

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

Subject to its express reservation of rights to supplement or amend its contentions as may be appropriate in view of discovery, further investigation, and/or the claim construction process, Plaintiff Stratasys, Inc. (“Plaintiff” or “Stratasys”) provides its preliminary disclosure of asserted claims and infringement contentions to Shenzhen Tuozhu Technology Co., Ltd., Shanghai Lunkuo Technology Co., Ltd., Bambulab Limited and Tuozhu Technology Limited (collectively, “Defendants” or “Bambu Lab”), pursuant to the Court’s Scheduling Order, D.I. 20; the Court’s October 30, 2024 Order extending the time to comply with P.R. 3-1, 3-2, 3-3, and 3-4, D.I. 22; P.R. 3-1; the Court’s May 9, 2025 Order (Dkt. No. 52); and Paragraph 3.1(a)(i) of the Discovery Order (Dkt. No. 35). Nothing in these contentions should be interpreted as an admission or concession regarding the scope of the asserted claims.

Disclosure of Asserted Claims for U.S. Patent No. 9,168,698 (“the ’698 Patent”) under P.R. 3-1(a): Claims 1, 2, 3, 4, 5, 7, 8, 9, 10, 12, and 15.

Disclosure of Accused Instrumentalities for the ’698 Patent under P.R. 3-1(b): For each of the Asserted Claims, all Bambu Lab branded or manufactured three-dimensional (3-D) printers with sensors for detecting force, including but not limited to the Bambu Lab A1, Bambu Lab A1 mini, and H2D printers, alone or in combination with Bambu Lab software, such as Bambu Studio (e.g. Bambu Studio v1 or Bambu Studio v2) or Bambu Handy, and all Bambu Lab Parts.

Based on information available to-date, the Bambu Lab A1 and A1 mini have no material differences relevant to these infringement contentions. See <https://bambulab.com/en-us/compare> (comparing A1 and A1 mini upon selection). The A1 includes several upgrades over the A1 mini, including a larger build volume, higher max build plate temperature, and larger display. *Id.* Accordingly, references to components or functionality of either the A1 or A1 mini in this chart—other than the larger build volume, higher max build plate temperature, and larger display—apply to both printers.

Based on information available to-date, Bambu Studio v1 and Bambu Studio v2 have no material differences relevant to these infringement contentions. See <https://wiki.bambulab.com/en/software/bambu-studio/release/release-note-2-0-0> (explaining additional features of Bambu Studio v2). Accordingly, references to functionality of either Bambu Studio v1 or Bambu Studio v2 in this chart apply to both versions of the software.

Disclosure of Priority Date under P.R. 3-1(e): The asserted claims of the ’698 Patent are each entitled to a priority date of at least as early as October 29, 2012.

Disclosures under P.R. 3-1(c)-(d): Stratasys identifies in the chart below specifically where each element of each Asserted Claim is found within each Accused Instrumentality.

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Disclosure under P.R. 3-1(f): At this time, Stratasys does not intend to rely on the assertion that its own products or other instrumentalities practice the claimed invention. Stratasys reserves the right to amend and/or supplement this disclosure as discovery progresses.

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Claim	Contention
<p>1. A method comprising: identifying build instructions for fabricating an object;</p>	<p>To the extent the preamble of the claim is limiting, the Accused Instrumentalities are used for identifying build instructions for fabricating an object.</p> <p>Bambu Lab sells various 3D printers, such as the A1, A1 mini, and H2D which are used for fabricating three-dimensional parts using build instructions.</p>  <p>The filaments in the picture are sold separately</p> <p>https://us.store.bambulab.com/products/a1; see also https://bambulab.com/en/a1.</p>

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The filaments in the picture are sold separately

<https://us.store.bambulab.com/products/a1-mini>; see also <https://bambulab.com/en/a1-mini/>

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*The filaments in the picture are sold separately

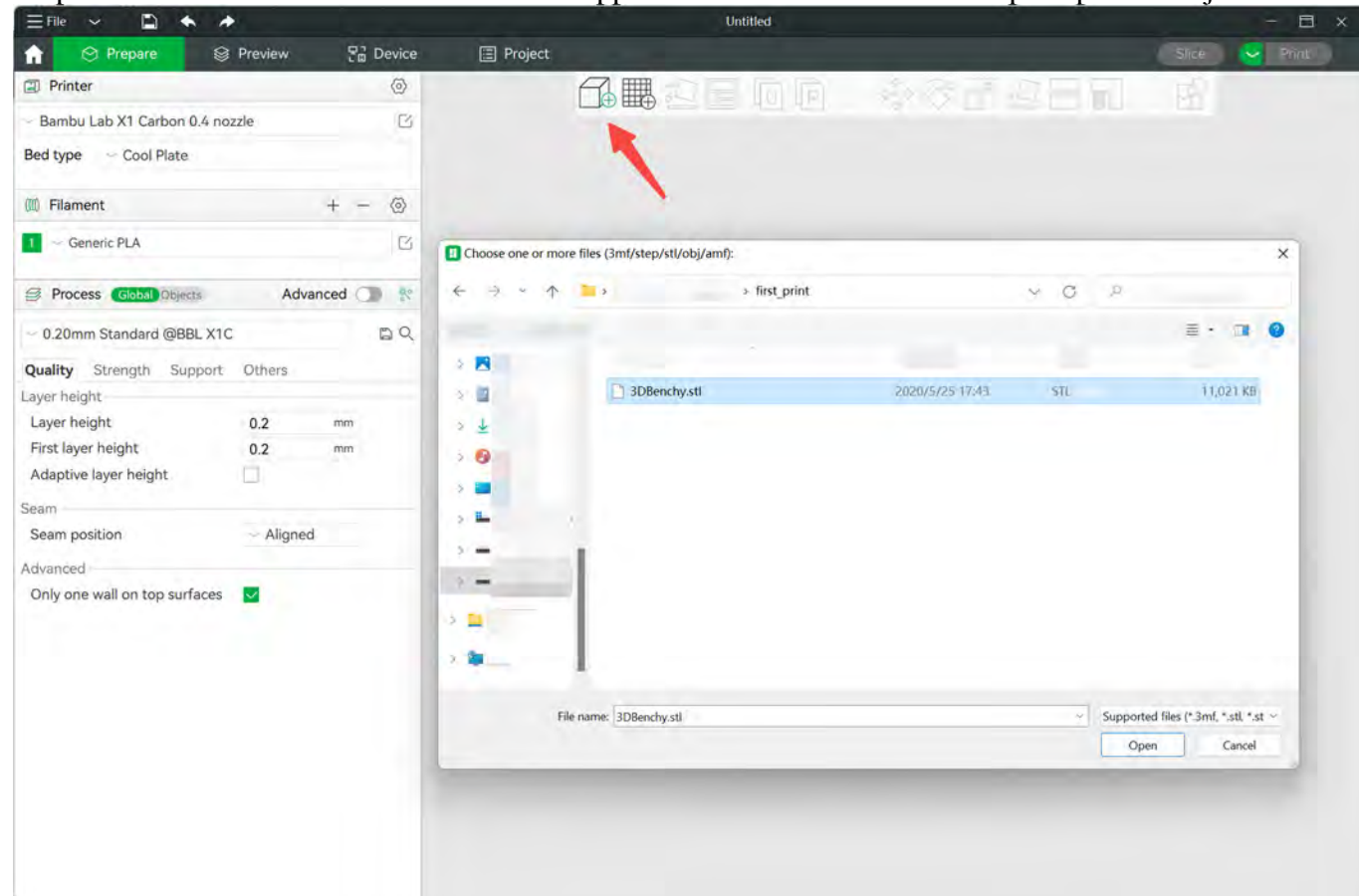
<https://us.store.bambulab.com/products/h2d>

For example, the Bambu Studio Quick Start Guide explains how a 3D model is loaded into Bambu Studio (v1 or v2) and is sliced to generate a .3mf file which is the file format used for the printer to be able to print the model. The .3mf file contains build instructions for controlling the Bambu Lab 3D printer during the printing of the object. See <https://wiki.bambulab.com/en/software/bambu-studio/studio-quick-start>:

“Add a model

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On the top toolbar of the preview pane, click on the first icon **add** to import a model. You can also drag and drop model files from a folder into Studio. Supported files include .3mf .stl .stp .step .amf .obj.



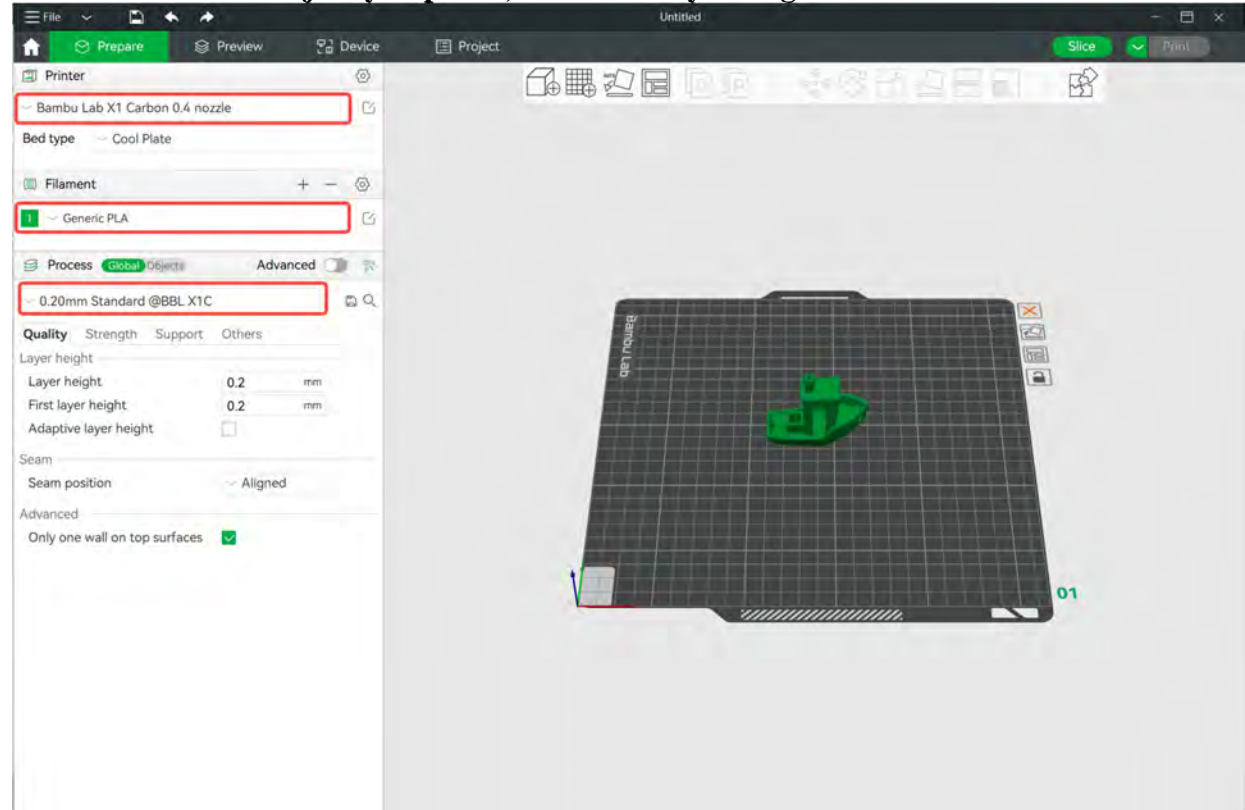
Select Printer/Filament/Process presets

To start slicing the model, you need to choose the presets for the machine you are using, for the filament you will print with and also the settings you want to print the model in.

1. Select the printer you are using from the drop-down list under **Printer**. This will also include the nozzle size you will be printing with
2. Under the **Filament** section, select the type of filament you intend to use from the drop-down list

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3. Choose the layer height you want your model to be printed in from the **Process** drop-down menu. **Always remember that the smaller the layer height, the longer the print will take. For the majority of prints, a 0.20mm layer height is the norm.**



Slice plate

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Once done, click on the **Slice** button located on the top hand right of Bambu Studio.

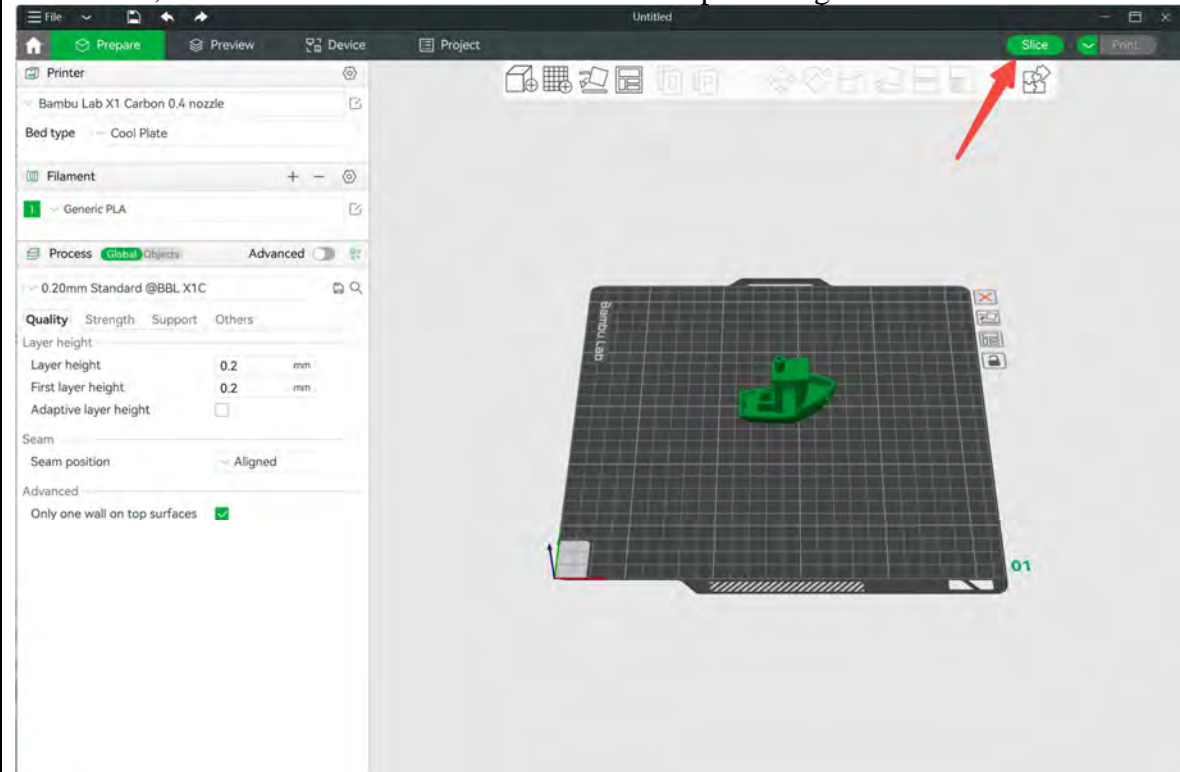
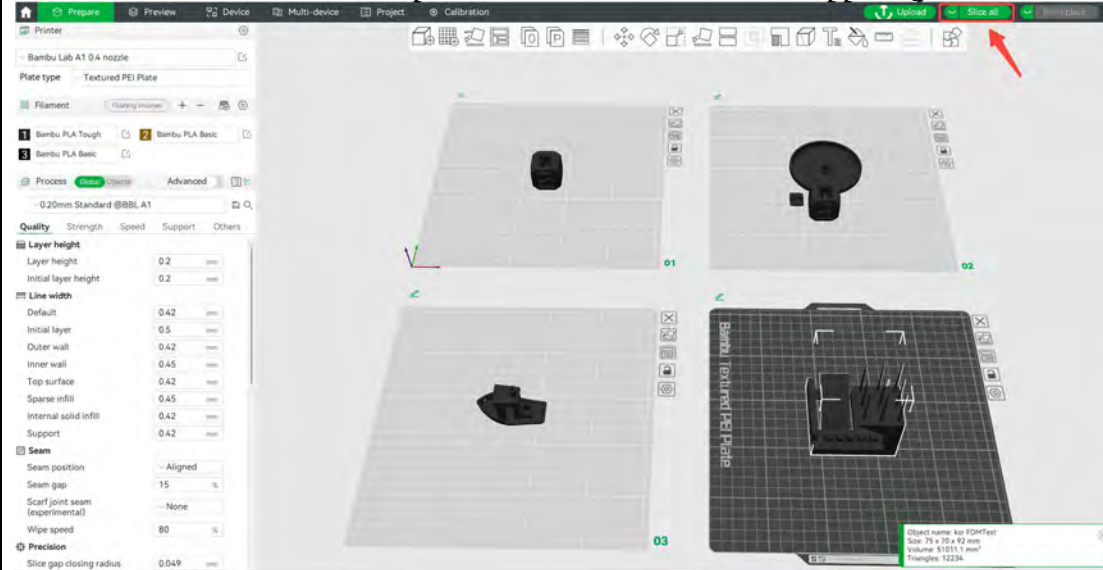


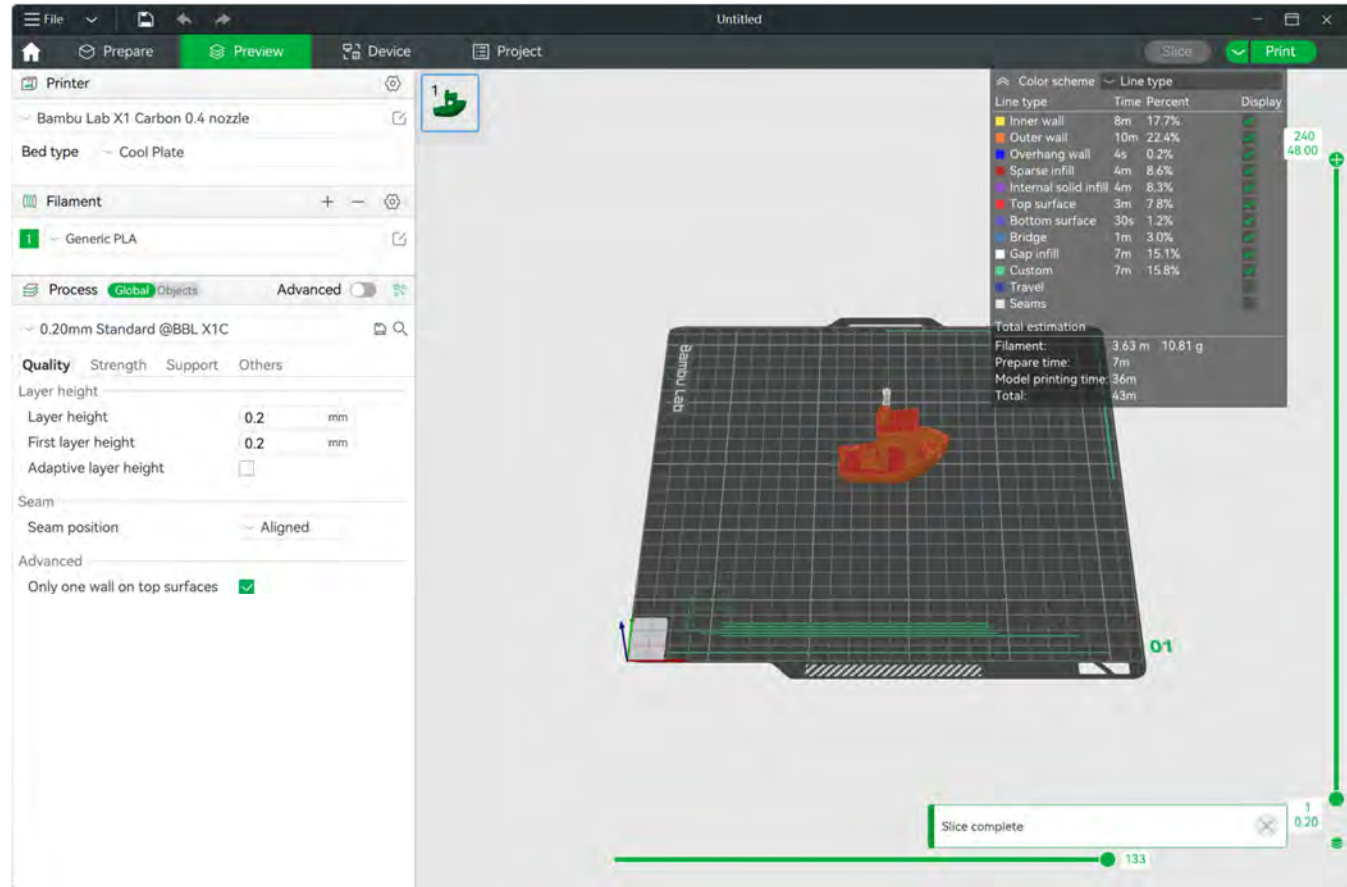
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If the model file contains multiple disks, click **Slice All** in the upper right corner of the screen.



Once done, the slicer will take you to the Preview pane which will show you what the sliced model looks after processing the .3mf file. The histogram on the right hand side will also show you information on the printing times for each parameter of the print.

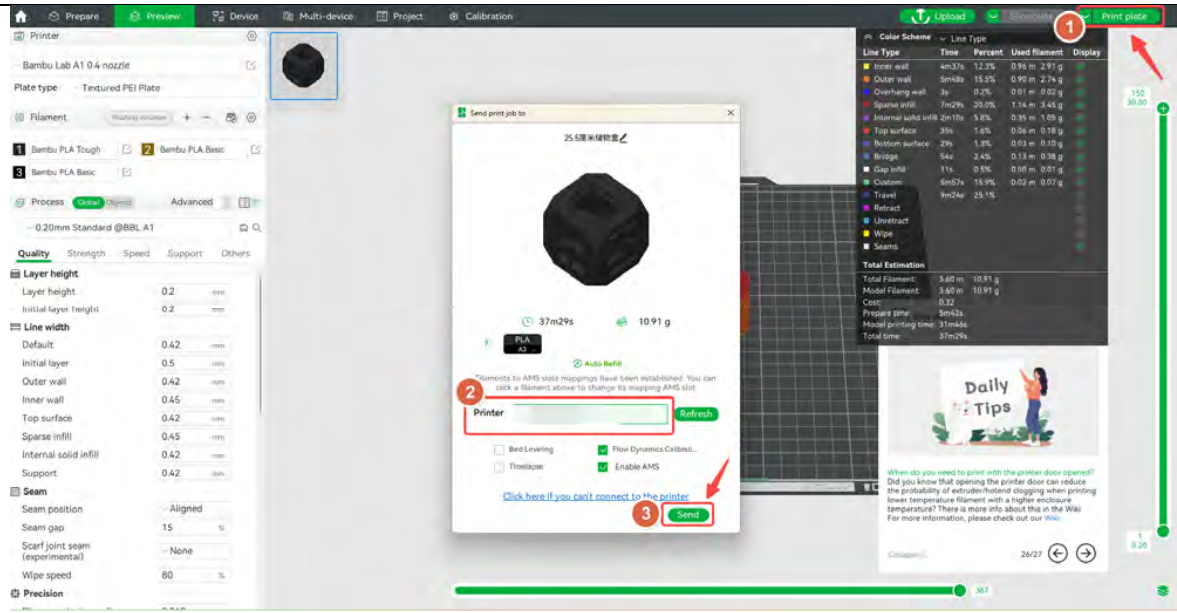
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Send print job Print plate

Click **Print** on the top right-hand corner. This will prompt a pop-up window with a quick preview of the model and will also ask you to select the Printer you want to send it to from the drop-down list, and you will also give you the option to choose whether or not you want the printer to perform certain functions like Bed Leveling, flow calibration, etc before the print starts. Once done, click “Send” to send the file to the printer and start printing.

