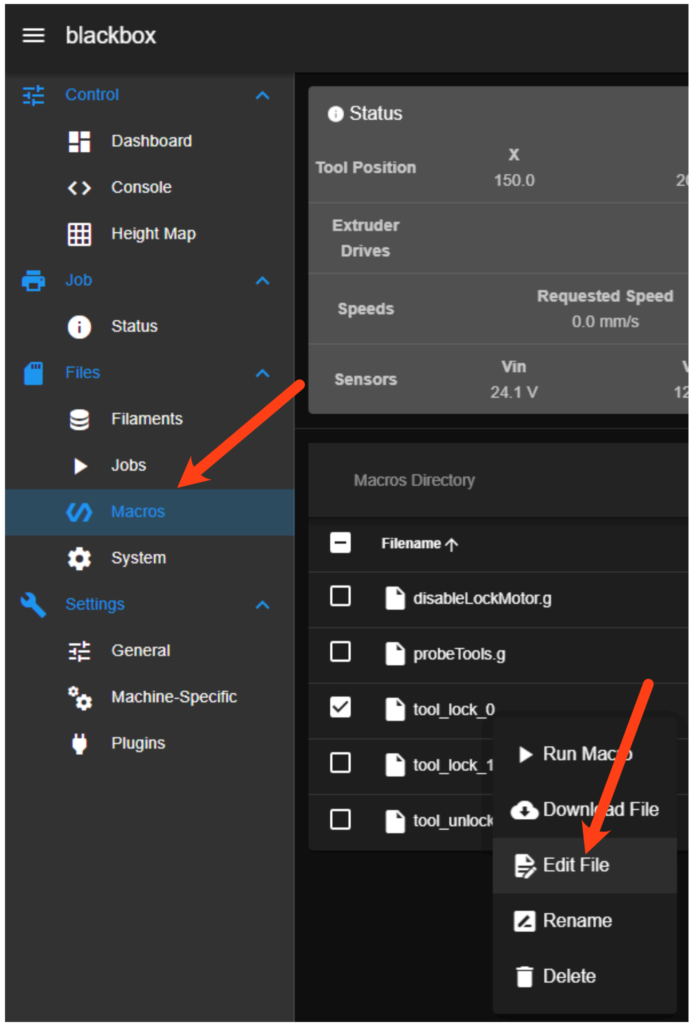
2. Wiggling the tool in any direction with light to light-moderate pressure does not result in movement of the tool independent of the X axis tool head.

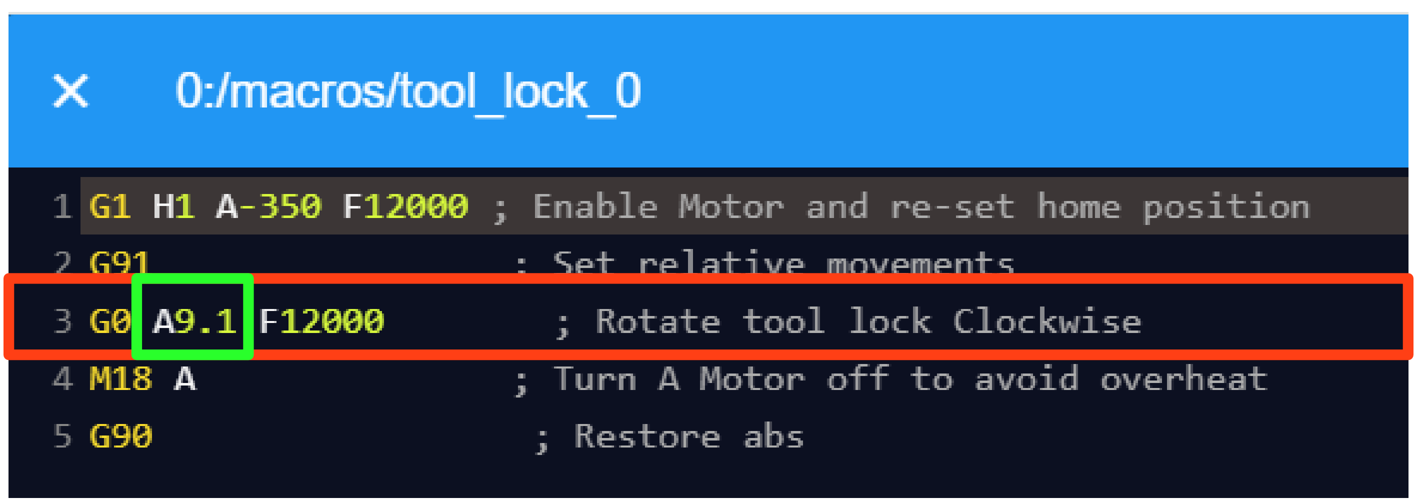
3. No excessive number of skipped steps on the A motor are present. It is OK for a few steps to be skipped during a given tool mounting procedure, but an excessive duration of them suggests your lock distance value is too high.



Once you've identified the correct value for a given tool, modify the associated lock macro to include it:

1. **Go to the "Macros" directory**
2. **Right click the macro for the tool you're working with and select "edit"**
3. **Replace the value at the shown location**
4. **Save**





Repeat this process for ALL tools equipped to the machine

TEST POINT: All equipped tools can be mounted by hand with a repeatable tension using only the locking macro associated with a given tool.

Finding + Teaching Tool Dock Positions

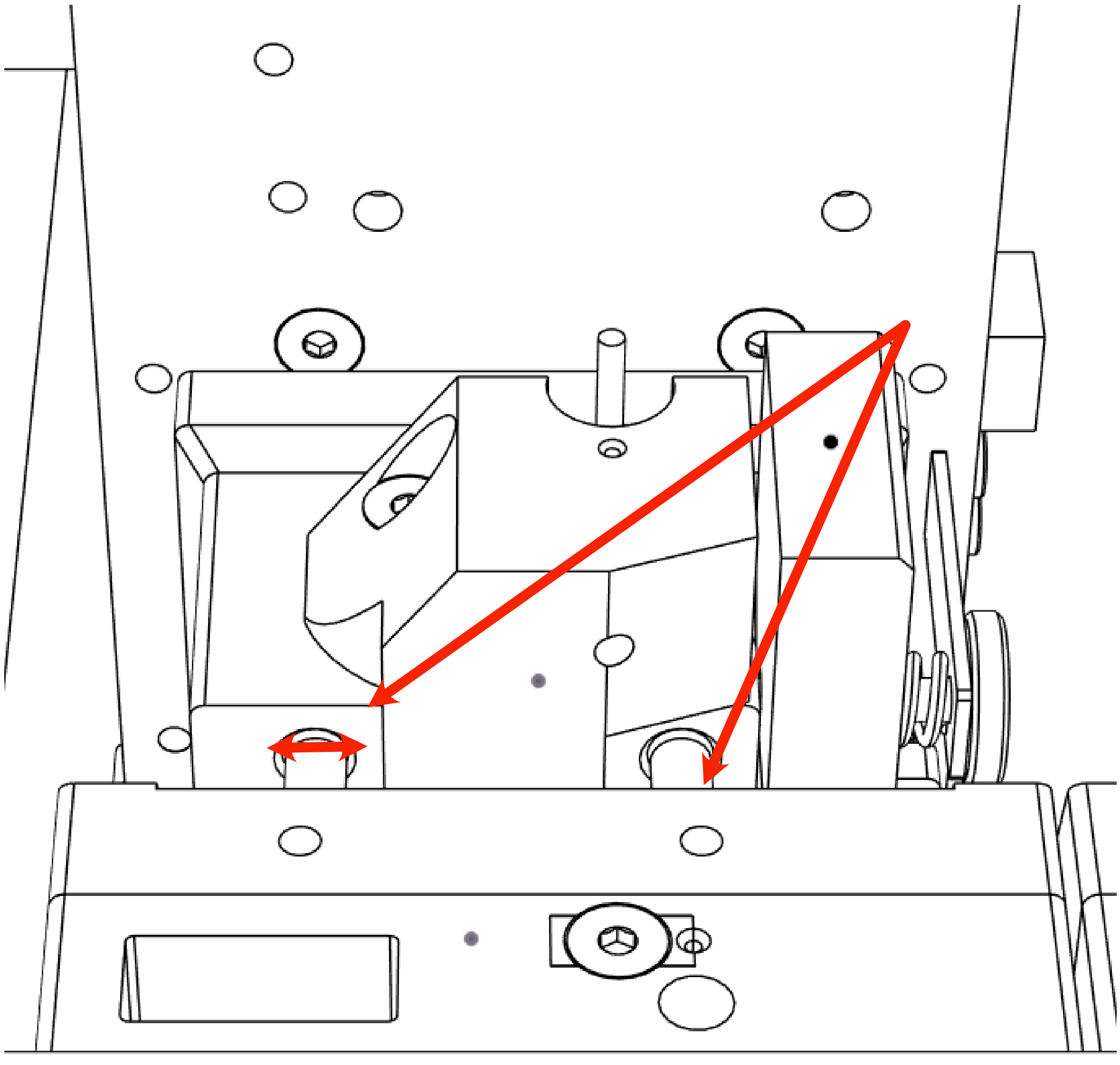
Each tool will require it's own specific and accurate tool dock location in the XY plane. Perform the following steps to acquire these values:

X VALUE:

1. Manually mount a given tool to the tool head using the lock macro as in the previous section.

2. Use Duet Web Control to manually jog the tool head + tool toward it's respective dock. Larger movements can be used at first, with incrementally smaller movements being needed for precision as you get closer to perfection.

