# Design Brief

## Problem Statement:

Acquiring printed circuit boards (PCBs) as a hobbyist designer will often involve a lead time of 1+ week for online orders, or difficult and expensive process for manufacturing at home. There is a need for a method of acquiring PCB’s that is both quick and accessible for a hobbyist level PCB designer to enable rapid prototyping.

## Background Research:

### Summary

PCB are composed of ...

PCB are often made by

### References

X. C. Wang and H. Y. Zheng, “High quality laser cutting of electronic printed circuit board substrates,” Circuit World, vol. 35, no. 4, pp. 46–55, Nov. 2009, doi: https://doi.org/10.1108/03056120911002415.

This research paper from Wang and Zheng, from the Singapore Institute of Manufacturing Technology, explores fabrication of PCBs using different laser cutting settings on a diode laser. The paper aimed to explore fabrication that minimized charring, delamination, and the heat affected zone that are often found on laser cut PCBs.

This paper was useful to compare PCB milling to laser cutting methods. Laser cutting appears to be very viable as a process, however it can be difficult to get the settings correct and the required equipment is expensive.

D. Wise, "PCB Fabrication," \*Technology Interface International Journal\*, Fall 2007. [Online]. Available: https://tiij.org/issues/issues/fall2007/01\_Wise/Wise-PCB%20Fabrication.pdf. [Accessed: 30-Sep-2024].

This is a paper from a Departmental Engineer at the University of New Mexico (UNM). It discusses the use of a mill to cut printed circuit boards(PCBs). The paper is written somewhat informally, and the references listed are not the most reliable. However, most of the information within the paper describes the hands-on process at UNM.

The paper walks the reader through the process of manufacturing a PCB on a desktop mill, all the way from design to settings up the machine and cutting. It discusses common issues and how to effectively set up a FR4 board.

A. Nae and B. Toma, "Study on Equipment for Manufacturing PCB," \*Journal of Petroleum-Gas University of Ploiesti\*, vol. 1, pp. 9-15, 2010. [Online]. Available: http://jpgt.upg-ploiesti.ro/wp-content/uploads/2024/02/9\_T\_1\_2010\_Nae-Andrei-BT.pdf. [Accessed: 30-Sep-2024].

This is a paper from two researchers at Petroleum and Gas University of Ploiești. It discusses the use of stepper motors for creating CNC routers. It highlights design principles and details, and different ways in which routers are frequently designed. There is also some discussion on electrical design and software controls.

This is useful as a guide for designing a rigid motion system that can carry a spindle. There is good discussion on different design choices such as moving gantry vs bed, as well as different components and how they affect the motion system.

Y. Crama, O. E. Flippo, J. van de Klundert, and F. C. R. Spieksma, "The assembly of printed circuit boards: A case with multiple machines and multiple board types," \*European Journal of Operational Research\*, vol. 98, no. 2, pp. 457-472, 1997. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0377221796002287. [Accessed: 30-Sep-2024].

This paper by Crama et al. Optimizes the process of placing components onto a PCB in a production line.

This paper was not very useful to this project; while it provided some insight into PCB assembly, it was highly focused on a factory setting rather than a custom production/hobbyist environment.

‌ "Principles of Mechanical Design," MIT Center for Bits and Atoms, 2021. [Online]. Available: https://fab.cba.mit.edu/classes/865.21/topics/mechanical\_design/index.html. [Accessed: 01-Oct-2024].

A guide from MIT on mechanical design principles for building rigid and precise systems. It discusses important concepts such as stiffness, backlash, pretension, and more.

This is a useful reference for any potential designs in the future. It outlines many important fundamental concepts, both theoretically as well as physical design choices.

K. K. Tan, T. H. Lee, and S. Huang, \*Precision Motion Control: Design and Implementation\*, 2nd ed. London, UK: Springer-Verlag, 2008. Available: DOI: 10.1007/978-1-84800-021-6

This is a textbook on motion control systems. It covers everything from actuators to gantry designs, to control systems, and more.

It is very useful as an in depth guide to designing a motion system. While it is a bit old, many of the fundamental concepts are still applicable.

**Further research needed on PCB simulation, common manufacturing techniques**

### User Research

Discussion with the owner of a desktop PCB mill (Ottermill):

* The Ottermill takes some setup to be able to run effectively
* PCB mills are very useful for quick prototyping and short turnaround times
* 2 side setup is difficult and time consuming to set up accurately

Industry professional advice

See full email in appendix.

### Related Designs

[PrintNC V4 | PrintNC Wiki](https://wiki.printnc.info/en/home)

Super nice design, 1.5-3k price range but super rigid frame

[Introduction to The MPCNC - V1 Engineering Documentation](https://docs.v1e.com/mpcnc/intro/)

Sub 500$ CNC router

[Prusa MK3s Pick and Place Extension [3D printed] 👌 (youtube.com)](https://www.youtube.com/watch?v=Mx4swtSQmE0)

Little head that goes onto any motion system, 25$ for a PNP head and can be controlled using any slicer

## Target Audience:

Hobbyist level PCB designer, with a mid range budget of $500-1000, and with limited space for additional equipment.

## Functional Decomposition

FR4 blanks > make traces> cut vias > cut outline > finished PCB

Need diagram

Decision matrix to decide solution

## Requirements

### Design Constraints

* General
  + Less than 2 hours to make
  + Fits on a desk
  + Free software
* Make traces
  + 2 sided PCB
  + Minimum track width: 0.25mm
  + Minimum track spacing: 0.25mm
  + Track width tolerance ±20% (±0.05mm at smallest width)
* Cut vias
  + 0.8mm via size
* Cut outline
  + PCB dimensions at least 150mmx150mm

### Design Criteria

* PCB quality
  + Need to come up with good metrics
* Manufacturing time
* Build size
* Build cost

## Timeline

Oct 1-14,

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Oct 1-13 | Oct-15- |  |  |  |  |