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For example, Bambu Studio v2 generates build instructions for use by a Bambu Lab 3D printer such as the Bambu Lab H2D. *See, e.g.*, <https://wiki.bambulab.com/en/h2/manual/h2d-first-print>.

“Initiate the print from Bambu Studio

Import the model you want to print in Bambu Studio, modify the printing parameters, click "Slice plate", and then click on "Print plate" to send the print job to the printer.

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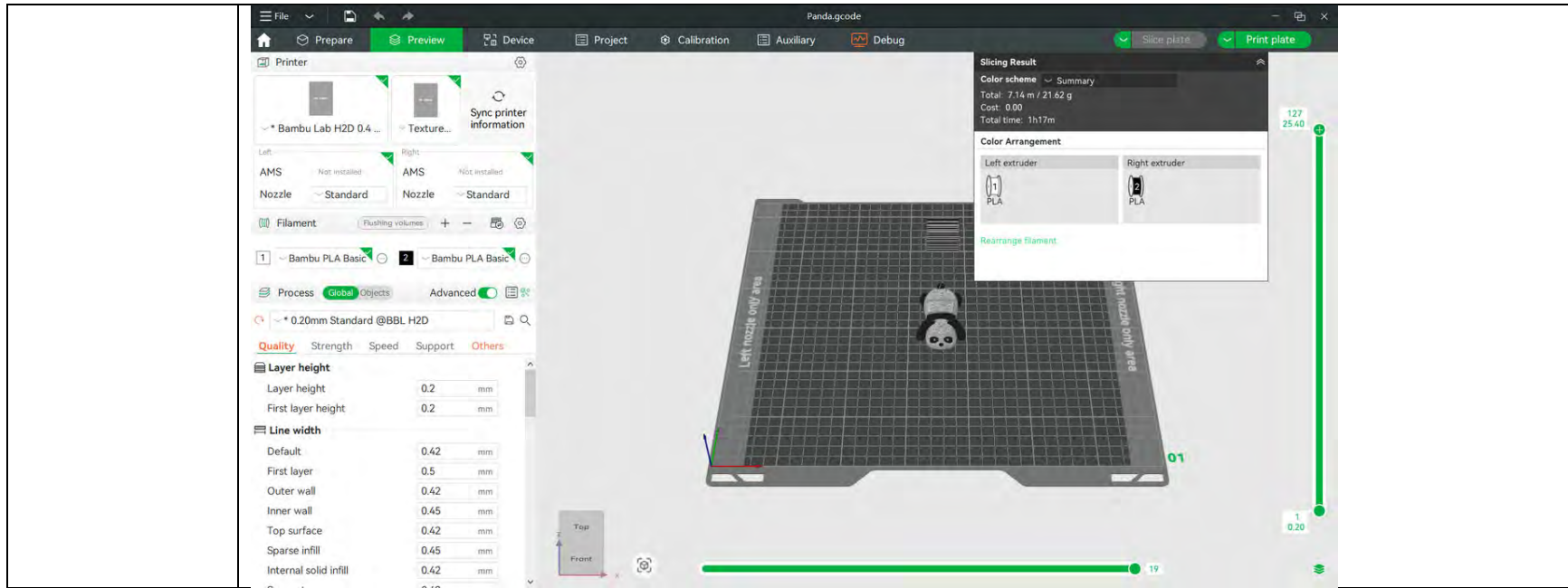
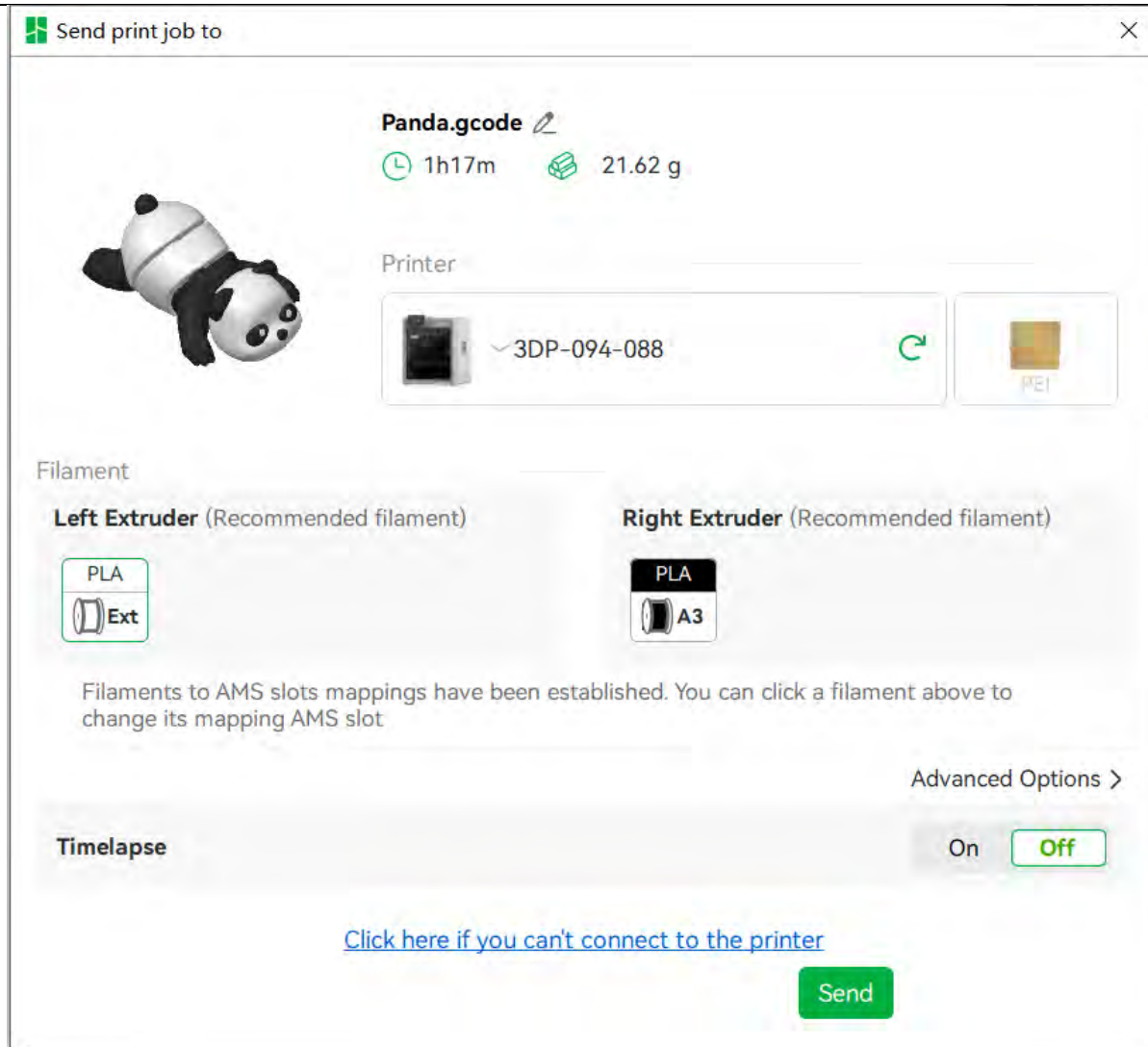


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Due to its dual nozzles, when printing multi-color models, Bambu Studio automatically calculates the most filament-efficient arrangement and groups the filaments accordingly.”

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Bambu Handy can similarly send build instructions for a model to the Bambu Lab A1, A1 mini, and H2D printers for printing. See <https://wiki.bambulab.com/en/studio-handy/handy/bambu-handy-quick-start>:

“Page Introduction

[Models] Interface Functions

The "Models" interface is where you can access [MakerWorld](#), allowing you to share models with others and view their work. You can also directly send your favorite models for printing.

There are two main tabs in the upper left corner of this screen. The "Discover" tab is where you can browse models and designers, and the "Following" tab is where you can check out the latest posts from designers you are following.

You can also access the contests section from the "Discover" tab. Bambulab regularly organizes contests, and designers from around the world participate in them. You can explore others' ideas or even participate yourself. Exciting prizes are awarded to the winners of each contest!

...

[Device] Interface Functions

After completing the printer binding, the application will automatically return to the device screen. The Device interface contains the top bar, printer monitoring image, item currently being printed (or the last previously printed item), and the printer controls.

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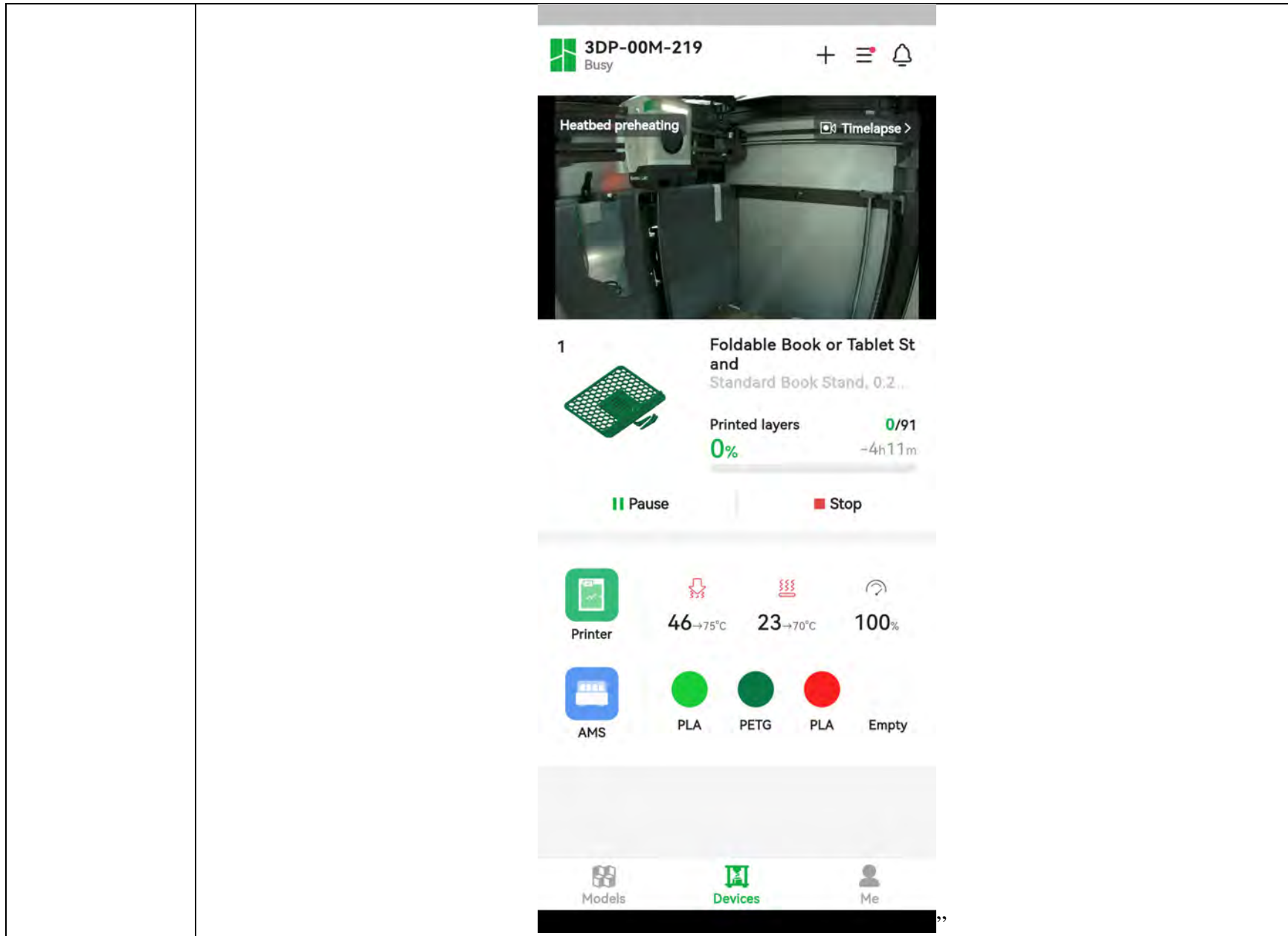


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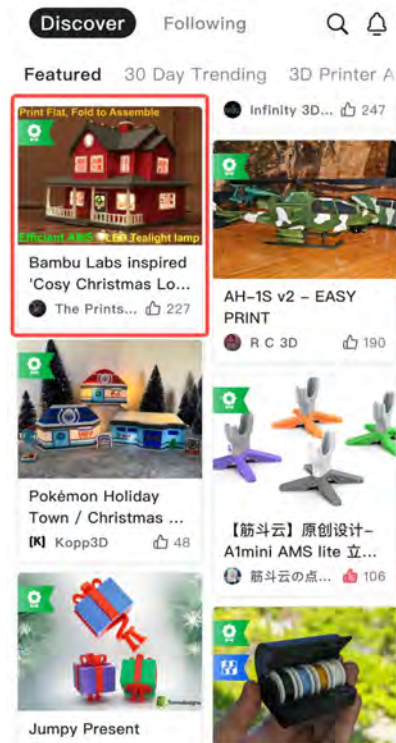
See also <https://wiki.bambulab.com/en/makerworld/tutorials/printing-tutorial-on-bambu-handy>:

“Basic Printing Tutorial

This chapter focuses on how to print 3D models on Bambu Handy. We will use a typical multi-part model as an example to cover various aspects involved in the printing process.

Step 1. Find a captivating 3D model

You can browse through the model list or use the search function to find the models you like.



Browse the model list and choose a model to print

Step 2. Choose a Print Profile

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Print Profile contains both the 3D data and print settings of a model. Usually, a model has several available print profiles. You can choose which Print Profile to use for printing based on your printer type, its ratings, and features(such as multi-colors).”

Software

Slicer & Software

Bambu Studio, Bambu Suite, Bambu Handy
Supports third-party slicers which export standard G-code, such as Super Slicer, PrusaSlicer and Cura, but certain advanced features may not be supported.

<https://bambulab.com/en-us/h2d/tech-specs>

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initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool,

The Accused Instrumentalities are used for initiating a build using a three-dimensional printer comprising a fabrication tool and one or more sensors mechanically coupled to the fabrication tool.

Bambu Studio (v1 or v2) and Bambu Handy, as well as the user interface on the Bambu Labs 3D printers (e.g., A1, A1 mini, and H2D printers) provide a prompt to the user to begin printing the object.

A request to fabricate an object from a three-dimensional model can be received at least via: 1) the user interface on the printer; or 2) via Bambu Studio or Handy app.

See <https://wiki.bambulab.com/en/software/bambu-studio/studio-quick-start>:

Printing from Bambu Studio

When printing with Bambu Studio, it's possible to send the sliced files directly to the printer via Wi-Fi. Here's how to do it:

1. Import the **3D model** you want to slice, and after adjusting the settings, click on the **Slice** button
2. After the model has been sliced, click on the **Print** button. A window will show up where the printer can be selected, and the calibration options can be enabled or disabled.
3. When ready to print, simply click the **Send** button, and the **file will be sent to the printer.** The printing process will start.


 **receiving a request**

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“What is Bambu Studio?”

Bambu Studio is based on PrusaSlicer by Prusa Research, which is from Slic3r by Alessandro Ranellucci and the RepRap community.

Bambu Studio is our cutting-edge, feature-rich slicing software developed by Bambu Lab, which is used to prepare the files for 3D printing. It contains project-based workflows, systematically optimized slicing algorithms, and an easy-to-use graphic interface, bringing users an incredibly smooth printing experience.

....

First Print

Log in to your account (optional, but strongly recommended)

[Prerequisite]: You will need the BambuNetworking plugin in order to log in.

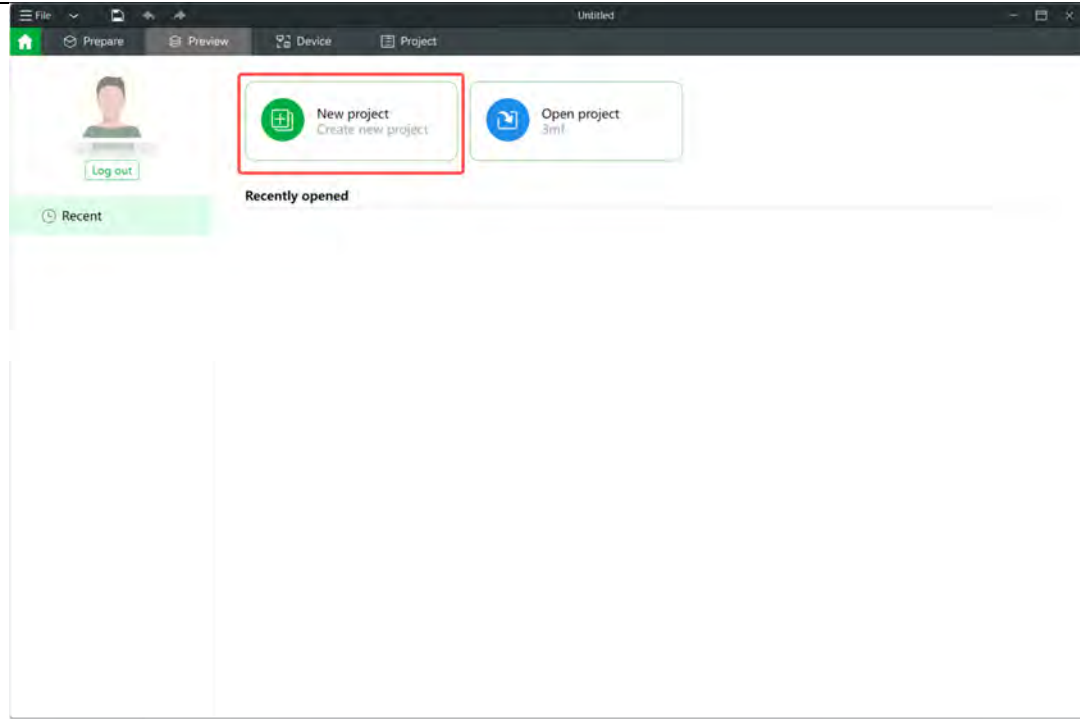
This is required to enable print history which allows you to reprint your history models on the Bambu Handy app. Also, your user settings can be synchronized to Bambu Cloud in order to share information among your PC devices.

....

Create a new project

To start slicing a model, click on **New Project**.

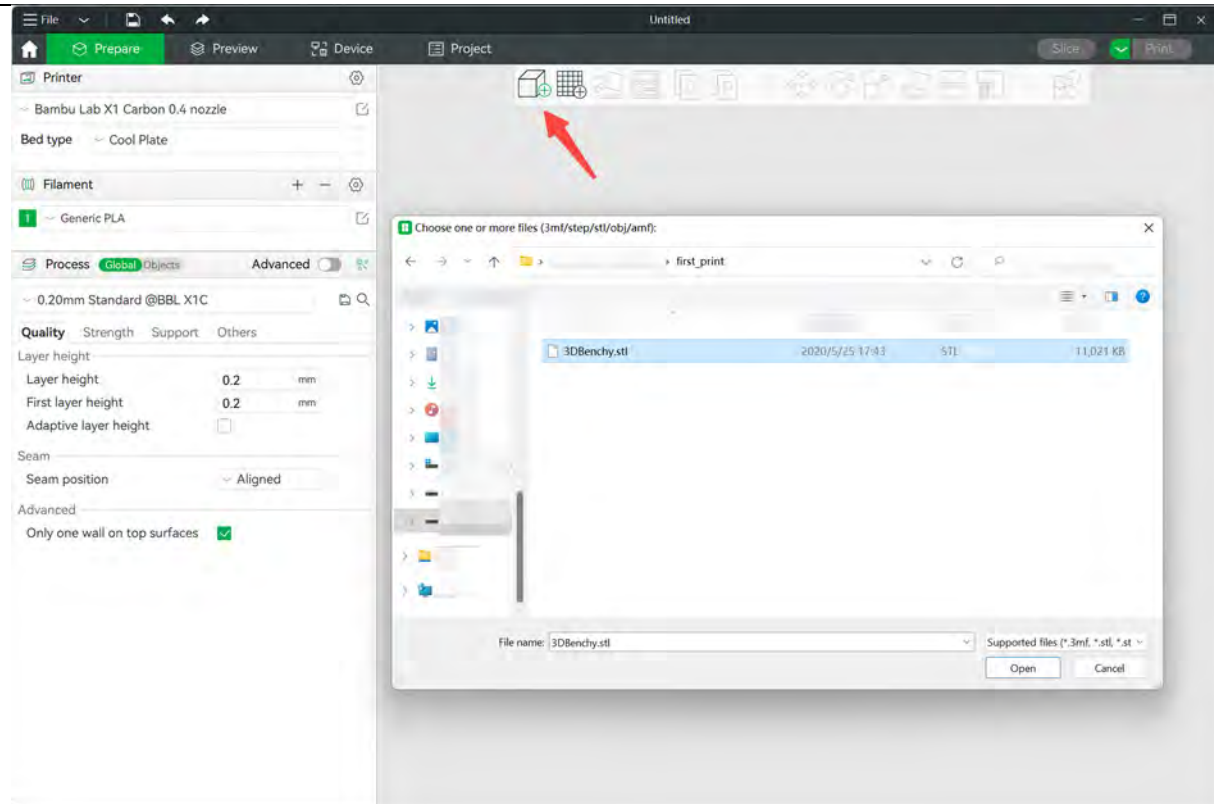
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Add a model

On the top toolbar of the preview pane, click on the first icon **add** to import a model. You can also drag and drop model files from a folder into Studio. Supported files include .3mf .stl .stp .step .amf .obj.

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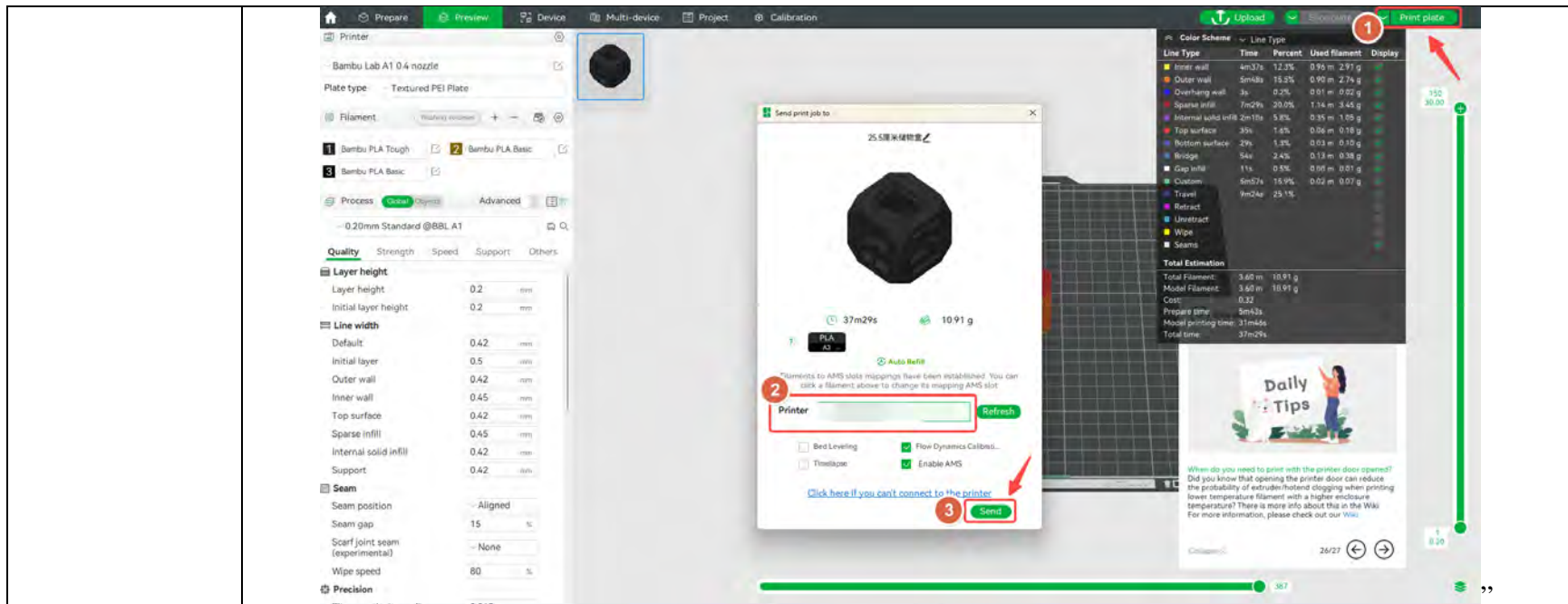
....

