

Notes recorded while setting up Makerlibre's mini Kossel with an Azteeg X5 controller.

Notice.

The Azteeg X5 controller does not come with firmware. It will not work properly until firmware is installed. The Azteeg X5 will not work or even communicate with a computer (over USB) unless a SD card is plugged into it. When powered up, the Azteeg X5 controller boots up and runs the firmware. The firmware checks for the presence of an SD card and for a file on the SD card called "config" (without the quotes). The file "config" is used to change default settings in the firmware. Most of the default settings are OK but some settings must be changed or the printer will not operate correctly and, worse, parts of the printer might be destroyed. Installing the firmware is a one-time event. Every time the controller boots it reads the config file.

The Azteeg X5 controller is based on the work at <http://smoothieware.org>. That site is well worth checking out.

See

<http://smoothieware.org/smoothieboard>
<http://smoothieware.org/supported-g-codes>
<http://smoothieware.org/3d-printer-guide>
<http://smoothieware.org/configuring-smoothie>

and

<http://smoothieware.org/delta>

Using Linux - Fedora 20

The controller is connected to the computer with an USB cable

A SD card is needed to run the controller. The SD card must contain a file named "config"

Using pronterface version 2014.01.26

In Pronterface click Settings, then Options, and change the value for build_dimensions to:
width = 160, depth = 160, height = 240, x-offset = -80, y-offset = -80, z-offset = 0
circular build platform = checked

Jumper setting for controller are shown in http://files.panucatt.com/datasheets/x5mini_wiring.pdf
Each motor can be set to different usteps using the associated M0, M1, and M2 jumpers.

Sample config file at <https://github.com/Smoothieware/Smoothieware/blob/edge/ConfigSamples/AzteegX5Mini.delta/config>

The sample config file must be modified for this printer!

From <http://smoothieware.org/configuring-smoothie>

"Do not use Notepad++ to edit the configuration file, it thinks it's smarter than everybody and modifies the file in invisible ways that can make it unreadable or confusing to Smoothie."

The controller comes with no firmware. Will start out with the Azteeg X5 powered by USB (its a jumper setting); 12V disconnected, no motors or other external wire connected, sample config file on SD card. Firmware must be installed (once) by adding firmware.bin to the SD card,

inserting the card into the controller, and powering the controller (plugging in the USB cable). The controller will change the filename to firmware.cur if it finds it. If the firmware is good, the middle 2 of 4 leds are flashing, outer 2 leds are solid on (with bad firmware, all 4 lights are on). From <http://smoothieware.org/flashing-smoothie-firmware>: "If there is a problem with the SD card, LED4 will be off. If this happens, you need to format the SD card, and if that fails, use another SD card."

Linux command line: lsusb (gives Bus 002 Device 003: ID 1d50:6015 OpenMoko, Inc)
After searching with the filemanager, found the Linux file
/dev/serial/by-id/usb-Uberclock_Smoothieboard_03012010AE2A10C152C1B334F5001E80-if00

It is a link to /dev/ttyACM0. Use this filename to connect with pronterface.
pronterface connects!

With pronterface, can enter these commands and see answers

@help
@version
@ls /sd

Build version: edge-ed3812f, Build date: Nov 10 2014 21:21:40, MCU: LPC1769, System
Clock: 120MHz

Install controller jumpers for 32 usteps on x, y, z. Install jumpers for 16 usteps on extruder motor.
Set jumper to run controller on 12V supply.