3. Continue until the tool is at the closest Y+ position it can be before beginning to contact the tool posts and you have the tool positioned similar to the image below:



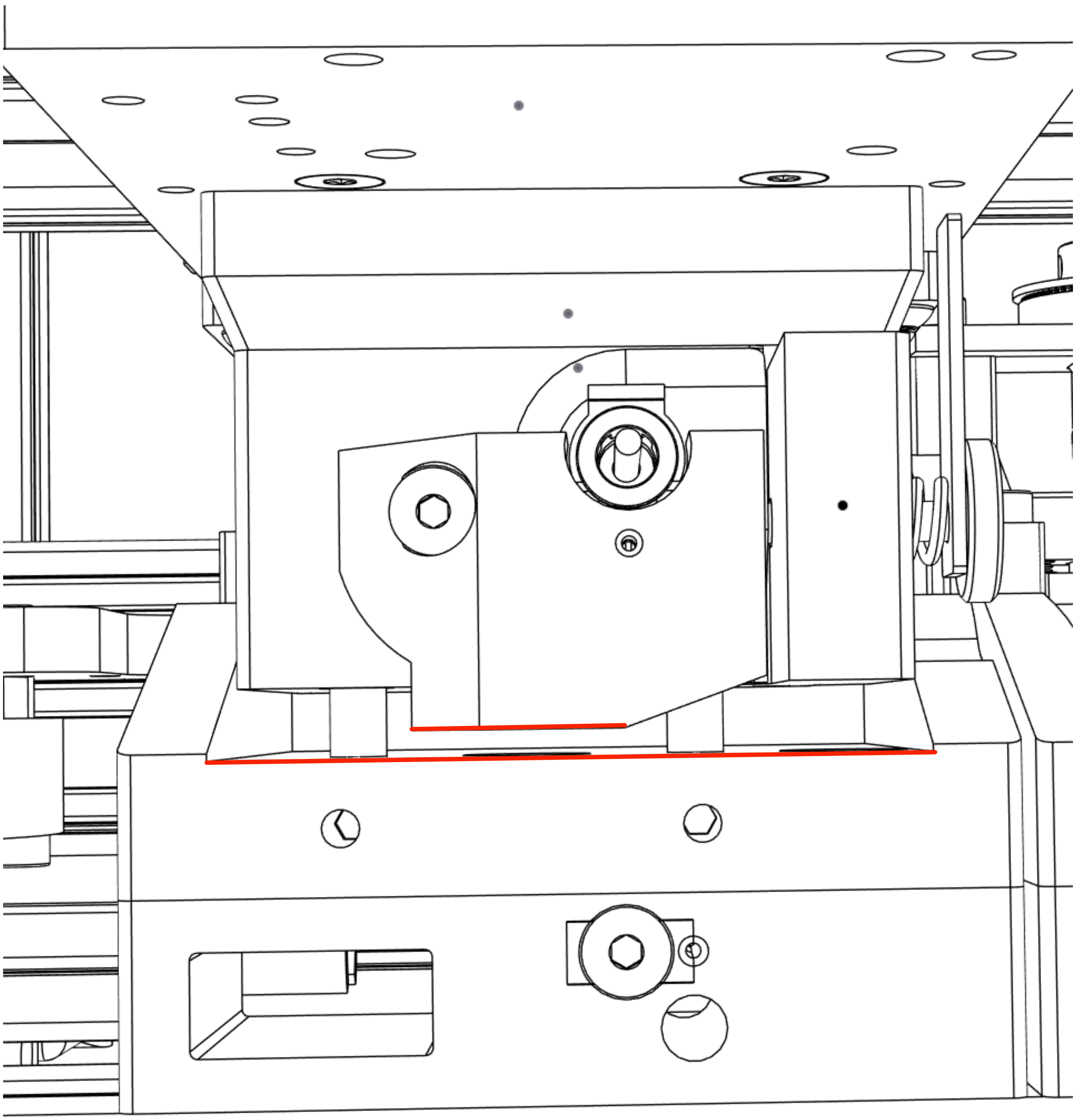
4. Note the displayed absolute X position of the gantry. This value will represent the X location of the tool dock in space.

Y VALUE:

CAUTION: Before proceeding with identifying the tool dock Y value, the set height of the tool docks must allow for the dock guide pins to slide into the tool without contacting the tool itself. Each tool dock is adjustable in the Z direction to enable correction for this if needed.

If your tool docks require multiple different height settings per tool for this to be achieved you likely have an issue with the cold block to X-plate adjustment consistency. See the FDM tool guide to resolve this.

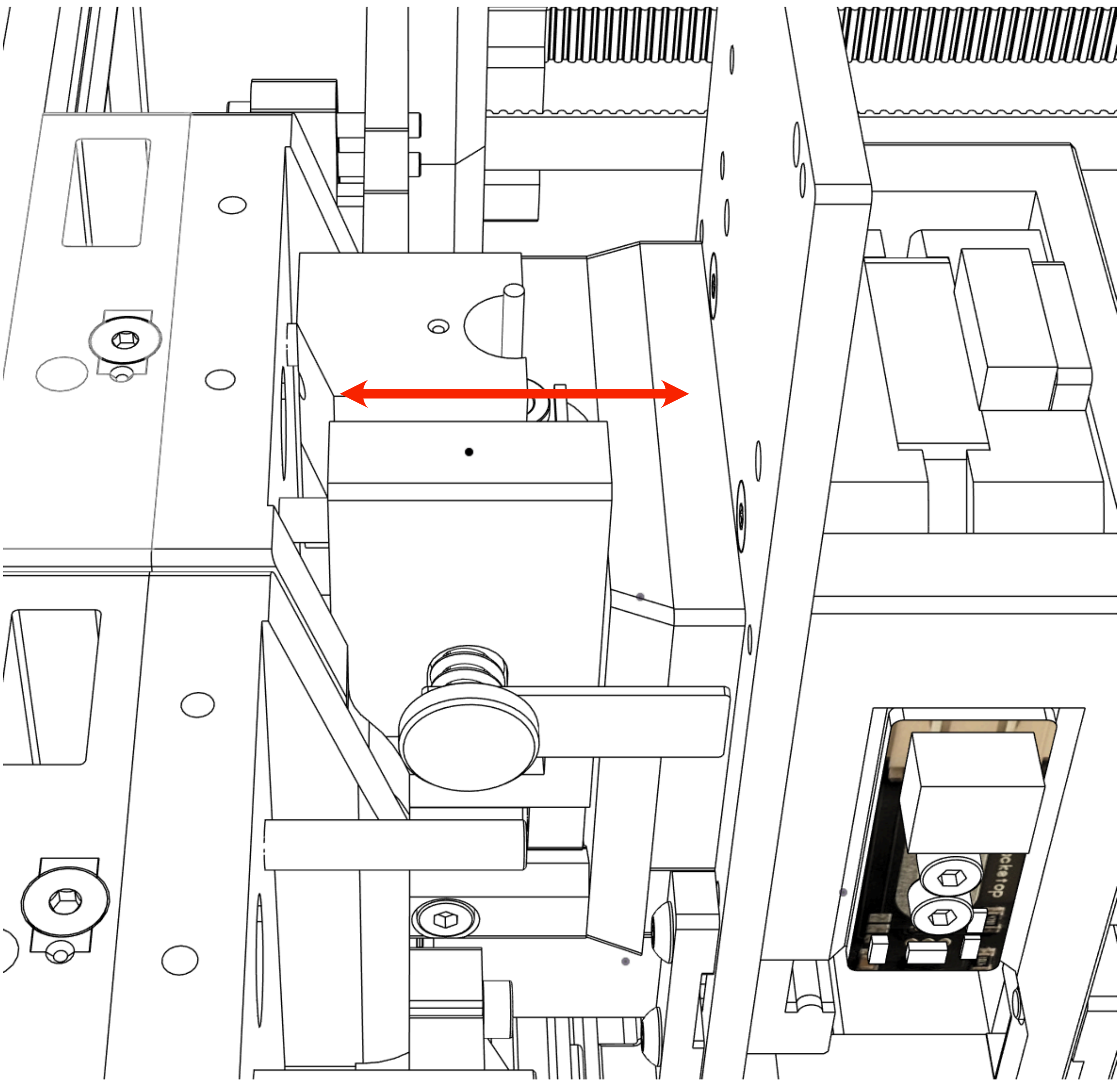
1. Slowly jog the tool head using using Duet Web Control in the Y+ direction until the distance between the face of the tool and the face of the dock is approximately 1.5mm (shown below)
2. Run the "Tool_Unlock" Macro to free the tool from the gantry.



Slowly jog the tool head in +0.1mm increments using using Duet Web Control in the Y+ direction while using your free hand to check the amount of movement allowed at each position (image below). The target value will meet the following conditions:

1. The tool 's position is lightly constrained by contact from both the X plate at the front of the tool cooler and the idle cooling bar at the back - effectively sandwiching the cold side between both passively cooled surfaces.
2. NO STEPPER MOTOR SKIPPING WAS OBSERVED - If you went too far in Y+ and skipped steps at any point you will need to dismount the tool and re-home the machine before another attempt!

Note the displayed absolute Y position of the gantry. This value will represent the Y location of the tool dock in space.



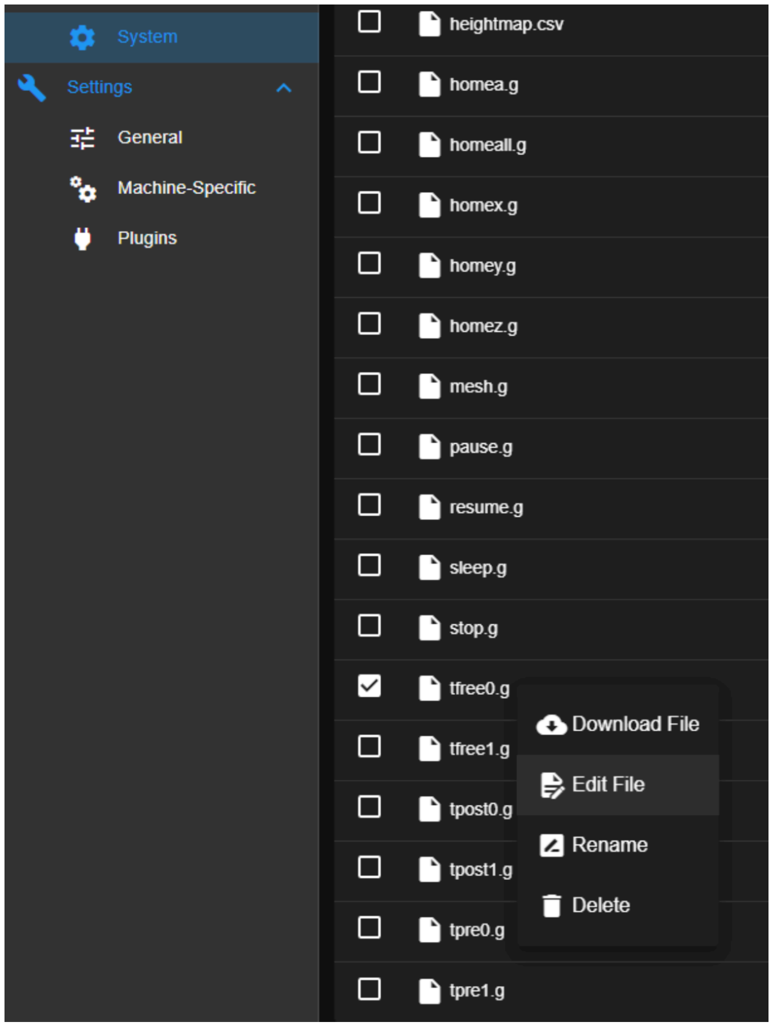
Do not yet leave this position! We will take this opportunity to perform some final checks and adjustments after modifying the macros that use the X and Y values you noted above.