Send print job

Print plate

Click **Print** on the top right-hand corner. This will prompt a pop-up window with a quick preview of the model and will also ask you to select the Printer you want to send it to from the drop-down list, and you will also give you the option to choose whether or not you want the printer to perform certain functions like Bed Leveling, flow calibration, etc before the print starts. Once done, click "Send" to send the file to the printer and start printing.

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See also <https://wiki.bambulab.com/en/h2/manual/h2d-first-print>:

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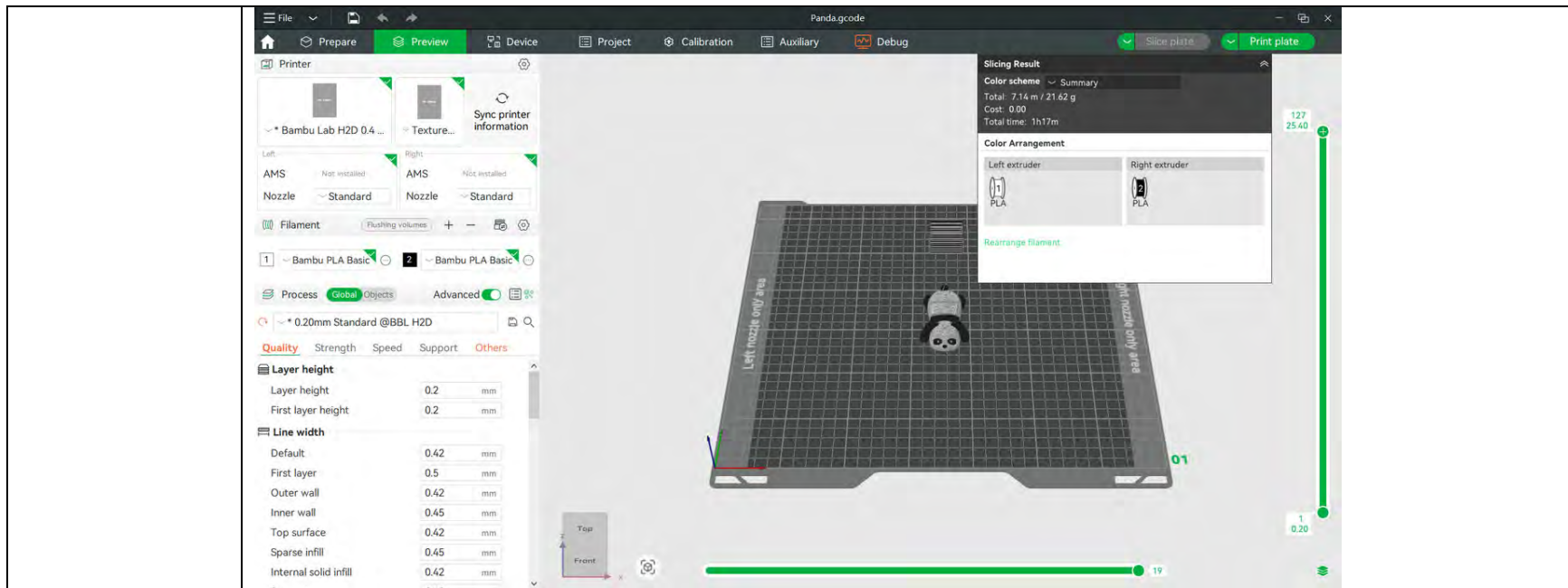
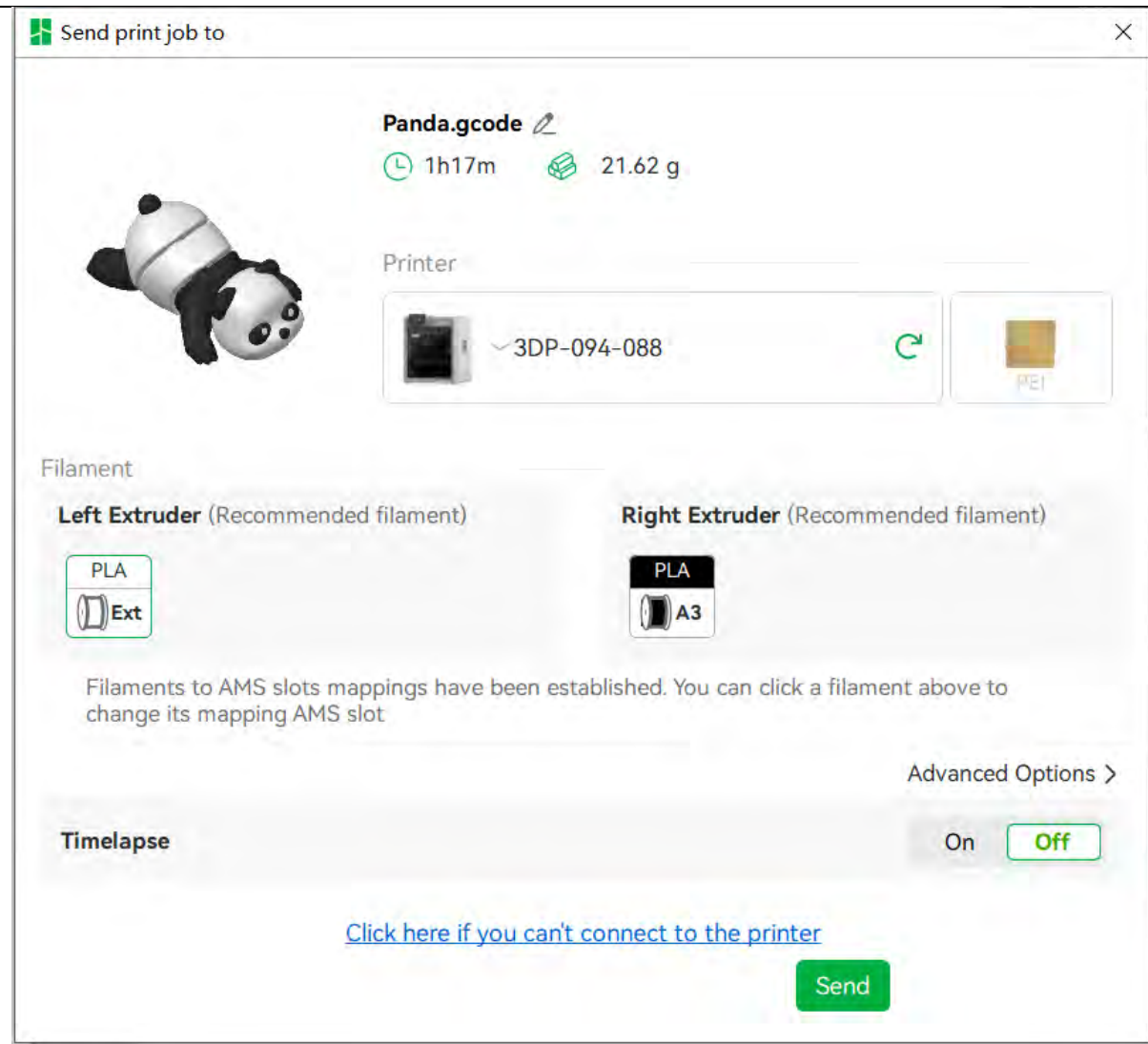






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Send print job to

Panda.gcode 

 1h17m  21.62 g




Printer


 3DP-094-088  

Filament

Left Extruder (Recommended filament)

PLA  Ext

Right Extruder (Recommended filament)

PLA  A3

Filaments to AMS slots mappings have been established. You can click a filament above to change its mapping AMS slot

Advanced Options >

Timelapse On **Off**

[Click here if you can't connect to the printer](#)

Send

Due to its dual nozzles, when printing multi-color models, Bambu Studio automatically calculates the most filament-efficient arrangement and groups the filaments accordingly.”

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See also <https://wiki.bambulab.com/en/studio-handy/handy/bambu-handy-quick-start>:

- ▶ **Printing History:** This option displays the printing history of jobs sent via the cloud for the current account over the last 3 months; jobs printed via SD card and LAN mode are not saved in the history. You can click on a specific record in the history to view the printing details or click the "Print Again" button to reprint the model. When printing again, you can manually select the material for that print, or you can print a specific part from that project when there are multiple parts. More information on printing specific parts will be covered in the advanced features section.

Print Parts/Skip Parts

There are two situations where you can select specific printing part. One of them is when the print is sent to the printer by bambu studio, you can select which part to print in the devices screen. The other is if the print is initiated from print history or pulled directly from MakerWorld. In both situations, if there are multiple parts in one plate, you can select which part you want to print using Print Parts/Skip Parts function, thus saving both time and materials. Note that if you choose to skip a part during the printing process, the operation can not be undone, and you will need to start printing again if you want to print the part. For more information about print parts/skip parts, reference to [Skip objects](#).

See also <https://wiki.bambulab.com/en/makerworld/tutorials/printing-tutorial-on-bambu-handy>:

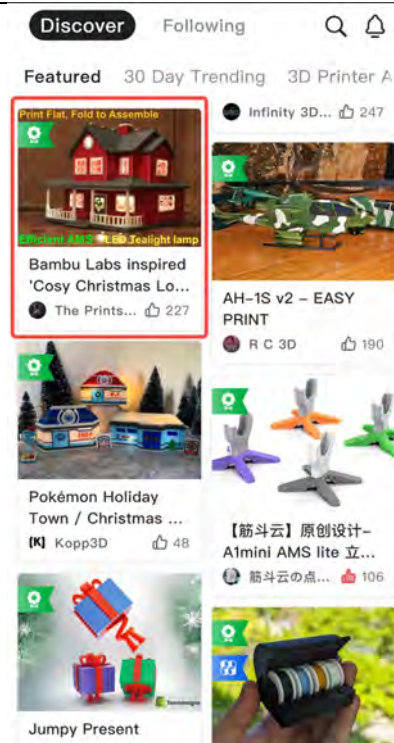
“Basic Printing Tutorial

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Browse the model list and choose a model to print

Step 2. Choose a Print Profile

Print Profile contains both the 3D data and print settings of a model. Usually, a model has several available print profiles. You can choose which Print Profile to use for printing based on your printer type, its ratings, and features(such as multi-colors).

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Bambu Labs inspired 'Cosy Christmas Lodge'

Household – Festivities

1.5K

The Printsmith

Follow

Introducing the "Cosy Christmas Lodge" 3D Model:

Embrace the holiday spirit with my latest 3D model, the Cosy Christmas Lodge. Designed with simplicity and holiday season warmth in mind, this miniature lodge brings a touch of festive charm to your space.

Printed flat for easy assembly, the Cosy Christmas Lodge maximizes the efficiency of your bambu AMS unit, reducing filament purges

227 311 21

Prepare to Print

1. Click "Prepare to Print"



Printers

X1 Carbon

P1S

P1P

X1

X1E

Print Profiles



0.16mm + 0.12mm layer for f
olding parts, 2 walls, 15% ...

Designer

7.8h 141g
3 plates 0.4mm



Recoloured for faste
- less filament swap

Designer

6.4h 130
3 plates 0.4

Print

2. Select your printer type and a print profile



7.8h 141g 6.4h 130
3 plates 0.4mm 3 plates 0.4

0.16mm + 0.12mm layer for folding parts, 2 walls, 15% infill

The Flat walls need to be printed at 0.12mm layer height or lower, otherwise the hinges will not be printed properly.

Efficient AMS print, fast and low filament wastage.

PLA | 34g PLA | 28g PLA | 4g PLA | 75g

Print Plates (3 plates)

Detail >

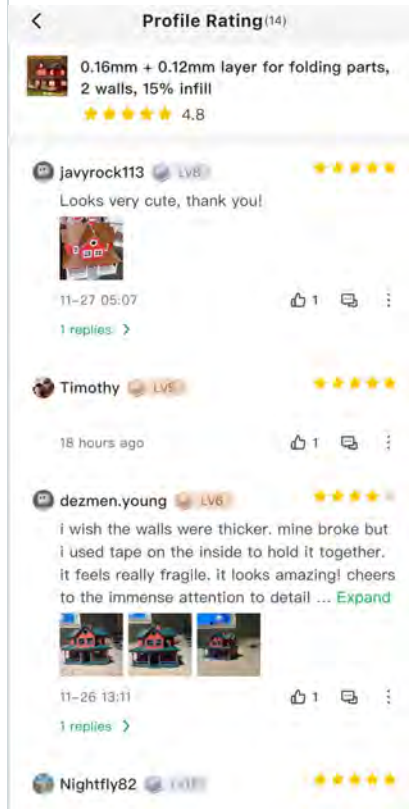
Rating Details (14)

★★★★★ 4.8 >

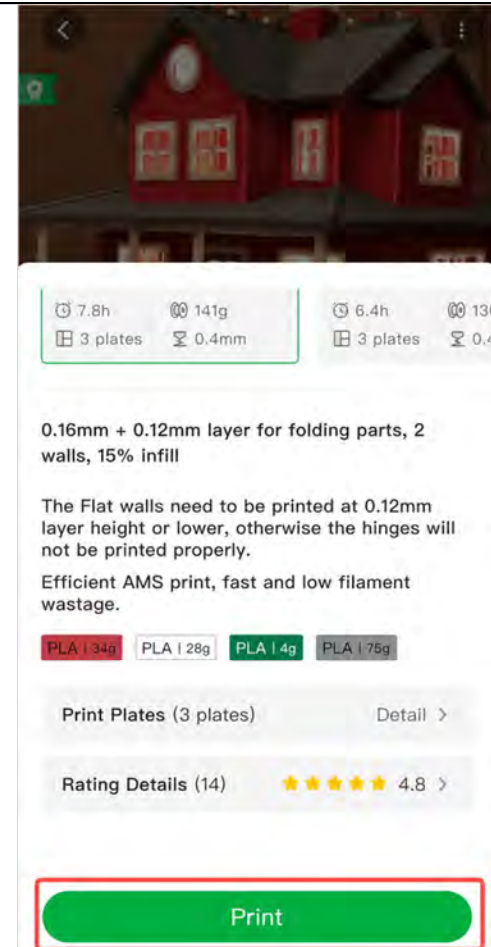
Print

3. [Optional] You may check other users' review of the selected print profile

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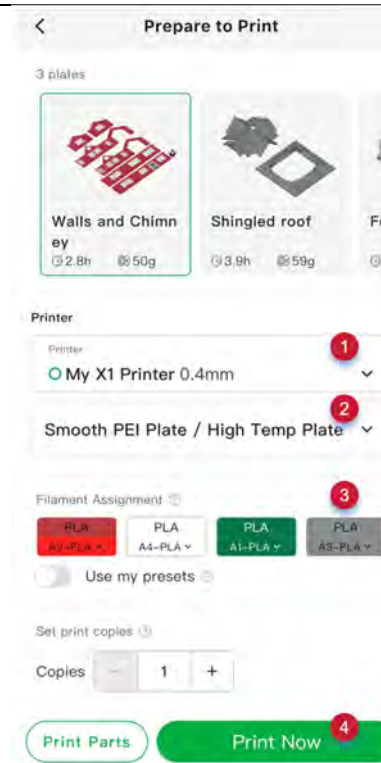
A example of reviews of selected print profile. If other users print successfully, you may also use this.



4. Click "Print" button to continue with this print profile

Step 3. Print the 1st plate

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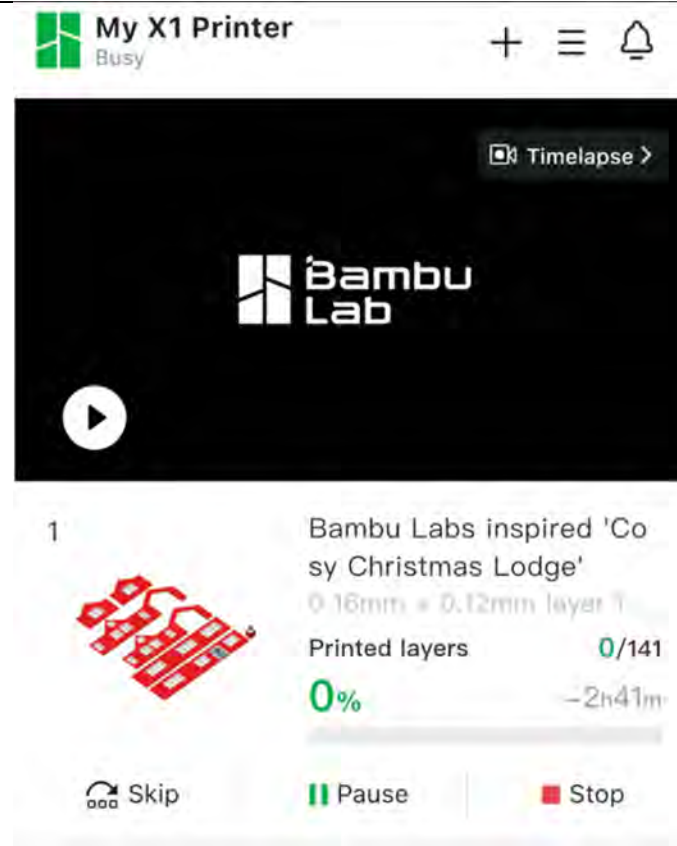
Printer with AMS

Here, several settings need to be checked/configured:

1. check/select the printer you want to set the print job to
2. check/select the plate type you are using
3. set filament(s)
 - if AMS installed: Bambu Handy will auto-assign the AMS slot (A1~A4) for target filament used in current print job according to the filament type and color. You may also change it according to your requirement.
 - if no AMS: choose the filament type mounted on the printer.
4. Click the "Print Now" button to send the print job to the designated printer.

After sending the print job, it will auto-jump to the device page where you can monitor the progress of the print.

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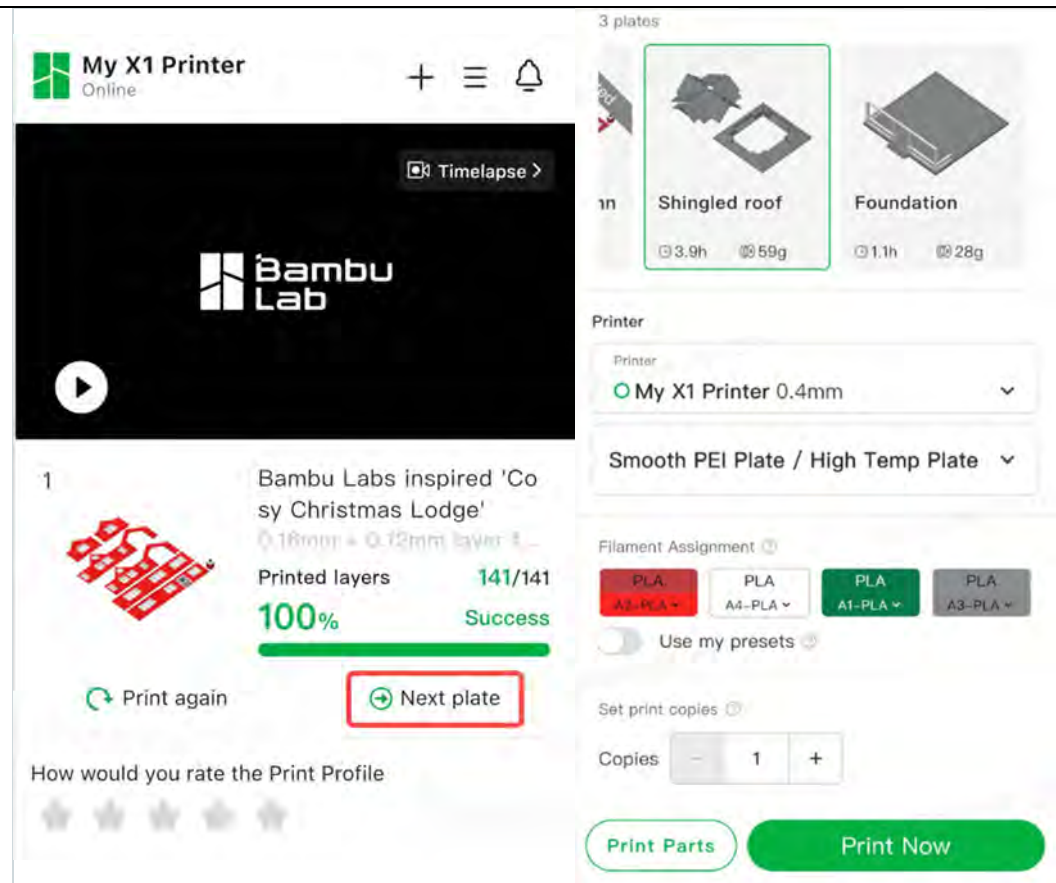
Note:

- If you have installed AMS and find that the slots in the **Filament Assignment** section display "?" when setting up materials, you need to configure the material types and colors for each slot of AMS on the device page first. AMS can automatically recognize Bambu Lab's materials, so manual configuration is not necessary.
- You may have noticed other settings, which will be explained in the Advanced Features section.

Step 4. Print other plates

If the model contains more than one plate, you can click "Next Plate" button to continue printing the next plate.

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The screenshot displays the Bambu Lab printer control interface. At the top left, it says "My X1 Printer Online". The main area shows a "Timelapse" video player with the Bambu Lab logo. Below the video, a print job is shown as "1" with a red house icon. The job is titled "Bambu Labs inspired 'Cozy Christmas Lodge'" and shows "Printed layers 141/141" and "100% Success". A green progress bar is at the bottom of the job details. Below the job details, there are two buttons: "Print again" and "Next plate", with the "Next plate" button highlighted by a red box. To the right of the job details, there are printer settings: "Printer: My X1 Printer 0.4mm", "Smooth PEI Plate / High Temp Plate", "Filament Assignment" (with four PLA options: A1-PLA, A4-PLA, A1-PLA, A3-PLA), and "Set print copies" (set to 1). At the bottom right, there are two buttons: "Print Parts" and "Print Now".

Alternatively, you may also quickly jump to the next plate from the print history of this model.”

Software

Slicer & Software

Bambu Studio, Bambu Suite, Bambu Handy
Supports third-party slicers which export standard G-code, such as Super Slicer, PrusaSlicer and Cura, but certain advanced features may not be supported.

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<https://bambulab.com/en-us/h2d/tech-specs>

See also <https://wiki.bambulab.com/en/a1-mini/manual/first-print-with-external-spool>:

2. Start printing

After ensuring the filament is loaded and the build plate is in place, you can proceed with printing.