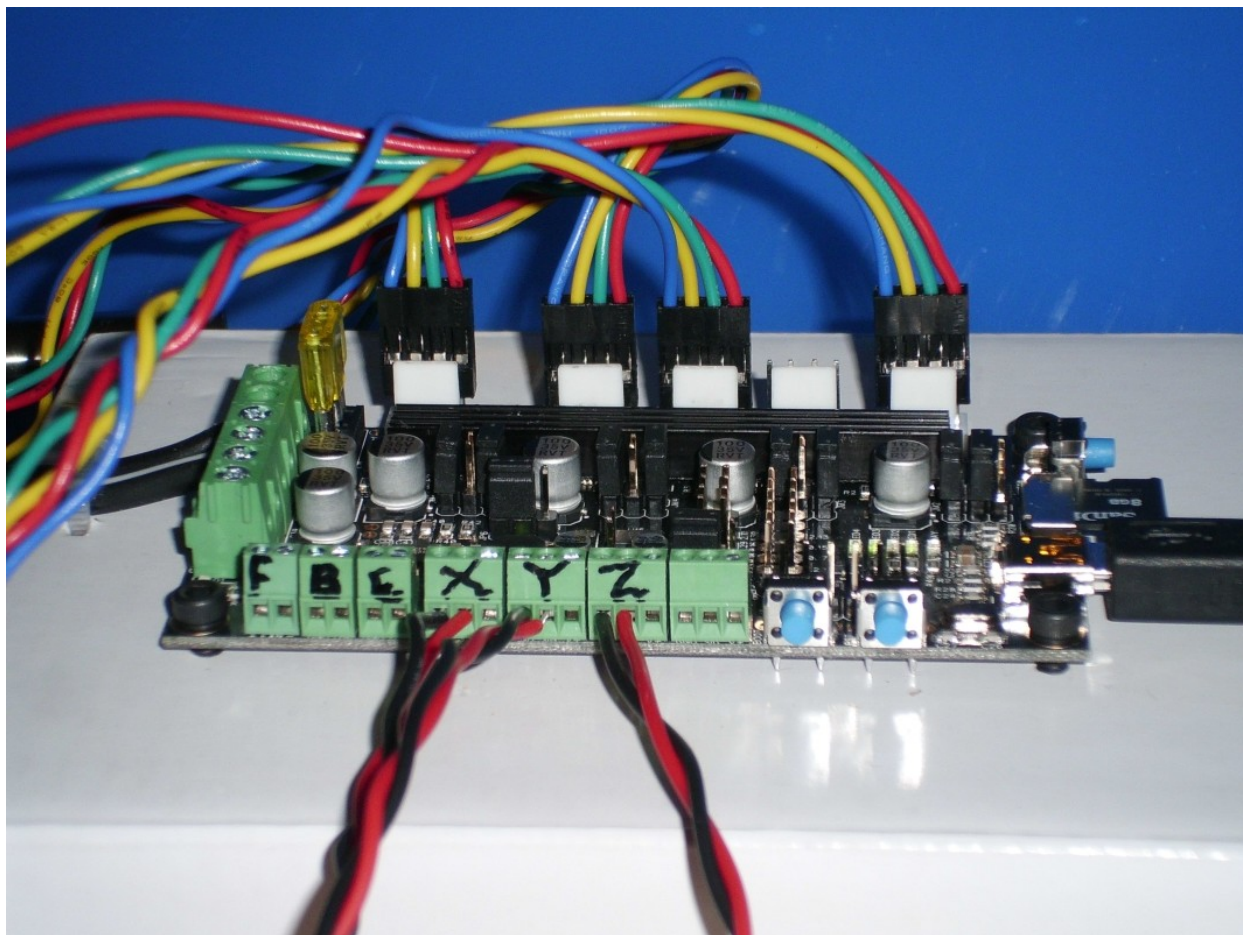
Attached 12V power connections.

Check each end-switch with an ohmmeter before connecting to controller. You are trying to make sure that the switch is wired correctly and that the wires are not broken, etc. If a switch does not work, the corresponding motor will not stop.

Attached end stop wires.

Attached motor wires. Motor connections are not keyed. Both orientations work but only one way is correct. The incorrect orientation makes the motor rotate in the wrong direction. Wire colors indicate plug orientation.

Make sure that the power supply is set to 110V and not 220V.



The site <http://smoothieware.org/delta> has a description of the setting found in “config”. It also has some printer calibration information for Smoothie software (used by the Azteeg X5).

Edited config file on SD card to put in some initial guesses:

```
arm_length      215.00
arm_radius      107.00
alpha_steps_per_mm  200 # (32 usteps/step)*(200 steps/rev)/(32 mm/rev)
beta_steps_per_mm   200
gamma_steps_per_mm  200

gamma_max       300 # below bed! change asap
alpha_current   0.75 # find better value later, max = 1.5
beta_current    0.75
gamma_current   0.75
delta_current   0.7
```

Will make more changes (hotend, bed, Airtripper) to the config file later.

Check Effector Motion

Started with the effector roughly centered both vertically and horizontally.

Note: the wires to the hotend and bed are not connected at this point.

