Building a High End FDM 3D Printer

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Abstract

Motivated by challenges encountered while maintaining a commercial 3D printer, our lab initiated a project to build a high-end, open-source FDM 3D printer from the ground up. This approach ensures organizational understanding of the system's mechanical design, electronics, and operation while providing valuable engineering experience to ME, EE, and Robotics students. The project was carried out by the Voron subteam, a group of Multidisciplinary Design Program (MDP) students within the BIRDS Lab. Through hands-on assembly, troubleshooting, and system integration, the team developed practical expertise while overcoming documentation gaps and component inconsistencies. This work highlights the value of open-source hardware in fostering modularity, improving maintainability, and strengthening engineering education.

Motivation

- What issues did our lab initially face?
  - Our ZMorph printer had a broken thermistor.
  - Commercial 3D printers have many problems: proprietary firmware, limited repairability, and opaque hardware design.
  - Could not receive help: no good documentation for commercial printers and company went out of business.
- What is a Voron?
  - The "VORON" project originally started as a small mission in 2015 to create a "no-compromise 3D printer" (Voron Design, n.d.). Shortly after launching, "VORON" grew into a community of like-minded engineers looking to push the boundaries of mechatronic design - access "VORON" via the QR code!
  - A high-end, open-source 3D printer with fully public mechanical, electrical, and firmware documentation.
- Why does a Voron fix our issues?
  - Fully open design: the lab can understand, repair, and modify every component, building in-house expertise so future teams can maintain and upgrade the printer.
  - Our lab intends on implementing changing toolheads that will allow us to print with dissolvable support material.
  - As more people build their own "Voron", more modifications are documented online leading to greater customization.



Figure 1: ZMorph



Figure 2: Voron Version 2.4

Ordering a Voron Kit

- Voron 2.4 kit ordered from 3DPrintersBay.
  - 300 mm × 300 mm build volume.
  - CNC machined tap leveling module for precise first-layer calibration.
  - Genuine Phaetus Rapido 2 Hotend PT1000 350C HF selected for our lab's printing requirements.

Documentation Inconsistencies with Voron 2.4

- Missing 3D-printed parts referenced in the official Voron 2.4 documentation.
- Wiring diagrams provided were for the Octopus controller board, not the Manta board included in our kit.
  - Multiple conflicting ways to wire the power supply to the main controller board.
- Other inconsistencies and confusing steps throughout the assembly process.

Our team was confused when we found out that we did not receive certain parts asked for in the general manual.

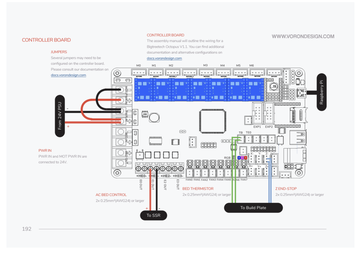

Figure 3: "Octopus" controller board, Voron 2.4R2 Build Guide (Manual, p. 192)

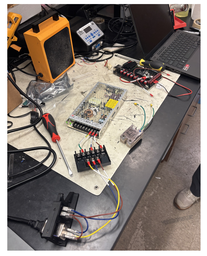

Figure 4: Voron team working on wiring!

- We decided to print these missing parts ourselves.
  - The project being open source gives us access to all the STLs required to build a Voron.

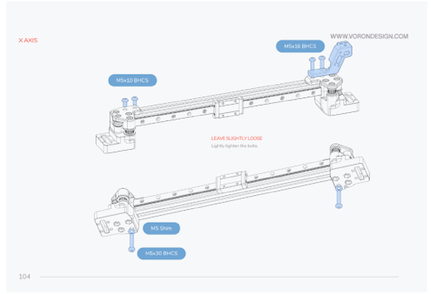

Figure 5: Missing cable chain bridge part referenced in the manual.

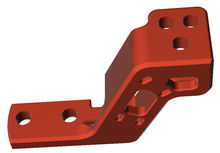

Figure 6: Cable chain bridge part in an STL viewer

STL filename:
`[a]_xy_joint_cable_bridge_3hole.stl`

Kit-Specific Guide Explains All Prior Inconsistencies

- Found a GitHub page maintained specifically for our Formbot Voron 2.4 kit.
  - Contains all necessary changes and corrections for our specific kit variant.
  - Resolved all previously encountered wiring, parts, and configuration inconsistencies.

Formbot 2.4 Kit vs. Classic 2.4 Kit

- The kit we ordered has differences from the canonical Voron 2.4 design.
  - The suppliers made multiple design choices that differ from the classic 2.4 build.
  - This is why we had different parts in our kit compared to the standard documentation.

Why is it Useful to Make Design Variations?

- The Voron we ordered featured many changes from the classic build.
- The Voron is a mechatronics project, so many design choices can work.
- 1) Heat Resistant Spacers vs. Washers — Heat-resistant spacers help the bed heat up more evenly and provide better mechanical stability than standard washers.



Figure 7: Heat-resistant spacers used in place of standard washers.



Figure 8: Umbilical wiring setup replacing a traditional cable chain.

- 2) Umbilical Instead of Cable Chain — Both options manage moving wires on the toolhead, but the umbilical simplifies routing and reduces wear.

Conclusion

- Building a Voron is not as simple as getting a kit and following instructions.
  - Documentation for modular open-source projects can be confusing.
  - There are a lot of ways to build a 3D printer.
- Note that we are not done yet.
- Next steps:
  - Assembling the toolhead.
  - Roping belts and wires.
  - Mounting main electronics components.
- Our team learned a lot.
  - Forced us to understand how the printer works at every level.
  - Made our own way when documentation fell short.
    - Wired the Motor Controller board correctly before finding the correct wiring diagram.
    - Searched for answers and found the correct kit-specific document.

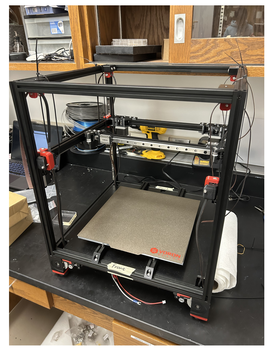

Figure 9: Voron progress as of April!

References

VORON Design — `https://vorondesign.com/`
3DPrintersBay — `https://www.3dprintersbay.com/voron-2`
Kit-Specific Notes Github — `https://github.com/Zev-se/Formbot-voron-2.4-build-guide/blob/main/guide.md`
M8P Bigtree Github — `https://github.com/bigtreetech/Manta-M8P/blob/master/V2.0/BIGTREETECH%20MANTA%20M8P%20V2.0%20User%20Manual.pdf`

Please feel free to access the URLs via LinkTree using this QR code!