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1 Welcome to the 3MS Documentation

The 3MS is short for MMMS, which stands for **M**odular **M**ulti **M**aterial **S**ystem

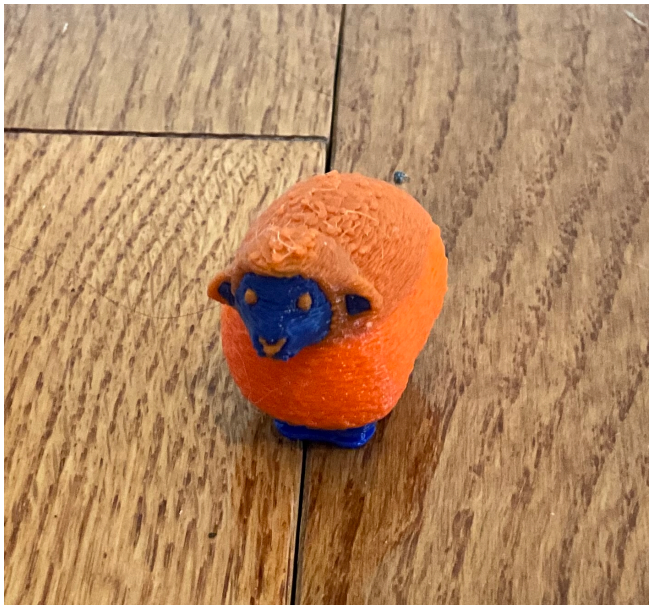
1.1 Inspiration

- Prusa MMU1
- Bambu AMS

1.2 Sample Prints

Sample Prints

Sheep



Model: Sheep by Cipis

Calendar

Model: Monolith Cryptic Calendar by Sevro

Voron Cube

Model: Voron Cube (bundled with OrcaSlicer), painted by me in OrcaSlicer

T-Rex

Printed at 50% scale

Model: T-rex by Cipis

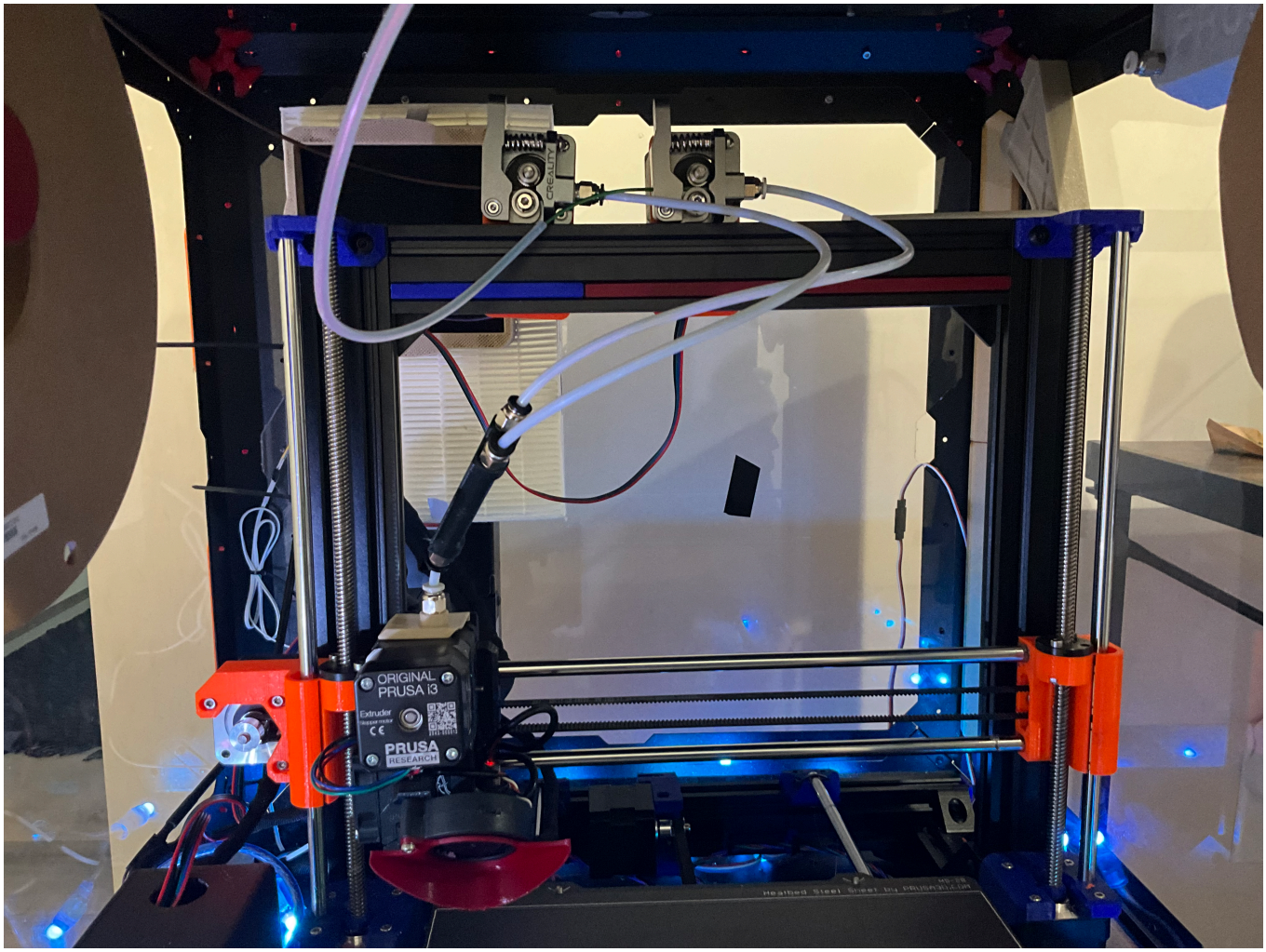
Lizard

Model: Striped lizard with pupils by EngMike

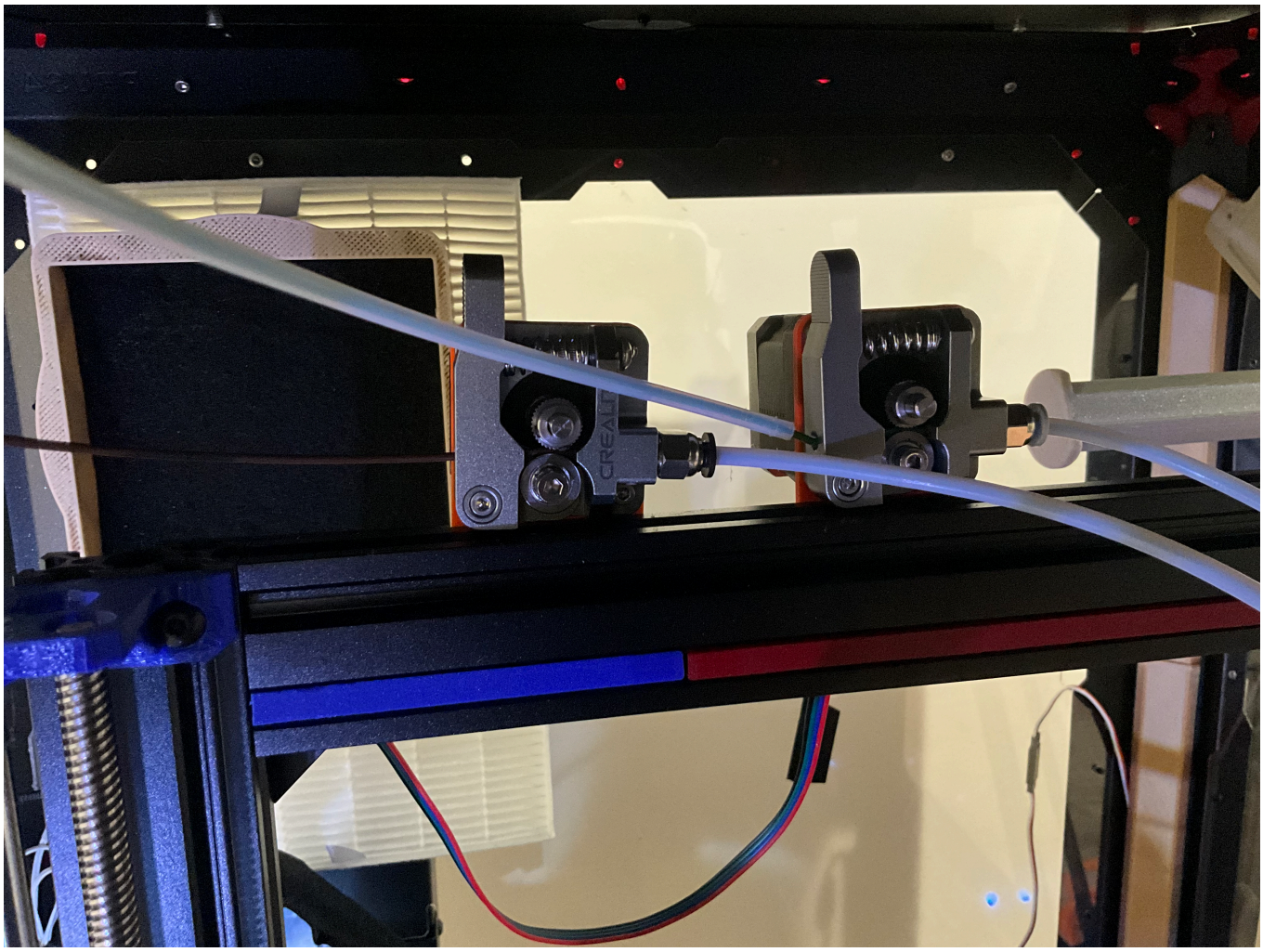
1.3 Photos

Photos

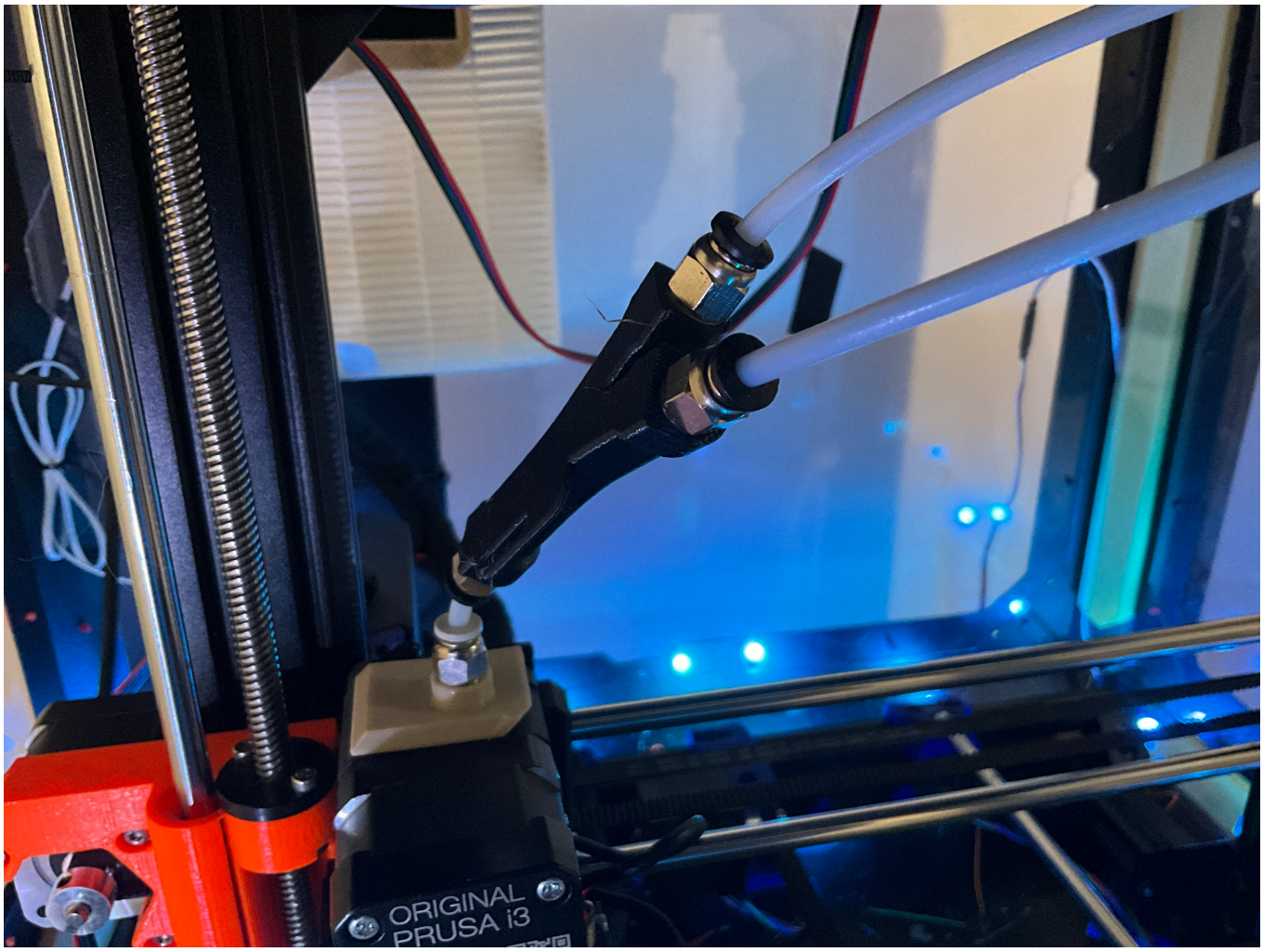
Full Printer



3MS



Y Splitter



1.4 Videos

West3D Video Series

Thank you to Allen Rowand from West3D for making this ongoing series on the 3MS.

1.5 Why 3MS?

Why use the 3MS when there are many other multi-material systems?

Here are a few reasons:

- **Simplified Design**: Minimal mechanical complexity for increased reliability.
- **Comprehensive Documentation**: Step-by-step guides to ensure smooth setup and operation.

- **Slicer-Agnostic**: No need for custom toolchange G-Code in your slicer.
- **Scalable**: Easily expand the system to handle any number of filaments.
- **Auto-Retries**: Automatic retries on failed tool changes to reduce downtime.
- **No Filament Cutter Needed**: Achieve clean tool changes without the need for filament cutters.
- **In Development: Rapid Tip Shaping**: Achieve even faster tool changes!

With that said, there are a few reasons why you might **not** want to/be able to use the 3MS:

- Klipper firmware is a requirement, so Marlin and RRF setups are a no go
- A filament sensor is required, so if you don't have one/don't plan to get one, the 3MS won't work with your setup

1.6 Requirements

To use the 3MS, your setup has to meet the following requirements:

- Run Klipper firmware
- Have SSH (PuTTY) access (99.9% of Klipper installations have this, and if you don't you really should setup SSH)
- Have one spare USB port
- Have an adapter to install a PTFE tube to the inlet of your printer's extruder.

1.7 How it works

Here is a example step by step of what goes on during a single 3MS toolchange from T0 to T1:

1. The slicer performs tip shaping and filament unloading.
2. 3MS unloads T0 by 200mm at 4500mm/min (75mm/s).
3. T0 is desynced from the extruder.
4. Filament unloading is verified.
5. T1 is synced with the extruder.
6. 3MS loads T1 by 210mm at 4500mm/min.
7. Filament loading is verified.
8. The printer loads the filament to the nozzle.

For more detail about the Tx command, see Flowchart.

Think of the 3MS as an extension to your current extruder's length. It allows for switching filaments without compromising any of the benefits of your printer's extruder.

The 3MS's motors work together with your printer's extruder. This way, there won't be any additional resistance from pulling the filament through a disabled extruder. Also, unloads and loads to/from the printer's extruder are fully synchronized with the 3MS. This allows for even faster toolchanges!

1.8 Get Started

To get started with the 3MS, see the Master Instructions.

Get Started

1.9 What about the 3DChameleon?

I recently created a klipper plugin for the 3DChameleon after purchasing a unit. I'm sure my Chameleon could have worked if I had tuned it further, but after several months with only partial success, I gave up. I am still open to pull requests for **3dchameleon-klipper** and will do my best to respond to issues there, but I won't be able to test it myself anymore.

If you are having reliability issues with the 3DChameleon, see 3DChameleon Conversion

2 Comparison of Multimaterial Systems

Not sure if you want to use the 3MS? Check this comparison between four common multimaterial systems.

3DChameleon MK4 **Automatic Color Changer**

Pros:

- Compatibility
- No custom firmware
- Price ($200)

Cons:

- Reliability
- Documentation

Prusa MMU3 **Multi Material Upgrade**

Pros:

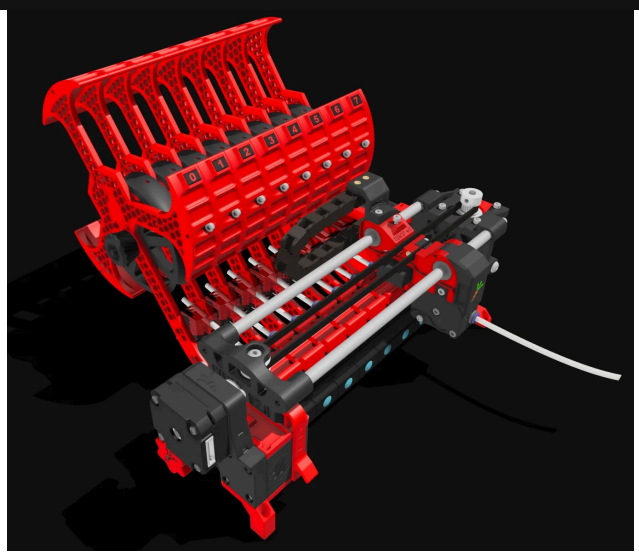
- Reliability
- Support
- Documentation

Cons:

- Compatibility
- Price ($300)

ERCF v2 **An expandable MMU for Klipper-based 3D-printers**

3MS **Modular Multimaterial System for Klipper 3D Printers**



Pros:

- Reliability
- Modular Design
- Active Community
- Documentation

Cons:

- Compatibility (only Klipper)
- Complexity

Pros:

- Simple Design
- Reliability
- Documentation
- Modular Design
- Price (~$140)

Cons:

- Compatibility (only Klipper)

3 Master Instructions

Due to the modularity of the 3MS, there are many ways to set it up. This guide attempts to encompass all supported ways of setting up the 3MS.

3.1 Basic Steps

The basic steps this guide will follow are:

1. Getting a BOM
2. Assembling your 3MS
3. Configuring your 3MS
4. Stepper motor setup
5. Slicer setup
6. First print
7. Troubleshooting
8. Updating

3.2 0. Explanations

Before starting the instructions, a basic understanding of how the 3MS works is recommended. There are two types of components in the 3MS:

- Controller

  This controls the 3MS stepper motors. This is usually an extra 3D printer mainboard purchased specifically for the 3MS. If your existing 3D printer mainboard has spare stepper ports, you can use them for the 3MS.

  The available configurations are specific to either an external mainboard setup, or utilizing spare stepper ports on your existing mainboard. If you are utilizing spare stepper ports, the name of the config will include "(main MCU)"

- Filament Units

  These move the filament. These are standard MK8 extruders (used on Ender 3's). You can use different extruders for the filament units, as long as you can mount them securely and they can attach to a PTFE tube. MK8 extruders are used as the default due to their low cost.

The number of filaments you will be able to print with is equal to the number of filament units you have. For example, two filament units will let you print with two colors. It is important to note that one filament unit will NOT let you print in multimaterial.

3.3 0.5. Choosing a Controller

Choose one of the controllers from Controllers before continuing.

3.4 1. Getting a BOM

Go to BOM to view the bill of materials for the number of filament units you want. Example BOM for two filament units and a SKR Mini E3 V2:

Name	Price	Quantity	Link	Notes
SKR Mini E3 V2	$34.99	1	Amazon	
Duponts	$9.99	1	Amazon	These wires are only sufficient to run steppers, not heaters
12V PSU	$7.39	1	Amazon	This PSU is only sufficient to run steppers, not heaters
NEMA17 Stepper Motor	$9.99	2	Amazon	You can use a pancake stepper if you want, but it will have less torque
MK8 Metal Extruder	$9.99	2	Amazon	
Capricorn PTFE Tubing	$11.49	1	Amazon	You likely won't need this for every unit, as this is usually too long for only one unit

3.5 2. Assembling your 3MS

Follow Assembly to assemble your 3MS.

3.6 3. Configuring your 3MS

1. Install Klipper firmware onto the MCU by following Firmware.
2. Install DynamicMacros, following instructions from here.
3. Follow Installation to install the 3MS configuration.
4. Follow Filament Sensor to setup your filament sensor with the 3MS.

3.7 4. Stepper motor setup

Follow Stepper Setup to setup and calibrate each of your filament units.

3.8 5. Slicer setup

Follow Slicer Setup to setup your slicer for the 3MS.

3.9 6. First print

Follow First Print to create your first multimaterial print with the 3MS.

3.10 7. Troubleshooting

Check Troubleshooting to find guides to troubleshoot your 3MS.

3.11 8. Updating

To update the 3MS configuration, go to the Update Manager in Mainsail/Fluidd and refresh the updates.

Next, find the "mmms" entry in the list. If there is an "Update" button next to it, click it and begin updating.