Plug the power supply into a powerstrip (it has a built-in switch).

Power on, pronterface connected.

M119 = Output Endstop status to serial port (pronterface). Use M119 command to check end-stop switches one at a time. All switches work and each is connected to the correct input.

Note: if the effector moves down instead of up when the printer is homed, kill the power fast and reverse the motor connection to the controller, try again. There is also a reset button on the Azteeg X5 that can be used (probably the preferred method).

Note: when playing around, one can send the effector crashing into the bed or a linear rail. Be careful and always be ready to press the reset button on the Azteeg X5. If the effector does hit something and you are lucky, the motor will stall (start skipping steps) and nothing will break. If a motor does stall, the printer will think that the effector is at the incorrect position - its time to stop and re home the printer.

Used pronterface button <+z 1> to move up 1-mm; works - motors are not reversed.

Used pronterface <Motors off> button; works.

G28 = home; works.

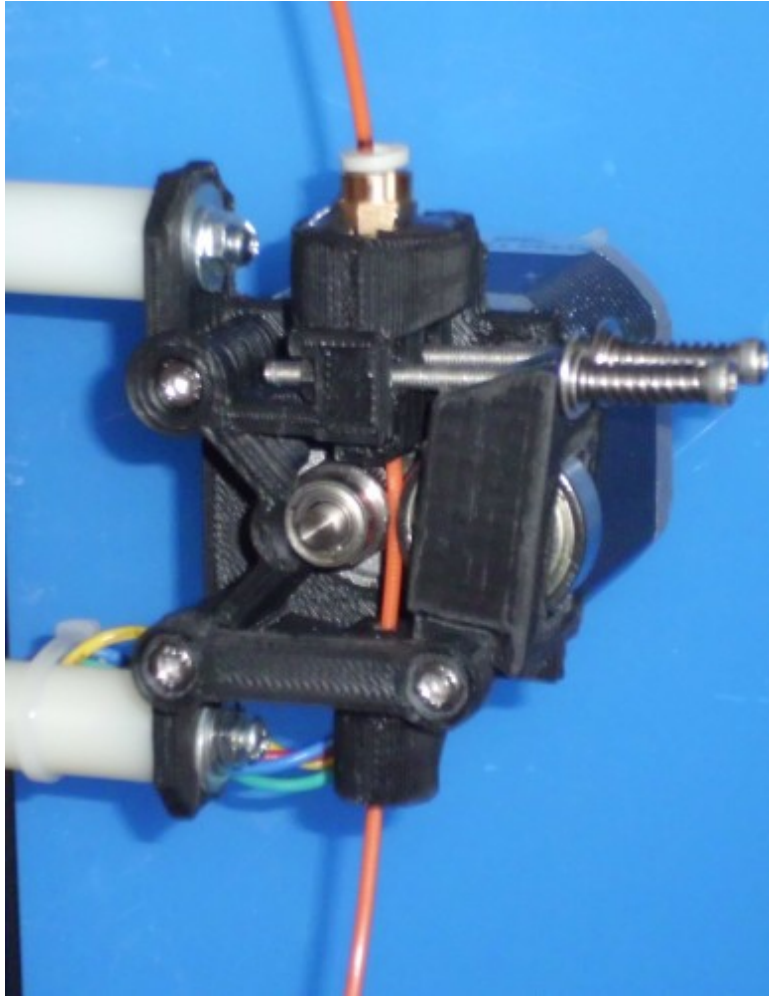
M84 = power down motors; works

Manually move effector down (slowly), G28, quickly press reset button on controller -> motors stop, pronterface loses connection to printer, will not reconnect, printer is now connected to the computer as /dev/ttyACM1, pronterface connects to this new address and works. Cycle printer power - printer is again /dev/ttyACM0. Not sure what happens if using Windows.

pronterface movement buttons move the effector as expected (left, right, forward, backward, up, down).

g0 x0 y0 z100	(move down 100-mm, centered)
M114	(get current position)
g2 i20	(move in circle)
g2 j20	(move in circle)
m84	(power down motors)

Airtripper Calibration



Cut off 2-ft of filament for testing and installed it in the Airtripper. The PTFE tubing is not installed. Used a Sharpie to mark the filament where it exits the Airtripper. Pressed pronterface button to extrude 5 mm of filament at 100 mm/min. Actual extrusion was 73 mm of filament. Must modify the config file on the SD card!

```
extruder_steps_per_mm 48.6 # Steps per mm for extruder stepper
```

Changed setting in config file. Pressed the controller reset button. Had to re connect pronterface to /dev/ttyACM1.