1. Initiate a print job using Bambu Studio

Install the Bambu Studio

Click here to [download Bambu Studio](https://bambulab.com/en/download/studio) : <https://bambulab.com/en/download/studio>

Bambu Studio

Download Bambu Studio: <https://bambulab.com/en/download/studio>

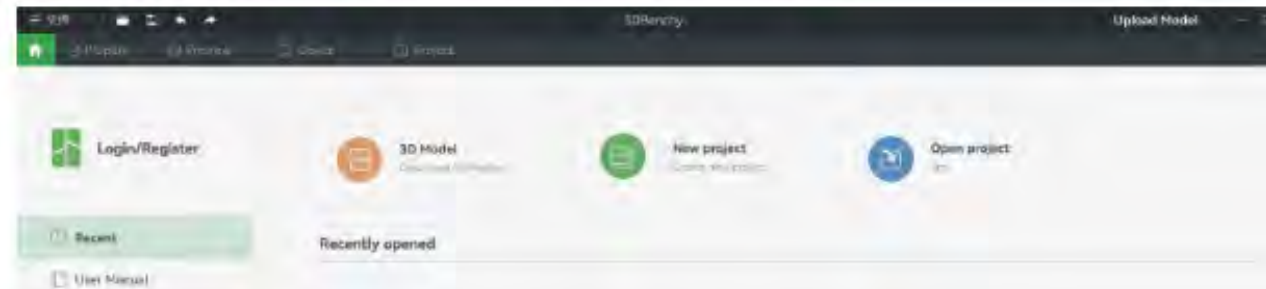


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“Slice and send the print”

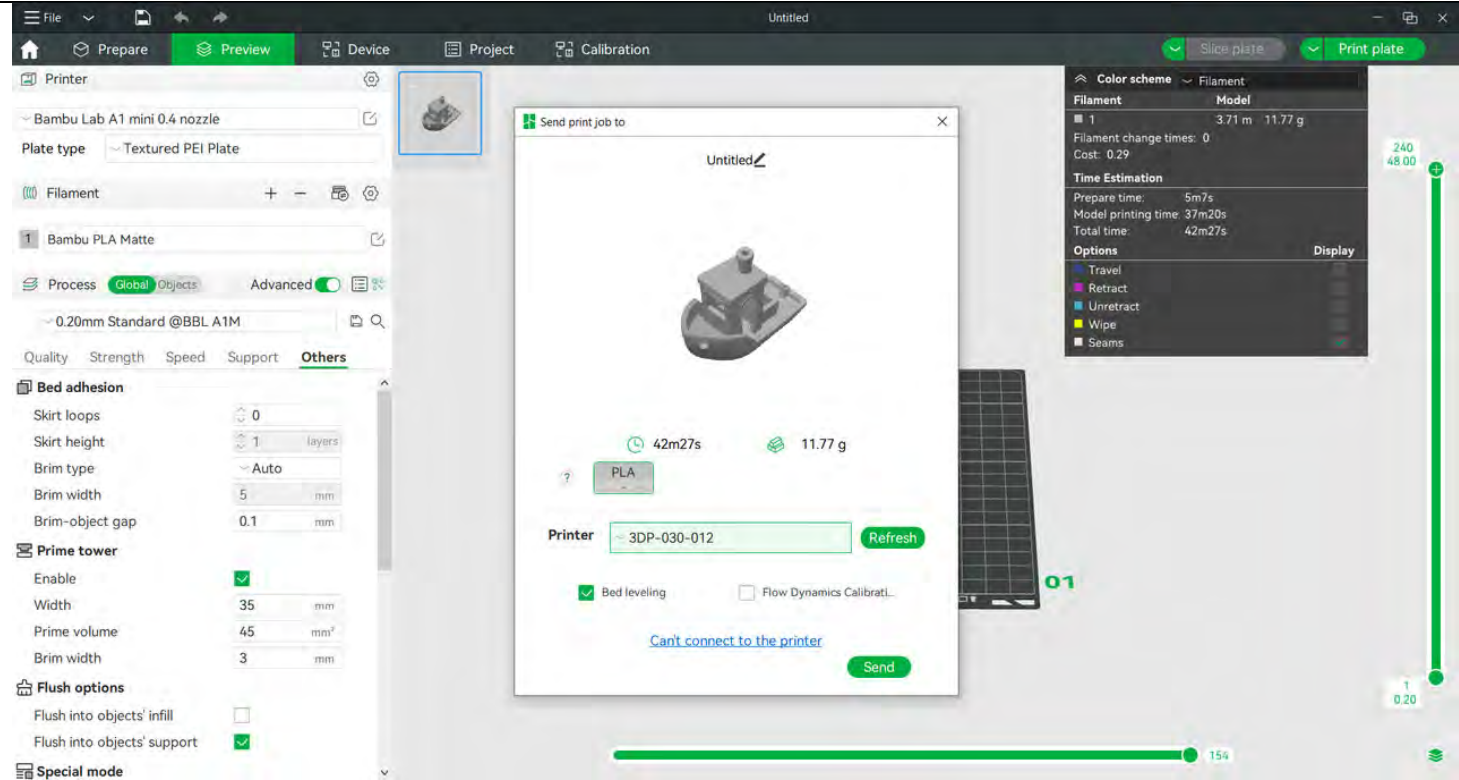
The screenshot displays the Bambu Studio software interface. On the left, the settings panel is visible, showing the printer (Bambu Lab A1 mini 0.4 nozzle), plate type (Textured PEI Plate), filament (Bambu PLA Matte), and process (0.20mm Standard @BBL A1M). The main workspace shows a 3D model of a part on a textured PEI plate. On the right, a detailed line type analysis table is displayed, showing the time and percentage for various line types. A green progress bar at the bottom indicates 154% completion. The interface also includes a 'Slice plate' and 'Print plate' button at the top right.

Line Type	Time	Percent	Display
Inner wall	7m13s	17.0%	
Outer wall	9m43s	22.9%	
Overhang wall	4s	0.2%	
Sparse infill	3m34s	8.4%	
Internal solid infill	2m24s	5.7%	
Top surface	3m7s	7.4%	
Bottom surface	18s	0.7%	
Bridge	1m37s	3.8%	
Gap infill	2m53s	6.8%	
Custom	5m19s	12.6%	
Travel	6m23s	15.0%	
Retract			
Unretract			
Wipe			
Seams			

Total estimation

Filament:	3.71 m	11.77 g
Cost:	0.29	
Prepare time:	5m7s	
Model printing time:	37m20s	
Total time:	42m27s	

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



2. Initiate the print using the built-in file.
Click "Print files" on the home page to access the built-in files on the SD card.

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Select the model you would like to print.



See also <https://wiki.bambulab.com/en/a1/manual/first-print-with-ams-lite>:

“1. Initiate a print job using Bambu Studio

Install the Bambu Studio:

Click here to [download Bambu Studio](https://bambulab.com/en/download/studio): <https://bambulab.com/en/download/studio>

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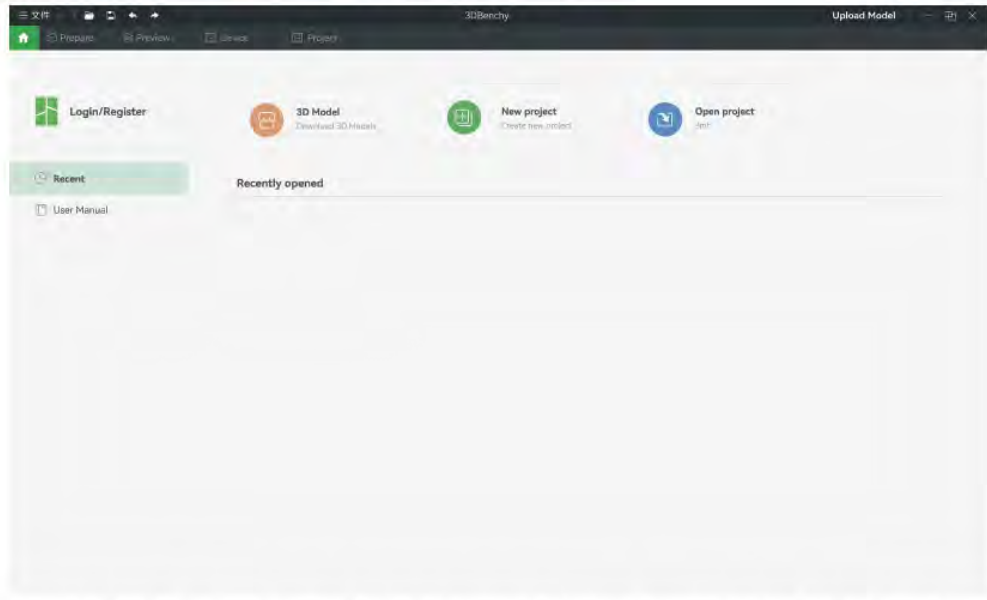
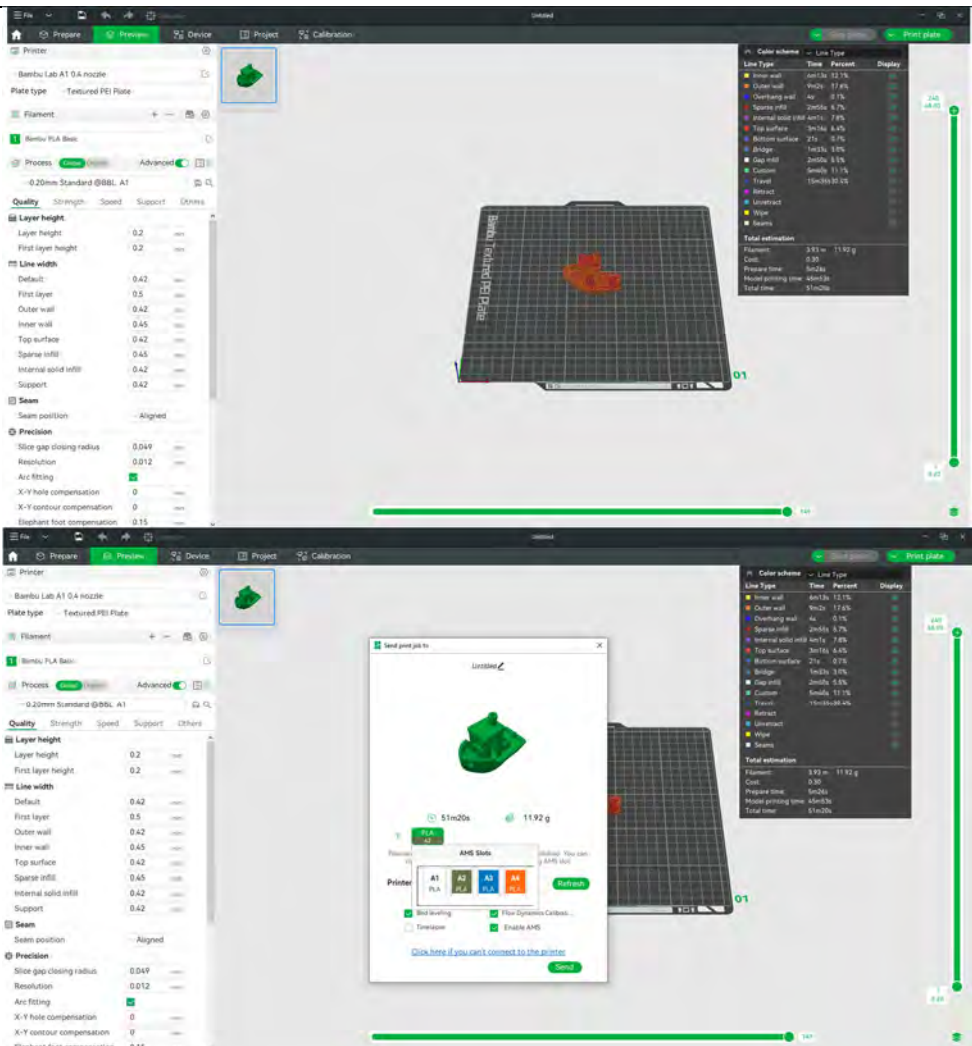
		<p>Bambu Studio</p> <p>Download Bambu Studio: https://bambulab.com/en/download/studio</p>  <p>Log in to Bambu Studio with your Bambu Lab account, which is the same for the Bambu Online store. Create or open a project.</p>
<p>Slice and send the print Select the model you want to print, click Slice Plate in the upper right corner, and then click Print Plate in the upper right corner.</p>		

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The image displays two screenshots of the Bambu Studio software interface, illustrating the process of initiating a print. The top screenshot shows the main interface with a 3D model of a green part on a grid. The bottom screenshot shows a 'Send print job to printer' dialog box overlaid on the interface, indicating the start of the print process.

2. Initiate a print using the built-in file
1. Click "Print files" on the home page to access the built-in files on the micro SD card.

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



2. Select the model you want to print.

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



3. Enable "Use AMS," and enabling the bed leveling and flow dynamics calibration functions is recommended.

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4. AMS filament Mapping

Map the actual filament used in the AMS lite to the filament specified in the print file. If no filament matches the color specified in the file, you can either place the specified filament in the AMS lite or choose another filament with the same properties and a close color match.

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



5. Click "Print"

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



“Initiate the print from the printer screen

We strongly recommend using a USB drive with your printer for storing printing recordings and historical print caches.

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



Click on "Print Files", then select the model you want to print.

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



Auto Bed leveling, flow dynamics calibration, and nozzle offset calibration are set to auto mode by default and can be adjusted as needed. Then click "Next".

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Select the appropriate filaments and start printing. Please note that the models preloaded in the printer or those stored on a USB are already sliced files, where the filament configurations in the sliced files are specifically matched to the extruder/hotend, making it impossible to forcefully switch to another extruder/hotend for printing.

If you are unable to select the filaments you want to print on the filaments matching page, you may need to adjust the filaments position appropriately by placing it into the AMS or external spool connected to another extruder.

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<https://wiki.bambulab.com/en/h2/manual/h2d-first-print>

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Bambu Lab 3-D printers include a fabrication tool and one or more sensors mechanically coupled to the fabrication tool.

For example, the Bambu Lab A1, A1 mini and H2D 3D printers include an extrusion nozzle and an extrusion force sensor (e.g., eddy force sensor).

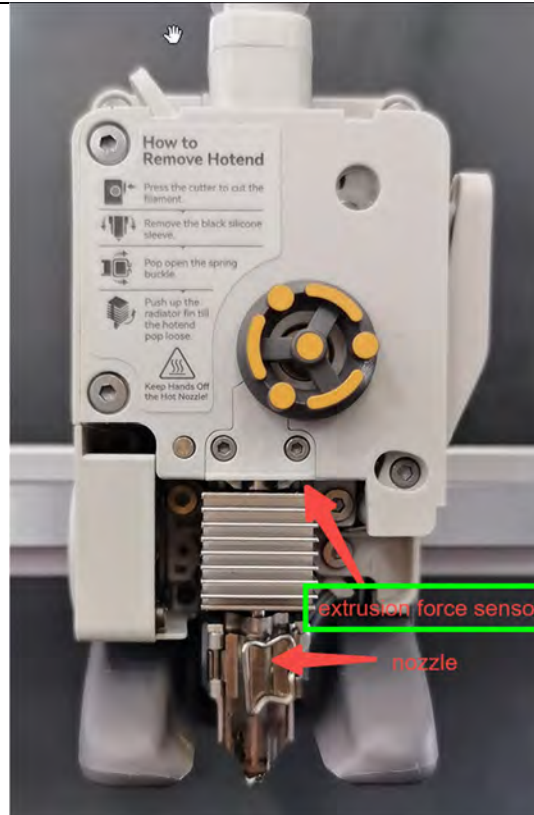
See e.g., <https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection> (describes the “the extrusion force sensor (eddy current sensor) in the tool head” on the A1 Mini printer); <https://wiki.bambulab.com/en/a1> (the “build plate detection” link on this page for the A1 printer links to the build plate detection article in the A1-mini manual at <https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection>):

“How to detect the build plate?

The principle of build plate position detection is to use the extrusion force sensor (eddy current sensor) in the tool head to detect the build plate. **When it starts the detection, the printer first lowers the tool head so that the nozzle touches the heatbed to confirm the zero coordinates in the Z direction. Then move to a specific position and move the tool head downwards to allow the nozzle to make a probing touch. If the build plate is placed, the nozzle will touch the part of the build plate to detect the change in force. If the build board is not placed, during the movement, it will only touch the air and no change in force will be detected, and the printer will determine that the build plate is not placed.”**

See also e.g., https://wiki.bambulab.com/en/a1-mini/troubleshooting/hmscode/0300_1A00_0002_0002:

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“A force sensor is installed above each hotend on the left and right sides of the toolhead, designed to detect the extrusion force applied by the hotend. Additionally, the force sensor is crucial for functions such as homing, leveling, nozzle Z offset calibration, and dynamic flow calibration. When the MC board fails to receive signals from the force sensor, this alarm is triggered.”

https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0003

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the one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure;

The Accused Instrumentalities include one or more sensors configured to detect a current contact force between the fabrication tool and a separate structure.

For example, in Bambu’s clump detection in both the A1,A1-mini and H2D printers, the nozzle making contact with the heat bed (during it’s “tentative touch” discussed in the excerpt below) indicates a clumping. The tentative touch is in the z direction, the extrusion axis.



How to detect the clumping?

The principle of nozzle clumping detection is to use the **extrusion force sensor (eddy current sensor)** to detect whether the nozzle is wrapped by the molten filament. When the detection is performed, the printer moves outside the heat bed and then makes a tentative touch. If the nozzle is not covered by filaments, the nozzle will only touch the air during this process, and the sensor will not detect any external force. If the nozzle is wrapped with filaments to form a thick mass, the mass will hit the heat bed during the above motion, and the extrusion force sensor will detect the change in force. Note: During this process, if the nozzle is wrapped by filaments or the build plate is not placed properly, the nozzle will touch the heat bed and the force change will be detected.

There are two types of nozzle clumping detection. After the detection is enabled, the printer will perform nozzle clumping detection when the following conditions are met:

- 1. After printing all the walls of the first object on the third layer of this plate, the tool head will move to the position of the purge wiper for the first detection.** The specific coordinates of the nozzle during detection: A1 mini (X-6, Y 170, Z-1); A1 (X 261, Y 250, Z-1). The detection process is shown in the following figure.

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<https://wiki.bambulab.com/en/a1-mini/manual/nozzle-warp-detection>; *see also* <https://wiki.bambulab.com/en/a1> (the “nozzle clumping detection” link on the A1 page links to <https://wiki.bambulab.com/en/a1-mini/manual/nozzle-warp-detection>).

Bambu Lab H2D:

“The Nozzle Eddy Sensor is used to detect whether the nozzle is wrapped by molten filament.”

<https://us.store.bambulab.com/products/nozzle-eddy-sensor>

Further, in Bambu’s build plate detection in both the A1 and A1-mini printers, the nozzle touches the heat bed to detect if the build plate is in place and detects a change in force. This touch is in the z direction, the extrusion axis.

The principle of build plate detection is to use the extrusion force sensor (eddy current sensor) in the tool head to detect the build plate. **When it starts the detection, the printer first lowers the tool head so that the nozzle touches the heat bed to confirm the zero coordinates in the Z direction. Then move to a specific position and move the tool head downwards to allow the nozzle to make a probing touch. If the build plate is placed, the nozzle will touch the part of the build plate to detect the change in force. If the build board is not placed, during the movement, it will only touch the air and no change in force will be detected, and the printer will determine that the build plate is not placed.**

<https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection>; <https://wiki.bambulab.com/en/a1> (the “build plate detection” link on this page for the A1 printer links to the build plate detection article in the A1-mini manual at <https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection>).

Further, in Bambu’s homing process in the A1, A1-mini and H2D printers, the nozzle touches the heat bed, with the eddy current sensor detecting whether the nozzle has made contact with the heat bed. [This touch is in the z direction, the extrusion axis.](#)

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Homing

A homing process refers to the printer detecting the stoppers for XYZ axes to determine the toolhead's zero coordinates in three-dimensional space. During the homing process, the printer uses the motors for X-axis (toolhead moving) and Y-axis (heatbed moving) to detect load to determine if they have reached their boundaries. For the Z-axis, homing will cause the toolhead to descend until the nozzle touches the heatbed. The eddy current sensor above the hotend will detect whether the nozzle has made contact with the heatbed.

<https://wiki.bambulab.com/en/a1/troubleshooting/homing-leveling-failure>; *see also*

<https://wiki.bambulab.com/en/a1-mini> (the “homing and leveling failure troubleshooting guide for A1 series” link on the A1-mini page links to <https://wiki.bambulab.com/en/a1/troubleshooting/homing-leveling-failure>).

Bambu Lab H2D:

“A force sensor is installed above each hotend on the left and right sides of the toolhead, designed to detect the extrusion force applied by the hotend. Additionally, the force sensor is crucial for functions such as homing, leveling, nozzle Z offset calibration, and dynamic flow calibration.”

https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0003

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

See also <https://wiki.bambulab.com/en/h2/manual/h2d-faq>:

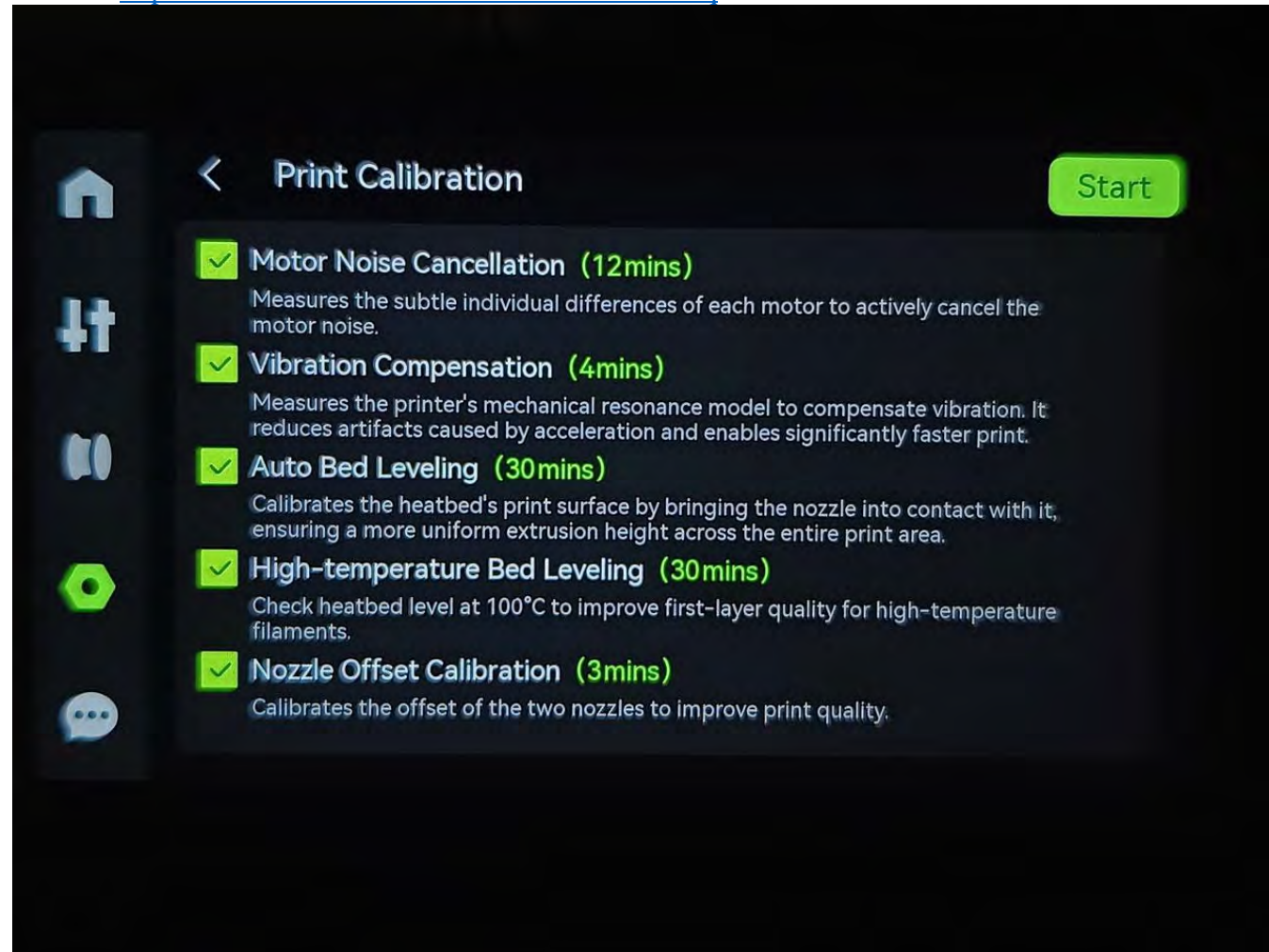


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detecting the current contact force based on a sensor signal from the one or more sensors; and

The Accused Instrumentalities are used for detecting the current contact force based on a sensor signal from the one or more sensors.