After updating, in your terminal, run:

```
sh ~/3MS/install.sh
```

This will install the new 3MS configuration. Next, restart Klipper:

> **Info**
>
> It is important to restart the Klipper **service**, and not just run the `RESTART` command.

Run this command in your terminal:

```
sudo service klipper restart
```

3.12 9. Tuning and Optimizations

After your 3MS is installed, it's time to tune and optimize it.

The best starting place for this is in the Materials Reference.

I. Setup

4 BOM

4.1 Number of filament units

First, choose the number of filament units you want. Each filament unit lets you print with an additional filament. Two filament units are the minimum. You can add or remove filament units after building, but the BOM and configuration will vary based on how many filament units you want.

4.2 Controller BOMs

Choose the BOM for your chosen controller from the list below:

- BTT SKR Mini E3 V2
- BTT SKR Pico
- BTT MMB
- BTT Octopus (main MCU)
- Zonestar ZM384 (main MCU)
- Mini RAMBo
- Geetech A30T

4.3 Filament Unit BOMs

For each filament unit, purchase this BOM:

Name	Quantity	Price	Link	Notes
NEMA17 Stepper Motor	1	$9.99	Amazon	You can use a pancake stepper if you want, but it will have less torque
MK8 Metal Extruder	1	$9.99	Amazon	Alternatively, you can use this Dual-drive MK8 based extruder
Capricorn PTFE Tubing	1	$11.49	Amazon	You likely won't need this for every unit, as this is usually too long for only one unit

I.I Controllers

5 Controllers

Follow this guide to determine which controller to use in your 3MS.

5.1 Options

The 3MS works on multiple different controllers.

> **Info**
>
> If your printer's mainboard has spare stepper ports, you can use them to control 3MS steppers. You can open an issue on Github (there's a template) to get a configuration made for your specific setup. Any controllers listed with "(main MCU)" use those spare stepper plugs.

Choose one of the following supported controllers (a checked box indicates it is fully tested, and an empty box indicates testers wanted):

- [x] BTT MMB (4 colors)

> **Recommended**

- [x] SKR Mini E3 V2.0 (4 colors)
- [x] Einsy RAMBo (main MCU) with SKR Mini E3 V2.0 (3ms MCU)

> **Expert modification**

- [x] Geetech A30T
- [ ] SKR Pico (4 colors)
- [ ] Zonestar ZM384 (main MCU) (4 colors)
- [ ] Mini RAMBo (4 colors)
- [ ] BTT Octopus (main MCU) (4 colors)

6 BTT SKR Mini E3 V2

Max filament units: 4

MCU Name: `3ms`

6.1 BOM

Name	Price	Quantity	Link	Notes
SKR Mini E3 V2	$34.99	1	Amazon	
Duponts	$9.99	1	Amazon	These wires are only sufficient to run steppers, not heaters
12V PSU	$7.39	1	Amazon	This PSU is only sufficient to run steppers, not heaters

6.2 Wiring

Route the wires from the NEMA17's to the controller board. Follow this table to determine which port to plug the motors into:

Filament Unit #	Motor Port
0	XM
1	YM
2	ZAM or ZBM
3	E0M

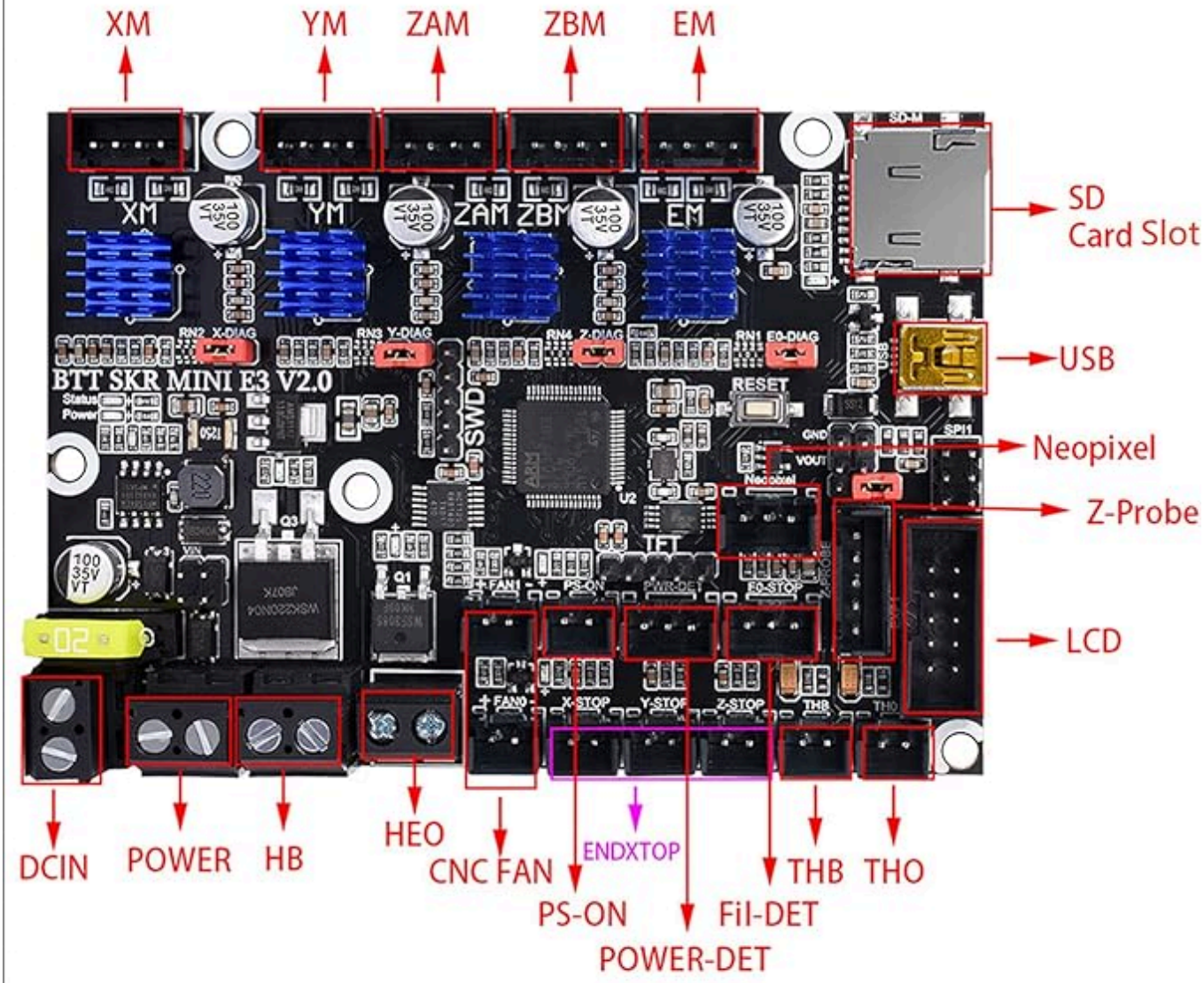
Now, grab your 12V PSU and two M-M duponts, one red and one black (M-M means that there is metal coming out of both ends of the cable). Plug the PSU into the wall, but don't plug the screw terminals into the PSU (the screw terminals have green)

1. Plug the red wire into the positive terminal of the screw terminals

2. Plug the black wire into the negative terminal of the screw terminals

> **Danger**
>
> These dupont cables are too thin to run much more than the stepper motors. If you run a heater or other power-intensive device off of the SKR board, the duponts and/or PSU can melt/catch fire. To reduce the risk of this, you can double up on the duponts or get thicker wires.

3. Following this image, choose either the DCIN or POWER input



4. Route the two wires inside closest to your chosen input

5. Using the markings on the board, plug the red wire into the positive terminal on the SKR

6. Using the markings on the board, plug the black wire into the negative terminal on the SKR
7. Verify all connections

> **Warning**
>
> If the wires are plugged into the wrong place, or swapped polarities, your SKR, Stepper motors, and/or PSU can be badly damaged.

8. Plug the PSU screw terminals into the PSU wire

If the SKR lights up, you wired it correctly!

Finally, plug the SKR into your Klipper host with the blue cable that came with it.

7 BTT SKR Pico

Max filament units: 4

MCU Name: `3ms`

7.1 BOM

Name	Price	Quantity	Link	Notes
SKR Pico	$35.99	1	Amazon	
Duponts	$9.99	1	Amazon	These wires are only sufficient to run steppers, not heaters
12V PSU	$7.39	1	Amazon	This PSU is only sufficient to run steppers, not heaters

7.2 Wiring

Route the wires from the NEMA17's to the controller board. Follow this table to determine which port to plug the motors into:

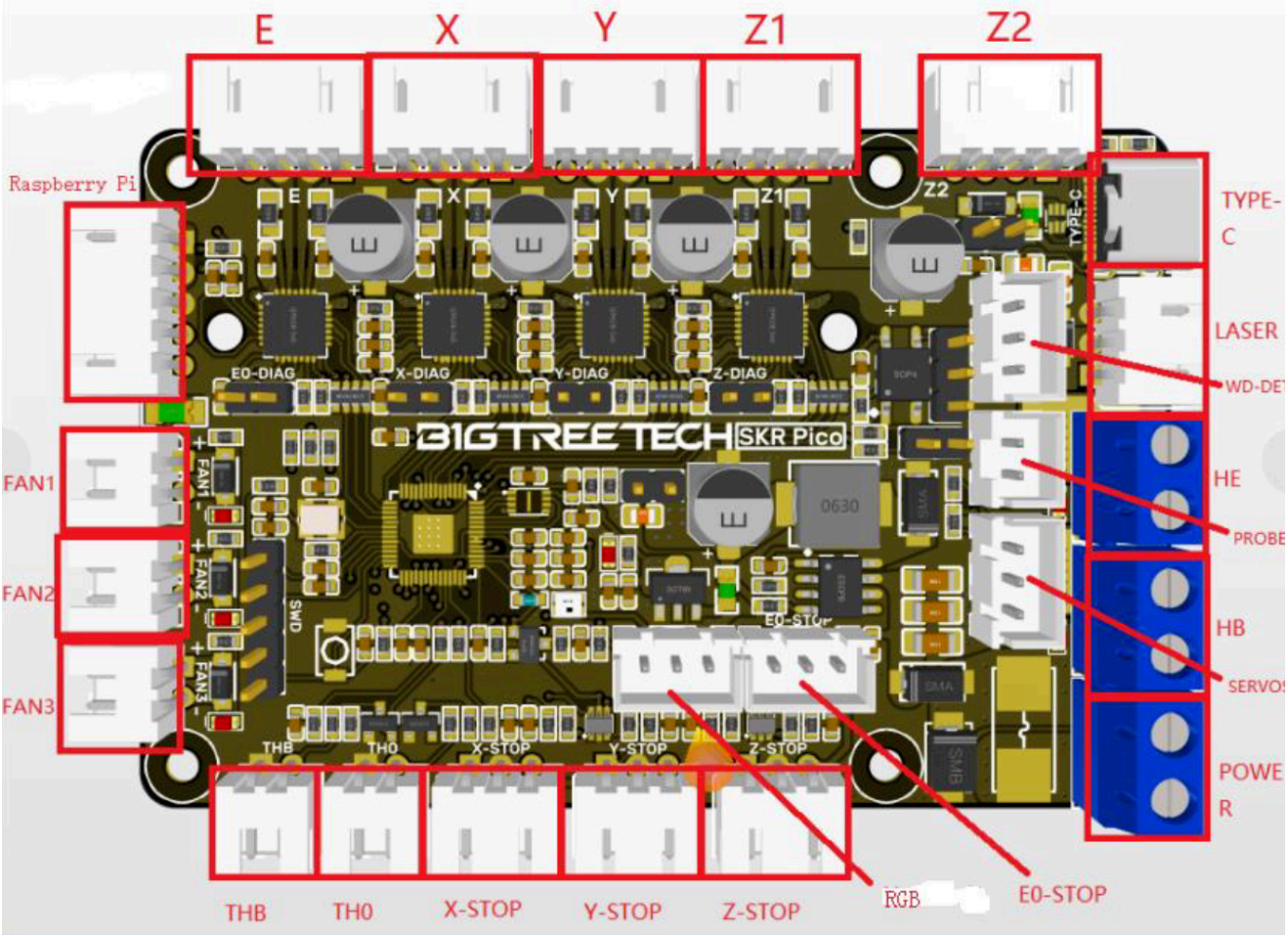
Filament Unit #	Motor Port
0	X
1	Y
2	Z1 or Z2
3	E

Now, grab your 12V PSU and two M-M duponts, one red and one black (M-M means that there is metal coming out of both ends of the cable). Plug the PSU into the wall, but don't plug the screw terminals into the PSU (the screw terminals have green)

1. Plug the red wire into the positive terminal of the screw terminals
2. Plug the black wire into the negative terminal of the screw terminals

> **Danger**
>
> These dupont cables are too thin to run much more than the stepper motors. If you run a heater or other power-intensive device off of the SKR board, the duponts and/or PSU can melt/catch fire. To reduce the risk of this, you can double up on the duponts or get thicker wires.

3. Following this image, locate the POWER input



4. Route the two wires inside closest to the POWER input
5. Using the markings on the board, plug the red wire into the positive terminal on the SKR
6. Using the markings on the board, plug the black wire into the negative terminal on the SKR
7. Verify all connections

> **Warning**
>
> If the wires are plugged into the wrong place, or swapped polarities, your SKR, Stepper motors, and/or PSU can be badly damaged.

8. Plug the PSU screw terminals into the PSU wire

If the SKR lights up, you wired it correctly!

Finally, plug the SKR into your Klipper host with the blue cable that came with it.

8 BTT MMB

Max filament units: 4

MCU Name: `3ms`

8.1 BOM

Name	Price	Quantity	Link	Notes
BTT MMB	$34.99	1	BTT	
Duponts	$9.99	1	Amazon	These wires are only sufficient to run steppers, not heaters
12V PSU	$7.39	1	Amazon	This PSU is only sufficient to run steppers, not heaters

8.2 Wiring

Route the wires from the NEMA17's to the controller board. Follow this table to determine which port to plug the motors into:

Filament Unit #	Motor Port
0	M1
1	M2
2	M3
3	M4

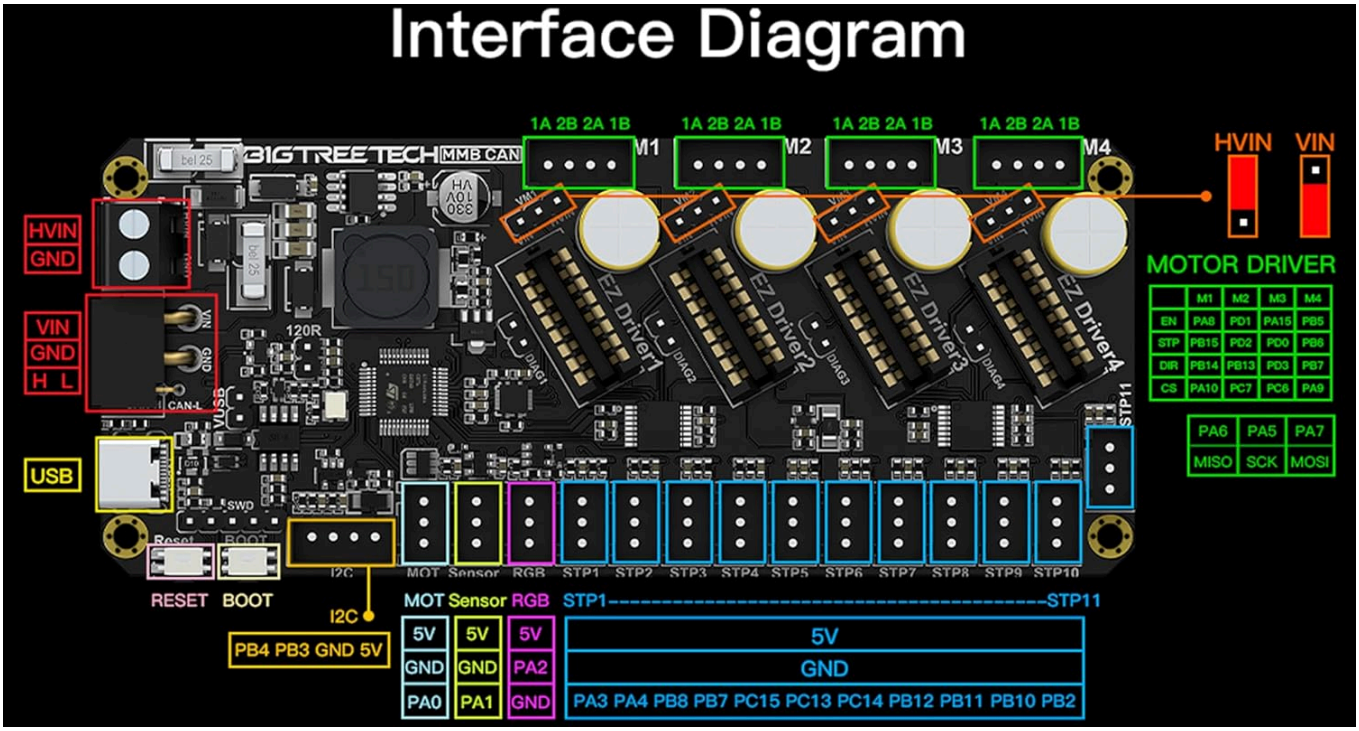
Now, grab your 12V PSU and two M-M duponts, one red and one black (M-M means that there is metal coming out of both ends of the cable). Plug the PSU into the wall, but don't plug the screw terminals into the PSU (the screw terminals have green)

1. Plug the red wire into the positive terminal of the screw terminals
2. Plug the black wire into the negative terminal of the screw terminals

Danger

These dupont cables are too thin to run much more than the stepper motors. If you run a heater or other power-intensive device off of the MMB board, the duponts and/or PSU can melt/catch fire. To reduce the risk of this, you can double up on the duponts or get thicker wires.

3. Following this image, locate the HVIN and GND inputs (top left)



4. Route the two wires inside closest to the HVIN and GND inputs
5. Using the markings on the board, plug the red wire into the HVIN terminal on the MMB
6. Using the markings on the board, plug the black wire into the GND terminal on the MMB
7. Verify all connections

Warning

If the wires are plugged into the wrong place, or swapped polarities, your MMB, Stepper motors, and/or PSU can be badly damaged.

8. Plug the PSU screw terminals into the PSU wire

If the MMB lights up, you wired it correctly!

Finally, plug the MMB into your Klipper host with the cable that came with it.

9 BTT Octopus (main MCU)

> **Warning**
>
> This configuration may not work with the BTT Octopus Pro.

Max filament units: 4

MCU Name: `main`

9.1 main MCU

This configuration is a `main MCU` configuration, meaning that your printer should already be running off a BTT Octopus and you don't need to purchase one.

9.2 BOM

Per filament unit:

1x TMC2209 ($7 each)

9.3 Wiring

Route the wires from the NEMA17's to the controller board. Follow this table to determine which port to plug the motors into:

Filament Unit #	Motor Port
0	MOTOR7
1	MOTOR6
2	MOTOR5
3	MOTOR4

10 Einsy RAMBo (main MCU) with SKR Mini E3 V2

Danger

This guide is an expert guide only

Info

This modification is designed for the Prusa MK3/S/S+, and depends on this Klipper configuration.

10.1 Why?

When printing fast, the TMC2130's on the Einsy RAMBo can get quite loud. The TMC2209's on the SKR Mini are much quieter and support denser microstepping.

10.2 BOM

Name	Price	Quantity	Link	Notes
PSU -> Einsy Cable	$7.99	1	PartsBuilt3D	
Stepperonline NEMA17	$9.99 each	Amazon	2	Replaces current XY motors

10.3 Wiring

First, unplug the 3MS steppers from the SKR Mini, and the XY steppers from the Einsy RAMBo. The motors will need to be switched due to different connector types between boards.

This table outlines the major wiring of this modification.

Einsy RAMBo	SKR Mini E3 V2	Motor
PSU+	POWER+	
PSU-	POWER-	
XM		3ms0

Einsy RAMBo	SKR Mini E3 V2	Motor
YM		3ms1
	XM	X
	YM	Y

10.4 Configuration

In your `printer.cfg`, comment out these lines:

printer.cfg

```
#[include klipper-prusa-mk3s/mk3s/steppers.cfg]
#[include klipper-prusa-mk3s/mk3s/tmc2130.cfg]
```

Next, copy the contents of `3ms/controllers/einsy_rambo_with_skr_mini/xy-motors.cfg` and `ze-motors.cfg` to `klipper-prusa-mk3s/skr/xy.cfg`, and `klipper-prusa-mk3s/mk3s/ze.cfg`, respectively.

Add the following new lines:

printer.cfg

```
[include klipper-prusa-mk3s/skr/xy.cfg]
[include klipper-prusa-mk3s/mk3s/ze.cfg]
```

Restart Klipper.

11 Zonestar ZM384 (main MCU)

Max filament units: 3

MCU Name: `main`

11.1 main MCU

This configuration is a `main MCU` configuration, meaning that your printer should already be running off a ZM384 and you don't need to purchase one.