Test by extruding 50 mm of filament at 1000 mm/min. Now measures correctly.

Note: a different filament spool might calibrate to a slightly different number. Most slicers have a “Extrusion multiplier” which can be used to “fudge” the calibration. The filaments all vary slightly in diameter so the slicer filament settings for each new spool will have to be “fudged” to compensate. Or perhaps add a M92 command to the start of the gcode.

Hotend Thermistor

Makerlibre states that the hotend was purchased from hotends.com. Hotends.com only seems to sell model "J-Head Mk V-BV" which uses a Semitec 104GT-2 thermistor. Will assume that this is the correct thermistor.

According to http://reprap.org/wiki/Thermistor#ATC_Semitec_104GT-2, the thermistor has beta=4267. Need to put this into the config file.

Will change the line

```
temperature_control.hotend.thermistor    EPCOS100K    # see http://smoothieware.org/ ...  
#temperature_control.hotend.beta         4066         # or set the beta value
```

to

```
temperature_control.hotend.thermistor    Semitec       # see http://smoothieware.org/ ...  
#temperature_control.hotend.beta         4066         # or set the beta value
```

Break

The following was done after the printer (mechanical) calibration.

Attach hotend wires to controller. Using pronterface, set hotend to 150 C to make sure it works. Hotend off.

The hotend does not maintain temperature very well. This is because the thermistor name was changed in the file config. It is necessary to auto-tune the controller so it can learn how to use the new type of thermistor.

PID auto-tuning

Connect to pronterface.

M303 E0 S200 (start auto-tune on hotend, best accuracy at 200 C)

This takes a long time (4 minutes). M304 will abort the auto-tune.

Cycle 4: max: 217.411, min: 198.772, avg separation: 0.774147

Ku: 34.8384, Pu: 46

Trying:

Kp: 20.9

Ki: 0.909

Kd: 120

PID Autotune Complete! The settings above have been loaded into memory, but not written to your config file.

Edit the file config and change the values of Kp = p_factor, Ki = i_factor, and Kd = d_factor

Found

# temperature_control.hotend.p_factor	39.98	#
# temperature_control.hotend.i_factor	5.00	#
# temperature_control.hotend.d_factor	79.91	#

Changed to

temperature_control.hotend.p_factor	20.9	#
temperature_control.hotend.i_factor	0.909	#
temperature_control.hotend.d_factor	120	#

Cycle power on printer.

A test of hotend @ 200 C still shows a large initial overshoot (215 C) but after a few minutes it is regulating much better than before auto-tuning. Will consider prewarming to 180 C before setting print temperature.

Heated Bed Thermistor

I found a description of what looks like the correct heated bed at

<http://www.thingiverse.com/thing:394130>

<http://www.emakershop.com/browse/listing?l=1081>

http://etherpod.org/blog/?page_id=7886

Will assume that this is correct and therefore the correct thermistor is

SMD thermistor Vishay NTCS0603E3104FXT

The beta for this thermistor is 4100.

Will change the config lines

```
temperature_control.bed.thermistor    EPCOS100K    # http://smoothieware.org/ ...
#temperature_control.bed.beta          4066         # or set the beta value
```

to

```
#temperature_control.bed.thermistor    EPCOS100K    # http://smoothieware.org/ ...
temperature_control.bed.beta            4100         # or set the beta value
```

Also, must enable the bed heating so will change

```
temperature_control.bed.enable         false        #
```

to

```
temperature_control.bed.enable         true         #
```

Break

The following was done after the printer (mechanical) calibration.

Attach bed-heater wires to controller. Using pronterface, set bed to 50 C to make sure it works.
Turn off.

PID auto-tuning

Have not tried it but the following should work. Connect to pronterface.

M303 E1 S60 (start auto-tune on bed - note now specifying E1, best accuracy at 60 C)

Edit the file config and change the values of Kp = p_factor, Ki = i_factor, and Kd = d_factor for the bed.