Open the “System” tab in Duet Web Control and locate the 3 macro files associated with the tool from which the above recorded values came from. The 3 macro files that will be modified are:

1. **tfree(n).g**
2. **tpost(n).g**
3. **tpre(n).g**

Where (n) represents the zero index tool number to be set.

Start by opening tfree(n).g and insert your recorded X value in the locations marked in GREEN




```
G91                        ; Set Relative Movements
G1 E-10 F2400
G1 Z3                      ; Pop the Z down slightly
G90                        ; Restore Absolute Movements
G53 G0 X246.2 Y294 F18000         ; Rapid to the approach position with tool-0. (park_x, park_y - offset)
G53 G1 Y333.3 F1000         ; Controlled move to the park position with tool-0. (park_x, park_y)
M98 P"/macros/tool_unlock" ; Unlock the tool
M18 E0                      ; Disable extruder stepper for next tool engagement.
G53 G1 Y294 F10000         ; Retract the tool.
```

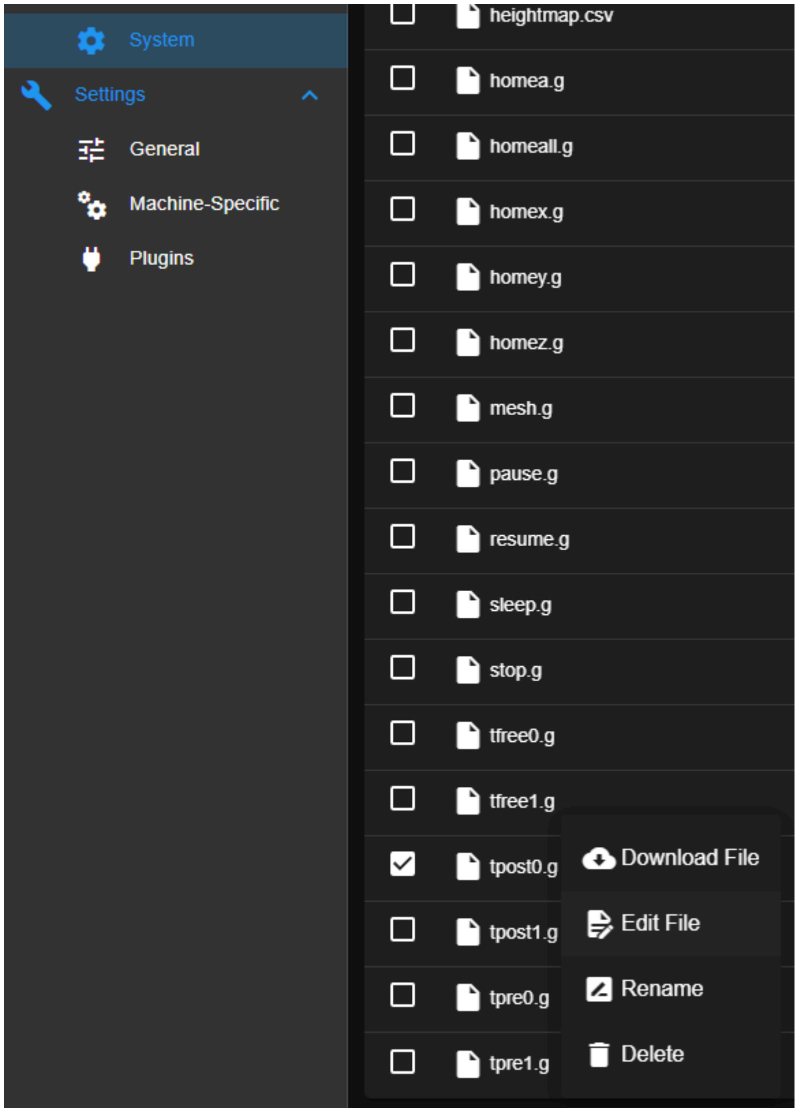
Save the file

Open tpost(n).g

Insert your recorded X value in the locations marked in GREEN

Insert your recorded Y value in the locations marked in BLUE

Note: The location shown in MAGENTA should be around 3mm less than the entry made to the Y value locations. You may adjust these now.

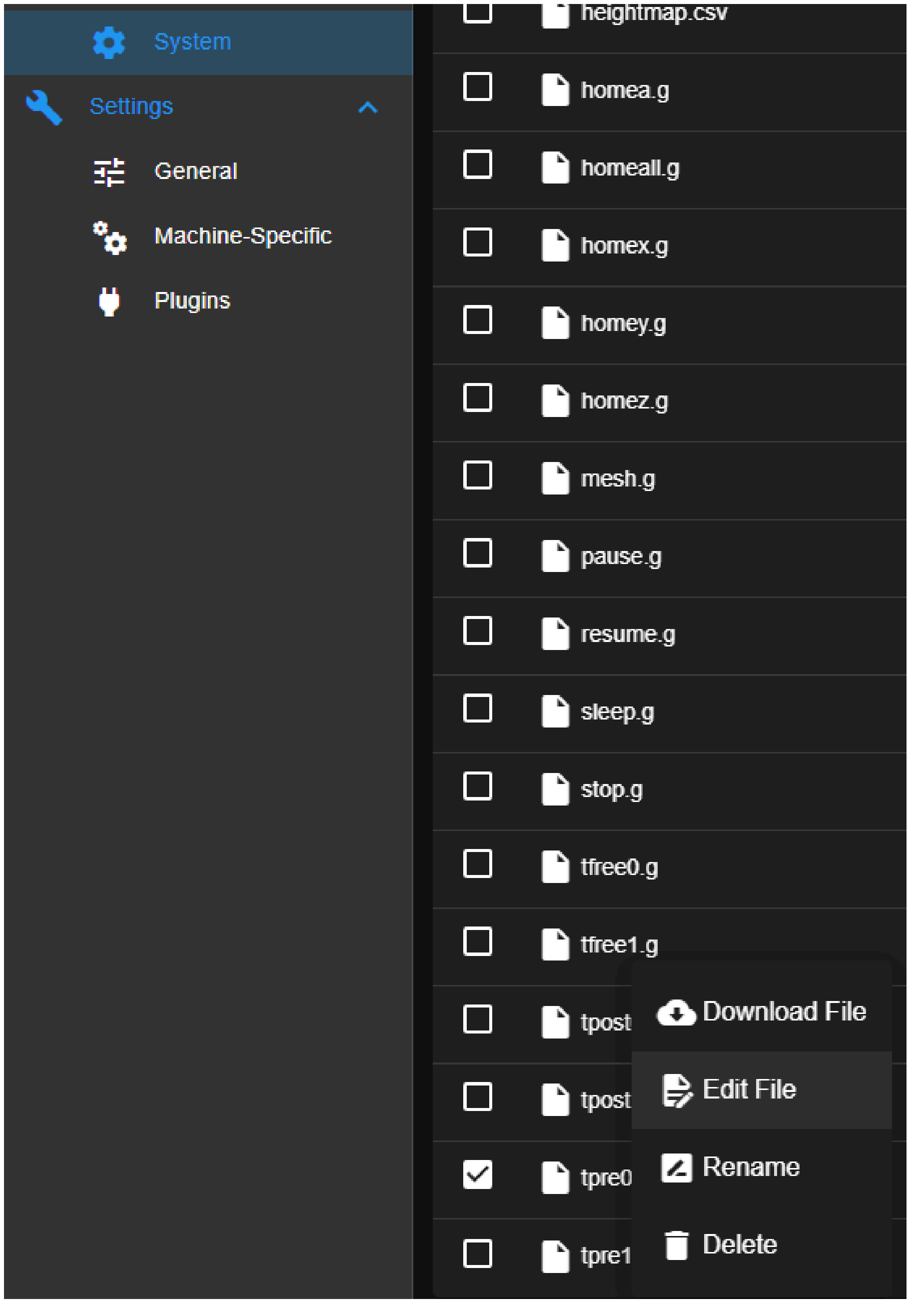



```
G53 G0 X246.2 Y294 F18000 ; Rapid to the approach position without any current tool.
M302 P0                   ; Prevent Cold Extrudes, just in case temp setpoints are at 0
M106 P0 S1
G53 G1 Y330 F3000          Move to the pickup position with tool-0.
G53 G1 Y333.3 F300        ; Contact the coupler by pushing on it.
M98 P"/macros/tool_lock_0" ; Lock the tool
```

Save the file

Open tpre(n).g

Insert your recorded X value in the locations marked in GREEN




```
; Runs after freeing the previous tool if the next tool is tool-0.
; Note: tool offsets are not applied at this point!

G0 X246.2 Y294 F18000 ; Rapid to the approach position without any current tool.
```

Save the file

Fine Tuning Cold Block Contact

The current position (as achieved by the tool dock calibration steps in the previous section) of the machine is perfect for checking and adjusting the tool docks and/or cold blocks to achieve proper contact during both tool-active and tool-inactive status.