11.2 Configuration

In your `3ms/macros.cfg`, edit the following section:

Before

macros.cfg

```
# Set the sync of provided TOOL to SYNC with extruder
### --- Comment if using the 3MS instead of your printer's extruder --- ###
[gcode_macro SET_TOOL_SYNC]
gcode:
    {% set tool = params.TOOL|int %}
    {% set sync = params.SYNC|int %}
    {% set motion_queue = "extruder" if sync == 1 else "" %}
    SYNC_EXTRUDER_MOTION EXTRUDER=3ms{ tool } MOTION_QUEUE={ motion_queue }
### --- Comment if using the 3MS instead of your printer's extruder --- ###
# [gcode_macro SET_TOOL_SYNC]
# gcode:
#   {% set tool = params.TOOL|int %}
#   {% set sync = params.SYNC|int %}
#   {% set ext_name = "3ms"+(tool|str) %}
#   {% if tool == 0 %}
#     {% set ext_name = "extruder" %}
#   {% endif %}
#   {% set motion_queue = "extruder" if sync == 1 else "" %}
#   SYNC_EXTRUDER_MOTION EXTRUDER={ext_name} MOTION_QUEUE={ motion_queue }
```

After

macros.cfg

```
# Set the sync of provided TOOL to SYNC with extruder
### --- Comment if using the 3MS instead of your printer's extruder --- ###
# [gcode_macro SET_TOOL_SYNC]
# gcode:
#   {% set tool = params.TOOL|int %}
#   {% set sync = params.SYNC|int %}
#   {% set motion_queue = "extruder" if sync == 1 else "" %}
#   SYNC_EXTRUDER_MOTION EXTRUDER=3ms{ tool } MOTION_QUEUE={ motion_queue }
### --- Comment if using the 3MS instead of your printer's extruder --- ###
[gcode_macro SET_TOOL_SYNC]
gcode:
  {% set tool = params.TOOL|int %}
  {% set sync = params.SYNC|int %}
  {% set ext_name = "3ms"+(tool|str) %}
  {% if tool == 0 %}
    {% set ext_name = "extruder" %}
  {% endif %}
  {% set motion_queue = "extruder" if sync == 1 else "" %}
  SYNC_EXTRUDER_MOTION EXTRUDER={ext_name} MOTION_QUEUE={ motion_queue }
```

11.3 Wiring

Route the wires from the NEMA17's to the controller board. Follow this table to determine which port to plug the motors into:

Filament Unit #	Motor Port
0	E0
1	E1
2	E2
3	E3

12 Mini RAMBo

Max filament units: 4

MCU Name: `3ms`

12.1 BOM

Name	Price	Quantity	Link	Notes
Mini RAMBo		1		
Duponts	$9.99	1	Amazon	These wires are only sufficient to run steppers, not heaters
12V PSU	$7.39	1	Amazon	This PSU is only sufficient to run steppers, not heaters

12.2 Wiring

Route the wires from the NEMA17's to the controller board. Follow this table to determine which port to plug the motors into:

Filament Unit #	Motor Port
0	XM
1	YM
2	ZAM or ZBM
3	E0M

Now, grab your 12V PSU and two M-M duponts, one red and one black (M-M means that there is metal coming out of both ends of the cable). Plug the PSU into the wall, but don't plug the screw terminals into the PSU (the screw terminals have green)

1. Plug the red wire into the positive terminal of the screw terminals

2. Plug the black wire into the negative terminal of the screw terminals

> **Danger**
>
> These dupont cables are too thin to run much more than the stepper motors. If you run a heater or other power-intensive device off of the RAMBo board, the duponts and/or PSU can melt/catch fire. To reduce the risk of this, you can double up on the duponts or get thicker wires.

3. Route the two wires inside closest to your chosen input
4. Using the markings on the board, plug the red wire into the positive terminal on the RAMBo
5. Using the markings on the board, plug the black wire into the negative terminal on the RAMBo
6. Verify all connections

> **Warning**
>
> If the wires are plugged into the wrong place, or swapped polarities, your RAMBo, Stepper motors, and/or PSU can be badly damaged.

7. Plug the PSU screw terminals into the PSU wire

If the RAMBo lights up, you wired it correctly!

Finally, plug the RAMBo into your Klipper host with the cable that came with it.

13 Geetech A30T

Contributed by @ImChrono

Max filament units: 7

MCU Name: `3ms`

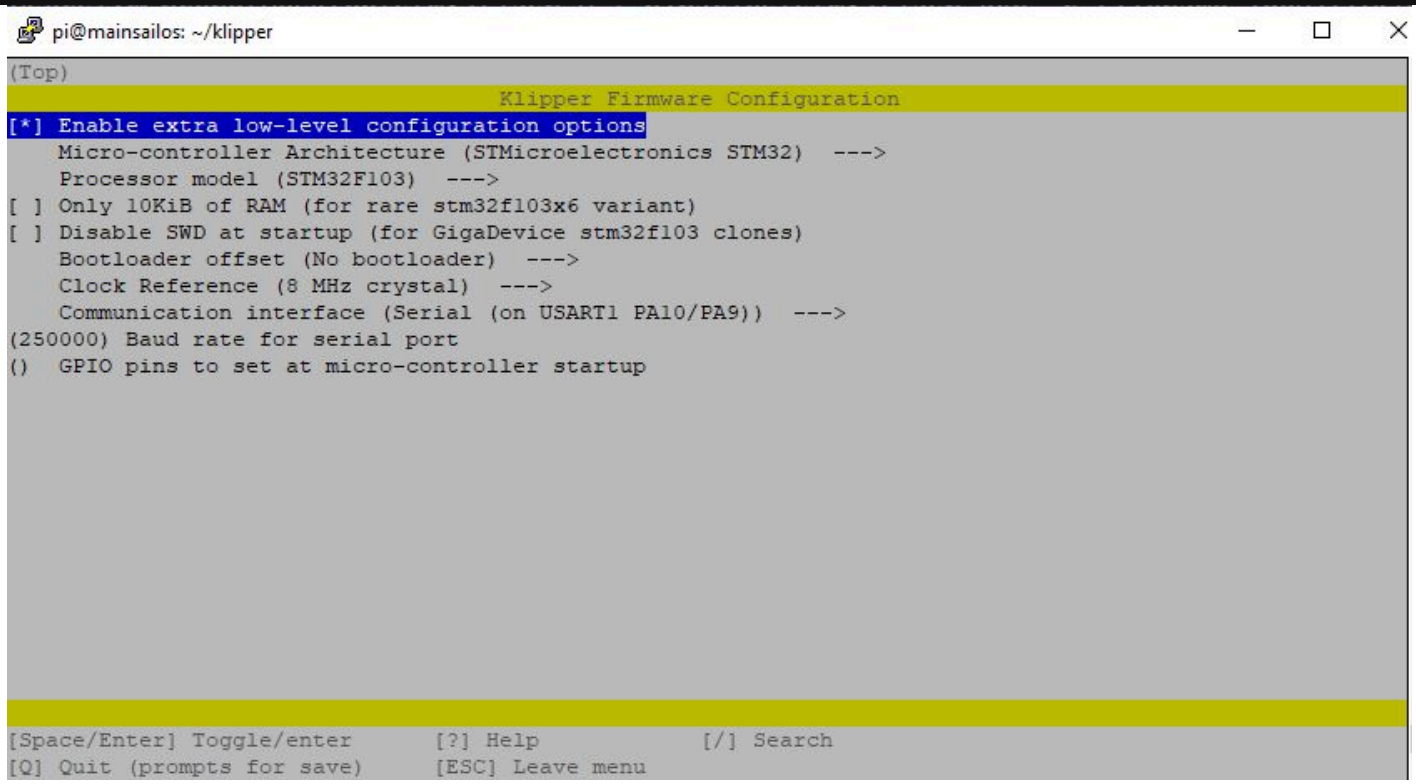
13.1 BOM

Name	Price	Quantity	Link	Notes
Geetech A30T	$34.99	1	Geetech	
Duponts	$9.99	1	Amazon	These wires are only sufficient to run steppers, not heaters
24V PSU	$7.39	1	Amazon	This PSU is only sufficient to run steppers, not heaters

13.2 Firmware

To flash Klipper firmware to the A30T, run the following command and see the following screenshot:

```
cd ~/klipper
make menuconfig
```



Next, connect the **BOOT0** jumper on the A30T and run:

```
stm32flash -i ',,,,,' -v -w out/klipper.bin -g 0 /dev/serial/by-id/<your-mcu-id-here>
```

13.3 Wiring

Route the wires from the NEMA17's to the controller board. Follow this table to determine which port to plug the motors into:

Filament Unit #	Motor Port
0	X
1	Y
2	Z0
3	Z1
4	E1
5	E2

Filament Unit #	Motor Port
6	E3

Now, grab your 12V PSU and two M-M duponts, one red and one black (M-M means that there is metal coming out of both ends of the cable). Plug the PSU into the wall, but don't plug the screw terminals into the PSU (the screw terminals have green)

1. Plug two red wires into the positive terminal of the screw terminals
2. Plug two black wires into the negative terminal of the screw terminals

> **Danger**
>
> These dupont cables are too thin to run much more than the stepper motors. If you run a heater or other power-intensive device off of the motherboard, the duponts and/or PSU can melt/catch fire. To reduce the risk of this, you can double up on the duponts or get thicker wires.

3. Route the four wires inside closest to your chosen input
4. Using the markings on the board, plug the two red wires into the positive terminal on the motherboard
5. Using the markings on the board, plug the two black wires into the negative terminal on the motherboard
6. Verify all connections

> **Warning**
>
> If the wires are plugged into the wrong place, or swapped polarities, your motherboard, Stepper motors, and/or PSU can be badly damaged.

7. Plug the PSU screw terminals into the PSU wire

If the motherboard lights up, you wired it correctly!

Finally, plug the motherboard into your Klipper host with the cable that came with it.

14 Assembly

Follow this guide to assemble your 3MS.

14.1 Printed Parts

An optional board enclosure for the SKR Mini E3 is available here.

Additionally, an optional universal mount for the MK8 extruder using M3 bolts is available here. Note that this requires 2-4 M3 bolts and a place to screw the bolts into.

~~Finally, you will need to print enough of these Y splitters for the filament.~~

The Y-splitter available here is now recommended.

14.2 MK8 Assembly

Next, assemble the MK8 extruders onto the NEMA17 motors using the provided instructions that came with them. If you use the mount provided above, make sure it is in between the MK8 and NEMA17.

14.3 Wiring

> **Note for Certain Printers**
>
> If your printer has Klipper running internally (not on an external computer), the controller (if not a main MCU config) is plugged into a USB port on the printer itself.

Follow one of the following guides based on your controller:

- SKR Mini E3 V2
- SKR Pico
- BTT MMB
- BTT Octopus (main MCU)
- Einsy RAMBo (main MCU) with SKR Mini E3 V2
- Zonestar ZM384 (main MCU)
- Mini RAMBo
- Geetech A30T

15 Firmware

Follow this guide to install Klipper firmware onto your 3MS MCU. This guide is a modified version of the Klipper Documentation.

Info

The following controller(s) can skip this guide:

- BTT Octopus (main MCU)
- Zonestar ZM384 (main MCU)

15.1 Create firmware.bin

Make sure your 3MS MCU is plugged into your Klipper Host. Run in your terminal:

```
cd ~/klipper
make menuconfig
```

In the menuconfig, configure it to your MCU. Instructions are included at the top of `3ms/controllers/xxx/steppers.cfg`.

Geetech A30T

If you're using a Geetech A30T controller, follow the flashing instructions here.

Run in your terminal:

```
make clean
make
```

The `klipper.bin` file, located in `~/klipper/out/klipper.bin` needs to be copied to a MicroSD card and renamed to `firmware.bin` (case-sensitive).

15.2 Install firmware.bin

Next, unplug the 3MS board from the PSU and your Klipper Host and insert the SD Card. Next, plug in the PSU, THEN the Klipper Host to the 3MS board. The firmware is now flashed.

15.3 Get MCU ID

In the terminal, run:

```
ls /dev/serial/by-id/
```

Example output:

```
usb-Klipper_stm32f103xe_33FFD1054746333809650557-if00
usb-Prusa_Research__prusa3d.com__Original_Prusa_i3_MK3_xxx-if00
```

In this case, the first line is the 3MS, and the second line is the 3D printer. Now that you know the id of the 3MS MCU, copy it and save it to a file:

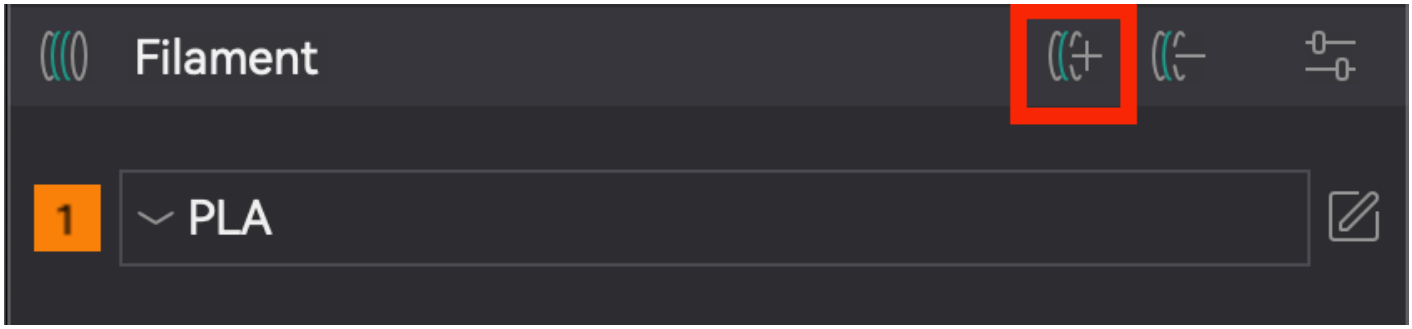
```
cd ~ && echo "<your-mcu-id>" >> mcu.txt
```

16 Slicer Setup

Follow this guide to setup the 3MS with your slicer. OrcaSlicer will be used in this guide, but these same settings (with different names) can be applied to PrusaSlicer and SuperSlicer.

16.1 Number of Filament Units

Set the number of filaments in your slicer to the number of filament units in your 3MS.



In OrcaSlicer, press the filament plus button until there are as many filaments displayed as you have filament units.

16.2 Klipper Start/End G-Code

In your Klipper `PRINT_START` macro, add the following right before your purge line:

```
MMMS_START INITIAL_TOOL={params.INITIAL_EXTRUDER}
```

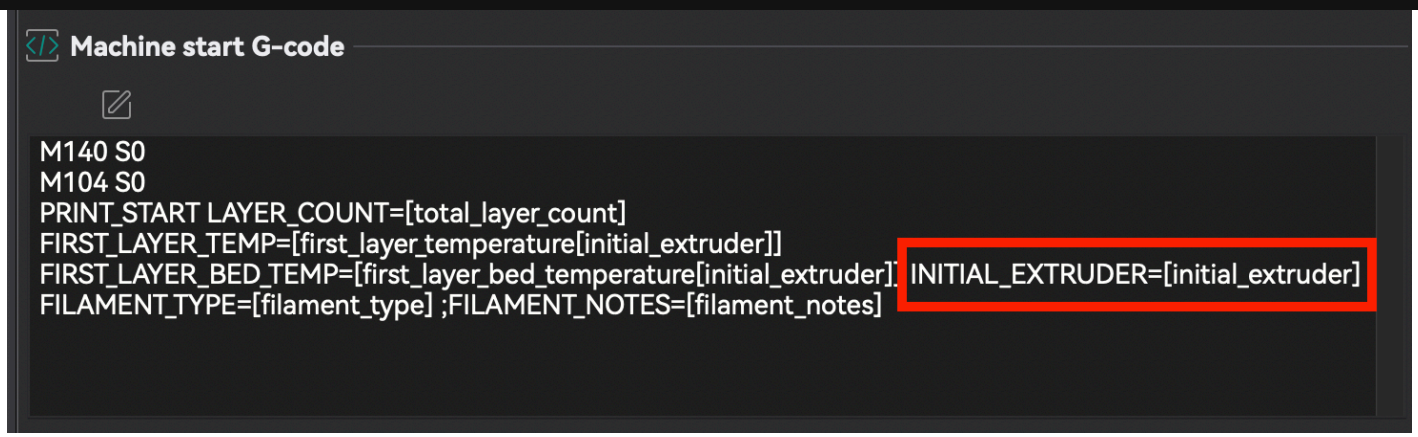
In your `PRINT_END` macro, add the following before the cooldown command is called:

```
MMMS_END
```

16.3 Slicer Start G-Code

In your slicer's Start G-Code, add the following parameter to your `PRINT_START`:

```
INITIAL_EXTRUDER=[initial_extruder]
```



16.4 Multimaterial Parameters

The last required step of setting up your slicer for the 3MS is setting the multimaterial parameters.

Navigate to `Printer Settings` -> `Multimaterial`. Check off the `Single Extruder Multi Material` checkbox.

16.4.1 Cooling Tube

The first two `Single extruder multi-material parameters` are hotend-specific.

The cooling tube refers to the length of PTFE tube in your hotend. For most hotends, this is usually in the heat sink.

Its position is measured as the distance from the **bottom** of the cooling tube to the **tip** of the nozzle.

Set those two parameters in your slicer.

16.4.2 Parking Position

The third parameter is extruder/printhead-specific.

The `Filament parking position` refers to the position where the filament is just above the extruder gears. During color swaps, the filament is unloaded to this position before the 3MS takes over. At the end of the toolchange, the next filament is in this same position.

Its position is measured as its distance to the **tip** of the nozzle.

16.4.3 Extra loading distance

This parameter refers to the extra distance the filament is loaded after a color swap is complete. This is usually a negative number.

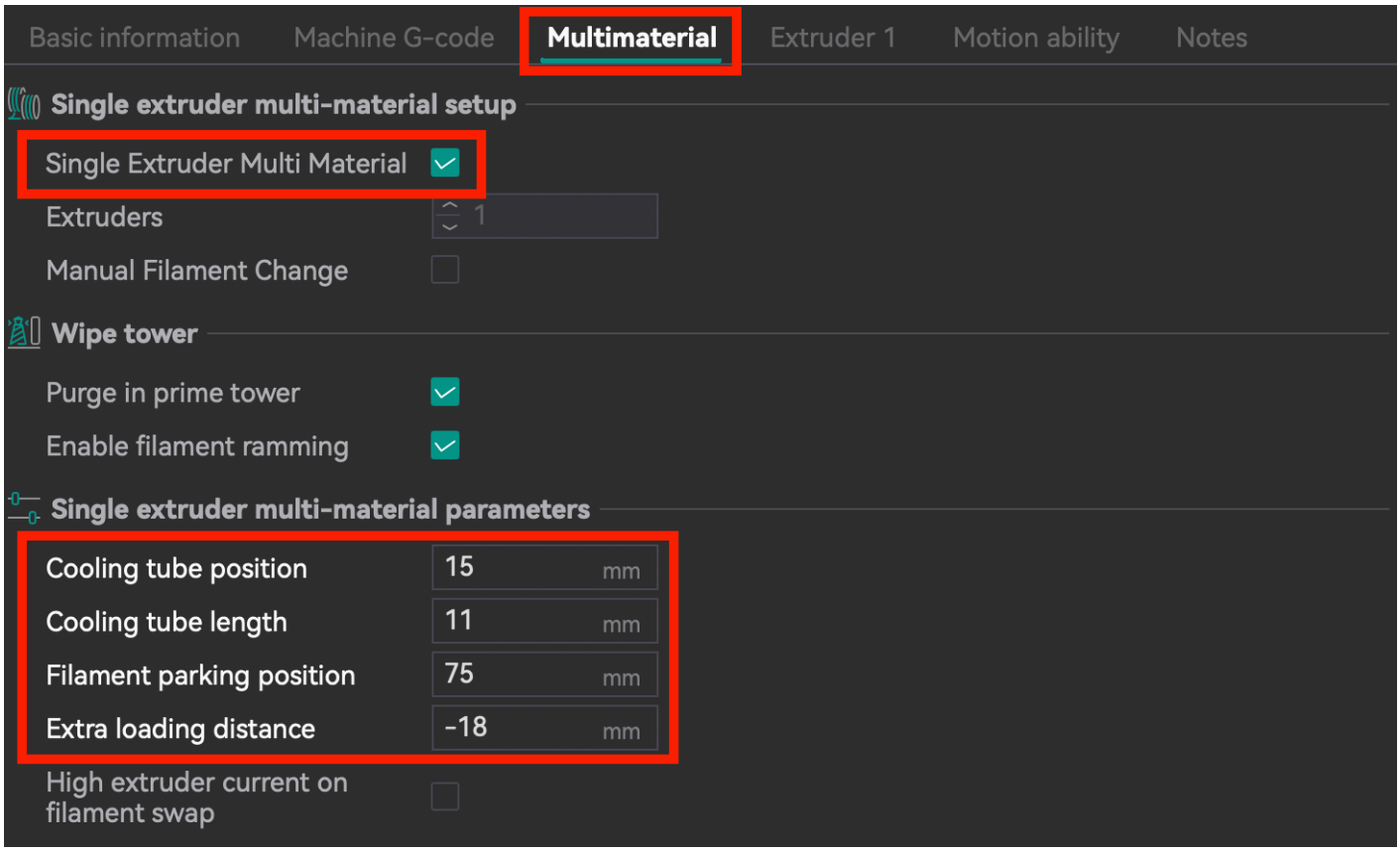
When a color swap is performed, the nozzle stays in the same place while the 3MS switches colors. This section will refer to this position as the "Swap position".