For example, the force sensor in the A1, A1-mini, and H2D detects a change in the current force to detect clumping.

See <https://wiki.bambulab.com/en/a1-mini/manual/nozzle-warp-detection>:



How to detect the clumping?

The principle of nozzle clumping detection is to use the extrusion force sensor (eddy current sensor) to detect whether the nozzle is wrapped by the molten filament. When the detection is performed, the printer moves outside the heat bed and then makes a tentative touch. If the nozzle is not covered by filaments, the nozzle will only touch the air during this process, and the sensor will not detect any external force. If the nozzle is wrapped with filaments to form a thick mass, the mass will hit the heat bed during the above motion, and the extrusion force sensor will detect the change in force. Note: During this process, if the nozzle is wrapped by filaments or the build plate is not placed properly, the nozzle will touch the heat bed and the force change will be detected.

There are two types of nozzle clumping detection. After the detection is enabled, the printer will perform nozzle clumping detection when the following conditions are met:

1. After printing all the walls of the first object on the third layer of this plate, the tool head will move to the position of the purge wiper for the first detection. The specific coordinates of the nozzle during detection: A1 mini (X-6, Y 170, Z-1); A1 (X 261, Y 250, Z-1). The detection process is shown in the following figure.

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	<p>Bambu Lab H2D:</p>
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“The Nozzle Eddy Sensor is used to detect whether the nozzle is wrapped by molten filament.”

<https://us.store.bambulab.com/products/nozzle-eddy-sensor>

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See also https://wiki.bambulab.com/en/a1-mini/troubleshooting/hmscode/0300_1A00_0002_0001:

HMS_0300-1A00-0002-0001: The nozzle is wrapped in the filament or the build plate is placed incorrectly

0300-1A00-0002-0001

 Edit

What it is

A1 series printers are equipped with the nozzle clumping detection function, you can refer to the wiki for details: [Nozzle clumping detection | Bambu Lab Wiki](#)

The extrusion force sensor is used to detect whether the nozzle is covered by filament, if the nozzle is covered by filament, or if the build plate is placed incorrectly, the force on the nozzle will change. When the nozzle clumping detection is enabled, the nozzle will move outside the heat bed and then continue to move down. If the nozzle is covered by the filament, forming a thick material mass, the process of the above movement will cause the material mass to hit the heat bed and cause the force change. The change in force will be detected by the extrusion force sensor (eddy current sensor coil).

Further, for build plate detection in the A1, A1-mini, and H2D the extrusion force sensor detects the current contact force.

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How to detect the build plate?

The principle of build plate detection is to use the extrusion force sensor (eddy current sensor) in the tool head to detect the build plate. **When it starts the detection, the printer first lowers the tool head so that the nozzle touches the heat bed to confirm the zero coordinates in the Z direction. Then move to a specific position and move the tool head downwards to allow the nozzle to make a probing touch. If the build plate is placed, the nozzle will touch the part of the build plate to detect the change in force. If the build board is not placed, during the movement, it will only touch the air and no change in force will be detected, and the printer will determine that the build plate is not placed.**

<https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection>

Further, for the homing process in the A1, A1-mini, and H2D the extrusion force sensor (eddy current sensor) will detect whether the nozzle has made contact (force) with the heat bed.

Homing

A homing process refers to the printer detecting the stoppers for XYZ axes to determine the toolhead's zero coordinates in three-dimensional space. During the homing process, the printer uses the motors for X-axis (toolhead moving) and Y-axis (heatbed moving) to detect load to determine if they have reached their boundaries. For the Z-axis, homing will cause the toolhead to descend until the nozzle touches the heatbed. The eddy current sensor above the hotend will detect whether the nozzle has made contact with the heatbed.

<https://wiki.bambulab.com/en/a1/troubleshooting/homing-leveling-failure>

Bambu Lab H2D:

“A force sensor is installed above each hotend on the left and right sides of the toolhead, designed to detect the extrusion force applied by the hotend. Additionally, the force sensor is crucial for functions such as homing, leveling, nozzle Z offset calibration, and dynamic flow calibration.”

https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0003

See also <https://wiki.bambulab.com/en/h2/manual/h2d-faq>:

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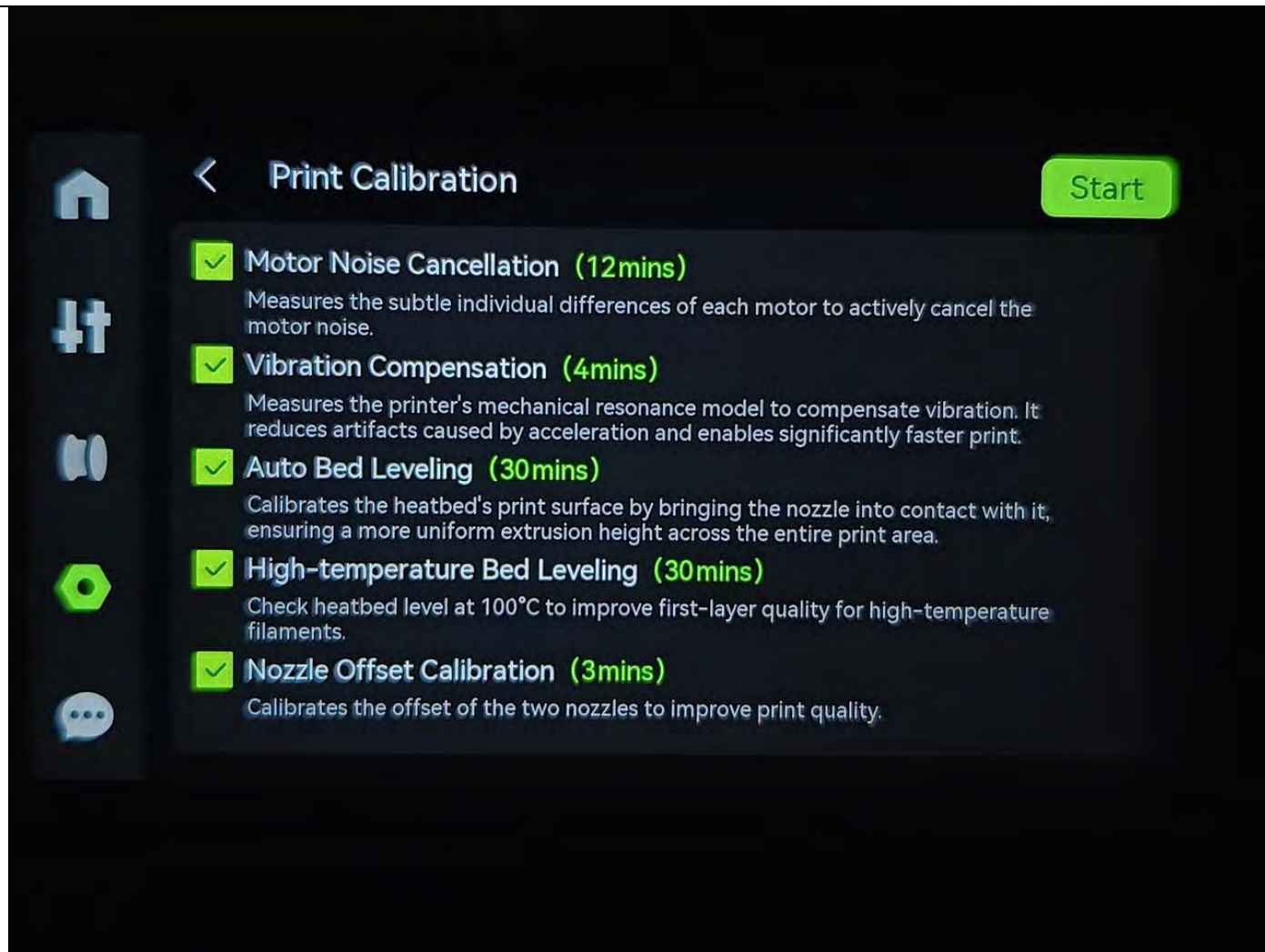


Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

<p>creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build.</p>	<p>The Accused Instrumentalities are each used for creating a control signal to control at least one component of the three-dimensional printer in response to the current contact force while depositing material during the build.</p> <p>For example, when the A1 or A1-mini printer detects nozzle clumping (in response to the current contact force while depositing material during the build), the printer automatically stops printing by creating a control signal to stop operation of the printer (e.g., including but not limited to the extruder).</p> <p>See e.g., https://wiki.bambulab.com/en/a1-mini/manual/nozzle-warp-detection:</p>
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Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

Nozzle clumping detection

This guide describes the nozzle clumping detection feature for A1 series printers

[Edit](#)

What is the nozzle clumping detection?

Nozzle clumping usually refers to the phenomenon that the nozzle is wrapped by the filament during printing because the filament is not stuck on the build plate or some other reasons, resulting in printing failure or even damage to the hot end, extruder, and other parts, as shown in the following figure.

Because of the possibility of damage to the printer, the Bambu A1 series is equipped with a nozzle clumping detection feature to deal with this situation, when the printer detects that the nozzle is wrapped in molten filament, it automatically stops printing and alerts it to avoid further damage to the printer after the wrapping.



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	Bambu Lab H2D:
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Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

“The Nozzle Eddy Sensor is used to detect whether the nozzle is wrapped by molten filament.”

<https://us.store.bambulab.com/products/nozzle-eddy-sensor>

Further, for build plate detection, the printing will start (control signal) when the build plate is properly placed (the extrusion forces sensor detects a change in force).

The build plate needs to be properly placed on the heat bed before starting the printing task,

How to detect the build plate?

The principle of build plate detection is to use the extrusion force sensor (eddy current sensor) in the tool head to detect the build plate. **When it starts the detection, the printer first lowers the tool head so that the nozzle touches the heat bed to confirm the zero coordinates in the Z direction. Then move to a specific position and move the tool head downwards to allow the nozzle to make a probing touch. If the build plate is placed, the nozzle will touch the part of the build plate to detect the change in force. If the build board is not placed, during the movement, it will only touch the air and no change in force will be detected, and the printer will determine that the build plate is not placed.**

<https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection>

Further, for the homing process, the printer will need to perform a successful homing (control signal) to perform the heat bed leveling, where the heat bed will need to be leveled before printing.

Before heatbed leveling, the printer will first perform homing. Therefore, the issues above will also cause the leveling to fail. If homing succeeds but leveling fails, common reasons are as follows:

Before printing on Bambu Studio or on the screen of the printer, select **Bed leveling** so that the printer will level the heatbed before starting printing.

<https://wiki.bambulab.com/en/a1/troubleshooting/homing-leveling-failure>

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

	Bambu Lab H2D:
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Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

“A force sensor is installed above each hotend on the left and right sides of the toolhead, designed to detect the extrusion force applied by the hotend. Additionally, the force sensor is crucial for functions such as homing, leveling, nozzle Z offset calibration, and dynamic flow calibration.”https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0003

See also <https://wiki.bambulab.com/en/h2/manual/h2d-faq>:

See also <https://wiki.bambulab.com/en/h2/manual/h2d-faq>:

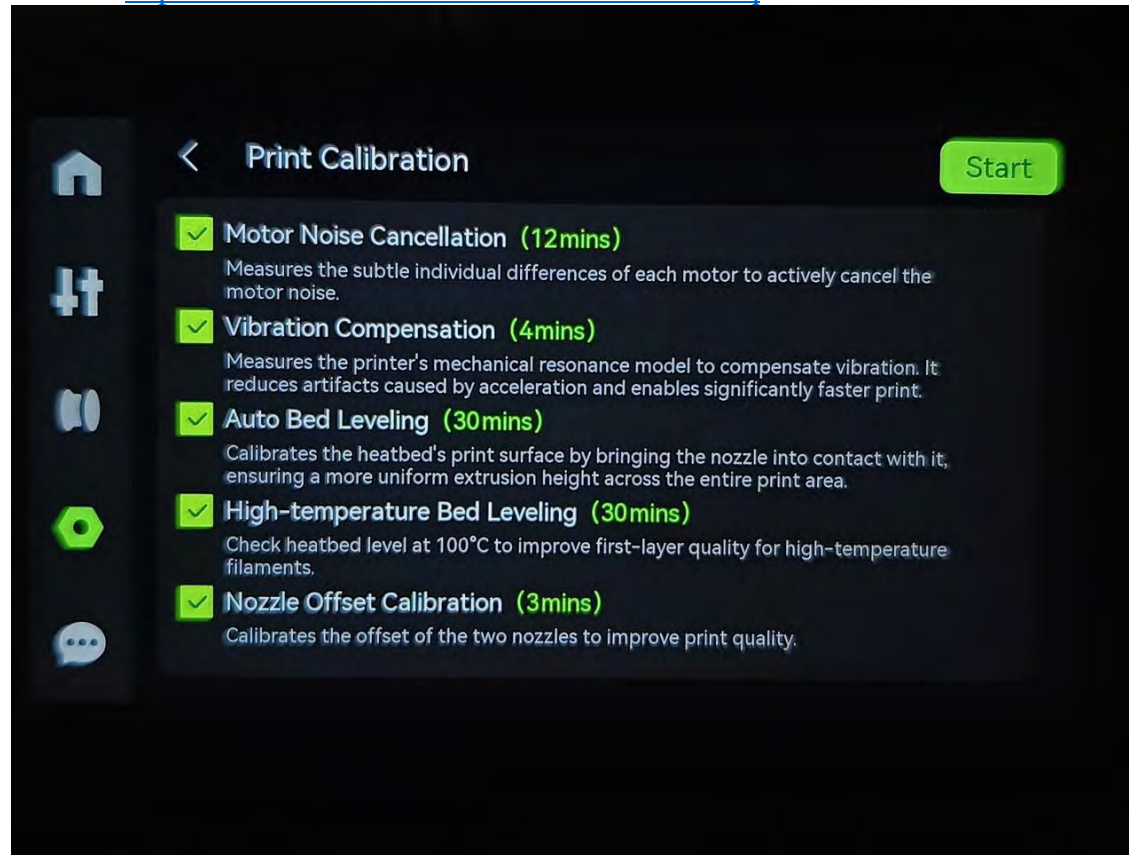


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<p>2. The method of claim 1, wherein the fabrication tool includes an extruder.</p>	<p>For each of the Accused Instrumentalities, the fabrication tool includes an extruder, as shown below:</p> <p>Extruder unit</p> <hr/> <p>The extruder motor and extruder gears are essential components of the extruder unit. The extruder motor pulls the filament from the spool and feeds it into the hotend. Once heated and melted, the filament is extruded through the nozzle to create the printed model. The extruder motor is critical in accurately controlling the length of filament extruded through the hotend and is a core component of a 3D printer.</p> <p>“Extruder unit</p> <p>The extruder motor and extruder gears are essential components of the extruder unit. The extruder motor pulls the filament from the spool and feeds it into the hotend. Once heated and melted, the filament is extruded through the nozzle to create the printed model. The extruder motor is critical in accurately controlling the length of filament extruded through the hotend and is a core component of a 3D printer.</p>
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Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



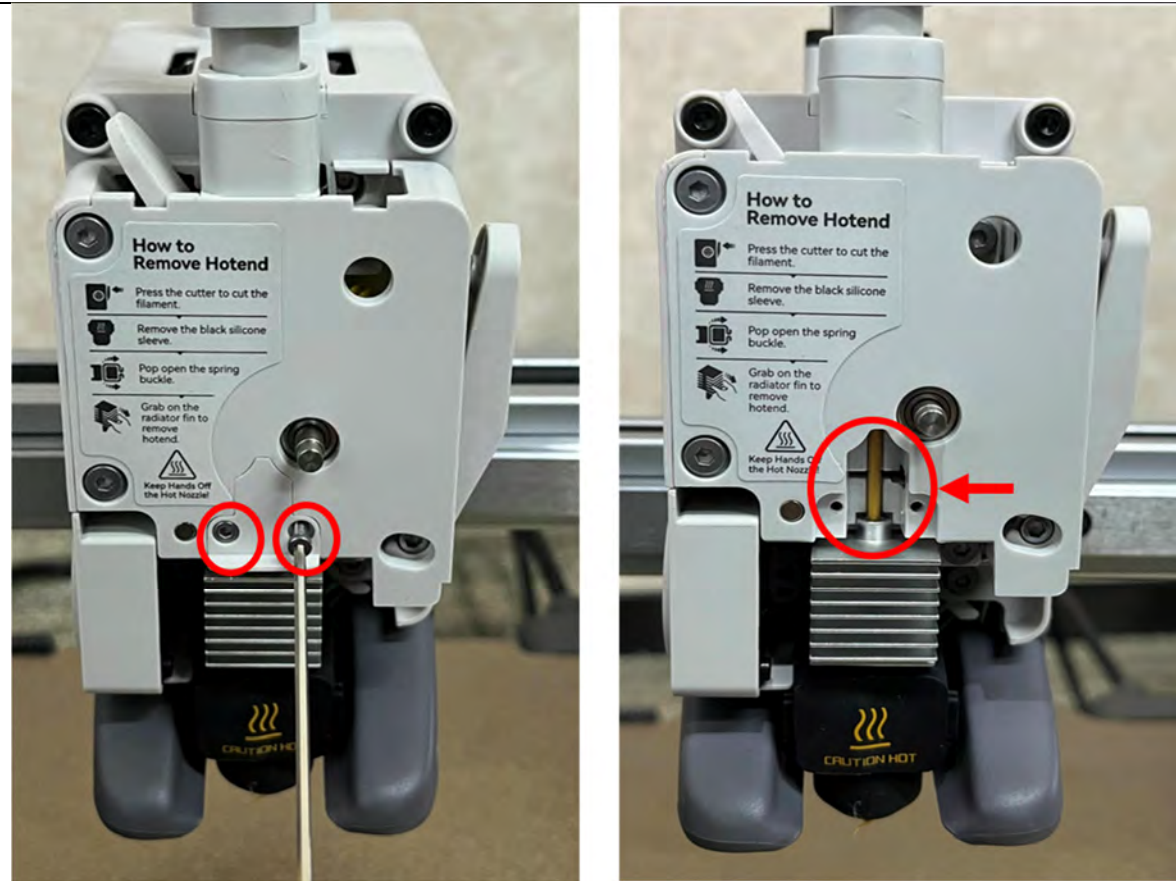
**Internal Gear Structure
of the Extruder**



Extruder motor

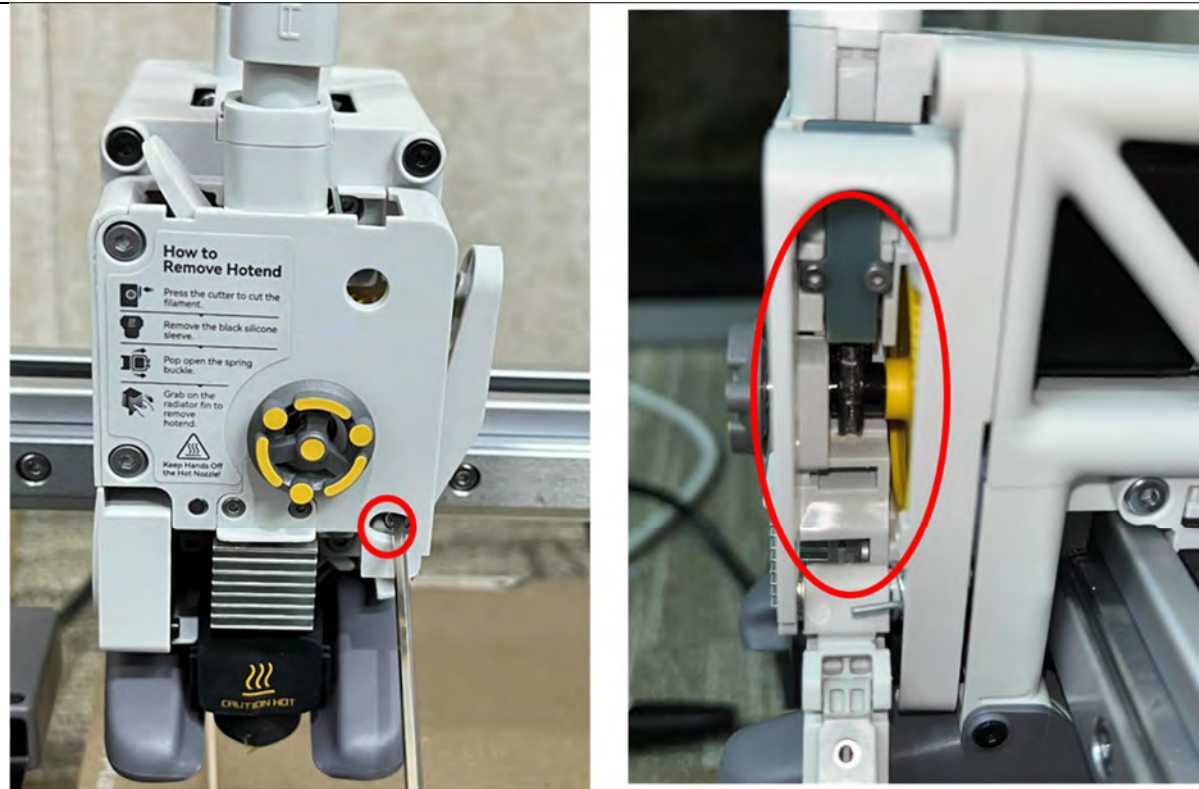
In the extruder unit, this small cover can be removed to observe the situation of filament clogging in the extruder gear.