Printer Calibration

An incorrect value for arm_radius will cause the effector to move in an arc above the bed.
An incorrect value for arm_length will cause the printed part to be larger or smaller than desired.
See <http://smoothieware.org/delta> and <http://minow.blogspot.ca/>.

The three endstop switches are not exactly the same distance above the bed. If this is not taken into account, the first few layers of the print will not be of uniform thickness. One side will be squished into the bed; the opposite side might even not adhere to the bed.

Jay Couture has a video “Manual Delta Calibration using M665 and M666 ”,
<http://www.youtube.com/watch?v=tDLbqLve128>

Note: when calibrating make sure that the end of the hotend is clean - no plastic residue on the tip that might touch the bed. Will first calibrate cold and then check/modify in heated state.

Calibrate endstops:

With pronterface:

<Home>

M501 (Load config-override file) File not found: /sd/config-override, OK for now
M666 x-5 y-5 z-5 (start with equal offsets)

<Home> (now homes below endstops)

M114 (X:0.000 Y:0.000 Z:300.000 A:386.485 B:386.485 C:386.485 E:0.000)

remember, gamma_max = 300 in config file

check with ruler, there is about 220 mm between hotend and bed (glass)

a move to z=0 will break the glass!

M500 (Settings Stored to /sd/config-override)

Use buttons to carefully move hotend 3 mm above bed

M114 (X:0.000 Y:0.000 Z:81.600 A:268.085 B:268.085 C:268.085 E:0.000)

create 4 pronterface buttons

<x>: g1 x-60.6 y-35 z81.6 f3000

<y>: g1 x-60.6 y-35 z81.6 f3000

<z>: g1 x+60.6 y-35 z81.6 f3000

<center> x0 y0 z81.6 f3000

Double check values before using; a value of z0 would break printer

If gamma_max is changed, the value for z must be changed!

Touch motors to make sure they are not getting hot.

<x>

Use built-in pronterface buttons -z and +z to carefully move hotend to just touch paper on bed

M114 (X:-60.600 Y:-35.000 Z:77.900 A:289.690 B:227.540 C:227.530 E:0.000)

<y>

Use built-in pronterface buttons -z and +z to carefully move hotend to just touch paper on bed

M114 (X:60.600 Y:-35.000 Z:78.500 A:228.140 B:290.290 C:228.130 E:0.000)

<z>

Use built-in pronterface buttons -z and +z to carefully move hotend to just touch paper on bed
M114 (X:0.000 Y:70.000 Z:77.700 A:227.320 B:227.320 C:289.490 E:0.000)

endstops y & z differ by 0.8 mm

Will keep x and change y-trim and z-trim

M666 x-5 y-4.4 z-5.3

<Home>

Check new distances to bed as above

<x> (X:-60.600 Y:-35.000 Z:78.000 A:289.990 B:227.840 C:227.830 E:0.000)

<y> (X:60.600 Y:-35.000 Z:78.100 A:227.740 B:289.890 C:227.730 E:0.000)

<z> (X:0.000 Y:70.000 Z:78.000 A:227.820 B:227.820 C:289.990 E:0.000)

Try again ...

M666 x-5 y-4.3 z-5.2

<Home>

Check new distances to bed as above

<x> (X:-60.600 Y:-35.000 Z:78.000 A:289.790 B:227.640 C:227.630 E:0.000)

<y> (X:60.600 Y:-35.000 Z:78.000 A:227.640 B:289.790 C:227.630 E:0.000)

<z> (X:0.000 Y:70.000 Z:78.000 A:227.720 B:227.720 C:289.890 E:0.000)

M500 (Settings Stored to /sd/config-override)

M501 (Check settings - look OK)

Calibrate arm radius:

Now need to get a better value for the arm_radius.

<Home>

<Center>

Use built-in pronterface buttons -z and +z to carefully move hotend to just touch paper on bed
M114 (X:0.000 Y:0.000 Z:78.500 A:264.985 B:264.985 C:264.985 E:0.000)

Center is different from perimeter by 0.5 mm.