If you notice blobs forming around the swap positions, **decrease** the `Extra loading distance` (set it to a **negative** number **further** from zero).

If you notice gaps around the swap positions, **increase** the `Extra loading distance` (set it to a **negative** number **closer** to zero).

16.4.4 Example Settings

Example settings are shown below for a Prusa MK3S+ with a Mosquito hotend.



> **Info**
>
> This is the last required part of slicer setup.

16.5 Optional: klipper_estimator

If you use klipper_estimator and want the toolchange represented in the time estimate, time your toolchange, then change your Change filament G-Code:

Change filament G-code

```
; ESTIMATOR_ADD_TIME 10 Toolchange
T{next_extruder}
```

Toolchange time (seconds)

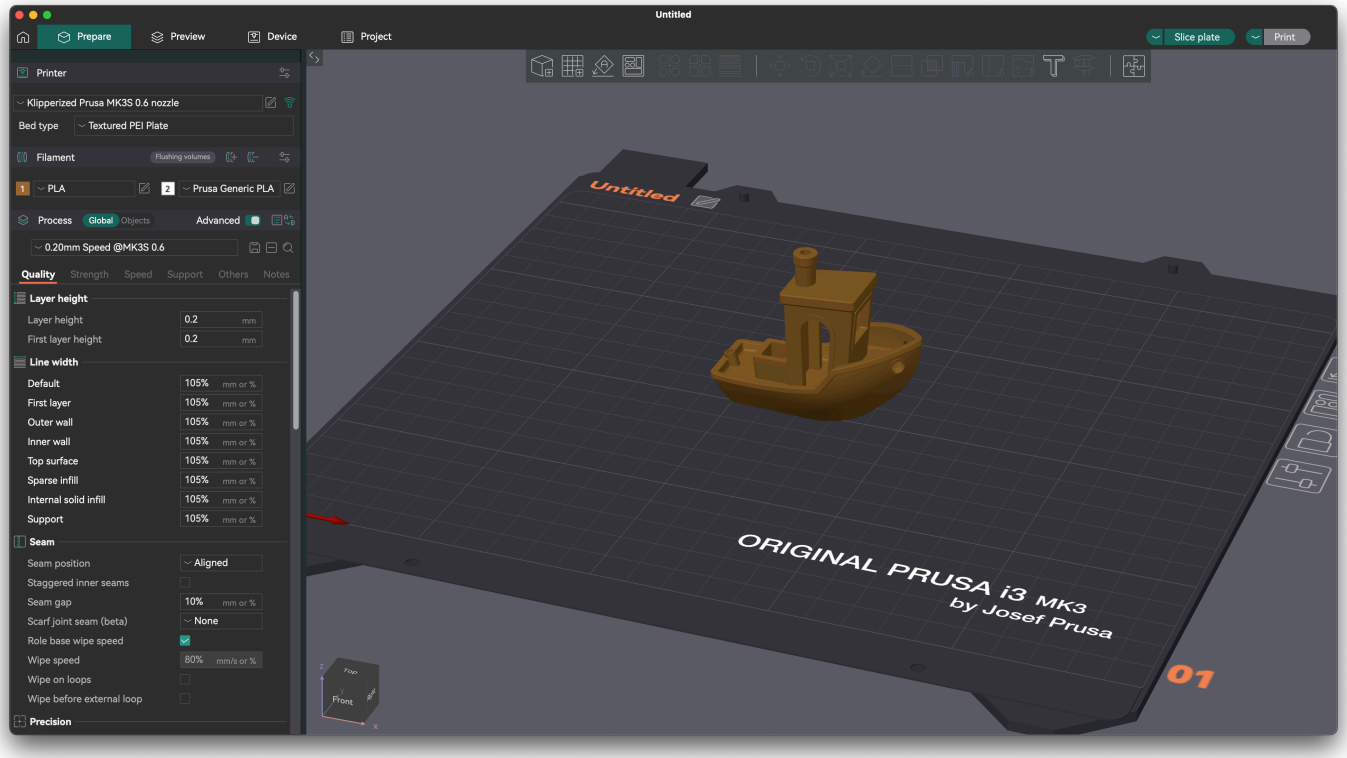
17 First Print

Follow this guide to begin your first multimaterial print. There are two main ways to prepare a model for multimaterial painting.

17.1 Method 1: Multimaterial Painting

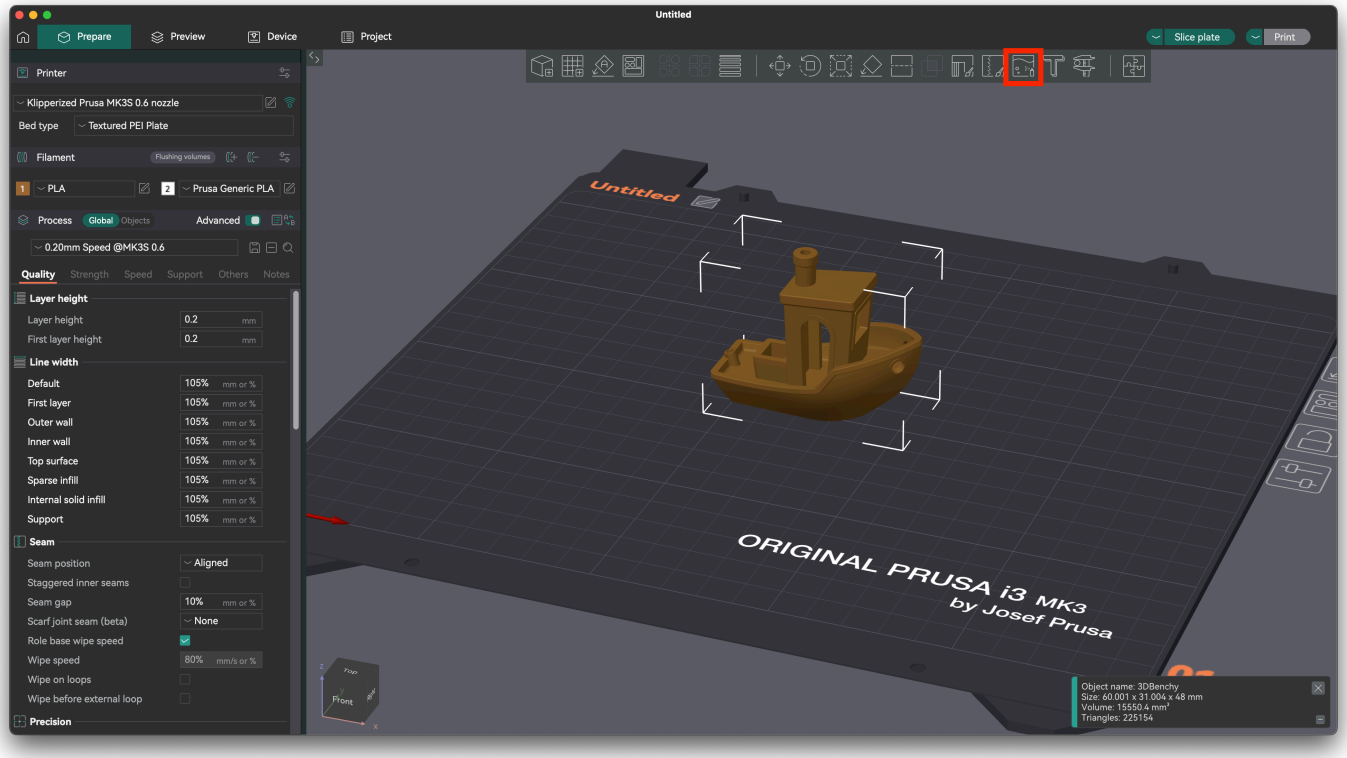
This method allows you to turn any model, even if it's not designed for multimaterial printing, into a multimaterial print. First, import your model into the slicer. In this case, a 3DBenchy will be used.

`⌘ Cmd` + `I` OR `^ Ctrl` + `I`

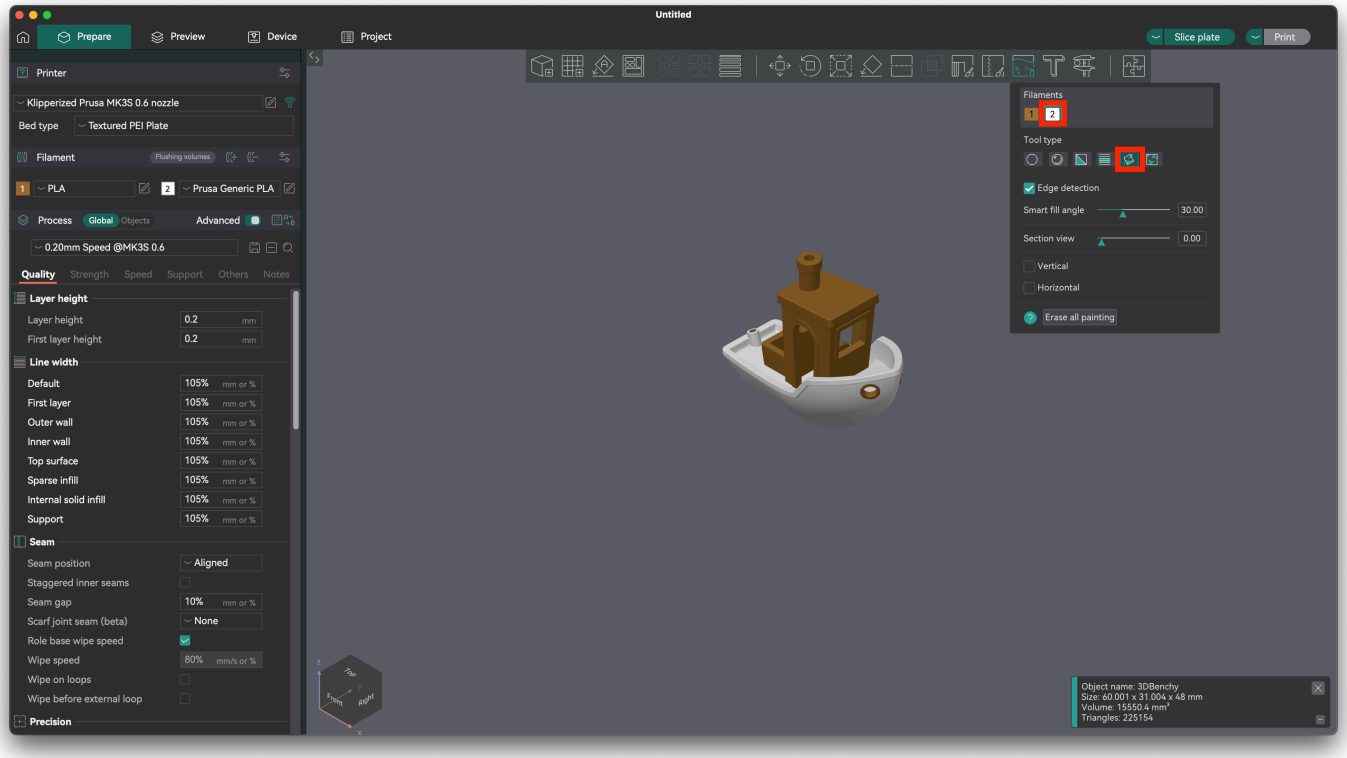


Next, select the model and click multimaterial painting at the top.

`N`

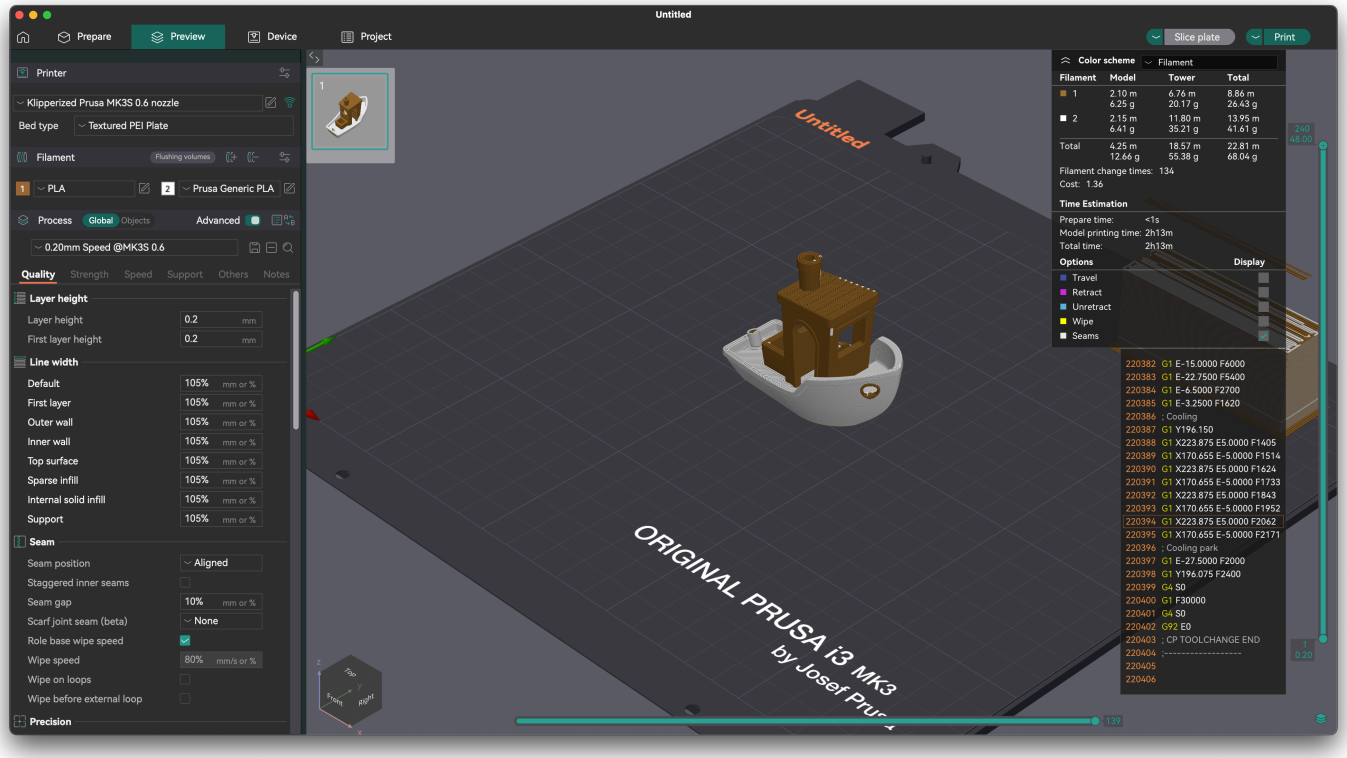


Once you're in this menu, you can choose any tool, tool size, and filament. Now, just drag over the model to apply the selected tool to the model. In this case, the hull of the 3DBenchy will be set to filament two using the fill tool.



Finally, hit slice and your model is ready to print!

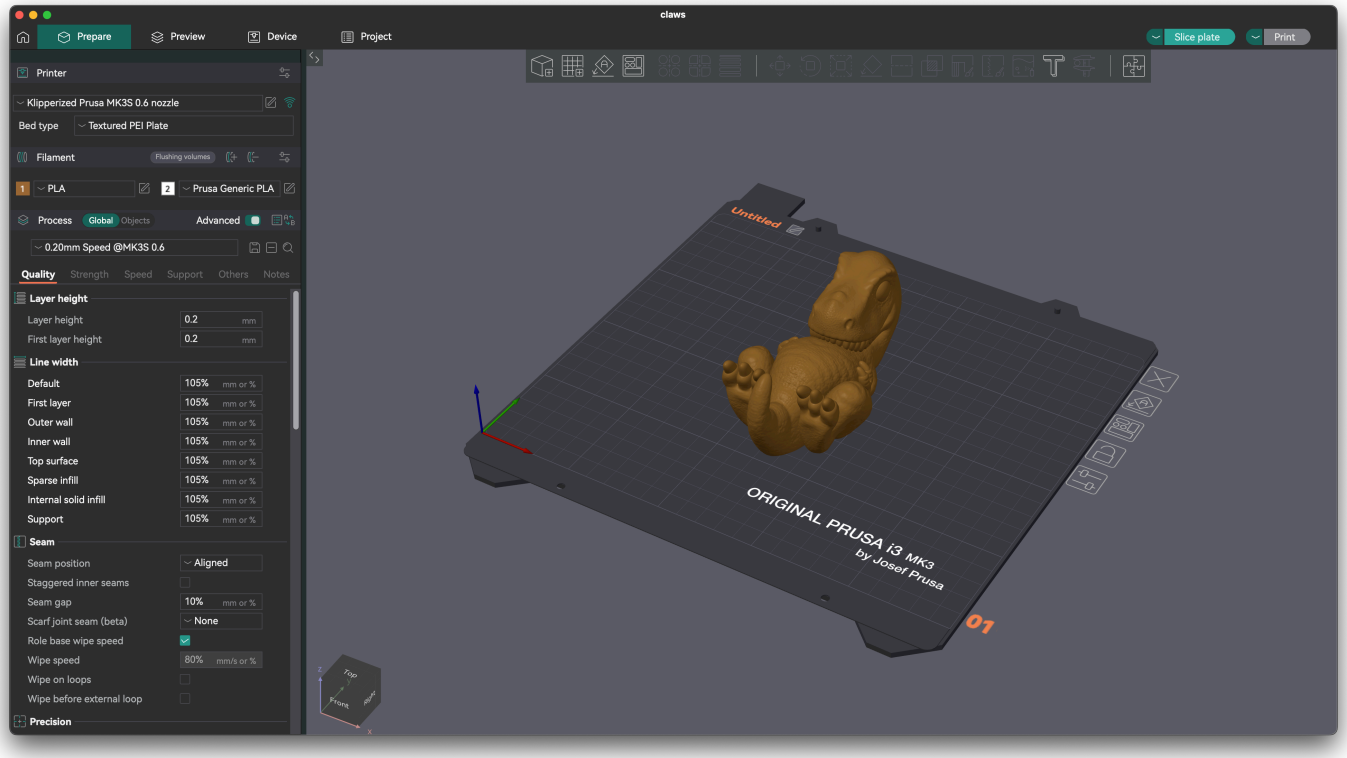
`⌘ Cmd` + `R` OR `^ Ctrl` + `R`



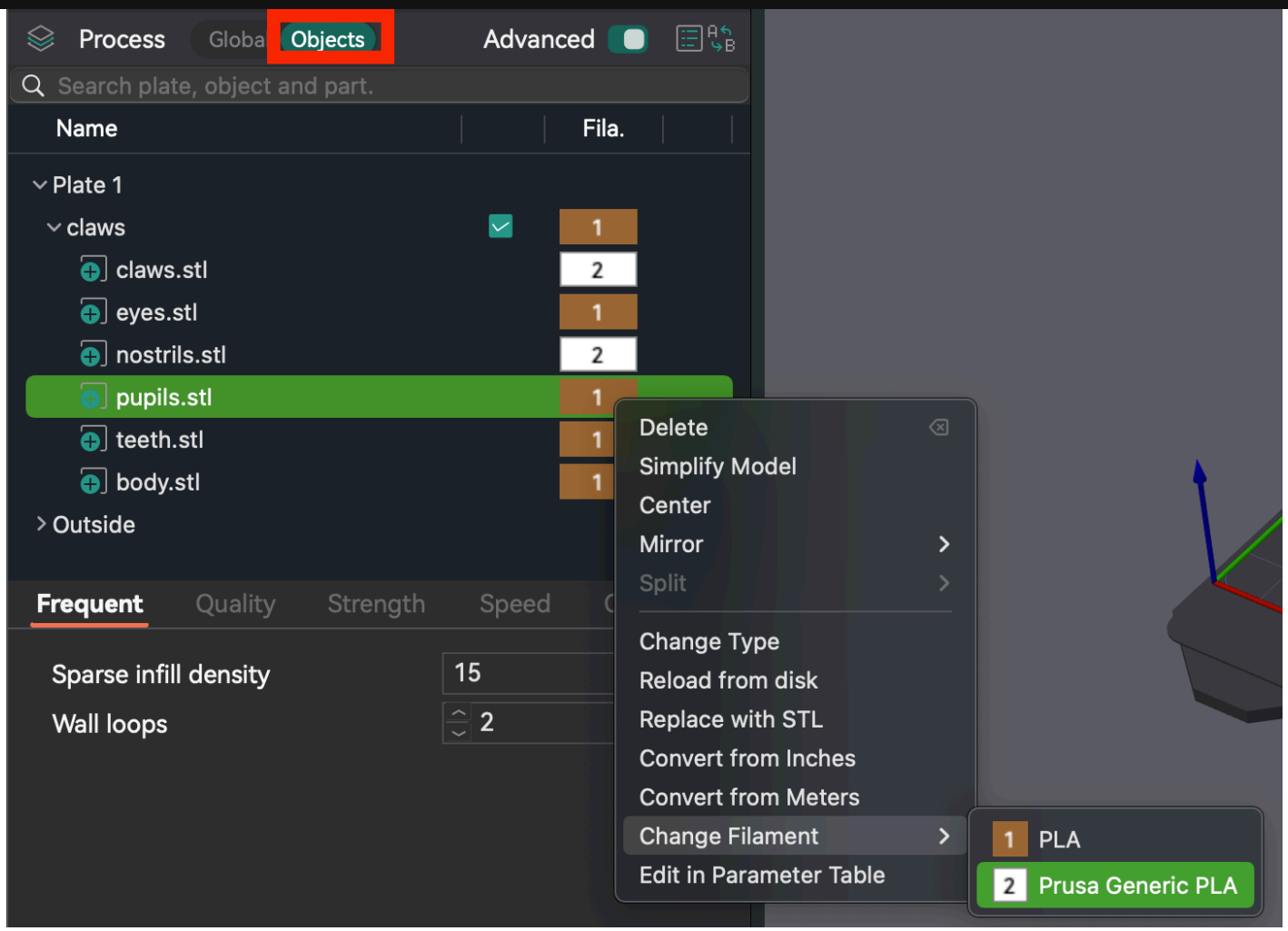
17.2 Method 2: Multimaterial Model

This method allows you to turn parts of a model to different materials. For this tutorial, this T-rex by Cipis will be used. First, import your model into the slicer. If prompted while opening to treat the model as multiple parts, select "Yes".