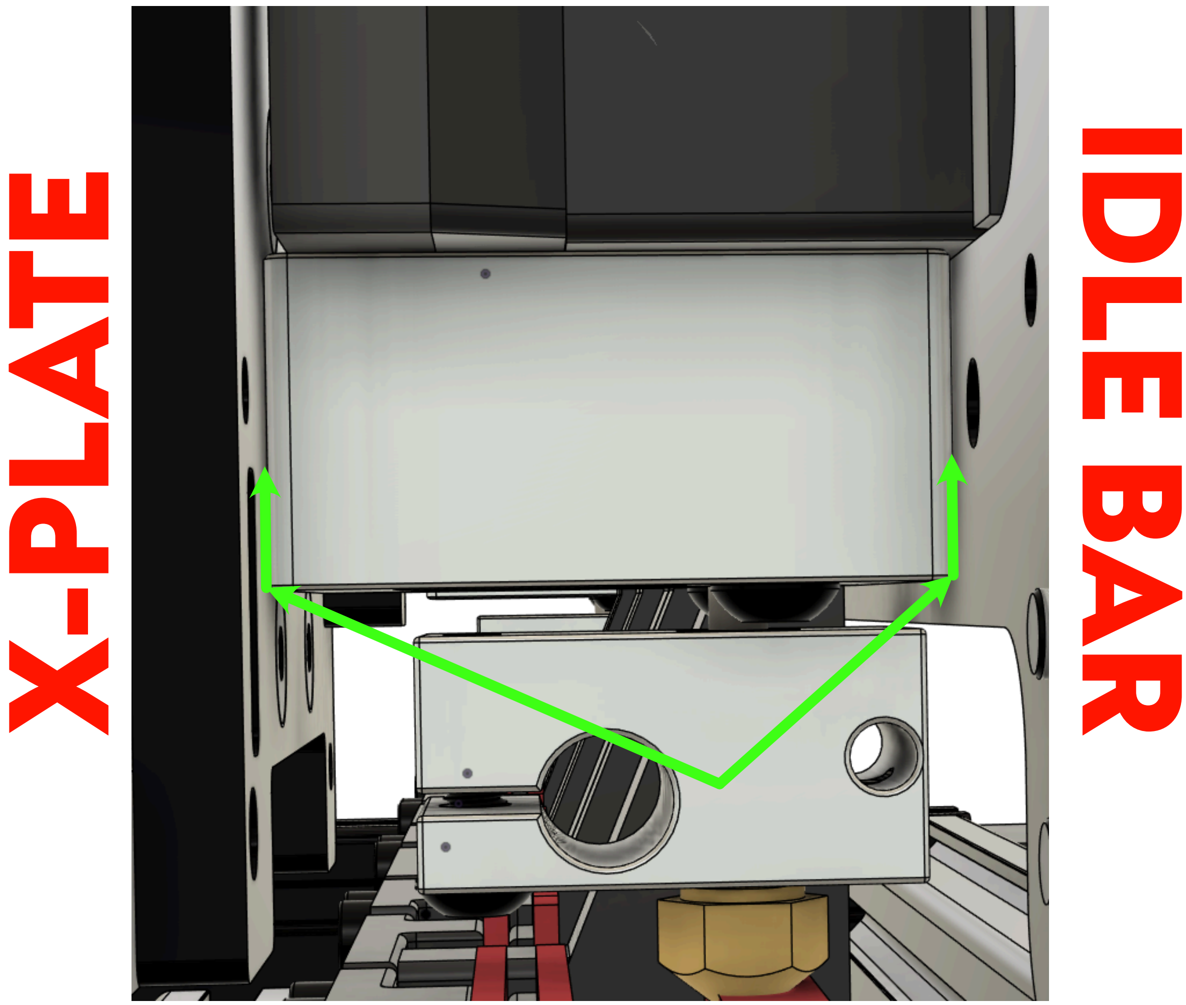
When the tool is active (printing) the cold side is conduction cooled through the interface with the X-plate.

When the tool is inactive (idle) the cold side is conduction cooled through the interface with the idle tool cooling bar.

It is important that the face of the cold block is contacting both surfaces squarely. Any gaps caused by misalignment can result in too much heat accumulating in the heat break - causing jams.

The process for this can be found in the FDM Tool and Tool Dock assembly guides. Take this opportunity to double check the contact points below.

Note: Some objects are hidden to better show the contact surfaces.



Jog the Y axis of the machine toward Y min until the extruder drive gear is clear of the now parked tools key way.

Repeat the above procedures for each tool to be commissioned!

TEST POINT: **All commissioned tools have followed the steps outlined in the above sections. Each tool has gone through a mount and dismount process without failure.**

Begin by power cycling the machine or pressing the emergency restart in Duet Web Control.

1. **Perform a "Home All" routine**
2. **Use the console within Duet Web Control to perform the following commands.**

T0

The tool head will approach tool 0 and proceed to engage it. The tool head will return to it's previous position before T0 was commanded.

If you have additional tools:

T1

The tool head will dock and release tool 0 and then proceed to engage tool 1. All motions should be performed cleanly without binding or sticking. Tool 1 will return to it's previous position before T1 was commanded.

If you have additional tools:

T2
T3
T4

Repeat the process above while observing the results until you've tested all equipped tools.

For your final tool:

T-1

The tool head will dock and release the currently equipped tool (regardless of its number) and then return to it's previous position before T-1 was commanded. All motions should be performed cleanly without binding or sticking.

Not thrilled with the result? Start fresh at the top of this commissioning guide and have another go. This is the foundation of your machine's performance going forward!

Setting the Z Offset Switch Location

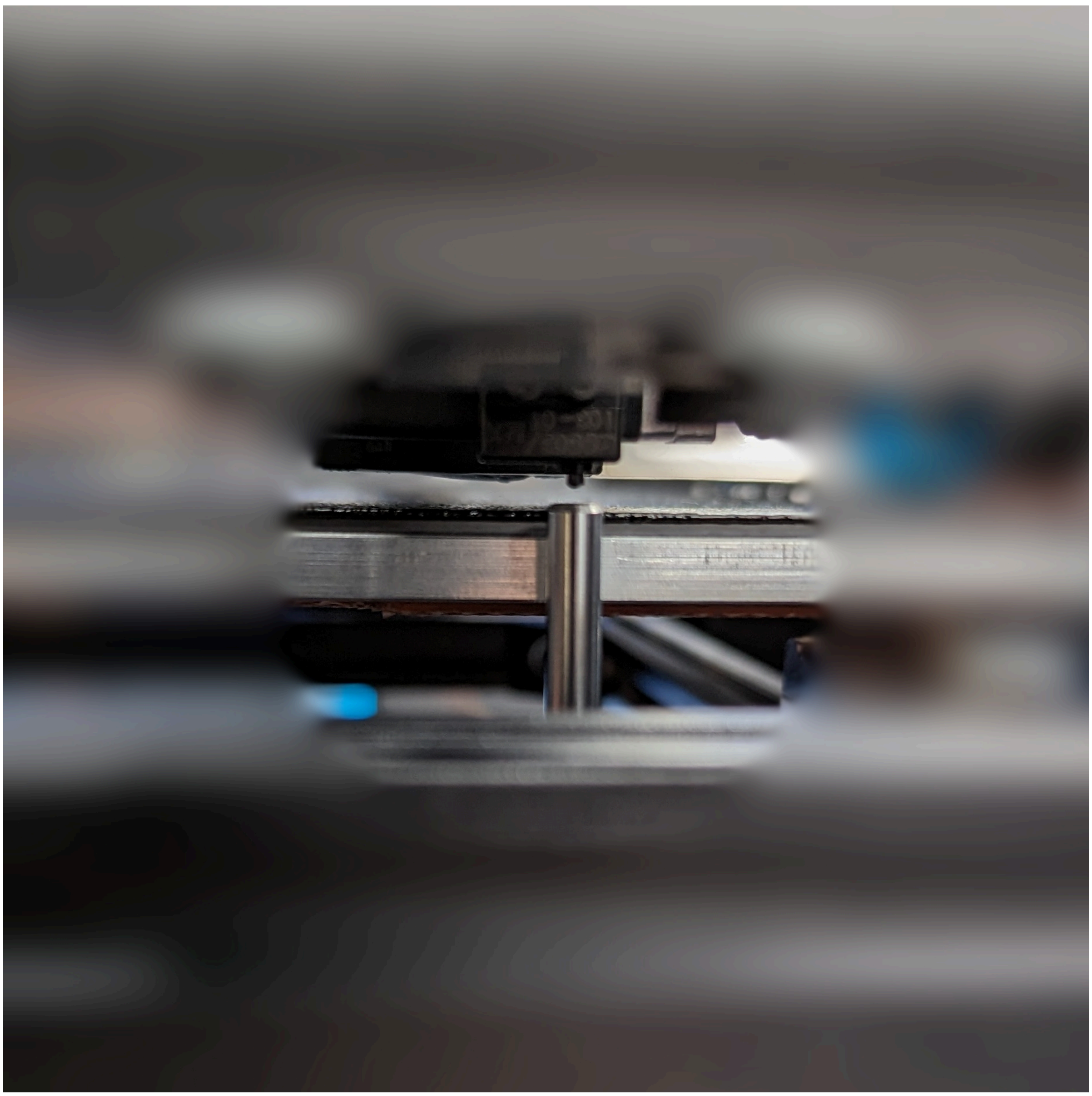
By default the downloaded base firmware has an X and Y value for the expected position of the Z offset probe pin.

The default value is:

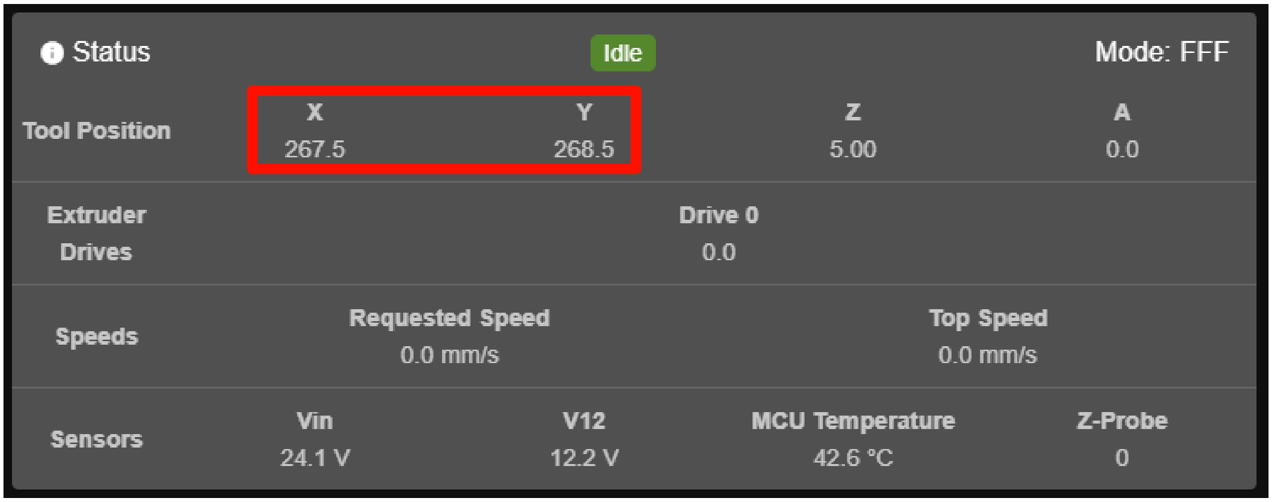
X= 266.2
Y= 268.5

Jog the machine manually to place the Z Probe centered over the Z offset Switch Pin as shown below.