M665 (L: 215.0000 R: 107.0000 Max Z 300.000)

M665 r108 (change value of R)

<Home>

<Center>... (X:0.000 Y:0.000 Z:78.400 A:264.305 B:264.305 C:264.305 E:0.000)

<x> (X:-60.600 Y:-35.000 Z:77.600 A:289.210 B:226.285 C:226.275 E:0.000)

oops, adjusted in the wrong direction, try again

M665 r106.5 (L: 215.0000 R: 106.5000 Max Z 300.000)

<Home>

<Center>... (X:0.000 Y:0.000 Z:78.500 A:265.270 B:265.270 C:265.270 E:0.000)

<x> (X:-60.600 Y:-35.000 Z:78.100 A:289.975 B:228.215 C:228.200 E:0.000)

finally

```
M665 r105      (L: 215.0000 R: 105.0000 Max Z  300.000)
<Home>
<Center>...    (X:0.000 Y:0.000 Z:78.500 A:266.115 B:266.115 C:266.115 E:0.000)
<x>            (X:-60.600 Y:-35.000 Z:78.500 A:290.630 B:230.015 C:230.000 E:0.000)
<y>            (X:60.600 Y:-35.000 Z:78.600 A:230.115 B:290.730 C:230.100 E:0.000)
<z>            (X:0.000 Y:70.000 Z:78.500 A:229.995 B:229.995 C:290.630 E:0.000)

M500           (Settings Stored to /sd/config-override)
M501           (Check settings - look OK)
```

Note:

Have not set gamma_max. Do not try to print until gamma_max is correct. It should be set such that a move to z0 makes the tip of the hotend barely touch a piece of paper on top of the bed. (If using tape on top of the glass, the paper test is done with the paper on top of the tape.) Heating the bed or hotend changes things so gamma_max is temperature dependent! Ten or twenty degrees will not make much difference - but heating the hotend to 200 C does make a difference. When gamma_max is changed, be sure to delete or modify the custom pronterface buttons <x>, <y>, <z>, and <Center>.

```
M665           (L: 215.0000 R: 105.0000 Max Z  300.000)
Use built-in pronterface buttons -z and +z to carefully move hotend to just touch paper on bed
M114           (X:0.000 Y:0.000 Z:78.600 A:266.215 B:266.215 C:266.215 E:0.000)
Distance from end stop to bed is 300 - 78.6 = 221.4 mm
```

Testing:

```
M665 z216.4     (set z0 to be 5 mm above bed for now)
<Home>
M114            (Z:216.400)
                Use some tape on extrusion to mark top of carriage
g0 z116.4       (should move down 100 mm; measure with ruler)
Use built-in pronterface buttons -z and +z to carefully move hotend to just touch paper on bed
M114            (Z:-5.000) seems to be working
```

For now, will set z0 to be 3 mm above bed. When machine powers up this will be the setting.

```
M665 z218.4
<Home>
M114            (Z:218.400)
M500            (Settings Stored to /sd/config-override)
g0 z0           (moves to 3 mm above bed)
```

edit 4 pronterface buttons

```
<x>: g1 x-60.6 y-35 z0 f3000
<y>: g1 x-60.6 y-35 z0 f3000
<z>: g1 x+60.6 y-35 z0 f3000
<center> x0 y0 z0 f3000
```

As long as the file /sd/config-override is on the SD card, it should override the settings in the file config. So on power up gamma_max is effectively 218.4.

Until I learn to trust the printer, will keep 218.4 and will only adjust - without saving - the value just before printing.

Note: need to make a backup copy of the SD card files config and config-override and save the backup files in a safe place.

Test Print

Load PLA filament through Airtripper and into hotend by hand, put idler on Airtripper.
Put some blue tape on glass because I have experience with it and this filament.
Select a g-code file for printing.

Open the file in a text editor and look at the first few lines. In particular check the temperature settings. Different plastics need different hotend temperatures.

Open the file in pronterface. Pronterface displays:
Loaded /home/jev/Things/gcode/1mm-bed-test.g, 477 lines
161.379796982 mm of filament used in this print
The print goes:
- from 57.33 mm to 92.66 mm in X and is 35.33 mm wide
- from 57.33 mm to 92.66 mm in Y and is 35.33 mm deep
- from 0.00 mm to 1.06 mm in Z and is 1.06 mm high
Estimated duration: 0:01:31

There is a problem here. The object should be centered at (0,0) but it was sliced for another printer which had different requirements. Will generate a new g-code file.