`⌘ Cmd` + `I` OR `^ Ctrl` + `I`

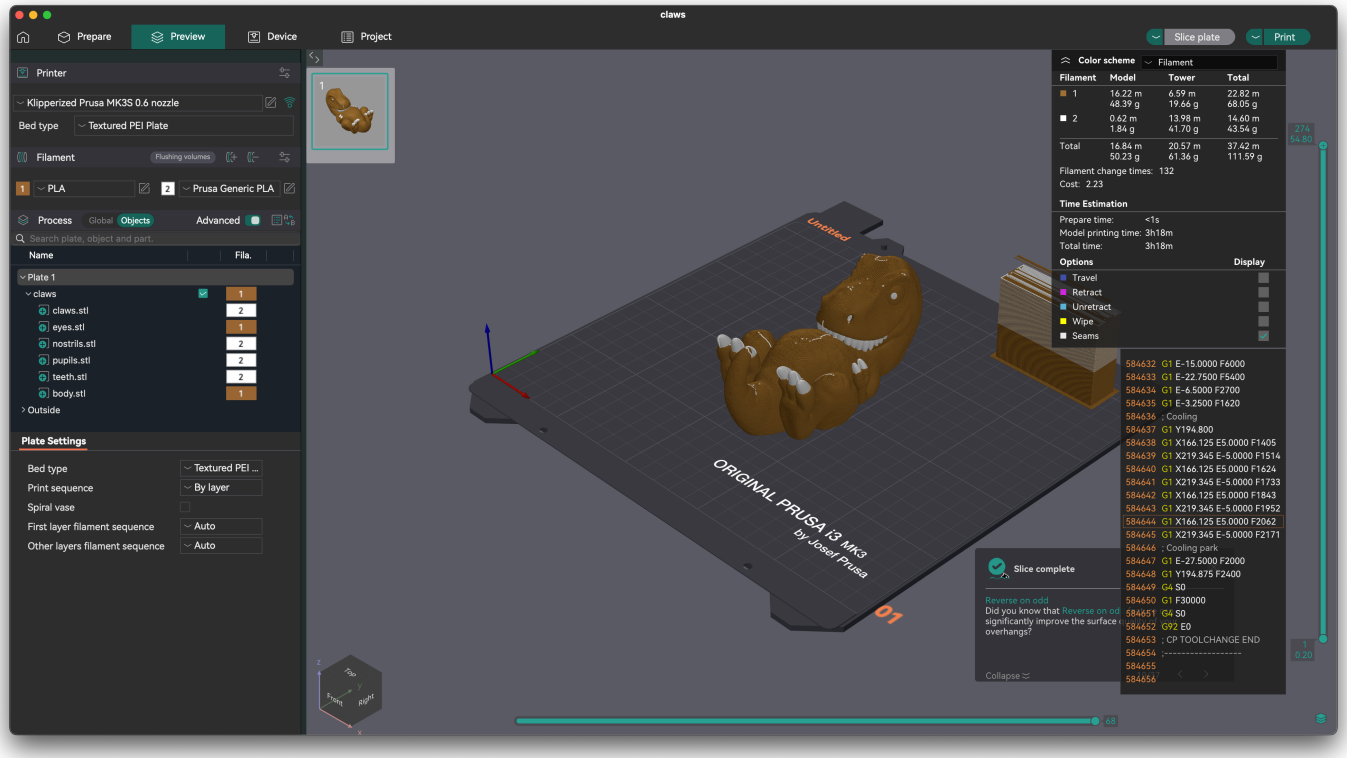


Next, go to object settings and change the different parts of the model to different colors.



Finally, hit slice and your model is ready to print!

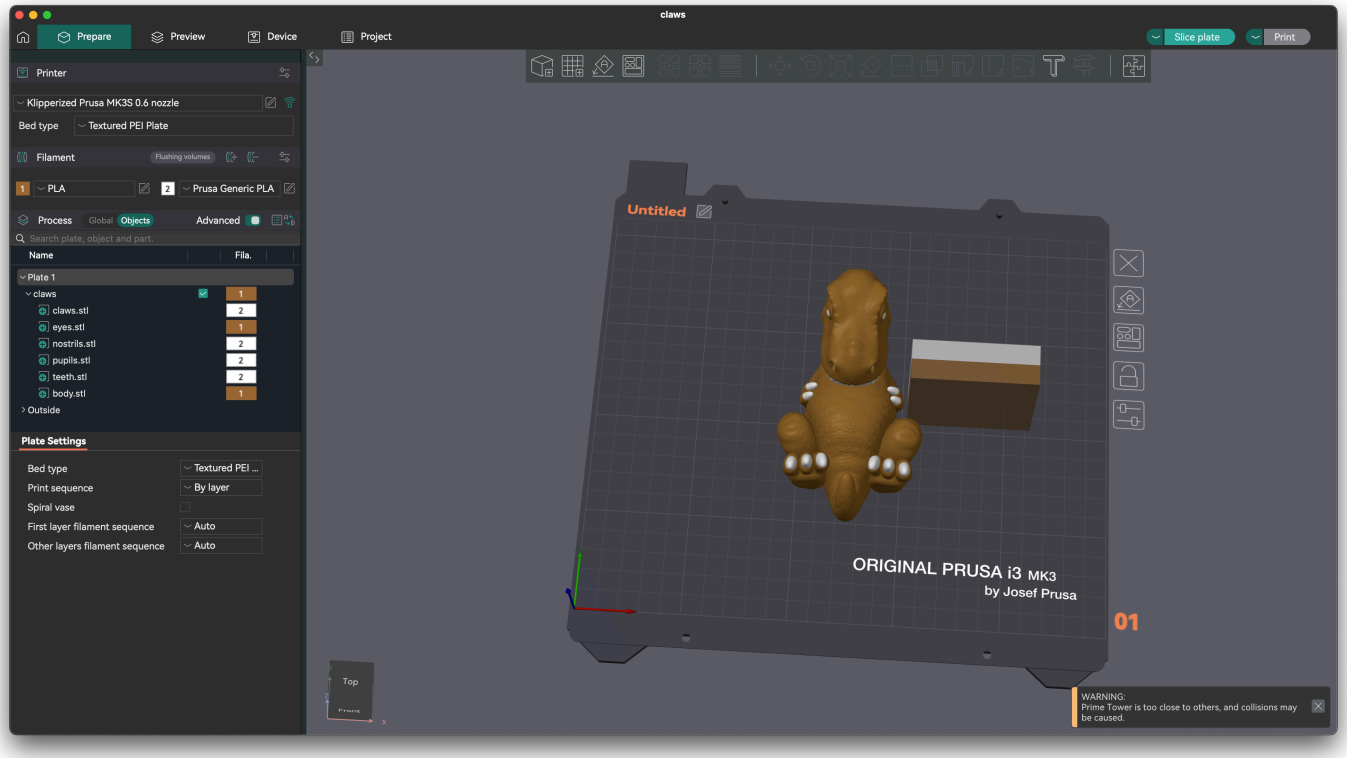
`⌘ Cmd` + `R` OR `^ Ctrl` + `R`



17.3 Wipe Tower Position

In the examples, you may have noticed that the wipe tower is far from the model. The travel time between the model and wipe tower adds up, and moving the tower closer can help reduce print time.

In the "Prepare" view, click and drag the wipe tower as close to the object as you can without colliding.

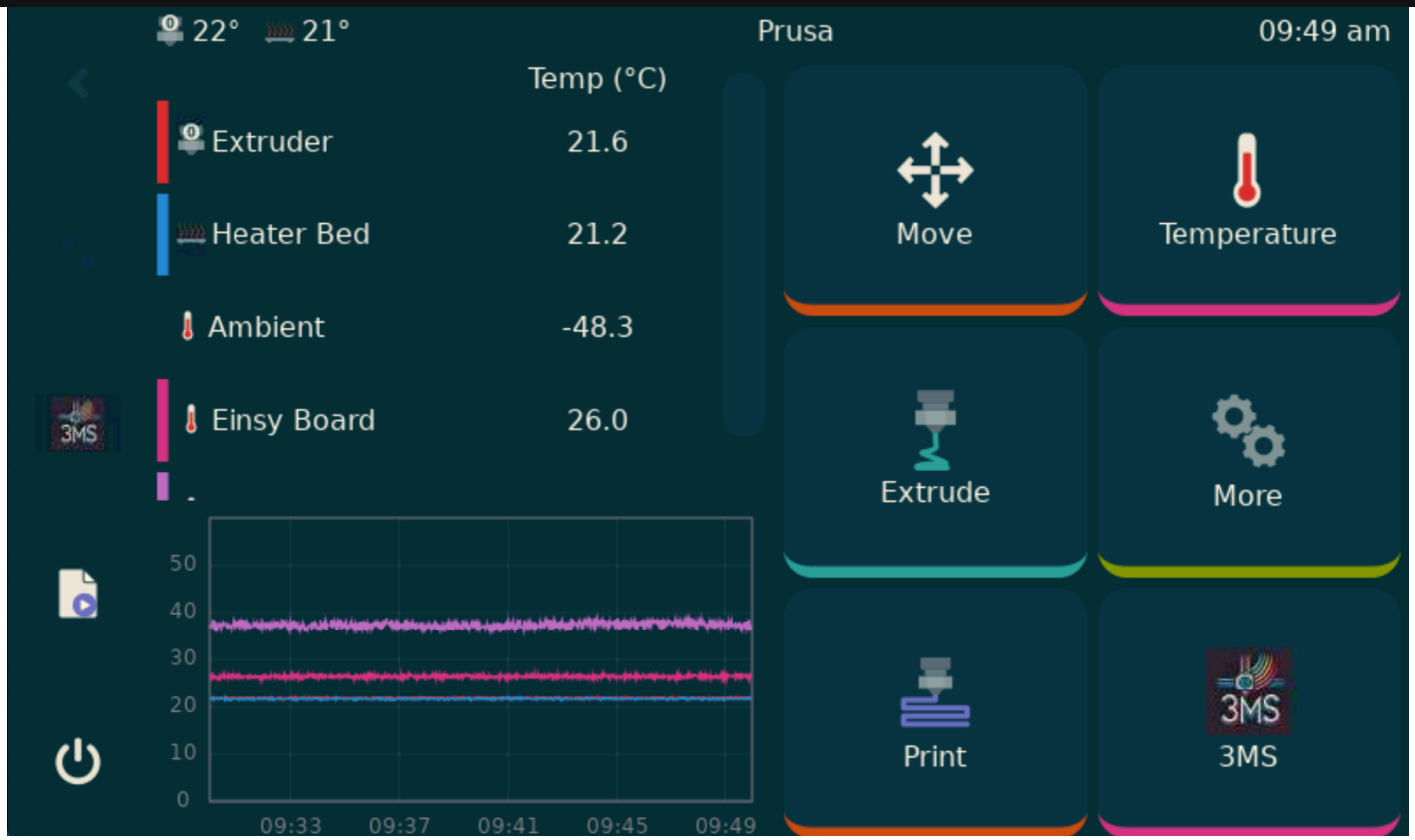


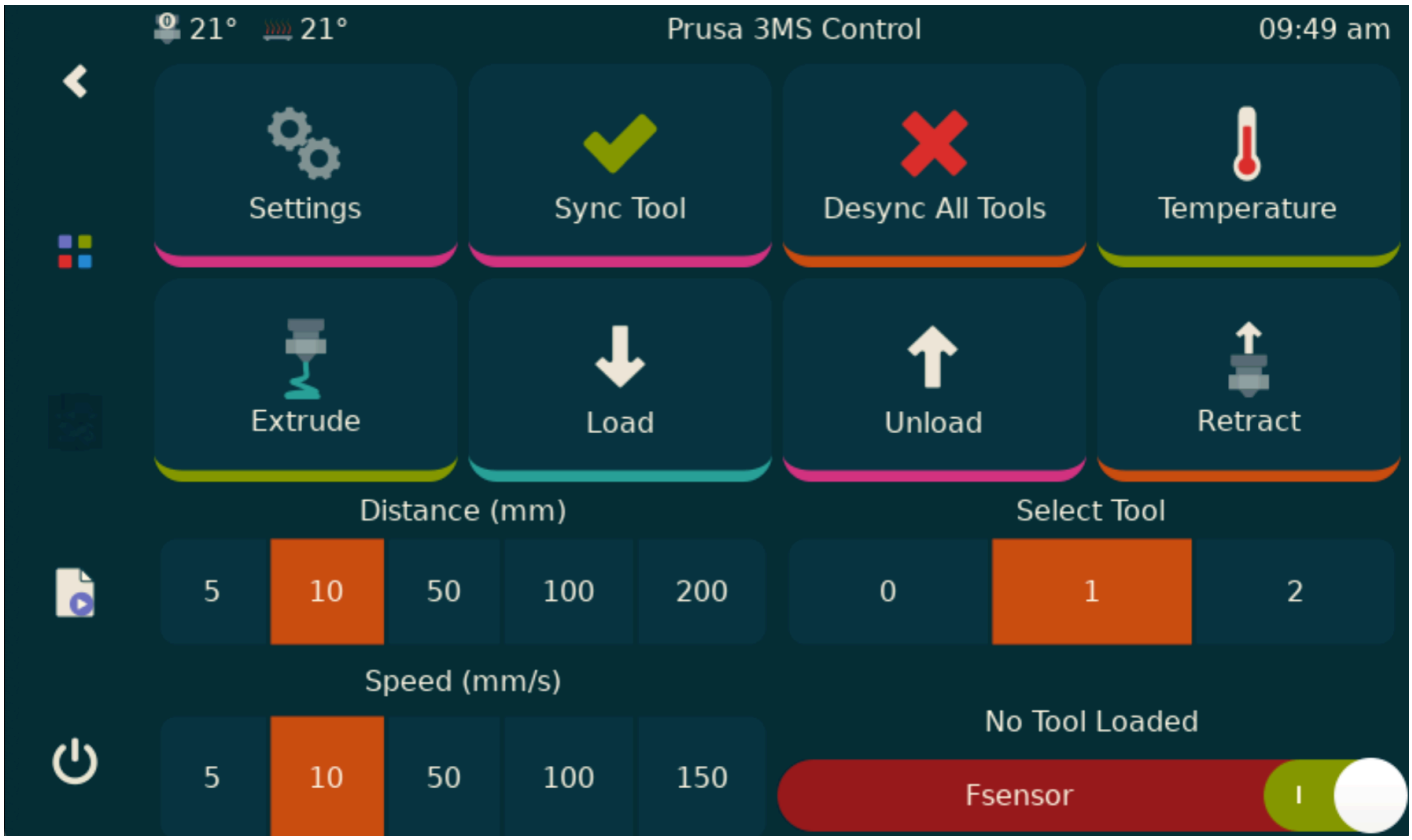
If you have a camera on your 3D printer, you may want to put the wipe tower "behind" the part from your camera's perspective.

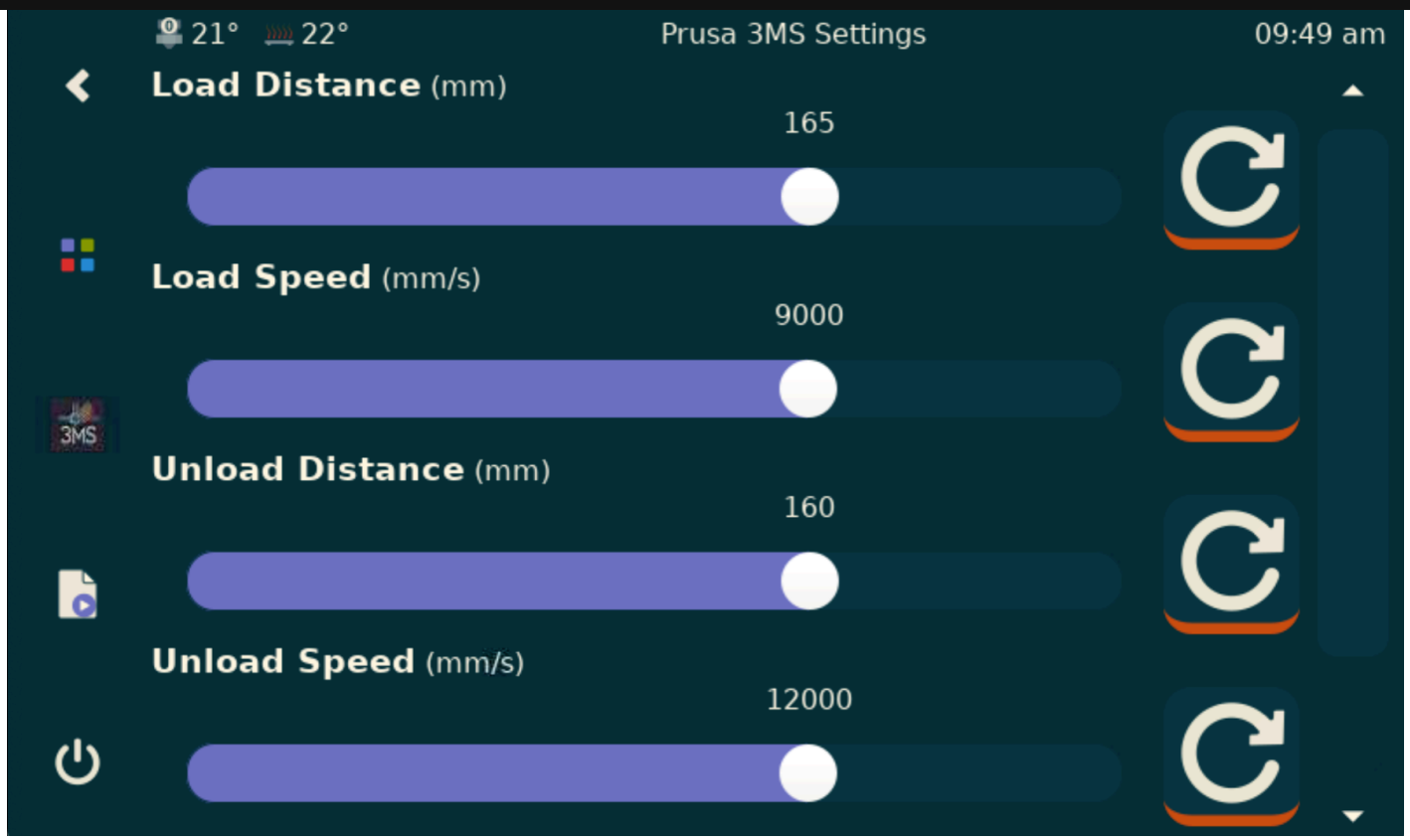
18 KlipperScreen

Info

This feature is still in an alpha state.


22°
21°
Prusa
09:49 am
Temp (°C)
Extruder
21.6
Heater Bed
21.2
Ambient
-48.3
Einsy Board
26.0
50
40
30
20
10
0
09:33
09:37
09:41
09:45
09:49
Move
Temperature
Extrude
More
Print
3MS


21°
21°
Prusa 3MS Control
09:49 am
Settings
Sync Tool
Desync All Tools
Temperature
Extrude
Load
Unload
Retract
Distance (mm)
5
10
50
100
200
Select Tool
0
1
2
Speed (mm/s)
5
10
50
100
150
No Tool Loaded
Fsensor



The 3MS has a custom fork of KlipperScreen you can use to control your 3MS.

18.1 Install

To install the 3MS KlipperScreen, first install KlipperScreen following instructions here. Then, run in your terminal:

```
cd ~
mv KlipperScreen KlipperScreen.old
git clone https://github.com/3DCoded/KlipperScreen-3MS KlipperScreen
cd ~/KlipperScreen
./scripts/KlipperScreen-install.sh
```

Restart KlipperScreen.

19 Creality K1 Series

Info

This guide applies to the following printers:

- Creality K1
- Creality K1C
- Creality K1 Max

Warning

This guide is still under construction

Creality K1 Series 3D printers use a custom version of Klipper, which can cause unexpected problems. Setting up the 3MS (or any Klipper addon) requires extra steps for K1 series printers.