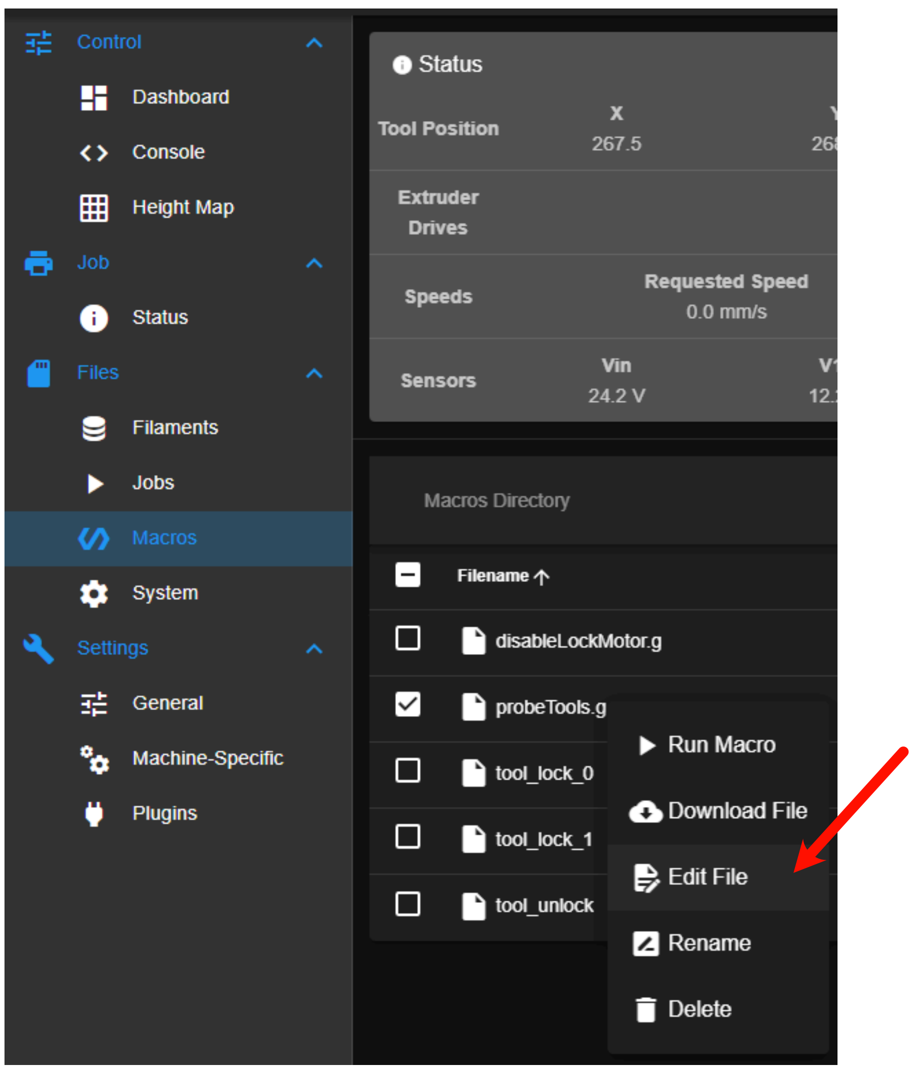
NOTE: It is important that no tool offsets are still presently applied! Consider restarting the machine and re-homing if your numbers deviate from default values by more than 10mm!



Once the correct position is reached, record the absolute X and Y values from Duet Web Control.



Open the "probeTools" Macro under the"Macros" Menu



Edit the corresponding values of the plateX and plateY variables

0:/macros/probeTools.g

```
; probeTools.G
; Original author: Haytham Bennani (H2B on Jubilee Discord - https://di
; This Macro is further tuned for use with Blackbox CE
; Firmware: RRF3.4.x and above
; This macro file utilizes the sexbolt Z switch by L.E.O.P.A.R.D and Ha
; USAGE NOTES:
;       - update the variables plateX and plateY as needed to reflect t
;       - ensure all your tools are at printing temperatures for best r
;       - ensure all your tool nozzles are clean from material and/or d
;       - this file is designed to probe 3 tools; if you have less, com
;       !! - ensure your definition for your doorknob probe (M558 line
;
; DISCLAIMER: You bear full responsibility and accountability for using
;4.3mm above bed = Trigger point for sexbolt
; ----------------------------------------------- machine setup
; probe X and Y coordinates
var plateX = 267.5
var plateY = 268.5
```

Save the file!

Heater Tuning

NOTE:

It is assumed at this time that your machine is electrically commissioned in that:

All thermistors report a similar resting (ambient) temperature
All heaters are functional and have been successfully warmed to 50C via the DWC or Paneldue interface

All heaters on Blackbox CE utilize PID tuning for more accurate temperature control, including the heated bed.

RRF has an automated tuning process to make this easy!

PID tuning the heated bed:

Before starting, your build plate should be installed so that it's thermal mass is accounted for!

Enter the following command into the console:

M303 H0 S70

Upon execution the firmware will cycle the bed heater while monitoring the associated thermistor. This is how it learns the real-world result of heating commands sent to the heater it self. Upon completion the firmware will display a success message containing an M307 command for you to use.

Paste the new M307 command in the config.g system file at line 47.

```
31 ; Axis Limits
32 M208 X0:308.5 Y0:335 A0:18
33
34 ; Endstops
35 M574 X1 S1 P"!io1.in"
36 M574 Y1 S1 P"!io2.in"
37 M574 A1 S1 P"!io4.in"
38
39 ; Z-Probe
40 M558 P8 C"io3.in" H1 F500:80 A5 T16000
41 G31 P1000 X0 Y0 Z0
42 M557 X0:290 Y0:280 S36
43
44 ; Heaters
45 M308 S0 P"temp3" Y"thermistor" T100000 B4138
46 M950 H0 C"out3" T0
47 M307 H0 R0.491 K0.330:0.000 D3.25 E1.35 S0.90 B0
48 M140 H0
```

PID tuning FDM Tools:

Each FDM tool requires it's own PID profile, especially for those using different types of hot ends.

FDM tools should be PID tuned while active (AKA mounted to the X carriage) - NOT while interfaced with the idle cooling dock!

Pickup tool 0 and enter the following command into the console:

M303 H1 S220

***Where Hn = the heater number you wish to tune (see below)**

Upon execution the firmware will cycle the tool 0 heater while monitoring the associated thermistor. Upon completion the firmware will display a success message containing an M307 command for you to use.

Paste the new M307 command in the config.g system file at line 52.

```
34 ; Endstops
35 M574 X1 S1 P"!io1.in"                                   ; c
36 M574 Y1 S1 P"!io2.in"                                   ; c
37 M574 A1 S1 P"!io4.in"                                   ; c
38
39 ; Z-Probe
40 M558 P8 C"io3.in" H1 F500:80 A5 T16000                  ; s
41 G31 P1000 X0 Y0 Z0                                      ; s
42 M557 X0:290 Y0:280 S36                                  ; c
43
44 ; Heaters
45 M308 S0 P"temp3" Y"thermistor" T100000 B4138            ; c
46 M950 H0 C"out3" T0                                      ; c
47 M307 H0 R0.491 K0.330:0.000 D3.25 E1.35 S0.90 B0        ; c
48 M140 H0                                                 ; m
49 M143 H0 S120                                            ; s
50 M308 S1 P"temp0" Y"thermistor" T100000 B4138            ; c
51 M950 H1 C"out1" T1                                      ; c
52 M307 H1 R4.914 K0.409:0.429 D2.11 E1.35 S1.00 B0 V24.0
53 M143 H1 S280                                            ; s
```

Repeat these steps for each equipped FDM tool, being sure to overwrite the M307 command associated with that particular heater. The standard mapping is as follows:

H0 = Bed
H1 = T0
H2 = T1
H3 = T2
H4 = T3
H5 = T4

Setting XY Offsets

In a perfect world all of our nozzles would end up in the same exact position as in CAD. Alas, the world is not perfect. There are multiple methods we can use to identify and record these offsets, with some being more automated than others. Once properly identified, each of our tool's nozzles will reach the same absolute position, despite those real-world inaccuracies introduced by slightly varying printed parts, wear or other factors.

This commissioning guide will not cover any of these methods in detail, as these are maintained on their own.

High Level Overview:

All methods make use of a 'control point.' Essentially this acts as a value by which all offsets are compared to. For Blackbox the control point is designated as the tip of the nozzle for tool 0.

I.e. Each tool's XY offsets are based on their difference when compared to tool 0. For this reason, tool 0's stated offsets (located in the G10 command for tool 0) is X0 Y0 Zn (Z calculated in the next step)

The 2 most-used methods of calibration are:

1. **Camera Assisted - This method uses a camera to locate the tip of the control point and each subsequent nozzle without the need for printed extrusions. The machine is jogged until the nozzle of tool 0 is centered over the on-screen cross hairs and submitted as the control point. Each tool is then jogged such that the center of the nozzle is in the cross hairs, with software calculating the offset to be recorded in your G10 commands.**

2. **Camera Assisted + Automatic AKA TAMV - This method is identical to method 1, but the entire process is automated using a raspberry pi and machine vision.**

It is extremely important that your nozzle returns to the same position regardless of how many times it is picked up and dropped off! This calibration requires repeatable tool changing kinematics to operate.

This process can take time, depending on the method you choose to use. It only needs done once, however - and not again unless changes are made to the X carriage or equipped tools. Drifting XY offsets are a direct result of mechanical issues, all of which this commissioning guide has evaluated.

Have at it!