Some Slic3r settings to start with (will find better numbers later)

bed-x = bed-y = 120 mm

center = (0,0)

Start-code = none

End code M104 S0 ; turn off extruder heating

M140 S0 ; turn off bed heating (not need, bed not heated, does not hurt)

G28 ; Home

M84 ; disable motors

Extruder: dia = 0.4 mm

retraction 3 mm @ 60 mm/s

Filament: dia 1.75 mm

multiplier 0.9

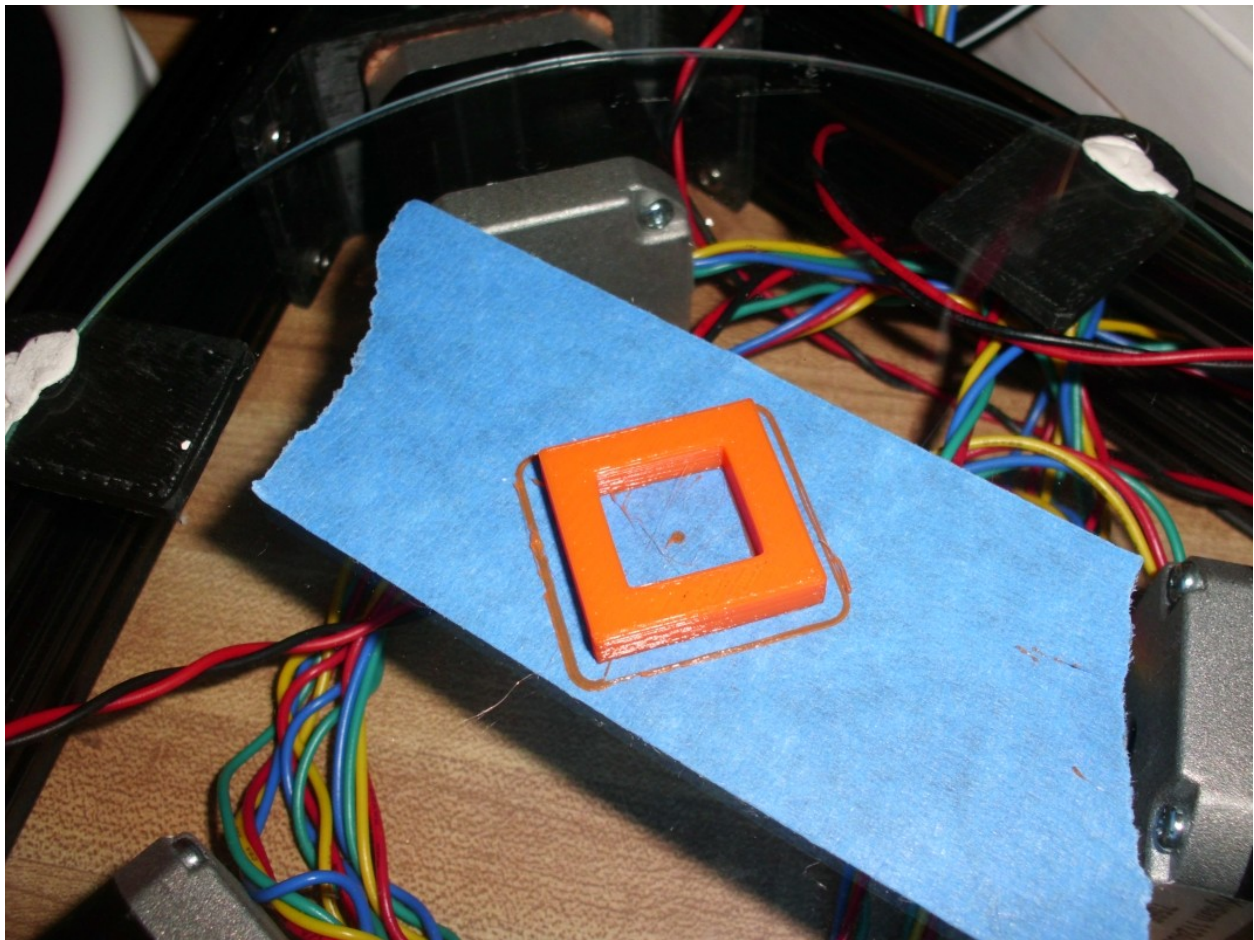
temperature = 200 C (PLA)