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



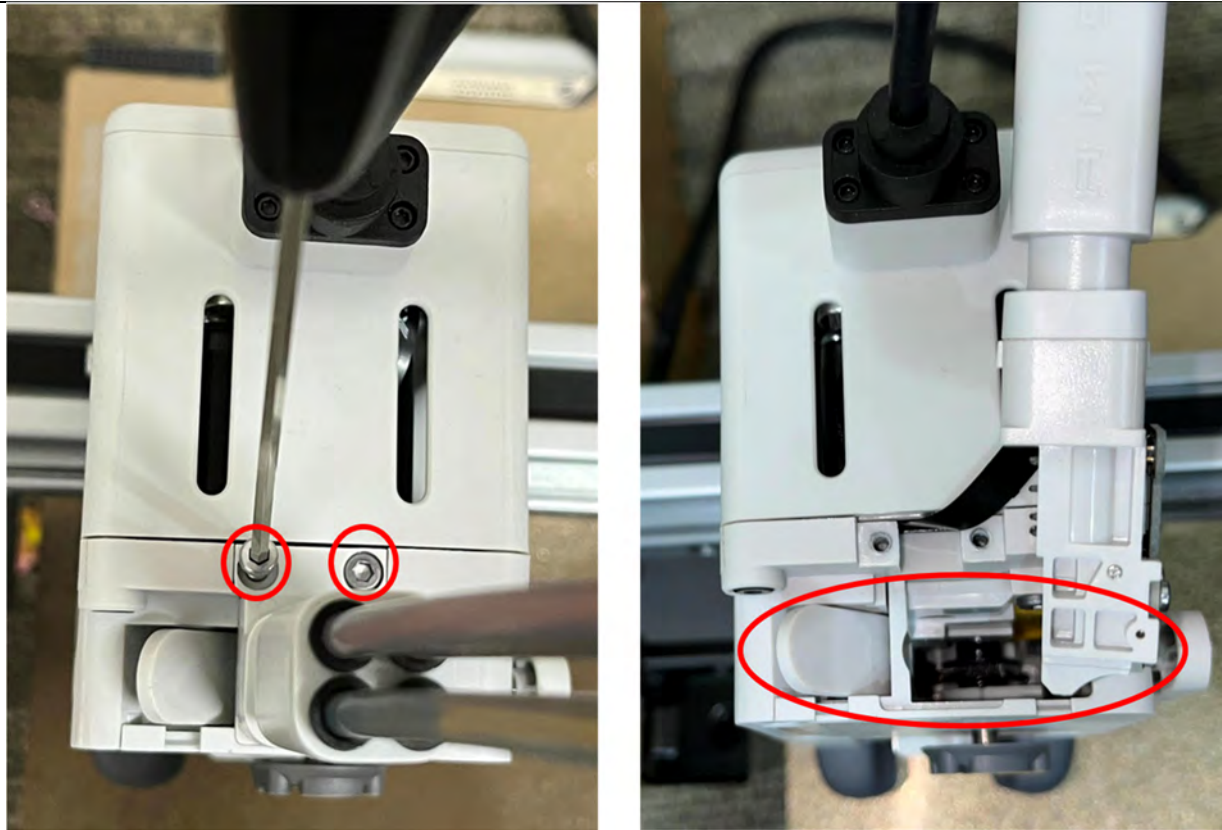
The extruder gear can also be observed from the side by releasing the cutter lever. When filament powder accumulates in the extruder gear, this position can be used to clean the residue.

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The filament hub can be carefully removed from the top (please be cautious when pulling the cable of the filament sensor), allowing observation from the top to check if the extruder gear is clogged.

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<https://wiki.bambulab.com/en/a1/manual/intro-a1>

See also <https://wiki.bambulab.com/en/a1-mini/manual/intro-a1-mini>:

“Extruder unit

The extruder motor and extruder gears are essential components of the extruder unit. The extruder motor pulls the filament from the spool and feeds it into the hotend. Once heated and melted, the filament is extruded through the nozzle to create the printed model. The extruder motor is critical in accurately controlling the length of filament extruded through the hotend and is a core component of a 3D printer.

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



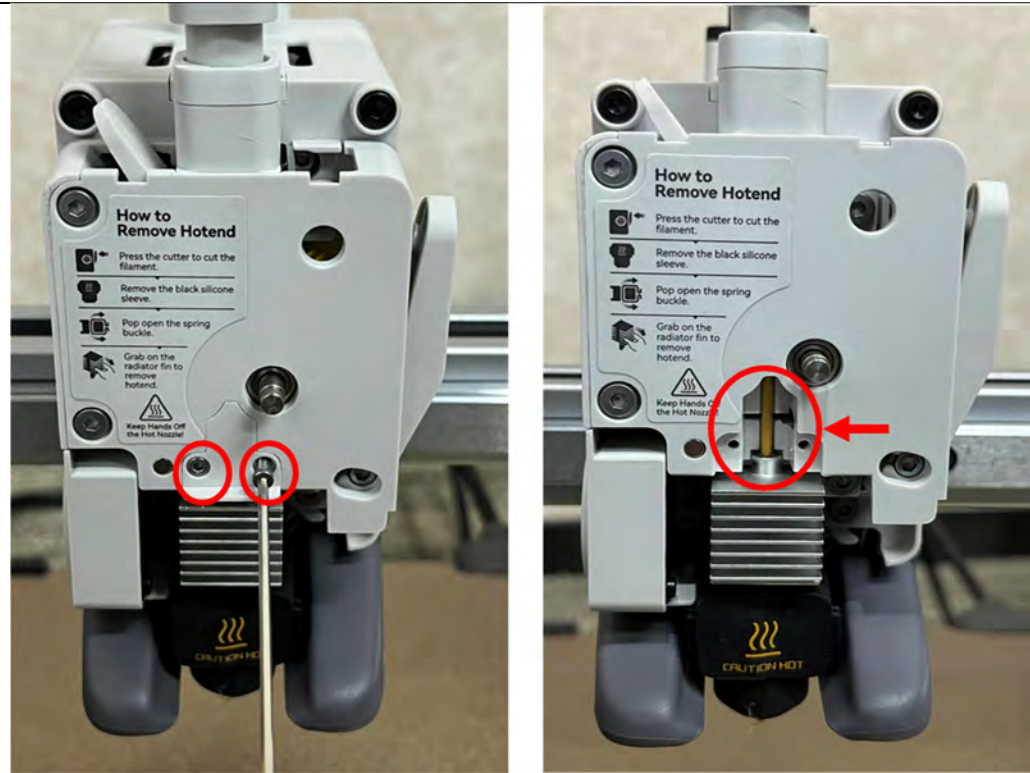
Internal Gear Structure
of the Extruder



Extruder motor

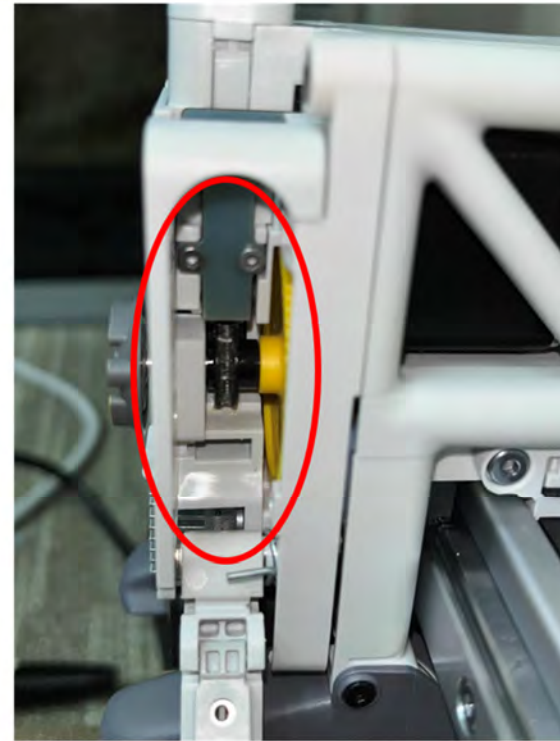
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Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



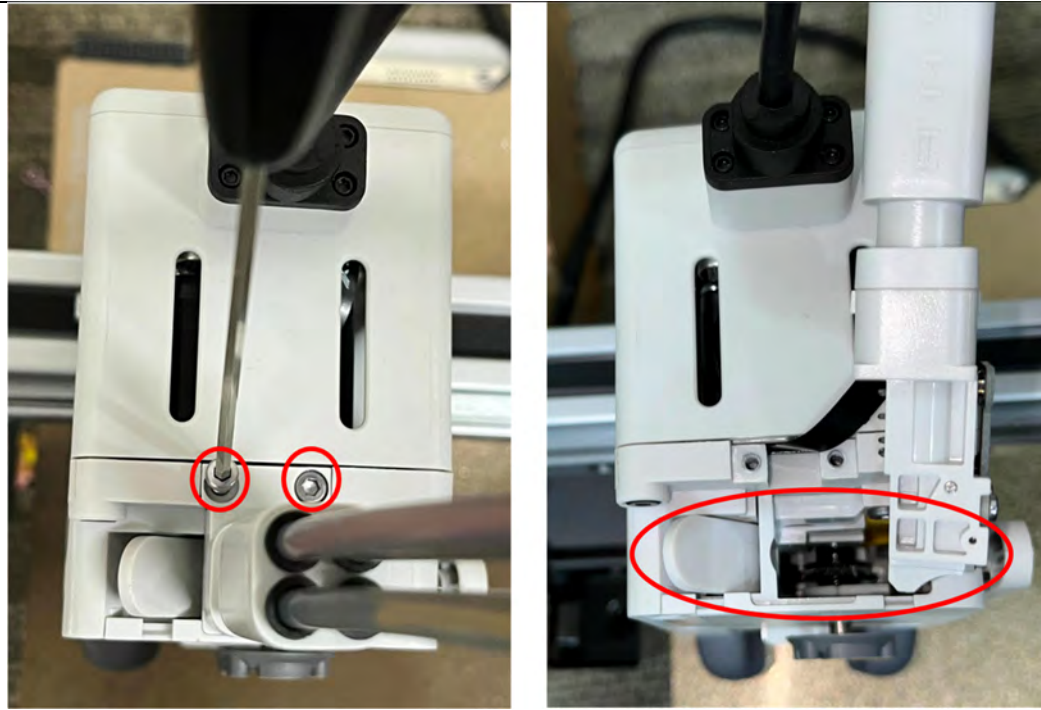
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Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



The filament hub can be carefully removed from the top (please be cautious when pulling the cable of the filament sensor), allowing observation from the top to check if the extruder gear is clogged.

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See also <https://wiki.bambulab.com/en/h2/manual/h2d-intro>:

“Extruder

The extruder is responsible for pulling the filament out of the spool and feeding it into the hotend. After heating and melting, it is extruded through the nozzle to generate a printed model.

The extruder needs to accurately control the length of extrusion and retraction of the filament to ensure the dimensional accuracy and appearance quality of the printed model. It is one of the core components of a 3D printer.

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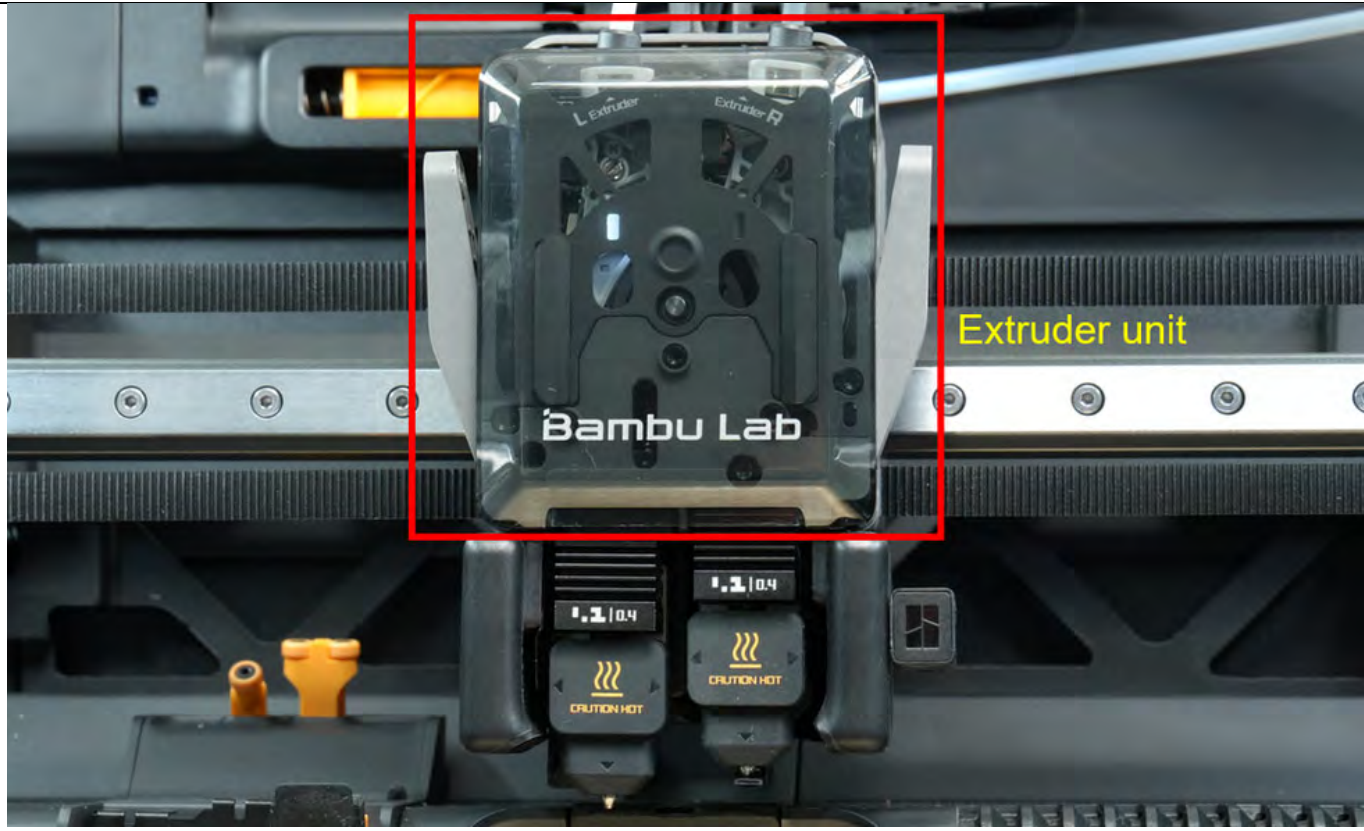


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<p>3. The method of claim 2, wherein the at least one component of the three-dimensional printer controls a feed rate for a build material used in the build.</p>	<p>For each of the Accused Instrumentalities, the at least one component of the three-dimensional printer controls a feed rate for a build material used in the build.</p> <p>For example, the A1 printer includes extruder control that operates using flow calibration.</p> <p>“Extruder unit The extruder motor and extruder gears are essential components of the extruder unit. The extruder motor pulls the filament from the spool and feeds it into the hotend. Once heated and melted, the filament is extruded through the nozzle to create the printed model. The extruder motor is critical in accurately controlling the length of filament extruded through the hotend and is a core component of a 3D printer.”</p> <p>https://wiki.bambulab.com/en/a1/manual/intro-a1</p> <p>The A1 mini additionally includes an extruder:</p> <p>“Extruder unit</p>
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The extruder motor and extruder gears are essential components of the extruder unit. The extruder motor pulls the filament from the spool and feeds it into the hotend. Once heated and melted, the filament is extruded through the nozzle to create the printed model. The extruder motor is critical in accurately controlling the length of filament extruded through the hotend and is a core component of a 3D printer.”

<https://wiki.bambulab.com/en/a1-mini/manual/intro-a1-mini>

The extruder unit of the A1 (as described at <https://wiki.bambulab.com/en/a1/manual/intro-a1>) and the A1 mini (as described at <https://wiki.bambulab.com/en/a1-mini/manual/intro-a1-mini>) pulls the filament from the spool and feeds it to the hot end assembly of the tool head module at a feed rate.

The extruder unit of the A1, A1-mini [and H2D](#) printers supports flow dynamics calibration. [See https://wiki.bambulab.com/en/software/bambu-studio/calibration_pa:](#)

“Flow Dynamics Calibration What is Flow Dynamics Calibration ?

From fluid mechanics, when a newtonian fluid flow through a hole, it needs pressure, and the pressure is proportional to the flow rate.

As the filament is not rigid body, when the extruder starts to extrude, the filament will be compressed to generate the pressure. The compression process will delay the response of the real flow, as the extruder only provides the amount of the filament that needs to extrude, no extra.

So we implemented the flow dynamic control to solve the problem, similar to the "Pressure advance" in Klipper or the "Linear advance" in Marlin, with some non-linear effect compensation added. When executing a flow rate cmd, the printer will do a fast extra extrusion to generate the pressure as fast as possible, to make the response of the flow can catch the response of the toolhead movement.

But how much "extra" extrusion is needed for a specific filament? As different filament has different stiffness and viscosity, under a certain flow rate, different filaments will need different amount. That's why flow dynamics calibration is needed.

....

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Especially for A1 Series printer, Flow Dynamics Calibration uses the eddy current sensor to detect the extrusion pressure, and if a third-party hotend is used, the calibration results may be inaccurate;”

....

A1 Series Printer

For A1 series printer, the flow dynamics calibration process is to discharge material at the position of the discharge assembly during the printing preparation stage, and calculate the suitable K value for the material based on the pressure changes detected by the eddy current sensor above the hotend. **If "Flow Dynamics Calibration" is checked before printing, a flow calibration will be performed when each filament of this printing task is replaced for the first time, so all materials used in this printing task will be calibrated by flow (supported since version 01.03.00.00).**

This calibration method is greatly affected by the hotend. Please ensure that you are using the official Bambu hot end. If you use a third-party hotend, the calibration value may be inaccurate.

In addition, due to the limitation of the maximum extrusion flow rate, when using a 0.2mm nozzle for calibration, it usually takes a long time to extrude, so please be patient.”

Bambu Lab H2D:

“A force sensor is installed above each hotend on the left and right sides of the toolhead, designed to detect the extrusion force applied by the hotend. Additionally, the force sensor is crucial for functions such as homing, leveling, nozzle Z offset calibration, and dynamic flow calibration.”

https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0003

The Bambu Lab H2D uses an eddy sensor for dynamic flow calibration. *See, e.g.,* <https://forum.bambulab.com/t/h2d-dynamic-flow-calibration/161819/5>.

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<p>4. The method of claim 2, wherein the at least one component of the three-dimensional printer controls a z-distance between the extruder and a build platform of the three-dimensional printer</p>	<p>For each of the Accused Instrumentalities, the at least one component of the three-dimensional printer controls a z-distance between the extruder and a build platform of the three-dimensional printer.</p> <p>For example, the A1 printer controls the z-distance between the extruder and the heat bed.</p> <p>Z-axis motion</p> <hr/> <p>The Z-axis motion system controls the vertical position of the print head relative to the print bed. It consists of dual optical shaft-linear bearing guide components, dual lead screws with nuts, stepper motors, and synchronous belt drive components. The dual lead screws are connected in series with the stepper motor through a synchronous belt, enabling synchronized motion of the two lead screws. Additionally, the synchronous belt is equipped with a quick tensioner and combined with a tension detection algorithm to ensure optimal tension range, ensuring precise and stable motion of the print head in the Z-axis direction.</p> <p>By simultaneously controlling the movement of the X-axis, Y-axis, and Z-axis, the A1 can achieve precise motion of the print head in all three directions. Typically, these movements are controlled by motors and their corresponding drive circuits, with the machine controller reading the print file and sending instructions to control the motion path and speed of the print head.</p> <p>https://wiki.bambulab.com/en/a1/manual/intro-a1</p> <p>The A1 mini also controls the z-distance between the extruder and the heat bed.</p>
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Z-axis motion

The Z-axis motion is used to control the vertical position of the printhead relative to the print platform. It comprises a lead screw, nut, coupling, and stepper motor. The stepper motor drives the lead screw to rotate through the coupling, thereby controlling the Z-axis motion of the tool head.

The A1 mini can precisely position the printhead in all three directions by controlling the X-axis, Y-axis, and Z-axis motion. Typically, these motions are controlled by motors and corresponding driver circuits. The print head's motion path and speed can be controlled by reading the print file through the machine controller and sending instructions.

<https://wiki.bambulab.com/en/a1-mini/manual/intro-a1-mini>

The H2D printer also controls the z-distance between the extruder and the heat bed.

Z-axis

The Z-axis of the printer consists of 3 lead screws, which are connected to the Z-axis stepper motor through a belt.

<https://wiki.bambulab.com/en/h2/manual/h2d-intro>

See also https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0008:

“During the homing, leveling, and hotend Z offset calibration process of the 3D printer, the nozzle lightly touches the heatbed to determine its precise position. However, if there are foreign objects between the nozzle and the heatbed, the printer will detect abnormal touch data. This causes the nozzle to attempt touching at the same position multiple times, eventually leading the heatbed to automatically lower by a certain distance and trigger an error message.”

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<p>5. The method of claim 2 further comprising comparing the current contact force to an expected contact force.</p>	<p>The Accused Instrumentalities are each used for comparing the current contact force to an expected contact force.</p> <p>For example, the Bambu A1, A1 mini and H2D use the extrusion force sensor (of the fabrication tool) to make a tentative touch with the heat bed. If there is no filament on the nozzle, the nozzle will only touch air (expected contact force). If there is filament on the nozzle to form a mass, the mass will contact the heat bed, and the extrusion force sensor will detect a change in force (current contact force):</p> <p>The principle of nozzle clumping detection is to use the extrusion force sensor (eddy current sensor) to detect whether the nozzle is wrapped by the molten filament. When the detection is performed, the printer moves outside the heat bed and then makes a tentative touch. If the nozzle is not covered by filaments, the nozzle will only touch the air during this process, and the sensor will not detect any external force. If the nozzle is wrapped with filaments to form a thick mass, the mass will hit the heat bed during the above motion, and the extrusion force sensor will detect the change in force. Note: During this process, if the nozzle is wrapped by filaments or the build plate is not placed properly, the nozzle will touch the heat bed and the force change will be detected.</p> <hr/> <p>https://wiki.bambulab.com/en/a1-mini/manual/nozzle-warp-detection</p> <p>Bambu Lab H2D:</p>
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“The Nozzle Eddy Sensor is used to detect whether the nozzle is wrapped by molten filament.”

<https://us.store.bambulab.com/products/nozzle-eddy-sensor>

Further, the Bambu A1 and A1 mini use the extrusion force sensor (of the fabrication tool) to touch the heat bed during build plate detection. If the build plate is placed, the nozzle will touch the build plate (expected contact force). If the build plate is not placed, the nozzle will only touch air, and the extrusion force sensor will not detect a change in force (current contact force).

The principle of build plate detection is to use the extrusion force sensor (eddy current sensor) in the tool head to detect the build plate. **When it starts the detection, the printer first lowers the tool head so that the nozzle touches the heat bed to confirm the zero coordinates in the Z direction. Then move to a specific position and move the tool head downwards to allow the nozzle to make a probing touch. If the build plate is placed, the nozzle will touch the part of the build plate to detect the change in force. If the build board is not placed, during the movement, it will only touch the air and no change in force will be detected, and the printer will determine that the build plate is not placed.**

<https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection>

Further, the Bambu A1, A1 mini and H2D use the extrusion force sensor (of the fabrication tool) to touch the heat bed during the homing process. The force sensor can detect if the nozzle touches the build plate (expected contact force). If the force sensor does not detect contact with the build plate by the nozzle (current contact force), an error has occurred such as the force sensor having an open circuit.

Homing

A homing process refers to the printer detecting the stoppers for XYZ axes to determine the toolhead's zero coordinates in three-dimensional space. During the homing process, the printer uses the motors for X-axis (toolhead moving) and Y-axis (heatbed moving) to detect load to determine if they have reached their boundaries. For the Z-axis, homing will cause the toolhead to descend until the nozzle touches the heatbed. The eddy current sensor above the hotend will detect whether the nozzle has made contact with the heatbed.