Thank you to @pvilbig for their patience with me here while I was figuring out how to adapt the 3MS to K1 series printers.

19.1 Configuration Installation

To install the 3MS configuration, SSH into your printer and run the following commands:

```
cd ~/
git clone -b main --single-branch https://github.com/3DCoded/3MS
cd 3MS
python3 install.py --path /usr/data/printer_data/config/3ms
```

Edit `3ms/main.cfg`:

```
[save_variables]
filename: /usr/data/variables.cfg
```

19.2 DynamicMacros

To install DynamicMacros, SSH into your printer and run the following commands:

```
cd ~/
git clone -b main --single-branch https://github.com/3DCoded/DynamicMacros
cd DynamicMacros
sh install-k1.sh
```

19.3 KlipperScreen

To setup KlipperScreen with the 3MS, run the following commands in SSH:

```
git clone https://github.com/3DCoded/KlipperScreen-3MS KlipperScreen
cd ~/KlipperScreen
./KlipperScreen/scripts/KlipperScreen-install.sh
```

II. Configuration

20 Configuration

This guide covers the configuration structure and options of the 3MS.

20.1 main.cfg

`main.cfg` is located in `3ms/main.cfg`. It contains the following:

- `[save_variables]` configuration section. This section sets the location where variables about the previous tool will be saved.
- `[include]` sections. These reference other configuration files covered in this guide. The included configurations are:
  - `settings.cfg`
  - `macros.cfg`
  - `controllers/xxx/steppers.cfg`

20.2 settings.cfg

`settings.cfg` contains the settings the 3MS uses during toolchanges in `macros.cfg`. Further information is here.

20.3 macros.cfg

`macros.cfg` contains the macros the 3MS uses during toolchanges. Further information is here.

20.4 controllers/xxx/steppers.cfg

`steppers.cfg` contains the MCU configuration for the 3MS. It contains the following:

- `[extruder_stepper 3msx]` This contains the pin mappings for the motor assigned to 3MS tool x.
- `[tmc2209 extruder_stepper 3msx]` This contains the pin mappings for the TMC2209 controlling the motor assigned to 3MS tool x.
- `[mcu 3ms]` This contains the serial path to the 3MS MCU.
- Other sections: These are configuration sections specific to the MCU and should not be modified.

20.5 KlipperScreen.conf

This contains the KlipperScreen 3MS menu configuration. For more information, see KlipperScreen.

21 Installation

Follow this guide to install the 3MS configuration and macros.

Info

All SSH commands are run on the Klipper Host (usually a Raspberry Pi) and are labeled like the following:

SSH

```
echo Hello World
```

Notice the "SSH" at the top of the code block.

All references to a mainboard usually refer to the 3MS board. If you are using a `(main MCU)` configuration, references to a mainboard refer to your printer's existing mainboard.

21.1 Clone Repository

First, clone the 3MS repository:

SSH

```
cd ~
git clone https://github.com/3DCoded/3MS
cd 3MS
```

Storage

If the `git clone` command fails due to lack of storage on your system, run the following set of commands instead:

SSH

```
cd ~
git clone -b main --single-branch https://github.com/3DCoded/3MS
cd 3MS
```

21.2 Install Script

K1 Series

If you are setting up the 3MS on a Creality K1 Series printer (K1, K1C, K1 Max), use the following install script instead:

SSH

```
python3 install.py --path /usr/data/printer_data/config/3ms
```

Run the install script:

SSH

```
sh install.sh
```

21.3 printer.cfg

In the Klipper web interface (e.g. Mainsail/Fluidd/OctoPrint), open `printer.cfg` and add:

printer.cfg

```
[include 3ms/main.cfg]
```

21.4 DynamicMacros

The 3MS configuration depends on DynamicMacros. If you haven't installed it already, follow the instructions here to do so.

Remove the following line from your `3ms/main.cfg` if it exists:

3ms/main.cfg

```
[include ./macros.cfg]
```

21.5 Moonraker Update Manager

To enable updates for the 3MS, add the following to your `moonraker.conf` (in the same folder as your `printer.cfg`):

moonraker.conf

```
# 3MS Update Manager
[update_manager mmms]
type: git_repo
path: ~/3MS
origin: https://github.com/3DCoded/3MS.git
primary_branch: main
is_system_service: False
install_script: install.sh
```

Warning

When updating via Moonraker, the following files will be overwritten:

- `macros.cfg`
- `KlipperScreen.conf`
- `endless/macros.cfg`

If you have any changes in these files, they will be lost when updating.

21.6 Purge Line

If you use KAMP for purging, set your `tip_distance` setting in `KAMP_Settings.cfg` to your filament parking position (this is the distance between your filament sensor and your nozzle).

If you use any other method of purging, add this line to your Start G-Code / `PRINT_START` macro right before your purge line, and after your `MMMS_START`:

```
G1 E100 F900
```

Replace `E100` with `E`+parking position

21.7 Controller

In `3ms/main.cfg`, edit the `[include ./controllers/xxx/steppers.cfg]` line, replacing `xxx` with the config name of your controller:

Controller Name	Config Name
SKR Mini E3 V2	`btt_skr_mini_e3_v2`
SKR Pico	`btt_skr_pico`
BTT MMB	`btt_mmb`

Controller Name	Config Name
BTT Octopus (main MCU)	`btt_octopus_main`
Zonestar ZM384 (main MCU)	`zonestar_zm384_main`
Mini RAMBo	`mini_rambo`
Geetech A30T	`gtm32_103_v1`

21.8 Configure MCU ID

Finally, to configure the MCU ID you saved from Firmware, run in your terminal:

SSH

```
cd ~ && cat mcu.txt
```

Copy the path that is output. Now, in your `3ms/controllers/xxx/steppers.cfg`, in the `[mcu 3ms]` section (towards the bottom), set the MCU ID.

Example:

Before

3ms/controllers/xxx/steppers.cfg

```
[mcu 3ms]
serial: /dev/serial/by-id/<your-mcu-id>
```

After

3ms/controllers/xxx/steppers.cfg

```
[mcu 3ms]
serial: /dev/serial/by-id/usb-Klipper_stm32f103xe_33FFD1054746333809650557-if00
```

22 Stepper Motors

Follow this guide to calibrate each of the stepper motors. Each of these steps should be repeated for each of your filament units, replacing `TOOL=0` with `TOOL=1`, and so on. Also replacing `3ms0` with `3ms1`, and so on.

> **Info**
>
> If your stepper motor shakes erratically while running any of these commands, your wiring may be incorrect.

22.1 Is the motor spinning?

Run this command:

```
SYNC_TOOL TOOL=0
G1 E50 F4500
```

If the motor spins, skip to the next step. If not, check your wiring first. If your wiring is fine, go to `3ms/steppers.cfg`. Locate the section named `[extruder_stepper 3ms0]`. In front of the `enable_pin`, add, an `!`. If there already is one, remove it. Example:

Before

3ms/steppers.cfg

```
enable_pin: !3ms: PD7
```

After

3ms/steppers.cfg

```
enable_pin: 3ms: PD7
```

22.2 Is the motor spinning backwards?

Preload each of the filament units with a piece of scrap filament by pushing the lever to release the tension, inserting filament, then releasing the lever to restore tension. Next, run this command:

```
SYNC_TOOL TOOL=0
G1 E50 F4500
```

Note which way the filament moves. If it moves forwards, away from the PTFE coupler, skip to the last step. If it moves backwards, you have two choices:

- Switch the motor's wires
- Invert the pin in the configuration

To invert the pin in the configuration, locate the configuration section for the filament unit spinning backwards, and invert the `dir_pin`. See the previous section for how to invert the pin.

22.3 How far does the filament move?

This section is a modified version of the Klipper Docs

Preload each of the filament units with a piece of scrap filament at least 200mm long by pushing the lever to release the tension, inserting filament, then releasing the lever to restore tension.

Use a ruler and a marker to place a mark 70mm from the inlet of the filament unit. Use calipers to measure the actual distance. Write it down, as it will be referred to as `<initial_mark_distance>`.

Next, run this command:

```
SYNC_TOOL TOOL=0
G1 E50 F1500
```

Use calipers to measure the new distance between the inlet of the filament unit and the mark. Write it down, as it will be referred to as `<next_mark_distance>`.

Calculate `<actual_extrude_distance> = <initial_mark_distance> - <next_mark_distance>`

In the `steppers.cfg` file (located in `3ms/controllers/xxx/steppers.cfg`), locate the configuration section for the current extruder. Example:

3ms/controllers/btt_skr_mini_e3_v2/steppers.cfg

```
[extruder_stepper 3ms0]
extruder: extruder
step_pin: 3ms: PB13
dir_pin: !3ms: PB12
enable_pin: !3ms: PB14
microsteps: 16
rotation_distance: 32.8450
```

Note the `rotation_distance` (last line). In this case, it is `32.8450`.

Calculate the new rotation distance: `new_rotation_distance = <rotation_distance> * <actual_extrude_distance> / 50`.

Round this result to three or four decimal places. Decrease it by 0.005 (this is so that if this result is slightly off, the 3MS filament unit will skip, instead of the printer's extruder stripping the filament during a print).

Set the new `rotation_distance` in your config. Save it and restart Klipper.

Info

If you use the same stepper motor brand and model for each of your filament units, you likely only have to do this step for one stepper, then copy over the rotation_distance to all the others.

23 Filament Sensor

Follow this guide to configure your filament sensor with the 3MS.

23.1 Location of Sensor

The filament sensor should be right before the extruder, and after the Y splitter. Other locations, such as between the hotend and extruder, have not been tested.

> **Warning**
>
> The 3MS has only been tested with a `filament_switch_sensor`, and not with a `filament_motion_sensor`

23.2 Configuration

To configure your filament sensor with the 3MS, open `3ms/settings.cfg` and change the following (assuming your filament sensor is named "runout_sensor"):

Before

3ms/settings.cfg

```
fsensor_name: "fsensor"
```

After

3ms/settings.cfg

```
fsensor_name: "runout_sensor"
```

24 Macros

24.1 3MS Settings

24.1.1 MMMS_SETTINGS

Stores the settings for the 3MS.

Default Settings

```
variable_load_distance: 210
variable_unload_distance: 200
variable_load_speed: 4500
vairable_unload_speed: 4500
variable_fsensor_delay: 2000
variable_num_tools: 2
variable_step_size: 99
variable_retry_dist: 50
variable_retry_speed: 900
```

Example Usage

```
MMMS_SETTINGS
```

24.1.2 SET_3MS_SETTINGS

Sets the configuration for the 3MS. Allows **temporary** customization of load and unload distances and speeds

Example Usage

```
SET_3MS_SETTINGS LOAD_DISTANCE=210 UNLOAD_DISTANCE=200 LOAD_SPEED=3500 UNLOAD_SPEED=5500
FSENSOR_DELAY=2500
```

24.1.3 GET_3MS_SETTINGS

Displays the configuration for the 3MS.

Example Usage

```
GET_3MS_SETTINGS
```

24.2 Filament Handling

24.2.1 MMMS_UNLOAD

Unloads filament by a specified distance and speed. If no distance/speed is specified, it uses the default unload distance/speed from `MMMS_SETTINGS`.

Example Usage

```
MMMS_UNLOAD DISTANCE=200 SPEED=5500
```

24.2.2 MMMS_LOAD

Loads filament by a specified distance and speed. If no distance/speed is specified, it uses the default load distance/speed from `MMMS_SETTINGS`.

Example Usage

```
MMMS_LOAD DISTANCE=210 SPEED=3500
```

24.2.3 CHECK_FSENSOR

Checks the filament sensor state. Pauses the print if the sensor state does not match the expected value.

Example Usage

```
CHECK_FSENSOR V=1
```

24.3 Tool Sync

24.3.1 SET_TOOL_SYNC

Sets the sync state of a tool. Syncs or desyncs the specified tool to/from the extruder.

Example Usage

```
SET_TOOL_SYNC TOOL=0 SYNC=1
```

24.3.2 SYNC_TOOL

Syncs the specified tool and desyncs all other tools to/from the extruder.

Example Usage

```
SYNC_TOOL TOOL=0
```

24.3.3 DESYNC_TOOL

Desyncs the specified tool from the extruder.

Example Usage

```
DESYNC_TOOL TOOL=0
```

24.3.4 CLEAR_TOOL

Clears the current tool selection by setting it to -1.

Example Usage

```
CLEAR_TOOL
```

24.3.5 DESYNC_ALL_TOOLS

Desyncs all configured tools.

Example Usage

```
DESYNC_ALL_TOOLS
```

24.4 Print Start and End

24.4.1 MMMS_START

Starts the print by checking the filament sensor. If filament is detected, the print is paused and the user is notified. Regardless of the filament sensor state, the initial tool is loaded.

Example Usage

```
MMMS_START INITIAL_TOOL=0
```

24.4.2 MMMS_END

Ends the print by unloading the current tool. If filament is detected after unloading, the user is notified.

Example Usage

```
MMMS_END
```

24.5 Tool Change

24.5.1 T0

Changes to tool 0.

Example Usage

```
T0
```

24.5.2 T1

Changes to tool 1.

Example Usage

```
T1
```

24.5.3 Tx

Changes to a specified tool. Replace `x` with the tool number.

Example Usage

```
T2
T3
```

III. Guides

25 Materials

Follow this guide to determine if your filament will work with the 3MS.

25.1 Materials Table

This table contains which filaments work in single mode and/or multimaterial mode with the 3MS.

Filament	Single Mode	Multimaterial Mode	Notes
PLA	Yes	Yes	
PLA+	Yes	Yes	
Silk PLA	Yes	Yes	
Matte PLA	Yes	Yes	
PETG	Yes	Yes	
TPU	Yes	Untested	

25.2 PLA(+)

PLA/PLA+/PLA Pro, etc. filaments are very easy to print in multimaterial with the 3MS. They also support the No Tip Shaping feature.

25.3 Silk/Matte PLA

Silk/Matte PLA filaments are slightly more difficult to print with or without the 3MS. They generally require tip shaping to work with the 3MS in multimaterial mode.

25.4 PETG

PETG filaments are easy to print in multimaterial with the 3MS. They will likely require tip shaping. Suggested settings options are provided below. Ideal settings for your setup will likely include a combination of the options.

Tip Shaping ›

25.5 TPU

TPU filaments are very difficult to print with or without the 3MS. If your printer can reliably print TPU, you can likely use it with the 3MS in single mode. To use it in multimaterial mode and/or improve reliability, see the experimental Dual Drive 3MS Extruders for TPU feature.

26 Tip Shaping Guidelines

Follow this guide to get faster and more reliable toolchanges with your 3MS.

26.1 Does My Filament Need Tip Shaping?

If your filament is in this list, then it likely won't need tip shaping, and you can use the No Tip Shaping feature:

- PLA (not Silk, Matte, or glitter variants)
- PLA+ (including PLA Pro, Tough PLA)
- PETG

If you filament wasn't in that list, continue reading this page.

26.2 Blobby Tips

If your filament tip has a thicker tip after unloading, you can do two things:

1. Print hotter
2. Decrease cooling moves

26.3 Stringy Tips

If your filament tip has a stringy tip after unloading, you can do two things:

1. Print colder
2. Increase cooling moves

You may also be able to use the No Tip Shaping feature.

26.4 Hook of Death

If you filament tip can't unload out of your extruder and forms a hook shape, you may need to replace the PTFE tube between your printer's extruder and hotend. You may also want to follow the recommendations for Blobby tips.

27 Toolchanges Without Tip Shaping or Filament Cutter!

Because the 3MS is synchronized to the printer's extruder, it can perform toolchanges without any tip shaping or filament cutter.

27.1 Should Tip Shaping be Used?

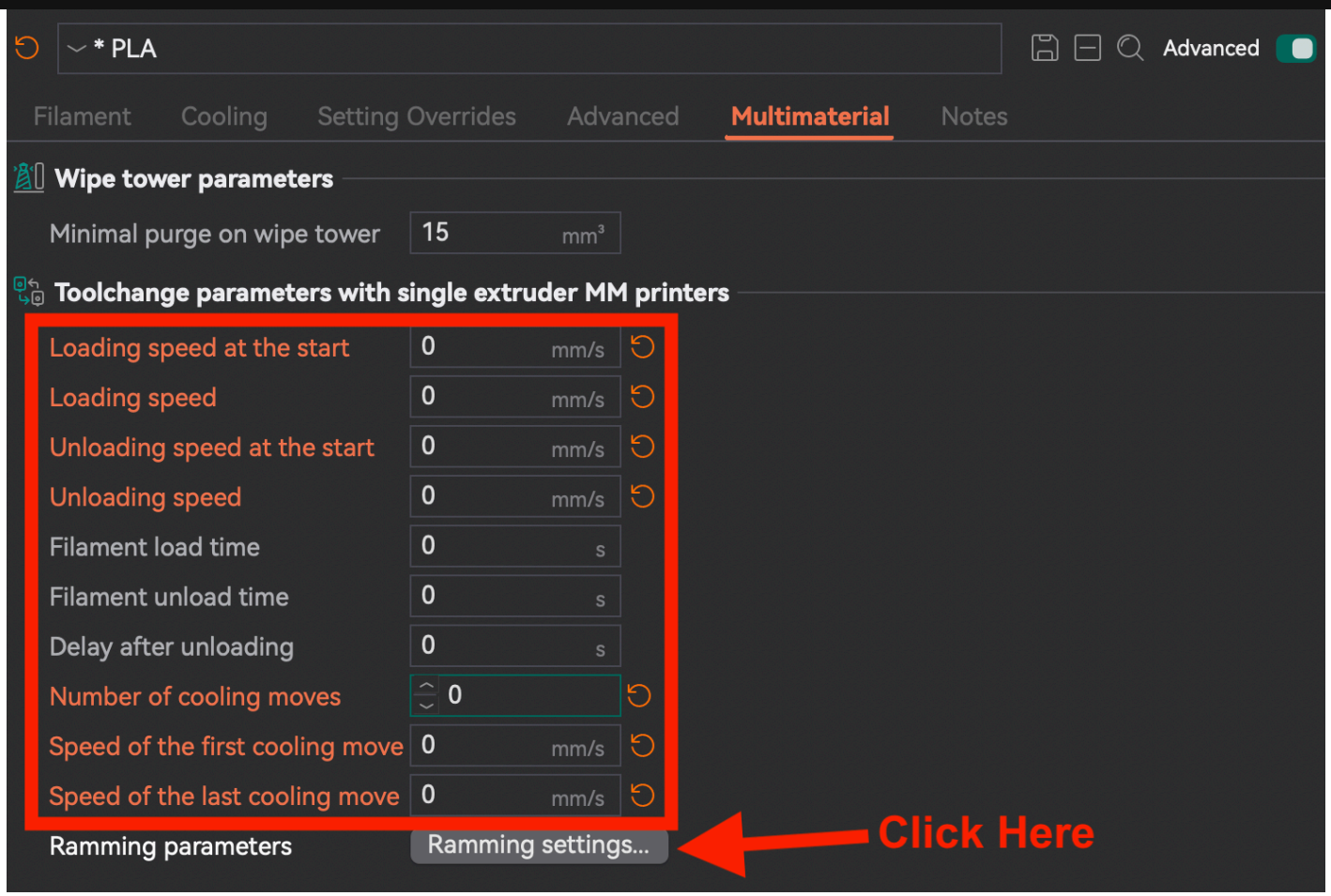
See Materials for information on whether or not tip shaping should be used for your filaments.