Layer height 0.2 mm

Open the new file in pronterface. Pronterface displays:
Loaded /home/jev/Things/Frame/frame-1-kossel.gcode, 2887 lines
542.906955242 mm of filament used in this print
The print goes:
- from -15.70 mm to 15.70 mm in X and is 31.40 mm wide
- from -15.70 mm to 15.70 mm in Y and is 31.40 mm deep
- from 0.00 mm to 5.00 mm in Z and is 5.00 mm high
Estimated duration: 0:16:15

Pronterface:
<connect>

<Home>
<Heat-Set> (Set heat to 200 C, wait for hotend to get to temperature)
<Extrude> (5 mm at a time until filament comes out cleanly)
<Center>
Use built-in pronterface buttons -z and +z to carefully move hotend to just touch paper on bed
M114 (Z:-2.800)
Add 2.8 to current gamma_max so that z0 will be a paper thickness above the bed
M665 (L: 215.0000 R: 105.0000 Max Z 218.400)
M665 z221.2
<Home>
<Extrude> (clean nozzle end - hotend is leaking hot filament)
<Print>



Although the first layer had a few defects because the filament was not feeding uniformly, the overall part looked good and had (close to) the right dimensions.

A quick check with calipers gave an outside dimension of 24.7 mm instead of 25.0 mm. Four measurements of the outside loop all were between 0.2 mm and 0.3 mm as expected. Want to tweak the endstop calibrations to do better.

New config Settings

```
arm_length          215.00
arm_radius          107.00
alpha_steps_per_mm  200 # (32 usteps/step)*(200 steps/rev)/(32 mm/rev)
beta_steps_per_mm   200
gamma_steps_per_mm  200
gamma_max           300 # below bed! Change asap
alpha_current       0.75 # find better value later, max = 1.5
beta_current        0.75
gamma_current       0.75
delta_current       0.7
extruder_steps_per_mm 48.6 # Steps per mm for extruder stepper
#temperature_control.hotend.thermistor EPCOS100K # see http://smoothieware.org/ ...
temperature_control.hotend.beta 4267 # or set the beta value
temperature_control.bed.enable true #
#temperature_control.bed.thermistor EPCOS100K # http://smoothieware.org/ ...
temperature_control.bed.beta 4100 # or set the beta value
temperature_control.hotend.p_factor 20.9 #
temperature_control.hotend.i_factor 0.909 #
temperature_control.hotend.d_factor 120 #
```

M501

Loading config override file: /sd/config-override...

;Steps per unit:

M92 X200.00000 Y200.00000 Z200.00000

;Acceleration mm/sec^2:

M204 S1000.00000 Z0.00000

;X- Junction Deviation, Z- Z junction deviation, S - Minimum Planner speed:

M205 X0.05000 Z-1.00000 S0.00000

;Max feedrates in mm/sec, XYZ cartesian, ABC actuator:

M203 X500.00000 Y500.00000 Z500.00000 A500.00000 B500.00000 C500.00000

;Optional arm solution specific settings:

M665 L215.0000 R105.0000

;Motor currents:

M907 X0.75000 Y0.75000 Z0.75000 E0.70000

;Home offset (mm):

M206 X0.00 Y0.00 Z0.00

;Trim (mm):

M666 X-5.000 Y-4.300 Z-5.200

;Max Z

M665 Z300.000

;E Steps per mm:

M92 E48.6000

;E Filament diameter:

M200 D0.0000

```
;E retract length, feedrate, zlift length, feedrate:  
M207 S3.0000 F2700.0000 Z0.0000 Q6000.0000  
;E retract recover length, feedrate:  
M208 S0.0000 F480.0000  
;E acceleration mm/sec^2:  
M204 E500.0000  
;PID settings:  
M301 S0 P10.0000 I0.3000 D200.0000
```

Things to do

- Backup SD files
- Do a better job calibrating
- Increase size of glass (looks like there is room)
- Install heated bed (might want a larger heater and external relay)
- Figure out where/how to mount controller
- Explore correct setting for Airtripper-filament-retraction settings in slicer
- Figure out how to install Viki controller (if I ever get one)
- Find a better way to tension belts.
- Make some spare parts for effector and Airtripper in case something breaks
- Check config setting for speed and acceleration
- Lower motor currents (M907)
- Add fan

Nov-22-2014, jev