<https://wiki.bambulab.com/en/a1/troubleshooting/homing-leveling-failure>

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	<p>Bambu Lab H2D: “A force sensor is installed above each hotend on the left and right sides of the toolhead, designed to detect the extrusion force applied by the hotend. Additionally, the force sensor is crucial for functions such as homing, leveling, nozzle Z offset calibration, and dynamic flow calibration.” https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0003</p> <p>See also https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0008: “During the homing, leveling, and hotend Z offset calibration process of the 3D printer, the nozzle lightly touches the heatbed to determine its precise position. However, if there are foreign objects between the nozzle and the heatbed, the printer will detect abnormal touch data. This causes the nozzle to attempt touching at the same position multiple times, eventually leading the heatbed to automatically lower by a certain distance and trigger an error message.”</p>
<p>7. The method of claim 5 further comprising terminating the build when a difference between the current contact force and the expected contact force indicates a fabrication error.</p>	<p>The Accused Instrumentalities are each used for terminating the build when a difference between the current contact force and the expected contact force indicates a fabrication error.</p> <p>For example, the Bambu A1, A1 mini and H2D stop printing (terminate the build) when nozzle clumping is detected (difference between current non-zero contact force and expected zero contact force is detected).</p> <p>What is the nozzle clumping detection?</p> <hr/> <p>Nozzle clumping usually refers to the phenomenon that the nozzle is wrapped by the filament during printing because the filament is not stuck on the build plate or some other reasons, resulting in printing failure or even damage to the hot end, extruder, and other parts, as shown in the following figure.</p> <p>Because of the possibility of damage to the printer, the Bambu A1 series is equipped with a nozzle clumping detection feature to deal with this situation, when the printer detects that the nozzle is wrapped in molten filament, it automatically stops printing and alerts it to avoid further damage to the printer after the wrapping.</p> <p>https://wiki.bambulab.com/en/a1-mini/manual/nozzle-warp-detection</p> <p>Bambu Lab H2D:</p>

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“The Nozzle Eddy Sensor is used to detect whether the nozzle is wrapped by molten filament.”
<https://us.store.bambulab.com/products/nozzle-eddy-sensor>

Further, the Bambu A1 and A1 mini will not start printing (terminate the build) when the build plate is not detected (difference between current contact force and expected contact force is detected).

The principle of build plate detection is to use the extrusion force sensor (eddy current sensor) in the tool head to detect the build plate. **When it starts the detection, the printer first lowers the tool head so that the nozzle touches the heat bed to confirm the zero coordinates in the Z direction. Then move to a specific position and move the tool head downwards to allow the nozzle to make a probing touch. If the build plate is placed, the nozzle will touch the part of the build plate to detect the change in force. If the build board is not placed, during the movement, it will only touch the air and no change in force will be detected, and the printer will determine that the build plate is not placed.**

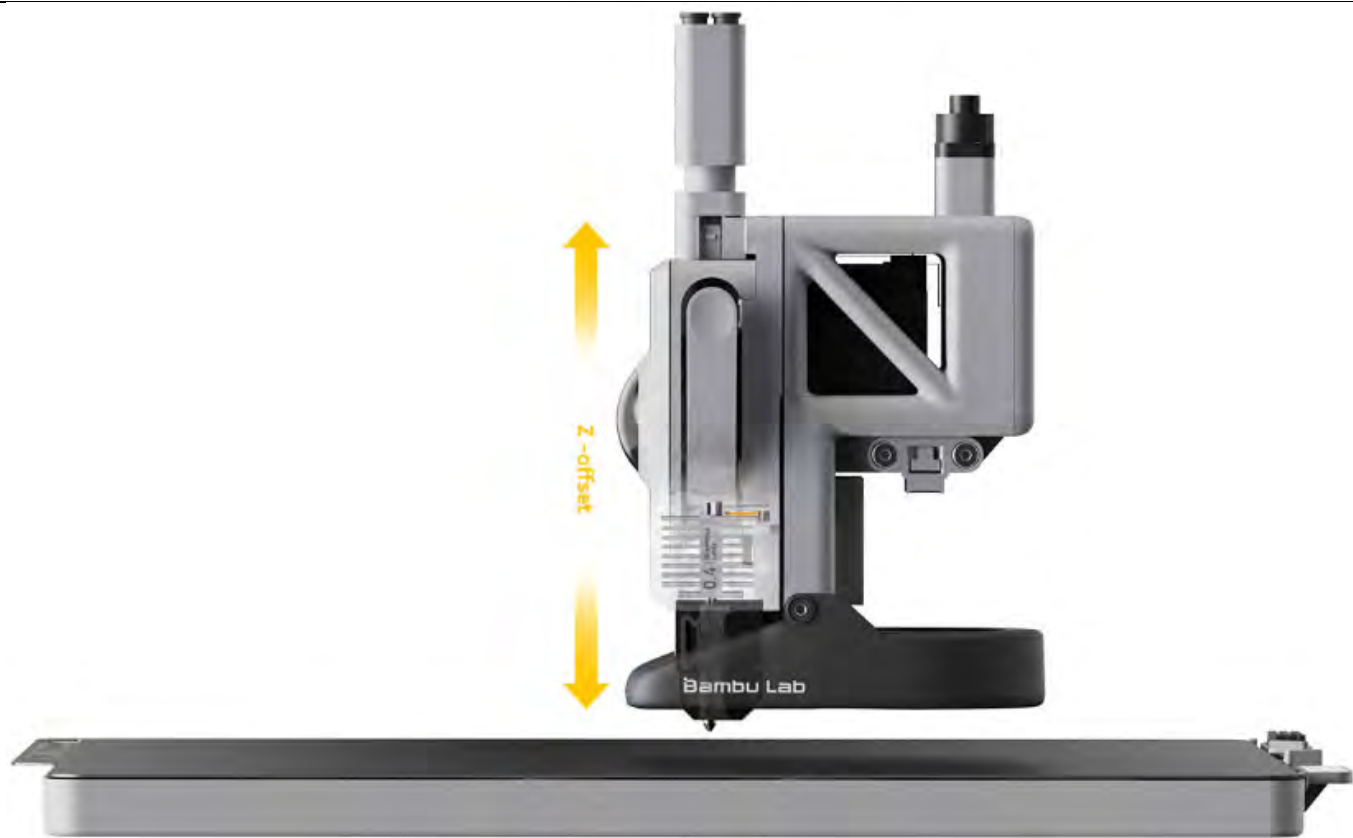
As we all know, in the 3D printing process, the nozzle extrudes the molten filament on the build plate to build a 3D model, so the build plate needs to be placed on the heat bed before printing. The A1 series printers are equipped with the build plate detection function, the printer can detect whether the user has placed the build plate properly before the printing starts, avoiding direct printing on the heat bed and causing printing failure or even damage to the heat bed. The following image is an error demonstration of a printer printing directly on the heat bed:

<https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection>

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<p>8. The method of claim 1 wherein the control signal includes a signal to the three-dimensional printer to change a distance between the fabrication tool and the separate structure.</p>	<p>For each of the Accused Instrumentalities, the control signal includes a signal to the three-dimensional printer to change a distance between the fabrication tool and the separate structure.</p> <p>For example, the A1/A1 mini can change the distance between the extruder (fabrication tool) and the heat bed (separate structure), as shown at https://bambulab.com/en/a1 and the images below.</p> <p>A1 handles various calibrations all by itself. It meticulously calibrates the Z-offset, bed-level, vibration resonance and nozzle pressure for EVERY print job, automatically.</p> <p>A1 probes the bed with the nozzle to measure the absolute Z-offset. No need to stick a paper as reference.</p>
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Similar A1 mini features are described at <https://bambulab.com/en/a1-mini>:

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Auto Filament Loading
Full-Auto Calibration
Auto Bed-Level

**Goodbye to Tedious
Manual Calibration And
Tuning**

A1 mini handles various calibrations all by itself. It meticulously calibrates the Z-offset, bed-level, vibration resonance and nozzle pressure for EVERY print job, automatically.

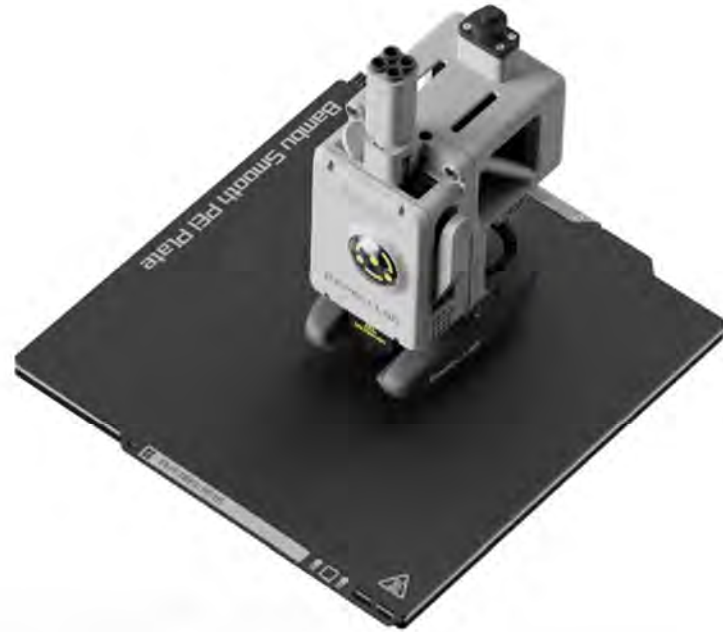


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Auto Bed-Level

Auto Z-Offset

Auto Vibration Calibration

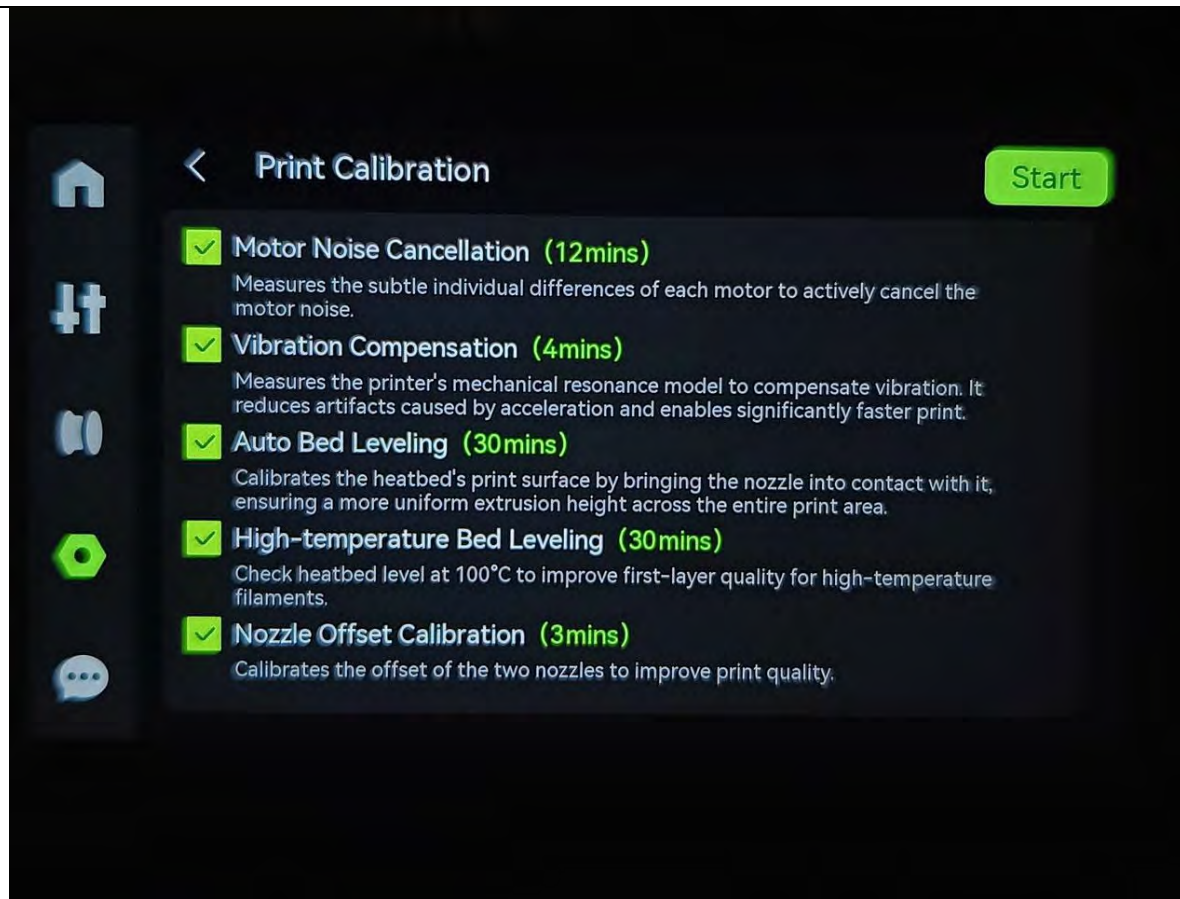
No More "Paper Method"

A1 mini probes the bed with the nozzle to measure the absolute z-offset. No need to stick a paper as reference.



The H2D also can change the distance between the extruder (fabrication tool) and the heat bed (separate structure) as shown at <https://wiki.bambulab.com/en/h2/manual/h2d-faq>:

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“ [T]he ordinary nozzle offset calibration (eddy current coil calibration solution) already includes the offset calibration in the Z direction, so as long as the ordinary nozzle offset calibration is performed, the offset data in the Z direction can continue to be used without any additional risks.”

See also https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0008:

“During the homing, leveling, and hotend Z offset calibration process of the 3D printer, the nozzle lightly touches the heatbed to determine its precise position. However, if there are foreign objects between the nozzle and the heatbed, the printer will detect abnormal touch data. This causes the nozzle to attempt touching at the

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same position multiple times, eventually leading the heatbed to automatically lower by a certain distance and trigger an error message.”

Further, in response to build plate detection (control signal), the A1 or A1 mini printer changes a distance between the tool and the separate structure (heat bed), as shown in the two images below. Specifically, the distance between the extruder (fabrication tool) and the heat bed (separate structure) is increased from the first image to the second image in response to a build plate not being detected (control signal), as shown by the display on the printer.



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<https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection>

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9. The method of claim 2 wherein the control signal includes a signal to the three-dimensional printer to change a feed rate of build material extruded by the extruder.

For each of the Accused Instrumentalities, the control signal includes a signal to the three-dimensional printer to change a feed rate of build material extruded by the extruder.

The A1 includes an extruder, as shown below:

Extruder unit

The extruder motor and extruder gears are essential components of the extruder unit. The extruder motor pulls the filament from the spool and feeds it into the hotend. Once heated and melted, the filament is extruded through the nozzle to create the printed model. The extruder motor is critical in accurately controlling the length of filament extruded through the hotend and is a core component of a 3D printer.

<https://wiki.bambulab.com/en/a1/manual/intro-a1>

The A1 mini additionally includes an extruder, as shown at <https://wiki.bambulab.com/en/a1-mini/manual/intro-a1-mini>:

Extruder unit

The extruder motor and extruder gears are essential components of the extruder unit. The extruder motor pulls the filament from the spool and feeds it into the hotend. Once heated and melted, the filament is extruded through the nozzle to create the printed model. The extruder motor is critical in accurately controlling the length of filament extruded through the hotend and is a core component of a 3D printer.

The H2D includes an extruder, as shown below:

Extruder

The extruder is responsible for pulling the filament out of the spool and feeding it into the hotend. After heating and melting, it is extruded through the nozzle to generate a printed model.

The extruder needs to accurately control the length of extrusion and retraction of the filament to ensure the dimensional accuracy and appearance quality of the printed model. It is one of the core components of a 3D printer.

<https://wiki.bambulab.com/en/h2/manual/h2d-intro>

The extruder unit of the A1 (as described at <https://wiki.bambulab.com/en/a1/manual/intro-a1>), the A1 mini (as described at <https://wiki.bambulab.com/en/a1-mini/manual/intro-a1-mini>), and the H2D (as described at <https://wiki.bambulab.com/en/h2/manual/h2d-intro>) pulls the filament from the spool and feeds it to the hot end

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assembly of the tool head module at a feed rate.

Further, when the Bambu A1, A1 mini, and H2D stop printing when nozzle clumping is detected (control signal), the feed rate of the build material is changed (from non-zero feed rate to zero feed rate).

What is the nozzle clumping detection?

Nozzle clumping usually refers to the phenomenon that the nozzle is wrapped by the filament during printing because the filament is not stuck on the build plate or some other reasons, resulting in printing failure or even damage to the hot end, extruder, and other parts, as shown in the following figure.

Because of the possibility of damage to the printer, the Bambu A1 series is equipped with a nozzle clumping detection feature to deal with this situation, when the printer detects that the nozzle is wrapped in molten filament, it automatically stops printing and alerts it to avoid further damage to the printer after the wrapping.

<https://wiki.bambulab.com/en/a1-mini/manual/nozzle-warp-detection>

Bambu Lab H2D:

“The Nozzle Eddy Sensor is used to detect whether the nozzle is wrapped by molten filament.”

<https://us.store.bambulab.com/products/nozzle-eddy-sensor>

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<p>10. The method of claim 2 further comprising detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.</p>	<p>The Accused Instrumentalities are each used for detecting a planarity of the separate structure based upon a number of contact force measurements across a surface of the separate structure.</p> <p>For example, the A1 series and H2D includes Auto Bed Leveling to detect a planarity of the heat bed, including performing a number of height measurements:</p> <p><u>A1 Auto Bed Leveling</u></p> <p>The auto bed leveling process for the A1 printer involves the following steps:</p> <p><u>Touch Probe Detection</u></p> <p>The hot end of the A1 printer is equipped with extruder head force sensing capability, which allows for detecting the contact between the extruder nozzle and the heated bed. When combined with the Z-axis movement, it enables direct measurement of the relative height of a specific point on the heated bed with respect to the center of the bed.</p> <p><u>Height Mapping</u></p> <p>By probing the hotbed through nozzle contact, A1 performs height measurements on 49 points arranged in a 7x7 grid on the hotbed, thus obtaining a height map of the hotbed. This height map records the height of each point on the 7x7 XY coordinate grid.</p> <p>https://wiki.bambulab.com/en/a1/manual/intro-a1</p>
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A1 mini Auto Bed Leveling

The A1 mini's auto bed leveling involves the following steps:

Touch Probe Detection

A1 mini has a feature to measure the force exerted on the hotend, which can be used to detect contact between the toolhead and the heatbed. Combining this with the up-and-down movement of the Z-axis, the A1 mini can directly measure the height of a specific point on the heated bed relative to the center of the bed.

Height Mapping

By touching the heatbed with the extruder head, the A1 mini performs height measurements at 36 points (6x6 grid) on the bed, creating a height map of the bed. This height map records the height of each point on the 6x6 grid in relation to the bed.

<https://wiki.bambulab.com/en/a1-mini/manual/intro-a1-mini>

If you are using Bambu Studio version 1.8 or earlier, the printer will perform a **fast leveling on 5 locations**, and compare it the previous data. If the difference is too great, the printer will perform a complete heatbed leveling. If not, it will start printing without performing a complete heatbed leveling. **For the number of locations in a complete heatbed leveling, it is 6*6 for A1 mini, and 7*7 for A1.**

<https://wiki.bambulab.com/en/a1/troubleshooting/homing-leveling-failure>

Videos showing such auto bed leveling for the A1 series are available at:

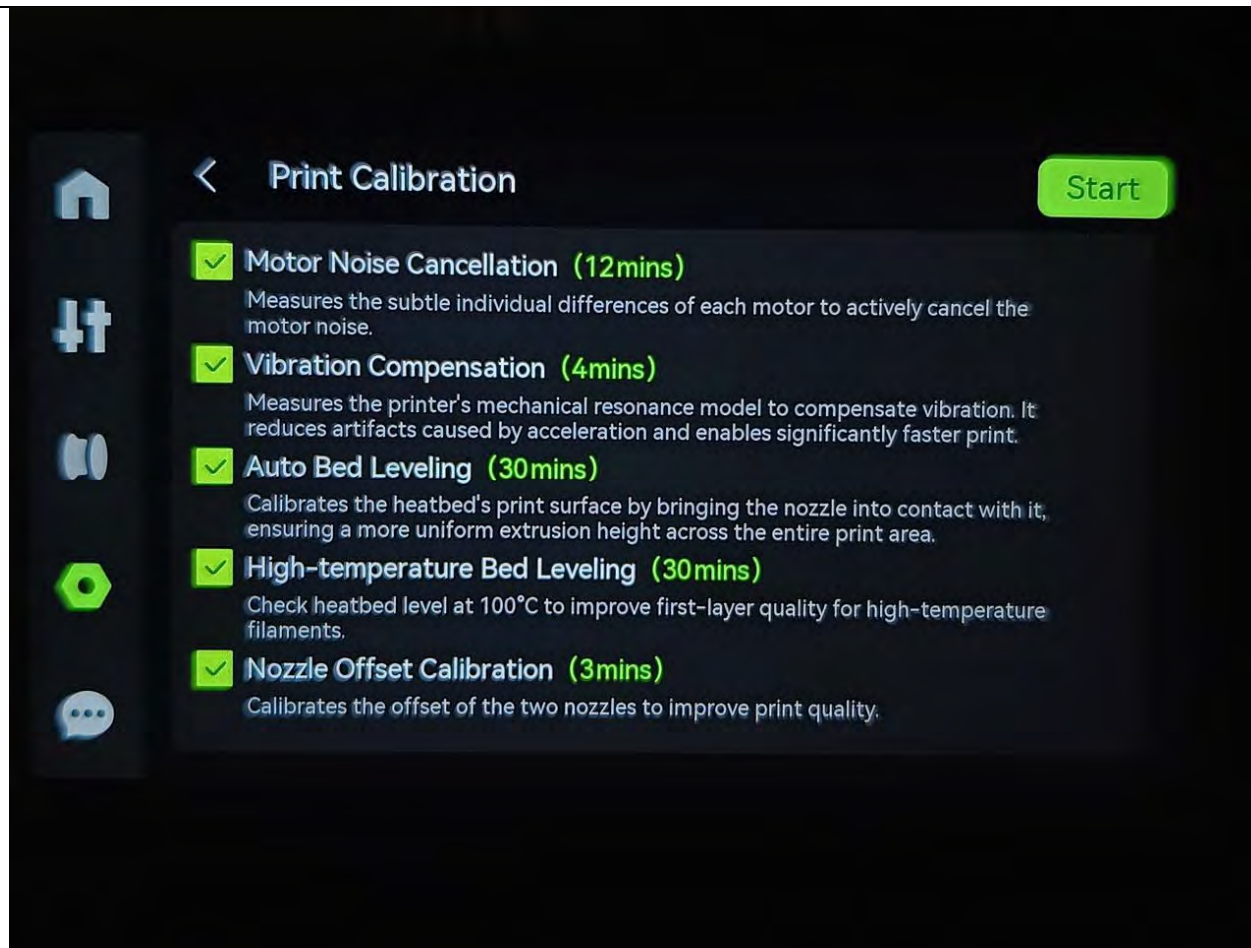
<https://www.youtube.com/shorts/Z4bMcA1mATw> and <https://www.youtube.com/shorts/XS6TcwA1qBg>

Bambu Lab H2D auto bed leveling:

“Auto bed leveling on the Print calibration page

- Heat the nozzle to 140°C;
- With the bed at room temperature, perform an 8×8 point leveling using the right nozzle;
- Heat the bed to 55°C, then perform another 8×8 point leveling with the right nozzle;
- Continue with a 22×22 point leveling using the right nozzle;
- Finally, switch to the left nozzle and perform an 8×8 point leveling.

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High-temperature bed leveling on the Print calibration page

1. Heat the bed to 100°C while heating the nozzle to 140°C;
2. Use the right nozzle to perform the following leveling steps:
 - 8×8 point leveling
 - 22×22 point leveling

Note: The high-temperature bed leveling data will be automatically applied when the bed temperature during the print job is $\geq 80^{\circ}\text{C}$. Suppose you have replaced, disassembled, or manually leveled the bed. In that case, it is recommended to run both Auto Bed Leveling and High-Temperature Bed Leveling

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	again on the Print Calibration page to ensure the machine obtains accurate bed plane data. Auto Bed leveling before printing
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Send print job

Cube ✎

🕒 35m1s 🧶 14.28 g

Printer

🖨️ ~ 3DP-094-067 🔄

🟡 PEI

Filament

Left Nozzle

Right Nozzle

PLA-CF

🧶 A2 ▾

Filaments to AMS slots mappings have been established. You can click a filament above to change its mapping AMS slot

Rearrange filaments of the left and right nozzles ->

[Click here if you can't connect to the printer](#)

Advanced Options ▾

Auto Bed Leveling

Auto On Off

This checks the flatness of heatbed. Leveling makes extruded height uniform.
*Automatic mode: Run a leveling check(about 10 seconds). Skip if surface is fine.