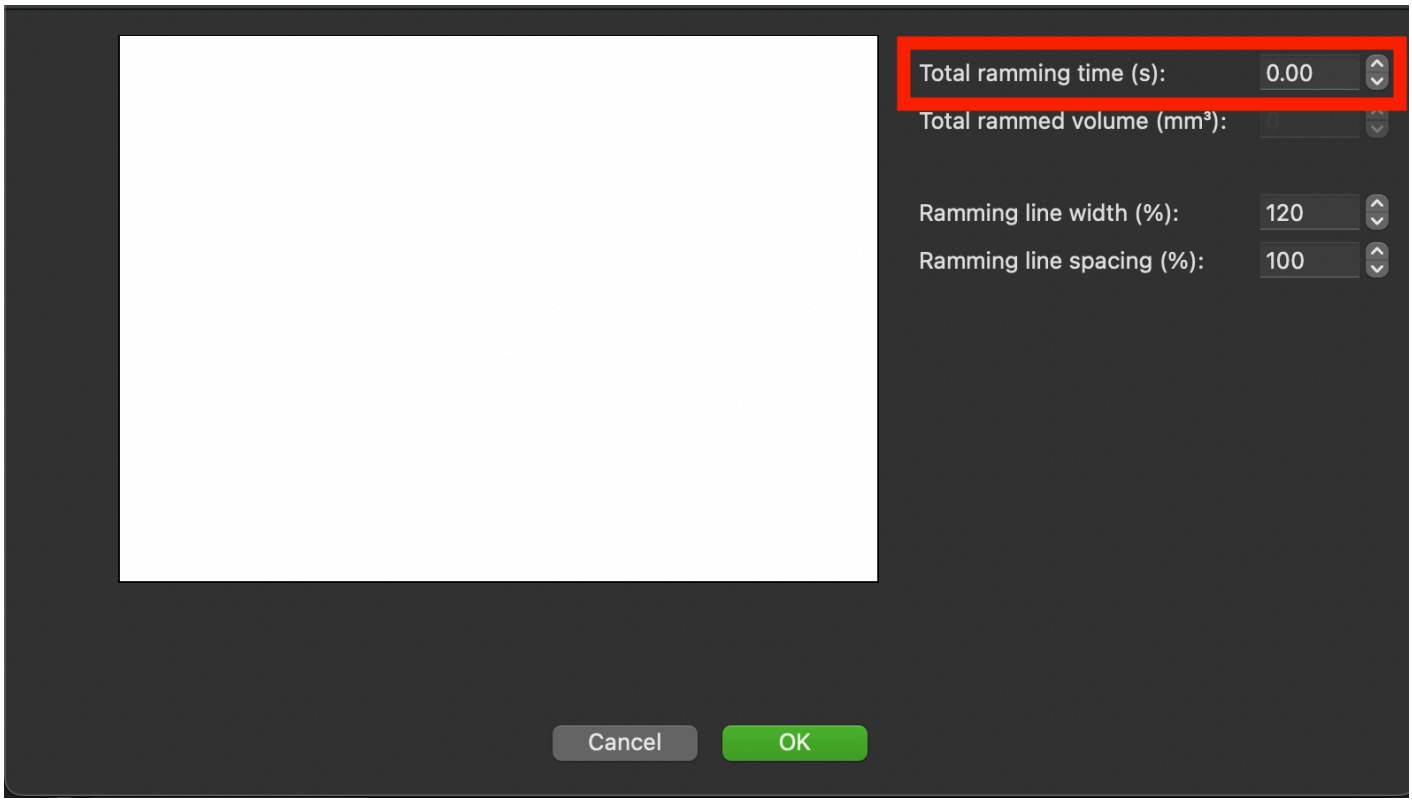
27.2 Slicer Setup

Setup your slicer for no tip shaping as follows.

27.2.1 Disable Filament Ramming

Disable filament ramming in `Filament Settings` -> `Multimaterial` -> `Toolchange parameters with single extruder MM printers`:



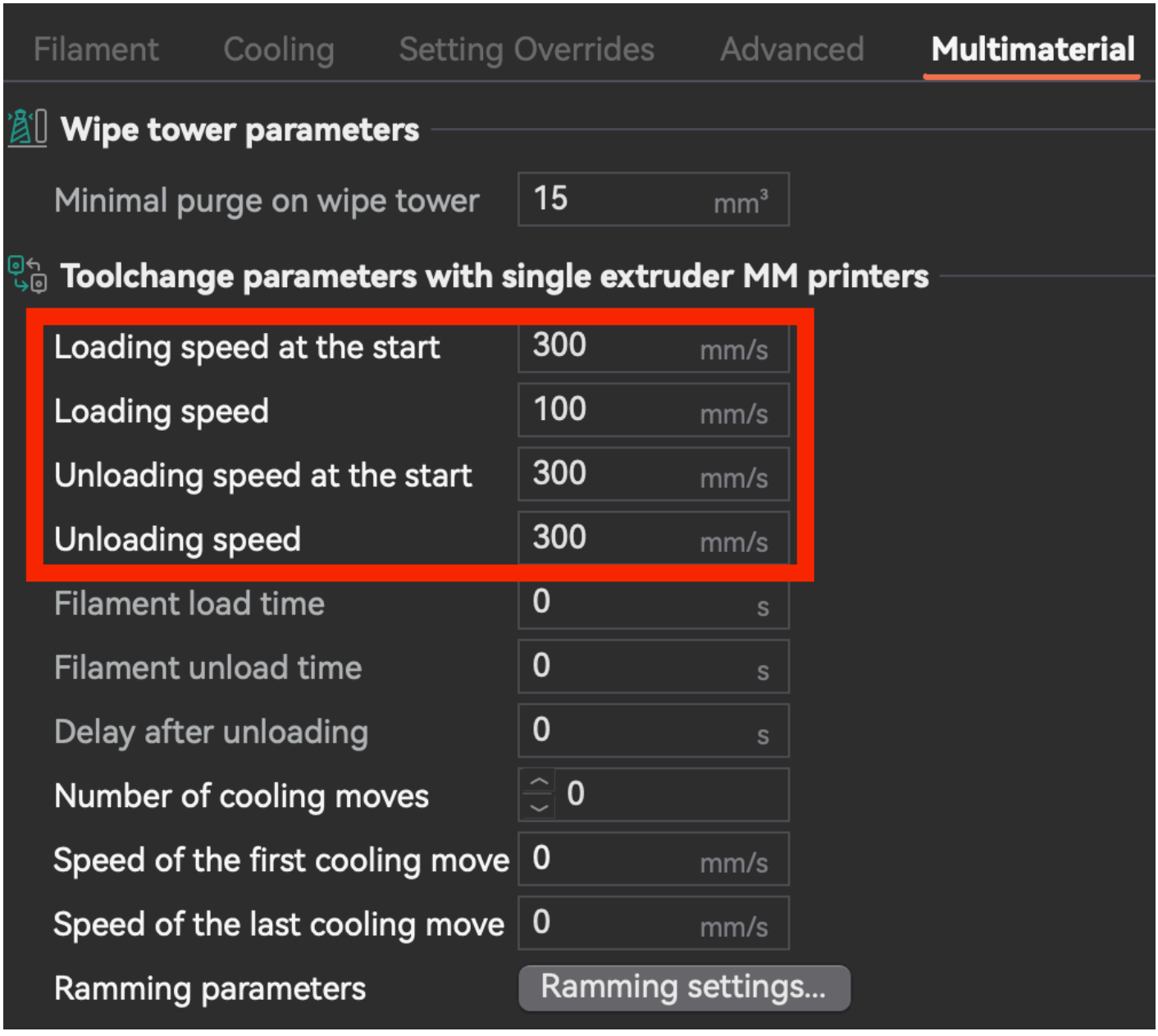


27.2.2 Unload/Load Speed

Next, change the `Unloading speed at start` and `Unloading speed` to 300 (faster is better here). Next, change the `Loading speed at start` and `Loading speed` to 300 and 100, respectively.

What this does

The main idea behind toolchanges without tip shaping relies on the filament being unloaded too fast to form a blob. Setting the `Unloading speed` settings allows this. Next, loading the filament back can be generally optimized by increasing the `Loading speed` settings.



27.2.3 Temperature

If your filament has very long strings on the end of them after unloading without tip shaping (longer than 2cm), decrease your filament temperature.

If your filament tip has a nearly flat tip, increase your filament temperature.

The ideal filament tip has a pointy end and a small string (less than 5mm). When in doubt, it is recommended to aim for a slightly stringy tip over a flat tip.

28 Manual filament cutter

This guide explains how to integrate a filament cutter with the 3MS system, allowing automatic cutting during the filament swap. This negates the need for tip shaping, makinng color swaps much faster and more reliable.

28.1 Table of Contents

28.2 Installation

To install the filament cutter, update your `3ms/main.cfg`:

3ms/main.cfg

```
[save_variables]
filename: ~/printer_data/config/3ms/variables.cfg

[include ./settings.cfg]
[include ./endless/settings.cfg]
[include ./cutter/settings.cfg]
[include ./controllers/btt_skr_mini_e3_v2/steppers.cfg]

[dynamicmacros 3ms]
configs: 3ms/macros.cfg, 3ms/endless/macros.cfg, 3ms/cutter/macros.cfg
```

28.3 Configuration

28.3.1 Cutter Settings

Edit your `3ms/cutter/settings.cfg`:

Variable	Example Value	Description
`parking_x_position`	280 mm	X parking position (near compress pin)
`parking_y_position`	-1 mm	Y parking position (near compress pin)

Variable	Example Value	Description
`start_x_cutter_position`	285 mm	X start position for cutting
`end_x_cutter_position`	310 mm	X position when blade is pushed
`start_y_cutter_position`	-1 mm	Y start position for cutting
`end_y_cutter_position`	-1 mm	Y position when blade is pushed
`travel_speed`	6000 mm/min	Speed to move to cutting position
`pushing_speed`	1600 mm/min	Speed to push the blade
`retries`	2	Number of repetions

Note

If X or Y is set to `-1`, it indicates that the toolhead moves along one axis to reach the parking position. The printer will adjust movement accordingly. If both axes are used, define both positions.

28.3.2 Modifying Settings

To change values temporarily, use the `SET_CUTTER_SETTINGS` macro. this can be usefull during troubleshooting and testing

```
SET_CUTTER_SETTINGS PARKING_X=290 PUSHING_SPEED=1700
```

29 3MS Bypass

Follow this guide to allow manually loading a spool to your printer, and bypassing the 3MS system.

29.1 Klipper Macros

Replace the `MMMS_START` line in your `PRINT_START` macro with:

```
{% if (params.BYPASS|default(0)|int) %}
    DESYNC_ALL_TOOLS
{% else %}
    # You can also put your ENDLESS_START line here too
    MMMS_START INITIAL_TOOL={params.INITIAL_EXTRUDER}
{% endif %}
```

Replace the `MMMS_END` line in your `PRINT_END` macro with:

```
{% if not (params.BYPASS|default(0)|int) %}
    MMMS_END
{% endif %}
```

29.2 Slicer GCode

1. Navigate to `Printer Settings` -> `Machine G-code`.
2. In your `Machine start G-code`, pass the `BYPASS=1` parameter to your `PRINT_START` macro.
3. In your `Machine end G-code`, pass the `BYPASS=1` parameter to your `PRINT_END` macro.
4. Save the new preset with a different name to differentiate it from your main preset.

30 Endless Spool

This feature is based off of Happy Hare firmware.

30.1 Requirements

To use endless spool, your printer must have *one* of the following:

- A filament sensor before your printer's extruder

> ✓ **Recommended**

OR

- A filament sensor before each of the 3MS's extruders

> ⚠ **Untested and deprecated**

The endless spool feature (currently) also only works when printing single-color models.

30.2 Install

To install the endlss spool, update your `3ms/main.cfg`:

3ms/main.cfg

```
[save_variables]
filename: ~/printer_data/config/3ms/variables.cfg

[include ./settings.cfg]
[include ./endless/settings.cfg]
[include ./controllers/btt_skr_mini_e3_v2/steppers.cfg]

[dynamicmacros 3ms]
configs: 3ms/macros.cfg, 3ms/endless/macros.cfg
```

30.3 Usage

To setup endless spool, first choose which filaments can be used as backups for each other. Example with three tools:

- T0 (PLA) -> T1(PLA)
- T1(PLA) -> T0(PLA)
- T2 (PETG) -> PAUSE

In this case, since T0 and T1 are backups for each other, they can be considered in the same "group" and assigned a group number. In this case, `1` will be used. Since T2 doesn't have a backup, it will be its own group. In this case, `2` will be used.

If your printer has a filament sensor before each of the 3MS's filament units, set the `single` setting to `0`. If your printer has only one filament sensor before its main extruder, set the `single` setting to `1`.

Edit your `3ms/endless/settings.cfg`:

3ms/endless/settings.cfg

```
[gcode_macro ENDLESS_SETTINGS]
single: 1 # <-- Set to 0 if you have a filament sensor before each of your 3MS extruders. Set to 1 if you have one filament sensor right before your printer's extruder.
variable_t0: 1
variable_t1: 1
### --- Uncomment below for more than two tools --- ###
variable_t2: 2
# variable_t3: -1
gcode:
    RESPOND MSG=""
```

30.4 Filament Sensors

If you have multiple filament sensors, change your filament sensors' `runout_gcode` to:

```
ENDLESS_RUNOUT T=0
```

For the filament sensor associated with T1, change the code from `T=0` to `T=1`, and so on.

If you have one filament sensor, change your filament sensor's `runout_gcode` to:

```
ENDLESS_RUNOUT
```

30.5 Custom GCode

To define custom filament runout functionality, you can define the `FILAMENT_RUNOUT` macro. Example:

```
[gcode_macro FILAMENT_RUNOUT]
gcode:
    RESPOND MSG="Filament runout T{params.T}!!!"
```

30.6 GCodes

To edit the Endless Spool state mid-print, run the `SET_ENDLESS_SETTINGS` command. Examples:

```
; Set T0 and T1 as backups for each other, and T2 as standalone
SET_ENDLESS_SETTINGS T0=1 T1=1 T2=2

; Set T0 as standalone, and T1 and T2 as backups for each other
SET_ENDLESS_SETTINGS T0=-1 T1=1 T2=1

; Disable endless spool
SET_ENDLESS_SETTINGS ENABLED=0

; Enable endless spool
SET_ENDLESS_SETTINGS ENABLED=1
```

To view the Endless Spool settings, run the `GET_ENDLESS_SETTINGS` command.

30.7 PRINT_START

In your slicer's print start GCode, add the following parameter to your `PRINT_START` macro:

```
NUM_TOOLCHANGES=[total_toolchanges]
```

Next, in your `PRINT_START` macro, add the following line **before** your `MMMS_START` call:

```
ENDLESS_START NUM_TOOLCHANGES={params.NUM_TOOLCHANGES}
```

This will ensure that Endless Spool is only enabled for single-color prints.

31 3DChameleon to 3MS Conversion

Follow this guide to convert a 3DChameleon to a 3MS.

31.1 BOM

Name	Price	Quantity	Link	Notes
SKR Mini E3 V2	$34.99	1	Amazon	
Duponts	$9.99	1	Amazon	These wires are only sufficient to run steppers, not heaters
12V PSU	$7.39	1	Amazon	This PSU is only sufficient to run steppers, not heaters
MK8 Metal Extruder	$9.99	2	Amazon	Alternatively, you can use this Dual-drive MK8 based extruder

The final cost of this upgrade is around $70.

31.2 Instructions

1. Release the eight bolts on the 3DChameleon unit to remove the two NEMA17 stepper motors.
2. Unplug the NEMA17's from the 3DChameleon electronics board
3. Remove the PTFE tubes from the 3DChameleon unit and the Y-splitter

Next, follow the Master Instructions except for the BOM section.

IV. Contributing

32 Contributing

If you want to contribute to the 3MS project, follow the instructions below.

32.1 Development Setup

Follow Development Setup to setup your system for development with the 3MS.

32.2 Controllers

If your contribution adds support for another controller type, see Controller Support.

32.3 Pull Request

Finally, submit a pull request. A developer will get back to you soon with feedback, before merging your pull request into the main project.

Thank you for your contribution to the 3MS project!

33 Development Setup

Follow this guide to setup your system for development with the 3MS.

33.1 Configuration Changes

1. Fork the 3MS repository
2. Create a new branch for your pull request (from the `main` branch)
3. Develop changes in the new branch

33.2 Documentation Changes

1. Fork the 3MS repository
2. Create a new branch for your pull request (from the `docs` branch)
3. Install Python.
4. Install Pipenv.
5. In your terminal, navigate to the 3MS folder, and run:

```
pipenv install
pipenv shell
```

6. Develop changes in the new branch, using the following command to run the documentation locally:

```
mkdocs serve
```

34 Controller Support

Follow this guide to add support for a new 3MS controller.

34.1 Requirements

To add support for a new 3MS controller, the following requirements must be met:

- Klipper natively supports the controller
- There is an official Klipper configuration for the controller

34.2 Request a new Controller

If you don't want to create the new controller configuration yourself, you can submit a Controller Request.

34.3 Supporting a new Controller

If the controller meets the aforementioned requirements, you can proceed with adding support for it.

The following example will be for a SKR Mini E3 V2.0 controller.

34.3.1 Removing Extra Config Sections

1. Remove all sections from the configuration **except** the following:
   - Stepper configurations (e.g. `[stepper_x]`)
   - TMC driver configurations (e.g. `[tmc2209 stepper_x]`)
   - Extruder configurations (e.g. `[extruder]`)
   - `[static_digital_output]`
   - `[board_pins]`
2. If the configuration is a main MCU configuration, remove the `[mcu]` section.
3. Add the following line to all `[static_digital_output]` and `[board_pins]` sections:

   ```
   1  mcu: 3ms
   ```

4. If the configuration is **NOT** a main MCU, replace `[mcu]` with `[mcu 3ms]`.

Full Configuration Before/After

34.3.2 Stepper Configuration

> **Note**
>
> In the following examples, the Z stepper is not included. When creating a 3MS configuration, you can (and probably will) use the Z steppers.

1. Change any stepper sections to an `extruder_stepper` named `3ms0`, `3ms1`, `3ms2`, etc. Example:

   Before

   ```
   [stepper_x]
   ...

   [stepper_y]
   ...
   ```

   After

   ```
   [extruder_stepper 3ms0]
   ...

   [extruder_stepper 3ms1]
   ...
   ```

2. Change any extruder sections to an `extruder_stepper`. Example:

   Before

   ```
   [extruder]
   ...

   [extruder1]
   ...
   ```

   After

   ```
   [extruder_stepper 3ms2]
   ...

   [extruder_stepper 3ms3]
   ...
   ```

3. Remove the extruder-specific configurations from the former extruders. Example:

Before

```
[extruder_stepper 3ms2]
step_pin: PB3
dir_pin: !PB4
enable_pin: !PD1
microsteps: 16
rotation_distance: 33.500
nozzle_diameter: 0.400
filament_diameter: 1.750
heater_pin: PC8
sensor_type: EPCOS 100K B57560G104F
sensor_pin: PA0
control: pid
pid_Kp: 21.527
pid_Ki: 1.063
pid_Kd: 108.982
min_temp: 0
max_temp: 250
```

After

```
[extruder_stepper 3ms2]
step_pin: PB3
dir_pin: !PB4
enable_pin: !PD1
microsteps: 16
rotation_distance: 33.500
```

4. Update any TMC configuration sections to reflect the new `extruder_steppers`. Example:

Before

```
[tmc2209 stepper_x]
...

[tmc2209 stepper_y]
...

[tmc2209 extruder]
...

[tmc2209 extruder1]
...
```

After

```
[tmc2209 extruder_stepper 3ms0]
...

[tmc2209 extruder_stepper 3ms1]
...

[tmc2209 extruder_stepper 3ms2]
...

[tmc2209 extruder_stepper 3ms3]
...
```

Full Configuration Before/After

34.3.3 Final Important Details

1. Remove all homing/endstop-related parameters from the stepper configuration sections. Example:

Before

```
[extruder_stepper 3ms0]
...
endstop_pin: ^PC0
position_endstop: 0
position_max: 235
homing_speed: 50
```

After

```
[extruder_stepper 3ms0]
...
# Endstop/homing parameters removed
```

2. Add the following line to all `extruder_stepper` sections:

```
extruder: extruder
```

3. Prefix all pin names **IN ALL SECTIONS** (not just motors) with `3ms:`. Any `!` or `^` should go **before** the `3ms:` prefix. Example:

Before

```
[extruder_stepper 3ms0]
step_pin: PB13
dir_pin: !PB12
enable_pin: !PB14
microsteps: 16
rotation_distance: 40
```

After

```
[extruder_stepper 3ms0]
step_pin: 3ms: PB13
dir_pin: !3ms: PB12
enable_pin: !3ms: PB14
microsteps: 16
rotation_distance: 40
```

Full Configuration Before/After ›

V. Troubleshooting

35 Troubleshooting

If you are having trouble getting your 3MS to work properly, check if the problem you're facing is in this list:

- Motor Skipping
- Filament Sensor False Alarm or Extra Pauses
- Underextrusion
- Failed Load/Unload
- Blobs/Gaps in wipe tower

If it is not in this list, please open an issue on Github.

36 Motor Skipping

If any of your extruder motors are skipping while using the 3MS, follow this troubleshooting guide to diagnose the issue and fix it.

36.1 Printer's Extruder

First, check if your printer's extruder is properly extruding. To check this, detach the PTFE tube from the inlet of your extruder, and manually load filament, using Klipper's controls for loading filament. If your printer's extruder is having trouble extruding plastic, you may have one of the following:

- Nozzle clog
- Heat creep jam

You can also slightly **decrease** the 3MS's `rotation_distance`.

36.2 3MS Extruder

If the printer's extruder is working properly, and you're still having skipping, check the filament tips. If the tip has a long string on it, or has a thick blob at the end, your filament tips may be to blame. If you have stringy tips, decrease your nozzle temperature while printing. If you have blobby tips, increase your nozzle temperature while printing. Alternatively, you can purchase PTFE tubes with a larger ID to allow for less precise tips.

You can also slightly **increase** the 3MS's `rotation_distance`.

37 Filament Sensor False Alarm/Extra Pauses

If during toolchanges, a failed toolchange false alarm occurs (print pauses even though toolchange was successful), follow this troubleshooting guide to fix it.

37.1 fsensor_delay

The main culprit for this issue is likely your `fsensor_delay` in `3ms/settings.cfg` is too short. Short values will cause more false alarms, and long values will cause less. Generally, the default 2000ms is good for most setups, but if you are having false alarms, you will have to increase it. To set it, use the `SET_MMMS_SETTINGS` command:

Klipper Console

```
SET_MMMS_SETTINGS FSENSOR_DELAY=3000
```

To save it permanently:

Before

3ms/settings.cfg

```
fsensor_delay: 2000
```

After

3ms/settings.cfg

```
fsensor_delay: 3000
```

38 Underextrusion

If your prints start to have gaps in the walls, you are likely experiencing underextrusion. Follow this troubleshooting guide to diagnose the issue and fix it.