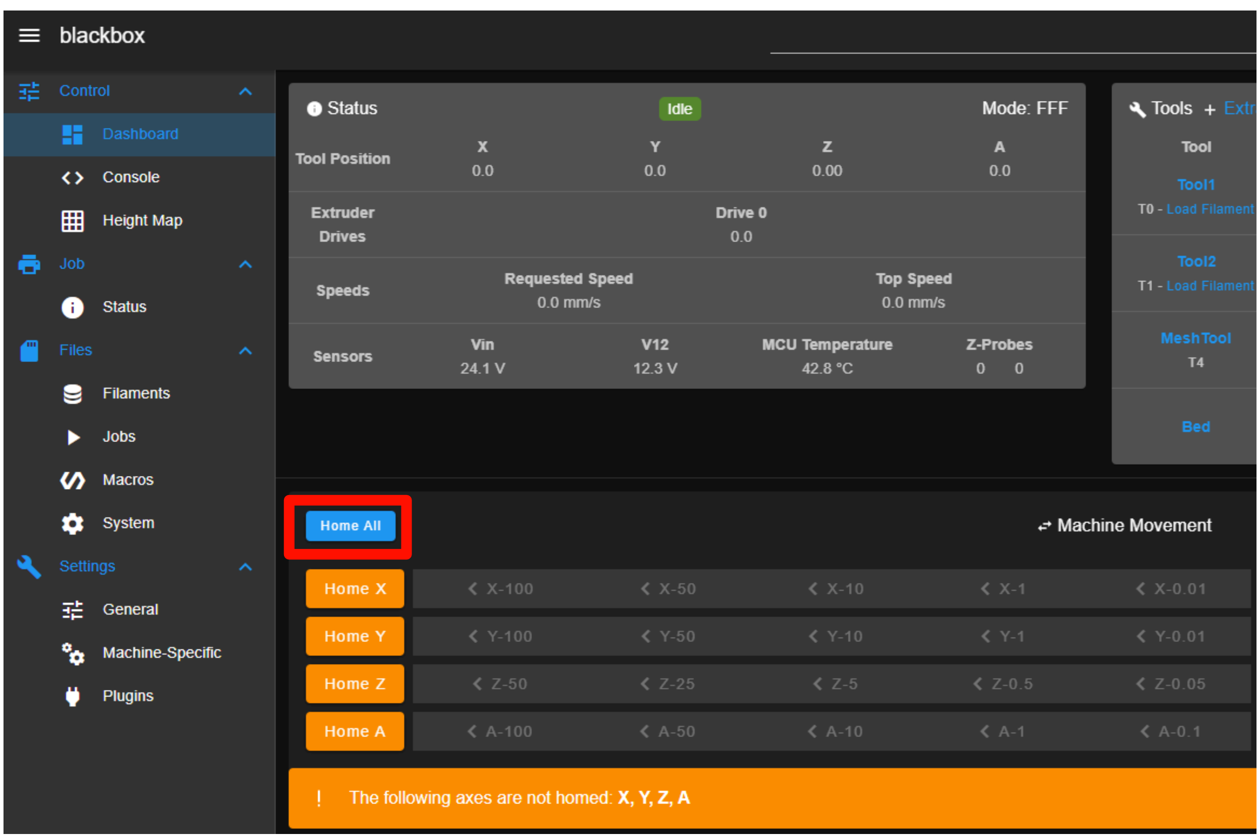
Return here when XY offsets have been set and confirmed

Setting Z Offsets

Just like X and Y offsets, tools/nozzles have varying Z heights as well. This can be due to assembly/part variations, or simply by using different types of tools.

Blackbox CE is equipped with a Z offset probe to automatically calculate these values for you via a macro called probe_tools.g

Begin by using the 'Home All' command - or G28 in the console on Duet Web Control

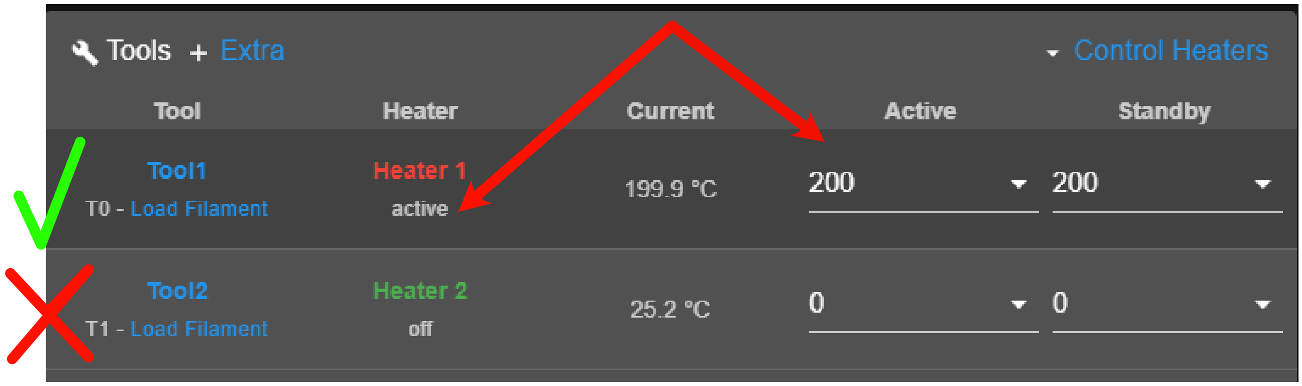


Activate the heated bed to a temperature of 60C

Activate the heater of all FDM tools to a temperature of 200-250C

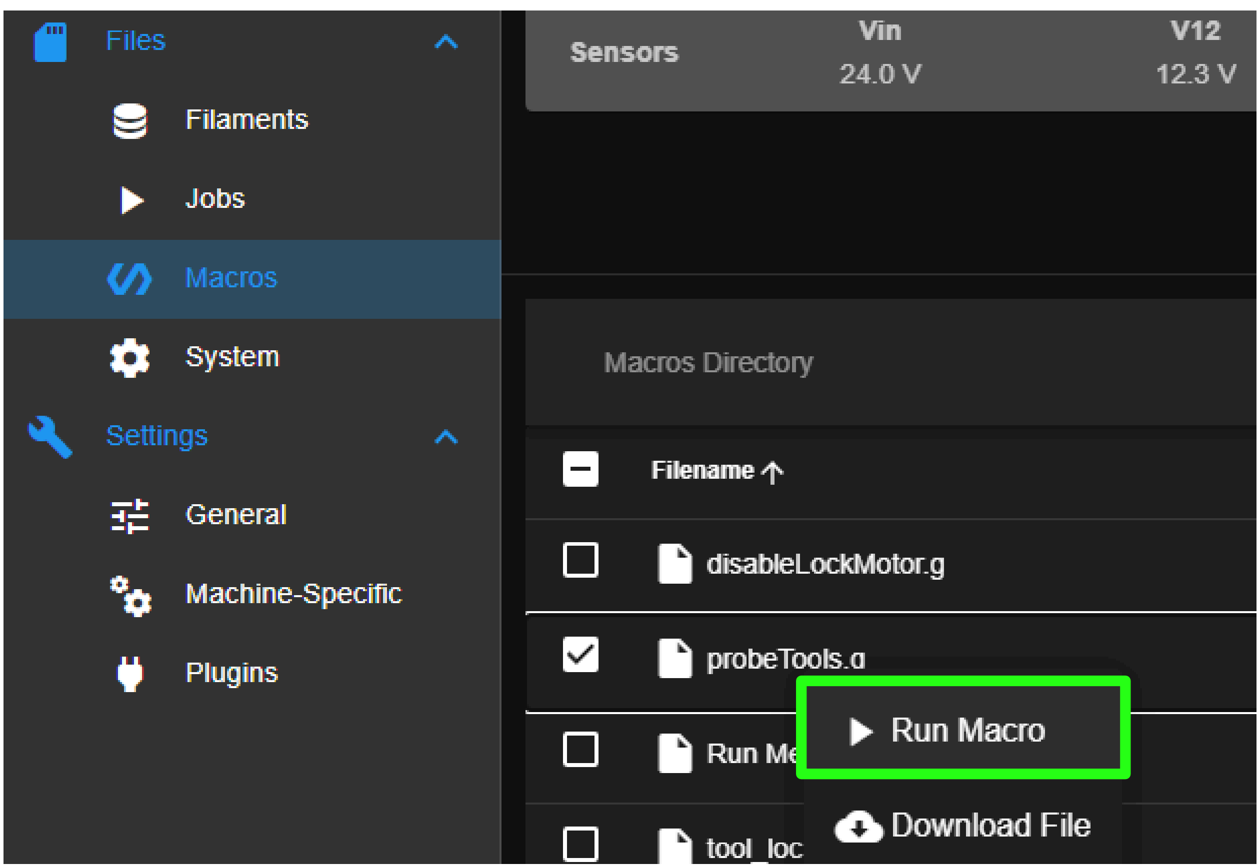
The target tool heating temperature is based on any filament currently loaded in a given tool. The goal is to soften the filament enough that it does not skew the result of our probing test.

To activate a heater without performing tool macros you can click 'Heater n' from the DWC and toggle it 'active' (shown in red below)



REHOME THE MACHINE ONCE MORE TO ESTABLISH NEW Z=0 DATUM

Navigate to the Macros tab in DWC and locate the 'probeTools.g' macro. Right click the macro and select 'Run Macro.'



Once started the machine will perform the following:

1. **Tool head moves to offset probe and raises Z until the offset probe switch is triggered**
2. **Resets Z height and raises again until the carriage mounted probe switch is triggered**
3. **Tool 0 is called and the nozzle is positioned over the offset probe**
4. **The machine raises Z until the offset probe switch is triggered**
5. **Tool 0 is put away**
6. **Steps 3-5 are repeated for each FDM tool**
7. **Steps 1-2 are repeated once more for confirmation**
8. **DWC outputs the calculated Z offsets into the console**

NOTE:

Calculated offsets must be moved into config.g if we want them to be stored and used going forward!

Adjust the value of each tool's G10 command to the value given by the probeTools macro.