Flow Dynamics Calibration

Auto On Off

Send

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When "Auto" mode is selected:

Before printing, a 5-point touch test will be performed on the corresponding areas of the model contour to determine whether partial leveling is needed.

- If partial leveling is required, use the 8×8 leveling points that cover the model's projection contour on the bed for leveling.
- If not required, skip the partial leveling step.

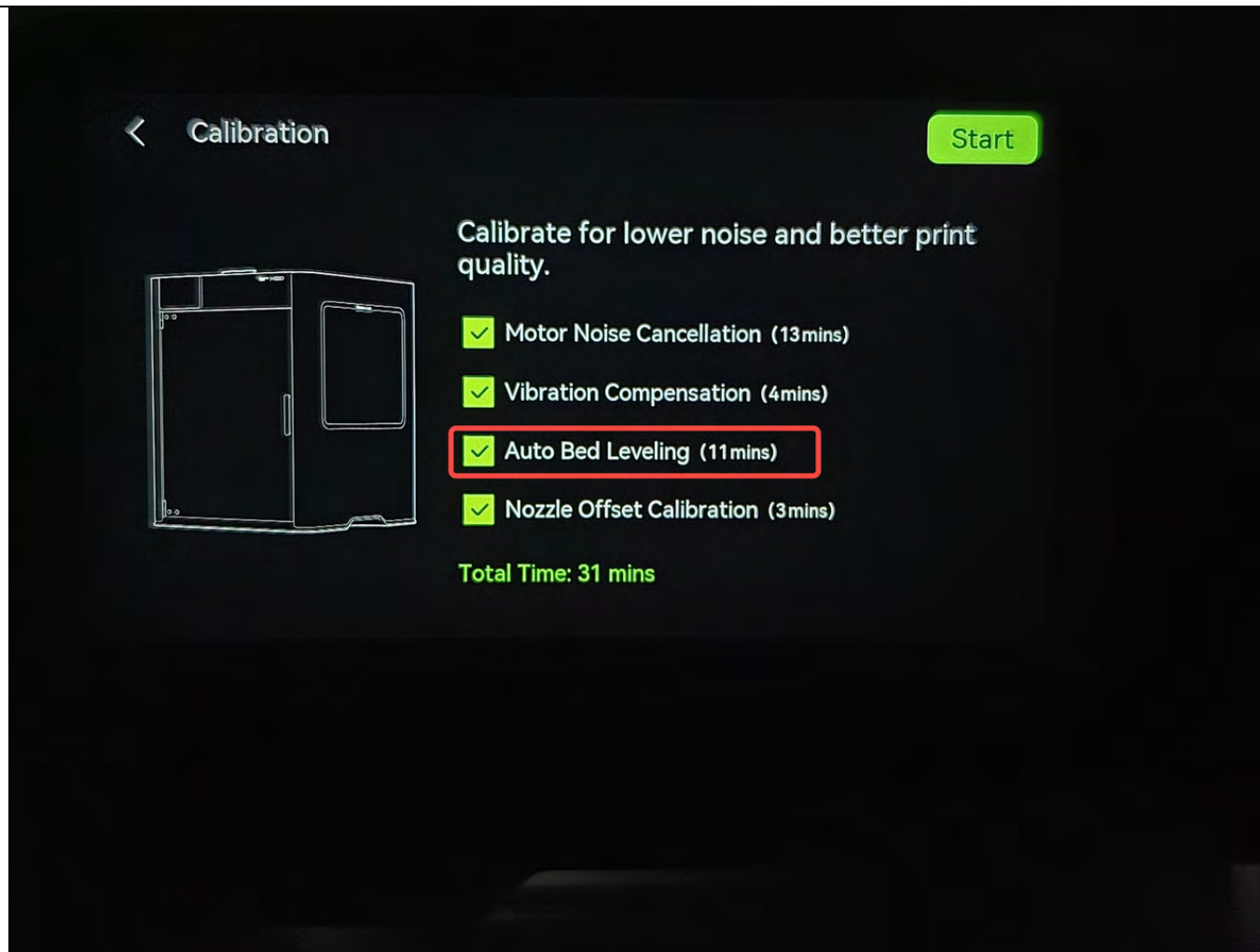
When "On" mode is selected:

- Directly perform partial leveling on the model contour area on the print bed.

Note: The partial leveling data and calibration leveling data (including Auto Bed Leveling and High-Temperature Bed Leveling) will be stored in the printer. During printing, the system will automatically combine and apply both sets of leveling data. This data remains effective until a new corresponding leveling task is performed to update it.

- **Auto Bed Leveling during the unboxing process**

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



1. Initial Leveling:

- Heat the nozzle to 140°C;
- With the bed at room temperature, perform an 8×8 point leveling using the right nozzle.

2. Post-Heating Leveling:

- Heat the bed to 55°C;
- Perform another 8×8 point leveling using the right nozzle.

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

3. Nozzle-Switching Leveling:

- Switch to the left nozzle and perform an 8×8 point leveling again.”

<https://wiki.bambulab.com/en/h2/manual/h2d-faq>

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

<p>12. The method of claim 1, wherein the build instructions include at least one instruction for achieving a specified contact force between the fabrication tool and a separate structure, and wherein the control signal controls the at least one component of the three-dimensional printer to achieve the specified contact force.</p>	<p>For each of the Accused Instrumentalities, the build instructions include at least one instruction for achieving a specified contact force between the fabrication tool and a separate structure, and the control signal controls the at least one component of the three-dimensional printer to achieve the specified contact force.</p> <p>For example, the A1 printer can probe the heat bed with the nozzle (contact force) to obtain a height map of the heat bed. The A1 printer can detect and adjust the height of the heat bed to improve print quality – a specified contact force between the extruder and the heat bed and controlling the height of the heat bed to achieve such contact force.</p> <p>By probing the hotbed through nozzle contact, A1 performs height measurements on 49 points arranged in a 7x7 grid on the hotbed, thus obtaining a height map of the hotbed. This height map records the height of each point on the 7x7 XY coordinate grid.</p> <p>With the auto-leveling function, A1 can automatically detect and adjust the height of the print bed before printing and during the printing process. This improves print quality and accuracy by avoiding adhesion issues caused by an uneven print bed surface. It enhances the success rate and consistency of prints.</p> <p>https://wiki.bambulab.com/en/a1/manual/intro-a1</p> <p>By touching the heatbed with the extruder head, the A1 mini performs height measurements at 36 points (6x6 grid) on the bed, creating a height map of the bed. This height map records the height of each point on the 6x6 grid in relation to the bed.</p> <p>Through the auto bed leveling function, the A1 mini can automatically detect and adjust the height of the print bed before printing and during the printing process. This improves print quality and accuracy by addressing issues caused by an uneven print bed surface, enhancing print success rates and consistency.</p> <p>https://wiki.bambulab.com/en/a1-mini/manual/intro-a1-mini</p> <p>For example, the H2D printer can probe the heat bed with the nozzle (contact force) to obtain a height map of the heat bed. The H2D printer can detect and adjust the height of the heat bed to improve print quality – a</p>
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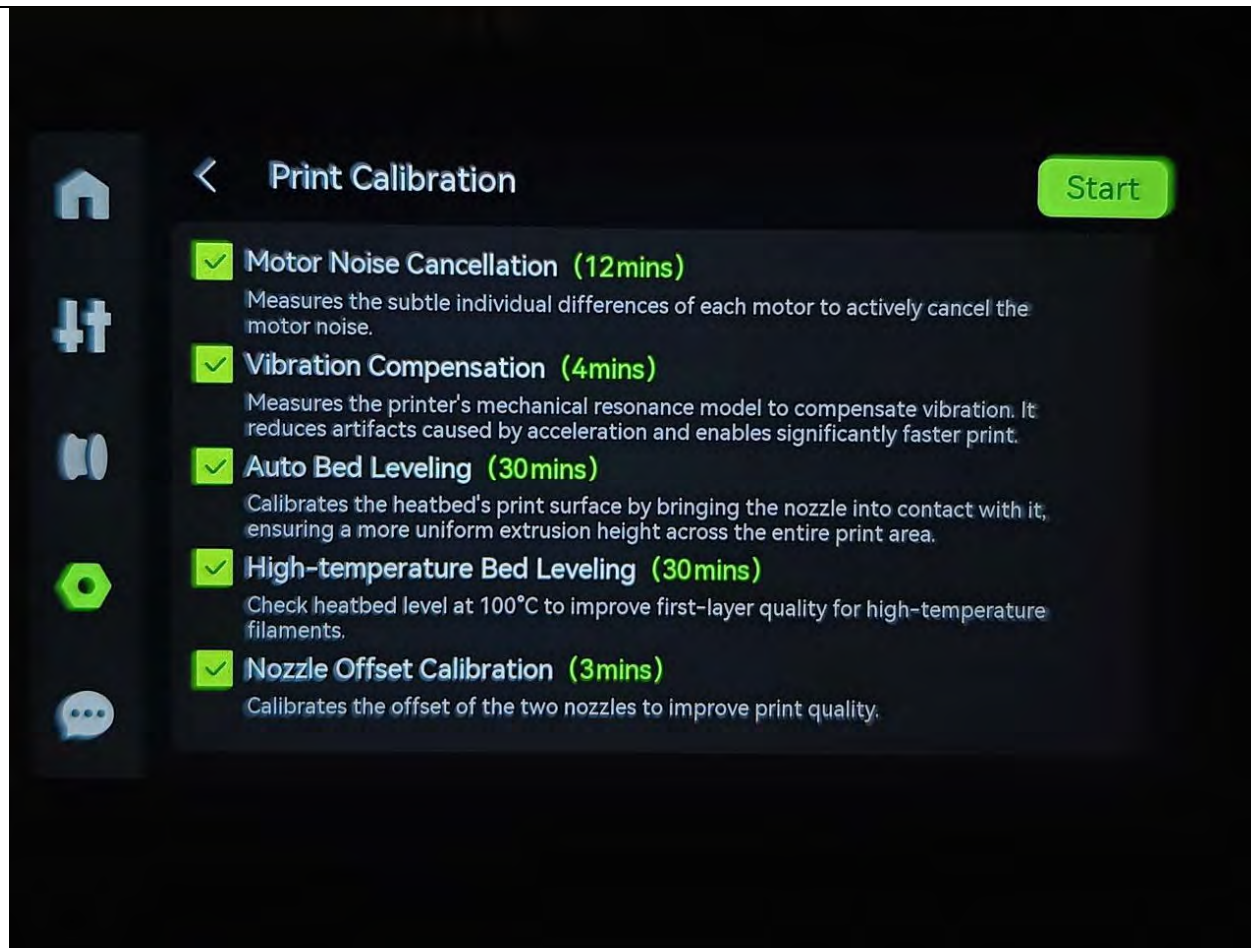
Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

specified contact force between the extruder and the heat bed and controlling the height of the heat bed to achieve such contact force:

“Auto bed leveling on the Print calibration page

- Heat the nozzle to 140°C;
- With the bed at room temperature, perform an 8×8 point leveling using the right nozzle;
- Heat the bed to 55°C, then perform another 8×8 point leveling with the right nozzle;
- Continue with a 22×22 point leveling using the right nozzle;
- Finally, switch to the left nozzle and perform an 8×8 point leveling.

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



High-temperature bed leveling on the Print calibration page

1. Heat the bed to 100°C while heating the nozzle to 140°C;
2. Use the right nozzle to perform the following leveling steps:
 - 8×8 point leveling
 - 22×22 point leveling

Note: The high-temperature bed leveling data will be automatically applied when the bed temperature during the print job is $\geq 80^{\circ}\text{C}$. Suppose you have replaced, disassembled, or manually leveled the bed. In that case, it is recommended to run both Auto Bed Leveling and High-Temperature Bed Leveling

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

	again on the Print Calibration page to ensure the machine obtains accurate bed plane data. Auto Bed leveling before printing
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Send print job

Cube ✎

🕒 35m1s 📦 14.28 g

Printer

🖨️ ~ 3DP-094-067 🔄 📦 PEI

Filament

Left Nozzle

Right Nozzle

PLA-CF

📦 A2 ▾

Filaments to AMS slots mappings have been established. You can click a filament above to change its mapping AMS slot

Rearrange filaments of the left and right nozzles ->

[Click here if you can't connect to the printer](#)

Advanced Options ▾

Auto Bed Leveling

Auto On Off

This checks the flatness of heatbed. Leveling makes extruded height uniform.
*Automatic mode: Run a leveling check(about 10 seconds). Skip if surface is fine.

Flow Dynamics Calibration

Auto On Off

Send

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

When "Auto" mode is selected:

Before printing, a 5-point touch test will be performed on the corresponding areas of the model contour to determine whether partial leveling is needed.

- If partial leveling is required, use the 8×8 leveling points that cover the model's projection contour on the bed for leveling.
- If not required, skip the partial leveling step.

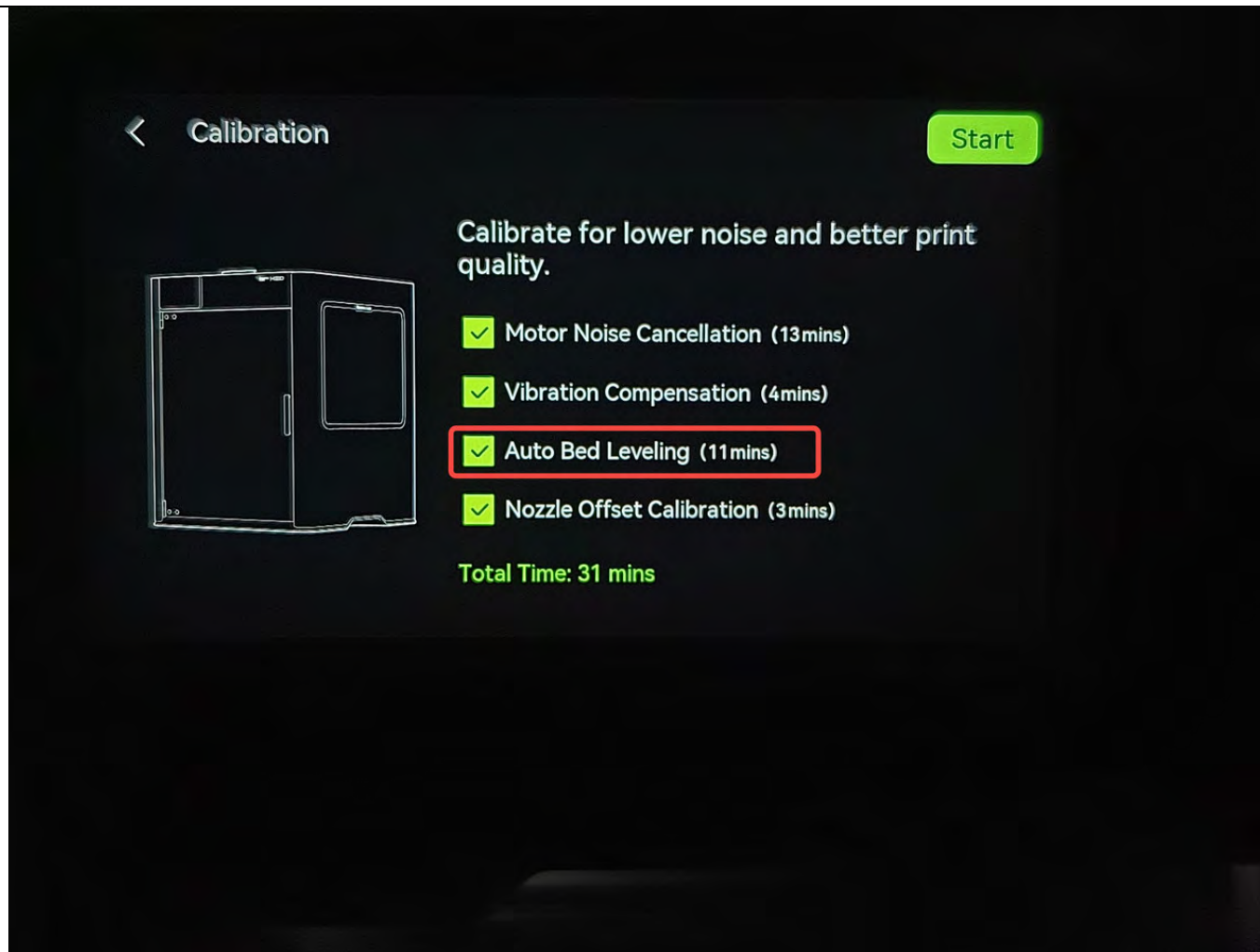
When "On" mode is selected:

- Directly perform partial leveling on the model contour area on the print bed.

Note: The partial leveling data and calibration leveling data (including Auto Bed Leveling and High-Temperature Bed Leveling) will be stored in the printer. During printing, the system will automatically combine and apply both sets of leveling data. This data remains effective until a new corresponding leveling task is performed to update it.

- **Auto Bed Leveling during the unboxing process**

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698



1. Initial Leveling:

- Heat the nozzle to 140°C;
- With the bed at room temperature, perform an 8×8 point leveling using the right nozzle.

2. Post-Heating Leveling:

- Heat the bed to 55°C;
- Perform another 8×8 point leveling using the right nozzle.

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3. Nozzle-Switching Leveling:

- Switch to the left nozzle and perform an 8×8 point leveling again.”

<https://wiki.bambulab.com/en/h2/manual/h2d-faq>

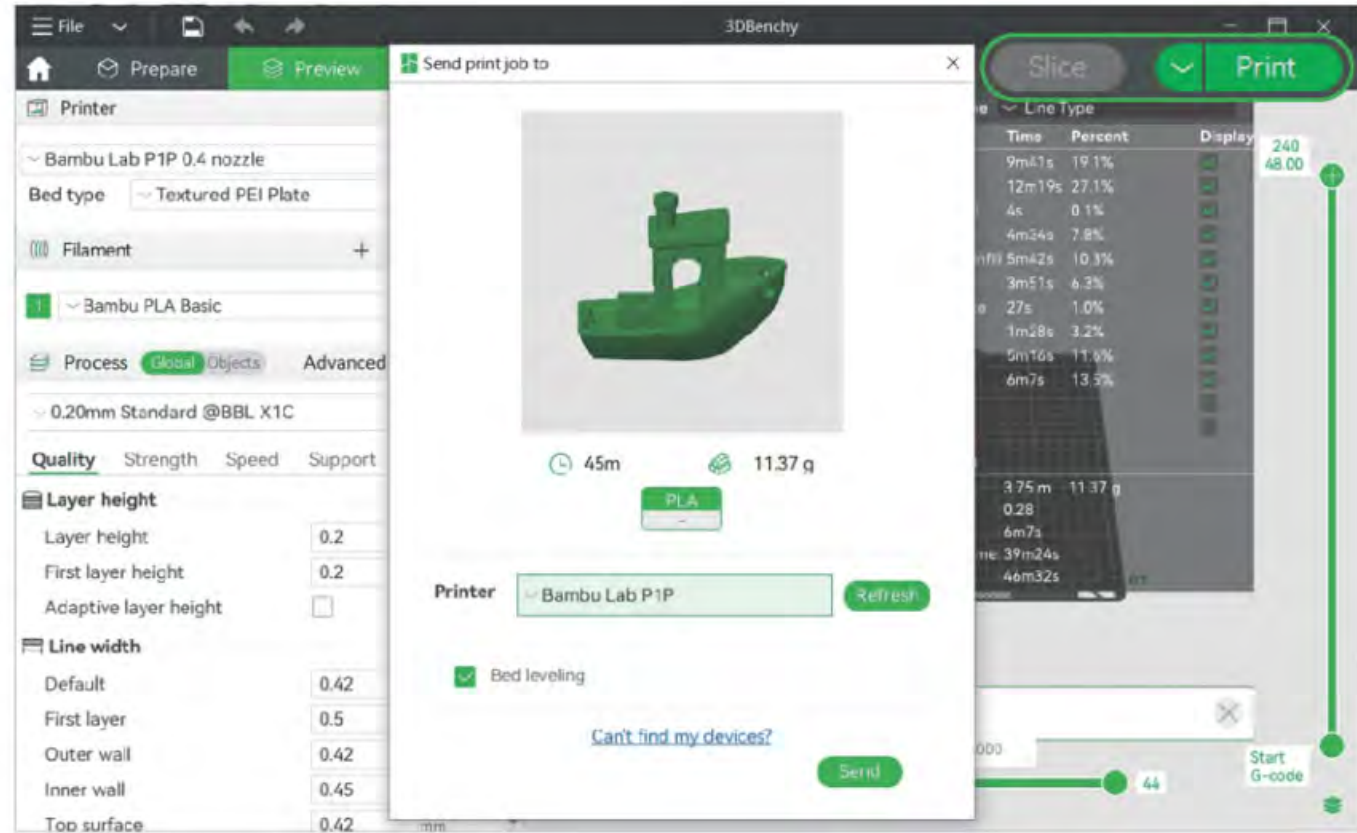
See also https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0008:

“During the homing, leveling, and hotend Z offset calibration process of the 3D printer, the nozzle lightly touches the heatbed to determine its precise position. However, if there are foreign objects between the nozzle and the heatbed, the printer will detect abnormal touch data. This causes the nozzle to attempt touching at the same position multiple times, eventually leading the heatbed to automatically lower by a certain distance and trigger an error message.”

Bambu Studio ([v1](#) or [v2](#)) can provide the build instructions to the printer that includes instructions for adjusting the height of the heat bed (specific contact force between the extruder and the heat bed) by selecting the bed leveling option, as shown below:

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Bambu Studio



<https://wiki.bambulab.com/en/p1/manual/print-from-bambu-studio>

Exhibit D - Exemplary Infringement Evidence for U.S. Patent No. 9,168,698

Send print job

Bambu Cube

54m20s 11.05 g

Printer

3DP-094-275

PEI

Filament

Left Nozzle

Right Nozzle

PLA

Ext

Not satisfied with the grouping of filaments? Regroup and slice ->

[Click here if you can't connect to the printer](#)

Timelapse Off

Auto Bed Leveling On

Flow Dynamics Calibration Auto

Nozzle Offset Calibration Auto

Send

<https://wiki.bambulab.com/en/h2/troubleshooting/first-layer-printing-optimization-guide>

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15. The method of claim 1 wherein the one or more sensors include at least one of a capacitive sensor, and optical sensor, an electromechanical sensor, an electromagnetic sensor, and an acoustical sensor.

For each of the Accused Instrumentalities, the one or more sensors include at least one of a capacitive sensor, and optical sensor, an electromechanical sensor, an electromagnetic sensor, and an acoustical sensor.

The Bambu Labs A1, A1 mini and H2D 3D printers include an extrusion nozzle with an extrusion force sensor (e.g., eddy force sensor) that is a type of electromagnetic sensor. For example, <https://wiki.bambulab.com/en/a1-mini/manual/build-plate-detection> describes the “the extrusion force sensor (eddy current sensor) in the tool head” on the A1 Mini printer.

See also e.g., https://wiki.bambulab.com/en/a1-mini/troubleshooting/hmscode/0300_1A00_0002_0002:



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As an additional example, https://wiki.bambulab.com/en/h2/troubleshooting/hmscode/0300_2500_0001_0003 describes the “force sensor [] installed above each hotend on the left and right sides of the toolhead, designed to detect the extrusion force applied by the hotend” on the H2D printer.