38.1 Extruder/Hotend Issues

First, try the solutions in this article in case there are any issues with your printer's extruder/hotend.

38.2 3MS rotation_distance

If your extruder and hotend are working fine, the next likely cause of underextrusion is your 3MS rotation_distance is too high. There are two likely causes and solutions, based on where in the print the underextrusion occurs:

- Whole print - 3MS motors working backwards from the extruder or not working at all

  Follow the wiring section of Assembly.

  Follow the first two steps of Stepper Setup.
- Partially through print - 3MS motors not turning enough

  Follow the last step of Stepper Setup.

39 Failed Load/Unload

If your printer is paused and displaying `Please load` or `Please unload`, follow this troubleshooting guide to diagnose the problem and fix it.

39.1 False Alarm

First, see False Alarm to ensure your filament sensor is properly configured and is being properly read by the 3MS macros.

39.2 Failed Unload

When your printer displays a `Please unload` message, pay attention to the `Tx` number it shows. For example, if it displays the message `Please unload T0`, it failed to unload the filament at T0. Follow these steps to recover the toolchange:

1. Detach the PTFE tube from the inlet of your printer's extruder (you may need to push down the lever on the 3MS extruder for that tool while doing this).
2. Manually pull the filament out of the printer's extruder.

   If it is stuck, try one of the following:

   - Reload the filament until it is extruding out of the nozzle, then unload the filament quickly while pulling firmly.
   - Open your printer's extruder assembly, pull the filament through, and cut off the tip.

   Also, see Skipping
3. Next, manually pull the filament all the way to where the filament is usually parked between toolchanges (before the Y-splitter).
4. Manually load the next filament. Check the console for a message like `T0 -> T1` indicating which filament is next (in this case T1). It should be loaded to the entry of the printer's extruder gears.
5. Resume your print.

Next, diagnose the problem based on these possible scenarios:

- Filament never unloaded out of printer's extruder

  This is a sign of poor tip shaping. The quick fix for this is to increase print temperatures. Also, see Skipping.
- Filament unloaded out of printer's extruder, but stopped before filament sensor

  This is a sign of your filament sensor causing excess friction on the filament, or your 3MS extruder tension too loose. For the 3MS tension too lose, simply rotate the tensioning screw on the 3MS extruder clockwise a couple rotations.

39.3 Failed Load

When your printer displays a `Please load` message, pay attention to the `Tx` number it shows. For example, if it displays the message `Please load T1`, it failed to load the filament at T1. Follow these steps to recover the toolchange:

1. Manually push the filament all the way to the inlet of your printer's extruder.

   If your filament isn't able to load, the previous tool may not have completely unloaded. See Failed Unload for more information.

2. Resume your print.

Next, diagnose the problem based on these possible scenarios:

- Previous filament didn't unload enough

  Increase your `unload_distance` in `MMMS_SETTINGS` (`3ms/settings.py`). You can test different values by using `SET_MMMS_SETTINGS` at runtime. Example:

  ```
  SET_MMMS_SETTINGS UNLOAD_DISTANCE=210
  ```

- Filament didn't load enough

  Increase your `load_distance` in `MMMS_SETTINGS` (`3ms/settings.py`). You can test different values by using `SET_MMMS_SETTINGS` at runtime. Example:

  ```
  SET_MMMS_SETTINGS LOAD_DISTANCE=220
  ```

VI. Experimental

40 Experimental

41 Rapid Tip Shaping

> **Warning**
>
> The rapid tip shaping feature is currently experimental. This page is not complete yet.

Rapid tip shaping allows for faster tip shaping and easier tuning of tip shaping.

41.1 Installation

Update your `3ms/main.cfg`:

3ms/main.cfg

```
[save_variables]
filename: ~/printer_data/config/3ms/variables.cfg

[include ./settings.cfg]
[include ./endless/settings.cfg]
#[include ./cutter/settings.cfg]
[include ./form_tip/settings.cfg]
[include ./controllers/btt_skr_mini_e3_v2/steppers.cfg]

[dynamicmacros 3ms]
configs: 3ms/macros.cfg, 3ms/endless/macros.cfg, 3ms/form_tip/macros.cfg #,
3ms/cutter/macros.cfg
```

Note the addition of `3ms/form_tip/macros.cfg` in the `[dynamicmacros]` config section.

41.2 Confiugration

The "cooling tube" refers to the length of PTFE found in your printer's hotend. This is usually in the heatsink of your hotend.

You want to measure (or Google) three things:

1. The distance from the bottom of the cooling tube to the tip of the nozzle
2. The length of the cooling tube
3. The distance from the top of the cooling tube to your extruder

Update your `3ms/form_tip/settings.cfg` with these settings:

3ms/form_tip/settings.cfg

```
[gcode_macro FORM_TIP_SETTINGS]
# Edit these settings for your printer
variable_cooling_tube_pos: 15 # <-- This is the distance from the bottom of the cooling tube to the tip of the nozzle
variable_cooling_tube_length: 11 # <-- This is the length of the cooling tube
variable_final_retract: 49 # <-- This is the distance from the top of the cooling tube to the extruder gears
```

The "parking position" refers to the location the toolhead will be at during a color swap (not on the wip tower). Ideally, this would be a purge bucket, but this can be anywhere **not** on the bed.

Update your settings:

3ms/form_tip/settings.cfg

```
variable_park_x: 125
variable_park_y: 205
variable_park_speed: 50 # mm/s
```

41.3 Tip Tuning

A standard tip tuning routine would look like this:

1. Load T0 to the nozzle

```
SYNC_TOOL TOOL=0
MMMS_LOAD
LOAD_FILAMENT
```

2. Run tip shaping:

```
FORM_TIP
```

3. Check your filament tip
4. Load the filament back to the nozzle for further tuning:

```
LOAD_FILAMENT
```

Steps 2-4 are repeated until your filament tip comes out looking like one of these:

TODO Picture

You can alter step 2 to get better tips, changing any of the following settings:

- `PUSH_DISTANCE`

This changes how much filament is pushed out initially. Generally, you don't need to change this.

- `PUSH_SPEED`

  This changes how fast the filament is pushed out initially. Increasing this generally creates a sharper filament tip. However, if this is too high, your printer's hotend may not be able to melt the filament quickly enough and result in your extruder skipping steps.

- `INITIAL_RETRACT_SPEED`

  This changes how fast the filament tip is retracted to the cooling tube. If this is too low, your filament tip may have a large string on the end. If this is too high, a small piece of filament may be left in your nozzle.

- `COOLING_SPEED`

  This changes how fast the filament tip is retracted through the cooling tube. If this is too high, your filament tip may come out still molten.

- `FINAL_SPEED`

  This changes how fast the filament tip is retracted from the top of the cooling tube to outside the extruder. Generally, you can increase this until your printer's extruder starts skipping.

When you get a good tip, change to T1, repeat, T2, etc:

```
MMMS_UNLOAD
SYNC_TOOL TOOL=1
MMMS_LOAD
LOAD_FILAMENT
```

41.4 Examples

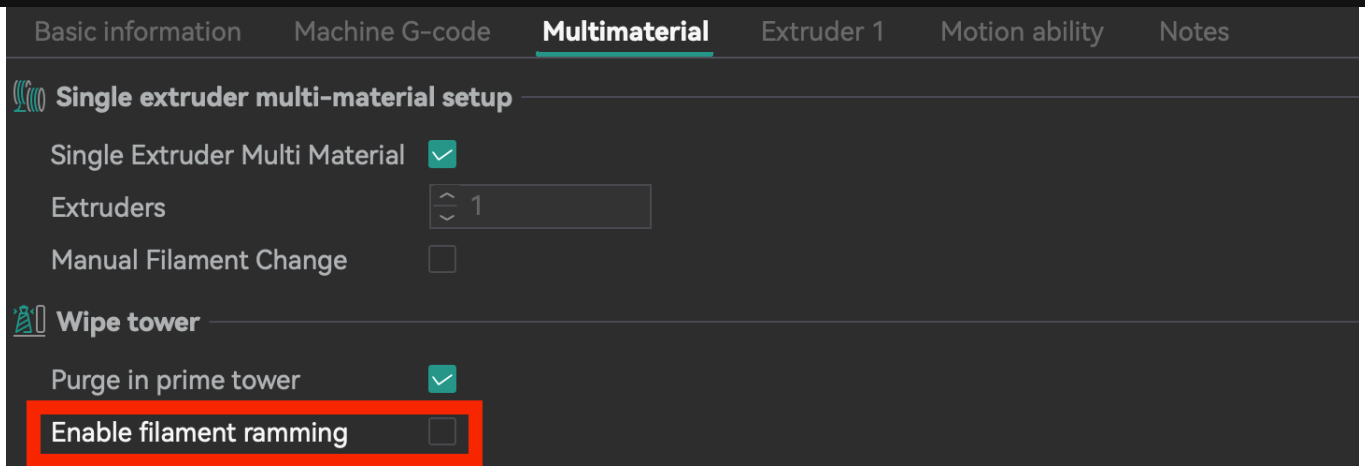
TODO show pictures of filament tips when a specific settings is altered

41.5 Slicer Setup

Follow these steps to setup your slicer for rapid tip shaping.

1. **Disable filament ramming**

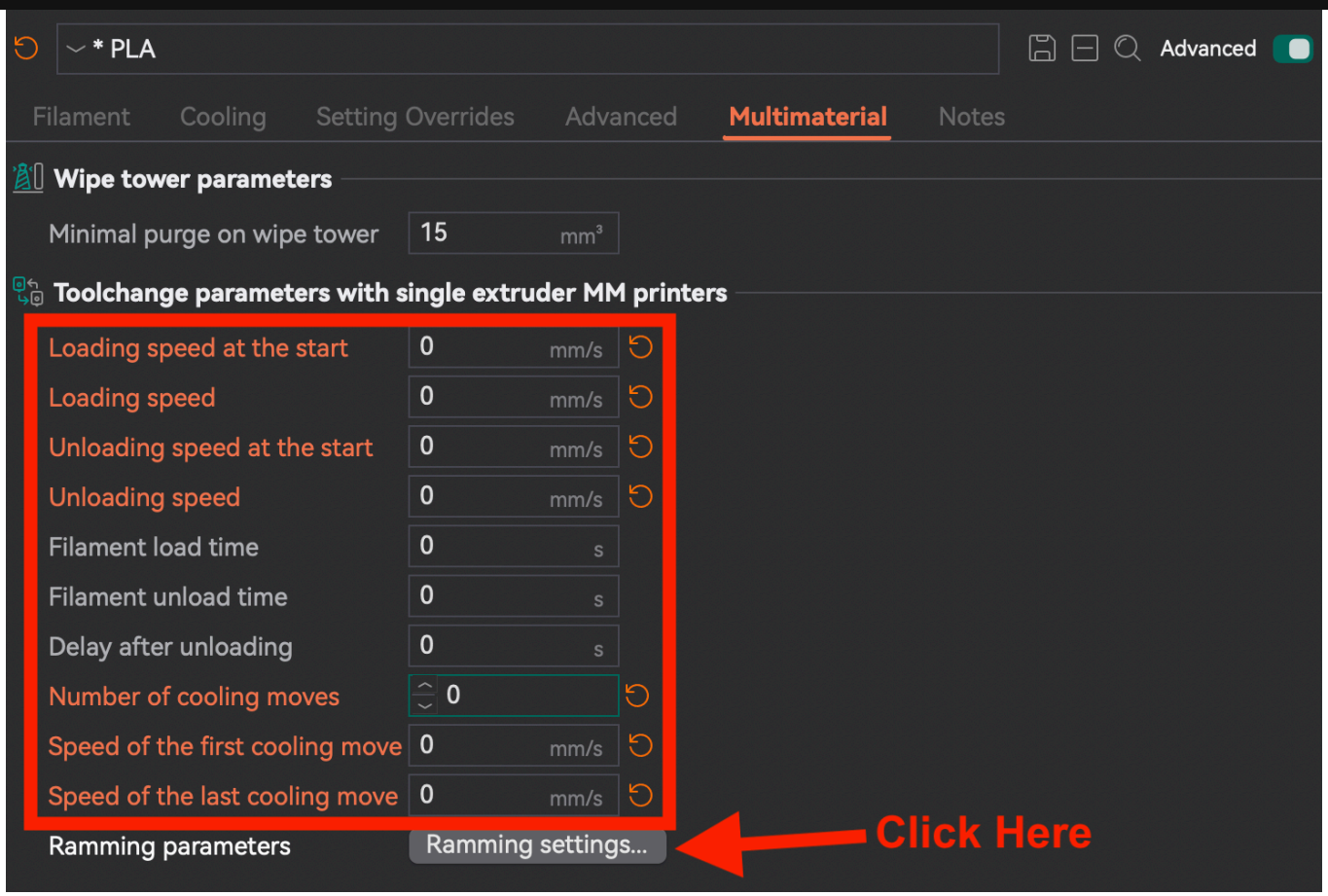
   Nagivate to `Printer Settings` -> `Multimaterial` and uncheck the `Enable filament ramming` checkbox.

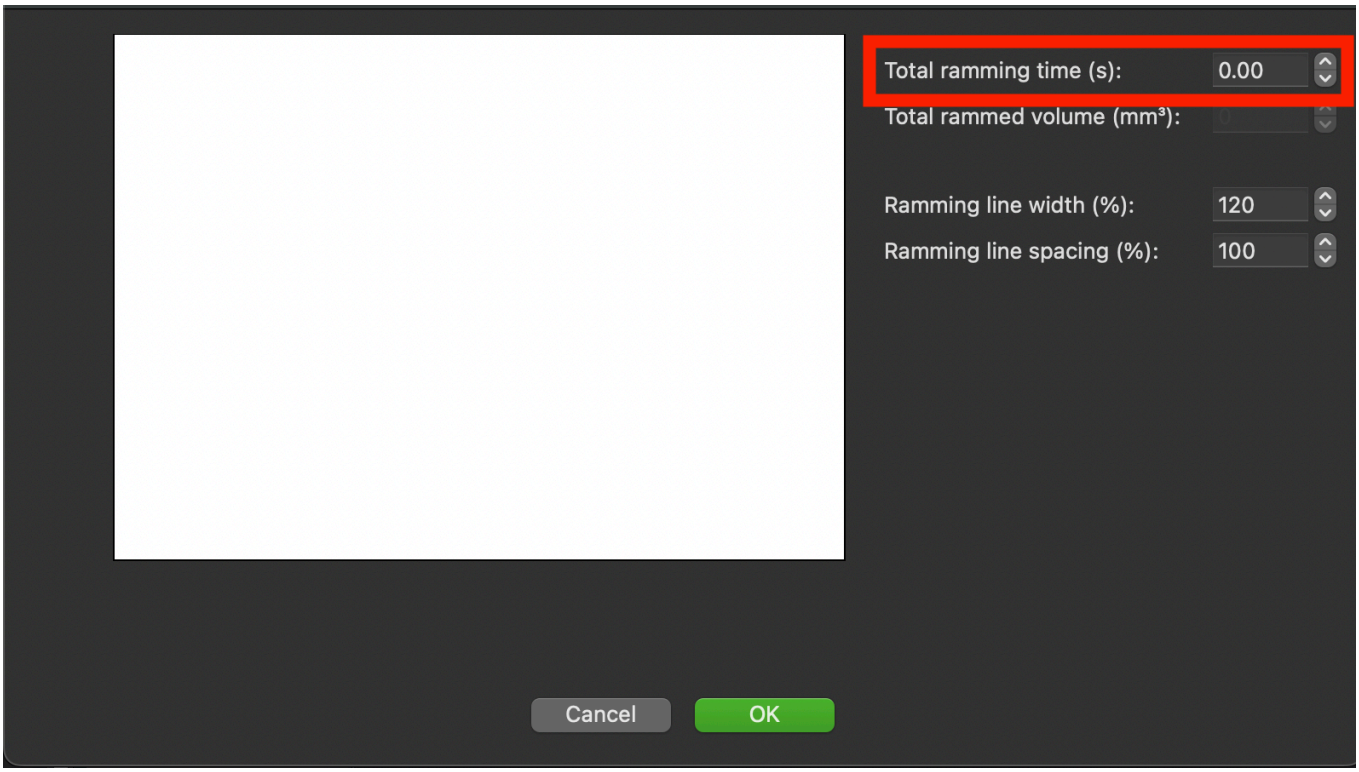


2. **Filament Settings**

   Repeat the following steps for each of your filaments.

   Navigate to `Filament Settings` -> `Multimaterial`, and disable all multimaterial settings.



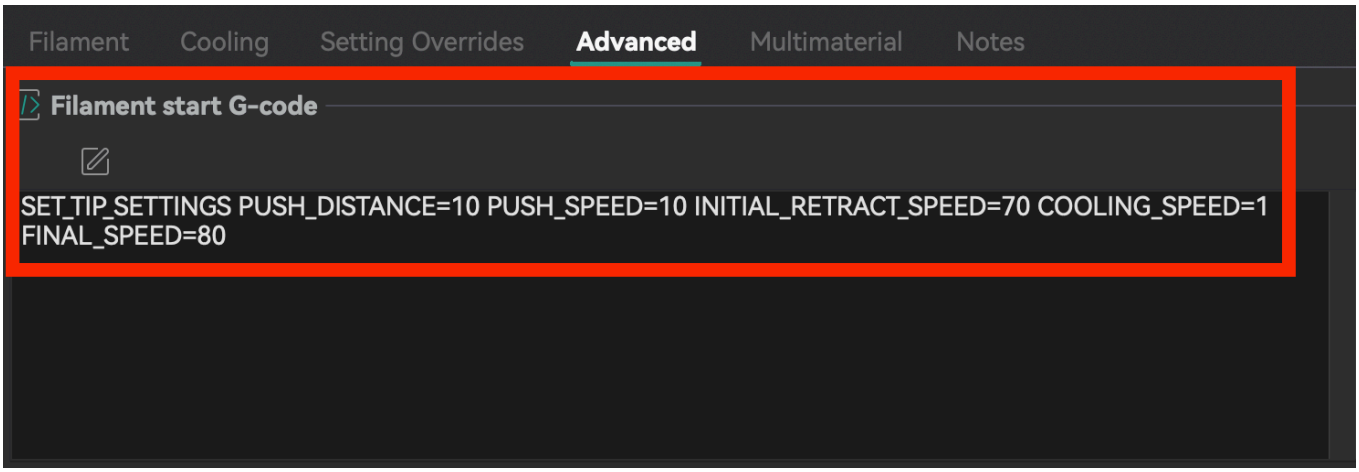


3. **Filament G-Code**

   Change your filament start G-code to the following, inserting your tuned values:

```
SET_TIP_SETTINGS PUSH_DISTANCE= PUSH_SPEED= INITIAL_RETRACT_SPEED= COOLING_SPEED=
FINAL_SPEED=
```

Add this G-Code to your filament settings in `Advanced`:



42 Dual Drive 3MS Extruders for TPU

The 3MS's existing single-drive extruders are prone to tangling with TPU during toolchanges. Dual drive 3MS extruders may fix this issue and allow for multimaterial printing with TPU.

> **Info**
>
> This page, and the features mentioned on it, are in development

The extruder used in this modification can be found on Amazon here.

42.1 Benefits

Current testing shows the following benefits:

- Increased reliability with rigid filaments
- Easier initial filament loading
- Less filament grinding

42.2 TPU Testing

Current testing with TPU (a check indicates it works):

- Single material TPU prints loaded via the 3MS
- Multimaterial TPU prints

43 Speed Limiting for TPU

TPU filament has a tendency to buckle when extruded at high speeds. This feature attempts to slow down the 3MS extruders during toolchanges only when TPU is involved in the toolchange.

> **Info**
>
> This page, and the features mentioned on it, are in development

43.1 Installation

To install the speed limiting feature, run in your terminal:

```
cd ~/3MS
git fetch
git checkout
git pull limited-speed
sh install.sh
```

Restart Klipper.

43.2 Configuration

Update your `3ms/main.cfg`:

3ms/main.cfg

```
[save_variables]
filename: ~/printer_data/config/3ms/variables.cfg

[include ./settings.cfg]
[include ./controllers/btt_skr_mini_e3_v2/steppers.cfg]

[dynamicmacros 3ms]
configs: 3ms/macros.cfg, 3ms/speedlimit.cfg
```

43.3 Usage

> **Info**
>
> This section is under construction

44 Toolchange Flowchart

This flowchart assumes a `fsensor_delay` of 2000ms.

```
graph TD
  A[T1] --> B[Toolchange T=1];
  B[Toolchange T=1] --> C{Same tool?};
  C --> |No| D{Previous filament loaded?};
  C --> |Yes| E{Do nothing};
  D --> |Yes| F[MMMS_UNLOAD];
  F --> G[DESYNC_TOOL TOOL=0];
  G --> H[G4 P2000];
  H --> I[CHECK_FSENSOR V=0];
  D --> |No| J[SYNC_TOOL TOOL=1];
  I --> J;
  J --> K[MMMS_LOAD];
  K --> L[G4 P2000];
  L --> M[CHECK_FSENSOR V=1];
  M --> N[Save new previous extruder]
```