NOTE:

The calculated Z offset values are NOT automatically adopted. A manual G10 entry into the console is required for each new value to be used, even if just for a single session.

```

; Tools
M563 P0 S"Tool1" D0.3 H1 F0
G10 P0 X-0.13 Y0.11 Z-0.887
G10 P0 R0 S0
M563 P1 S"Tool2" D0.3 H2 F0
G10 P1 X-0.47 Y-0.28 Z0.058
G10 P1 R0 S0
```

Save the config.g file and select 'Run Config' when prompted to restart

Confirming the new Z offset values:

1. Re-home the machine

2. Activate the heated bed to a temperature of 60C

3. Activate the heater of all FDM tools to a temperature of 200-250C

4. Activate tool 0 and jog the machine to X150 Y150

5. Slowly raise the bed using either DWC or PanelDue until the Z position begins to reach 0.15mm

6. Place a piece of paper or a feeler gauge between the build plate and nozzle

7. Continue raising the Z axis until the paper or feeler blade has a light preload and note the value shown for the Z axis. If using a piece of standard printer paper the Z position should read 0.1-0.15mm

This procedure is confirming that a given Z position (for example 0.2mm) results in a matching real-world value. This offset value is a result of the previously performed probeTools.g macro.

If your value is correct:

Move on to confirm all remaining FDM tools in the same way by repeating steps 4 - 7

If your value is not correct:

Line 23 of the probeTools.g macro contains a static modifier applied to all tools upon completion of the calculation. This value can vary by switch hardware and position, and can be used to fine-tune your results. Once modified you will need to re-run the probeTools.g macro for new values and repeat the above testing steps.

```
18 ; ----------------------------------------------- machine setup
19 ; probe X and Y coordinates
20 var plateX = 308.5
21 var plateY = 238
22 var staticOffset = -0.45 ; static modifier of final result
23 ; set acceleration values for P&T for smoother movement
24 M204 T4000 P4000
25 ; instantaneous velocity change limits for smoother movement
26 M566 X400 Y400 P1
27 ; re-define doorknob probe in case it is missing
28 M558 K1 P8 C"^io5.in" F200 H50
29 ; disable any mesh compensation applied to the machine
30 M561
31
```

TEST POINT: **All tools correctly reach a commanded absolute Z position reliably and repeatably.**

Performing / Adjusting Bed Mesh:

Blackbox uses a mechanical Z probe to probe the bed and produce a mesh table for perfect first layers. We can use this mesh to fine-tune our Z axis in relation to the gantry as well as for mesh compensation in RRF.

It is generally good practice to probe the bed after warming it for 10-15 minutes. The kinematic coupling of our heated bed to the bed frame will eliminate a high percentage of deviation from heat expansion, but not all.

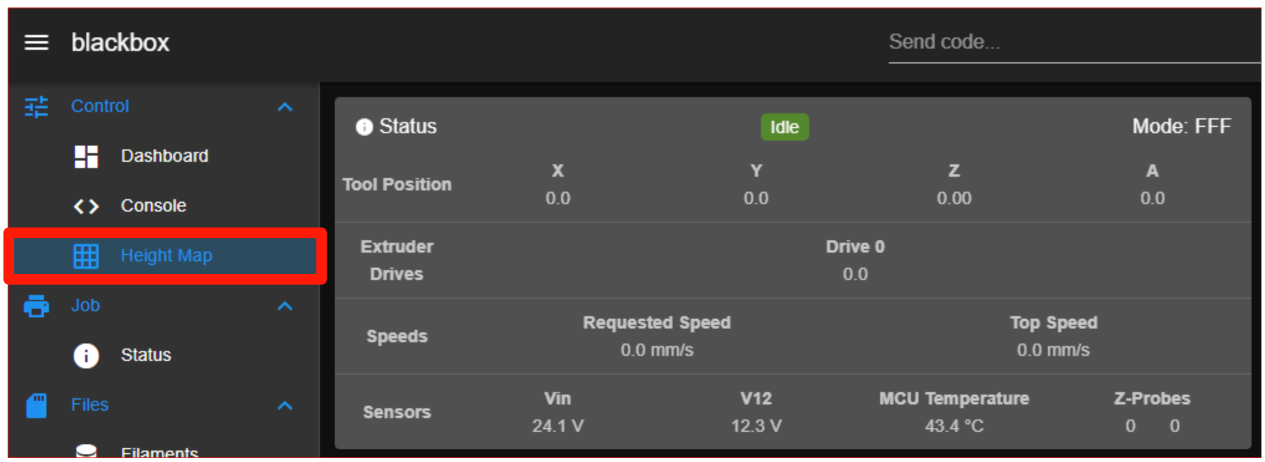
1. **Heat the bed to 60C and wait 10 minutes for heat soak to occur.**
2. **Home the machine - this will establish a new Z=0 datum from which the mesh is built**
3. **Enter the following command into the console in either DWC or PanelDue:**

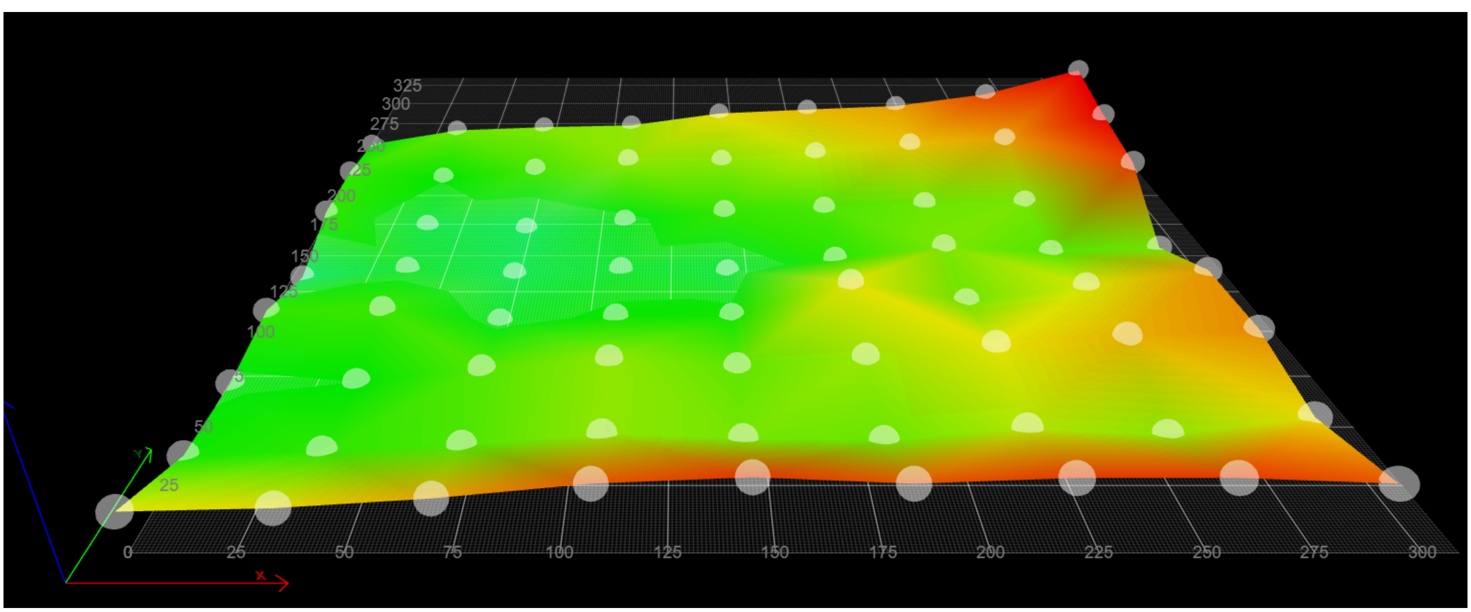
G29

4. **Upon execution the machine will attempt a mesh leveling routine by probing a few dozen points on the bed. If successful a message will be generated in the console with an overview of the results.**

Did your bed mesh fail? Non wiring related failures usually come from a deviation in height across the bed that exceeds reasonable values. See the troubleshooting section below.

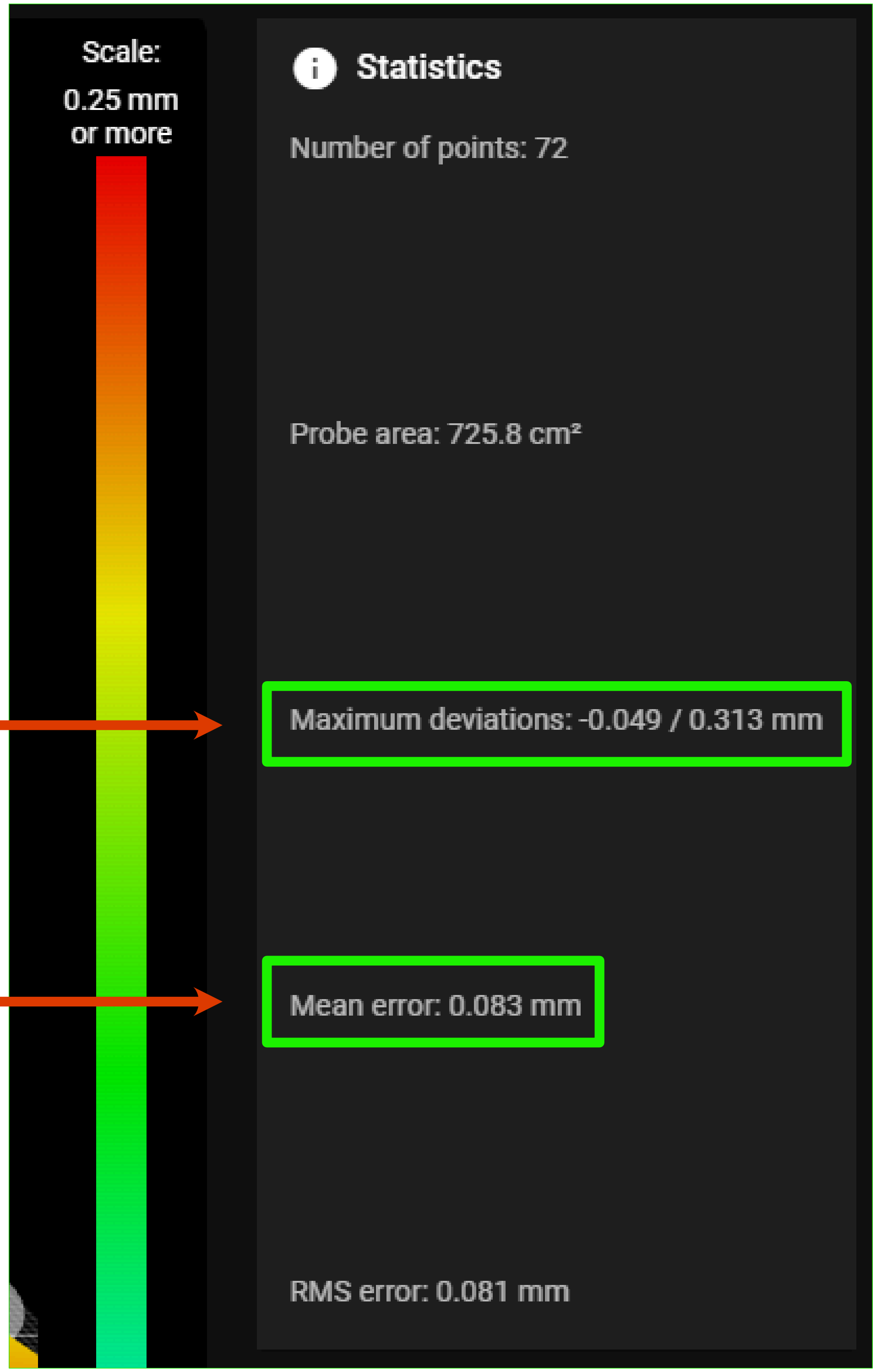
5. **Open the height map from within DWC**





The lowest and highest value measured on the point cloud

The result of all values measured in the Point cloud averaged



Target mean error value = <0.35mm

Mechanical adjustments using mesh results:

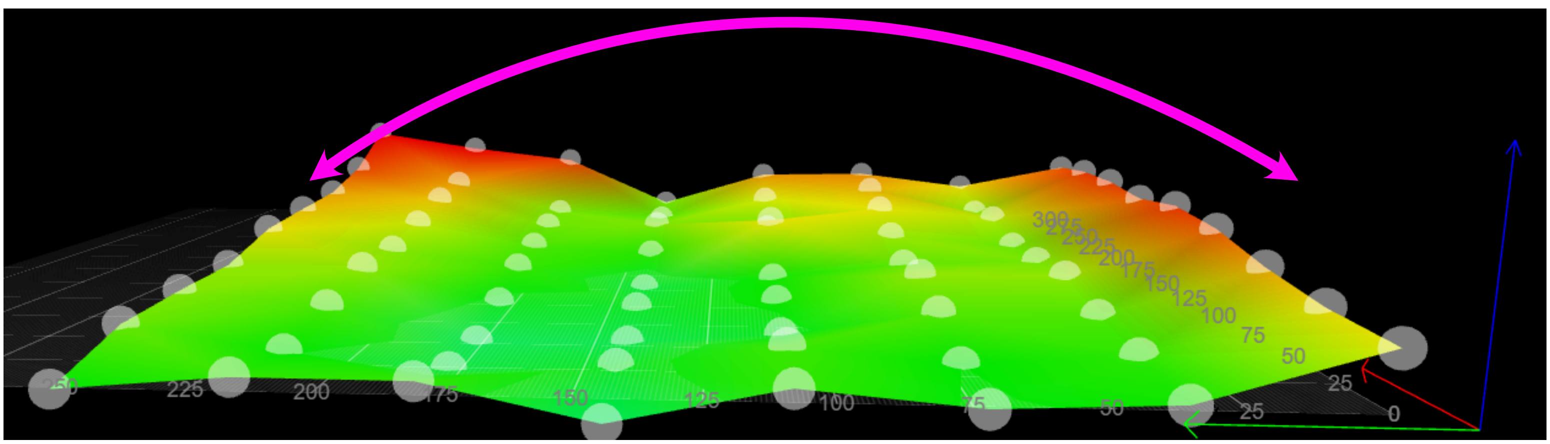
There are 5 possible points of adjustment that can be used to tram the bed to the gantry. In a perfect world your bed frame will be tram to both the machine frame and the gantry, but in the real world we prioritize the gantry for any small adjustments.

NOTE:

The main adjustment for the pitch (Y axis) and roll (X axis) of the bed are adjusted in guide 3 and referenced a few steps above. Using the printed tools or a couple of pairs of 123 blocks, the bed frame itself is referenced to the 2060 extrusions at the bottom of the machine. The following adjustments are meant to supplement - NOT replace them

Remember that what we're doing here is bringing the bed into tram with the gantry (and thus away from tram with the frame) to achieve a printing plane.

Adjustment Points 1 & 2:

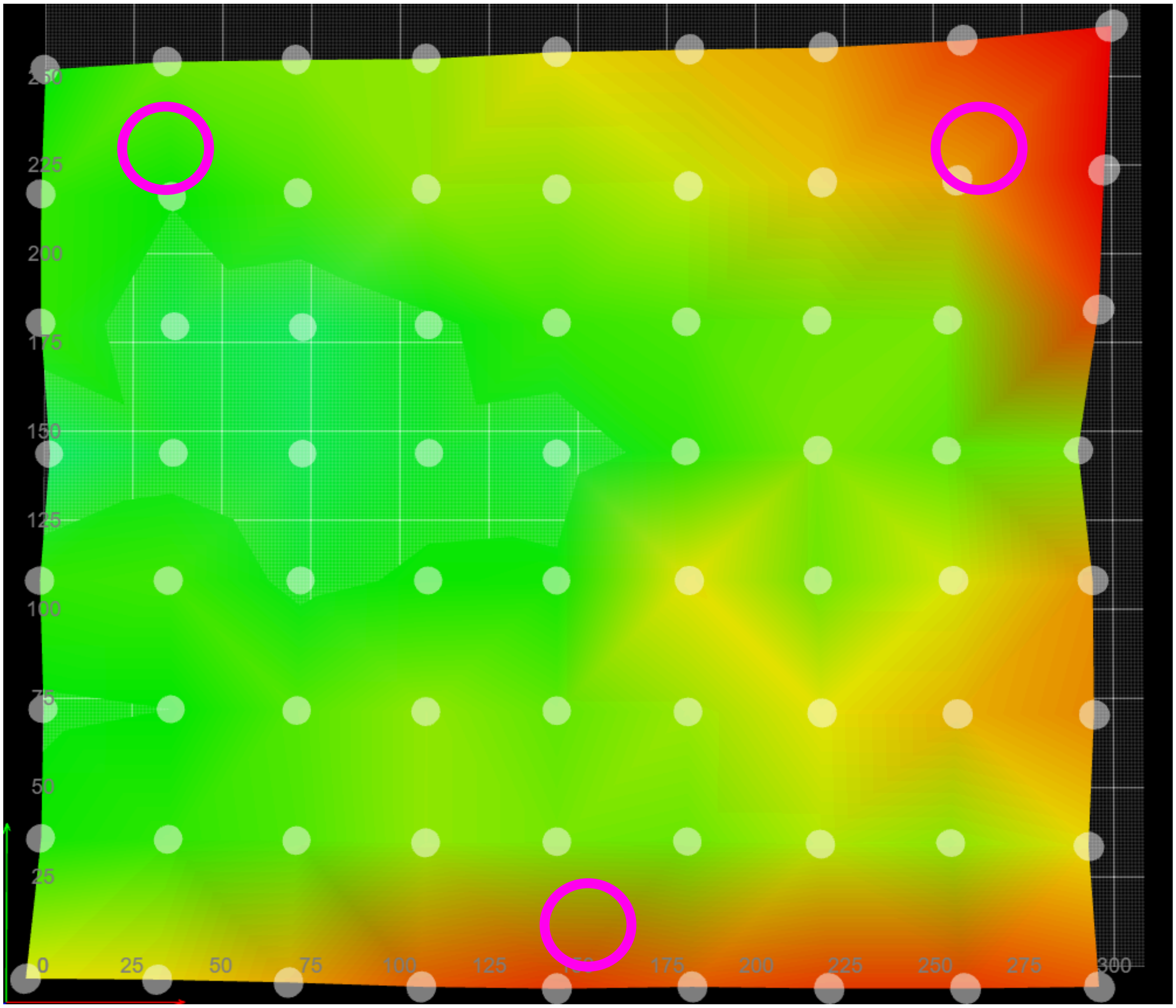


Just as noted during gantry de-racking, the printing plane's flatness should be prioritized over even belt tension (within reason)

Tightening the Z axis drive belt on either side of the bed frame will raise the bed frame, and loosening the drive belt will lower the bed frame. This allows us to make some small additional adjustments to the tilt of the bed along the Y axis.

Use this option for beds that have a clear tilt with a transition line down the Z axis.

Adjustment Points 3, 5 & 5:



The kinematic coupling used to mount the heated bet itself can also be adjusted for mesh-tuning.

The bed is mounted atop 3 total contact points that can be manipulated 0.12mm at a time using a shim of standard printer paper cut into a small circle.

These shims can be placed underneath the magnet of a given kinematic mount and then reassembled and re-checked.

NOTE: Avoid shimming these points beyond 0.4mm to maintain a proper thread engagement with the associated fasteners.

Bed Mesh Troubleshooting

ISSUE: My mesh fails due to "limit position not reached" or "switch triggered during probing move":

This is most often caused by a bed that has significant variance between the center of the bed (where Z=0 is established during homing) and the area of the bed at which the mesh fails.

Start by repeating the basic frame leveling procedure from Guide 3.

Increase the "Dive Height" value by increasing the H parameter of the M558 command inside config.g. This value is 1 (mm) by default but can be increased to 5mm temporarily. This will allow the mesh calibration to complete and offer a height map that can be used to tram the bed properly. This is shown above.

0:/sys/config.g

```
M569 P0.1 S1
M569 P0.2 S0
M569 P0.3 S0
M569 P0.4 S0
M584 X0.0 Y0.1 Z0.2 E0.3 A0.4
M350 X16 Y16 Z16 E16 A1 I1
M92 X160.00 Y160.00 Z1000 E781.00 A160.00
M566 X900.00 Y900.00 Z900.00 E1200.00 A120.00
M203 X30000.00 Y30000.00 Z2100.00 E3000.00 A500.00
M201 X4000.00 Y4000.00 Z800.00 E5000.00 A800.00
M906 X1400 Y1400 Z1400 E1000 I98
M906 A800 I20
M84 S30

; Axis Limits
M208 X0:308.5 Y0:335 A0:18

; Endstops
M574 X1 S1 P"!io1.in"
M574 Y1 S1 P"!io2.in"
M574 A1 S1 P"!io4.in"

; Z-Probe
M558 P8 C"io3.in" H1 F500:80 A5 T16000
G31 P1000 X0 Y0 Z0
M557 X0:290 Y0:280 S36
```