



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 4, April 2024

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

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# A Mini CNC PCB Plotter Using Arduino - UNO

Pawar Rahul S., Kumbhar Gaurav S., Ghalme Shivam D., Dr. Date A. R.

<sup>[1-3]</sup> U.G. Student, Hsbpvt's GOI Faculty of Engineering College, Kashti, Maharashtra, India

<sup>4</sup>Assistant Professor, Hsbpvt's GOI Faculty of Engineering College, Kashti, Maharashtra, India

**ABSTRACT:** This project demonstrates how to use an Arduino Uno to create a mini CNC PCB plotter. This project walk you through building a CNC plotter so it will be inexpensively design and print PCBs at home. It uses stepper motors and rails from DVDs and CD ROMs to create a small CNC PCB plotter for the X, Y, and Z axes. The maximum printing area for our example project will be 4\*4 cm. The project works on serial communication. The need for computer numeric control (CNC) plotter machines is quite strong these days due to technological advancements. Low-cost printed circuit boards (PCBs) are in high demand as purchasing PCBs from businesses or the internet may be expensive. With the use of a small CNC PCB plotter, anybody may now affordably print their own PCBs at home. They can effectively and cheaply print and design their own PCBs, and they can innovate without worrying about incurring large costs. Numerous industries, including education, hobbies, new technologies, and engineering students, will use this initiative. This article shows off a reasonably priced little CNC PCB plotter model. Additionally, you may use this gadget to sketch paintings, tattoos, wood carvings, and laser printing as needed. As said, this system will be completely functional and include some multitasking functions. With the help of accessible components and sets of algorithms, this project will be able to sketch and sculpt a circuit on a PCB. Initially, the user must use any program, such as "inks space," to convert the picture file into G code before feeding it to the computer via processing software. In this project, the controlling device is an Arduino Uno. In a CNC plotter, it converts G-code into machine instructions that are supplied to the motor driver.

**KEYWORDS:** Arduino-uno, CNC Shield, Driver, Servo Motor, Stepper Motor, Dc Motor.

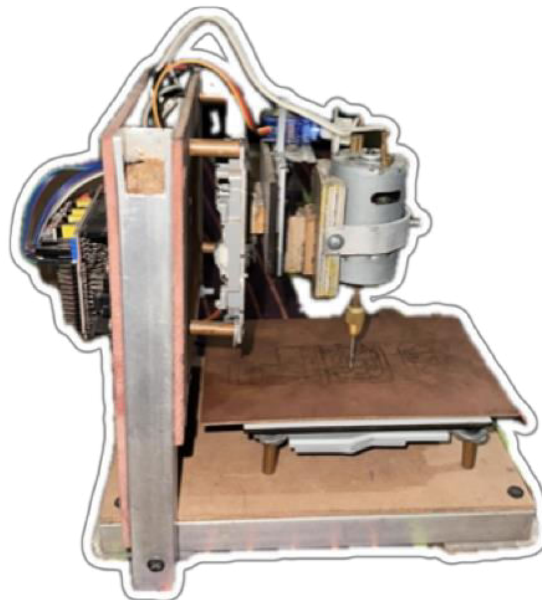
## I. INTRODUCTION

A CNC plotter machine focus on making a 2d image or engraving a image as per needs on a plane surface. The Arduino based mini CNC PCB plotter is a computer controlled system. It uses a Microcontroller and CNC shield with motor drivers to control moments of the X,Y&Z axis. Stepper motor with rails extracted from Cd drivers a CNC shield, motor drivers, Arduino Uno a 12v DC motor are components used for the project. The project works on serial communication. The image is turned into a G code through "ink space" software this G-code is convert to machine code that controls the movements of the X,Y& Z axis. 12v Dc motor, pen, laser or any other engraving mechanical tool can be used in mechanism. It will have a 4\*4cm printing area. The purpose is to make it a PCB printer but can also used for multiple purpose like wood carving, sketching, laser printing. This CNC plotter can print difficult designs that take times to do it manual it saves time, cost and manual work. This project is a low cost project, has great reliability & efficiency. It can design our own PCB at low cost and innovate new things for future, students can innovate new things by designing and printing their own PCB's. This project will be used in many sectors like educational use, hobbyist, industries, new innovations, engineering students. This paper demonstrate the building of mini CNC PCB plotter for X,Y,Z axis using stepper motors and rails from DVD's, CD ROM's. For this demo project printing area will be maximum 4\*4 cm This project works on serial communication. Due to advancement in technology now a days, demand for computer numeric control (CNC) plotter machine is very high. Printing (PCB) printed circuit board from companies or online is costly so low cost PCB's are on high demand. Now anybody can print their own PCB at home in low cost by use of mini CNC PCB plotter. They can print and design their own PCB's at low cost and efficiently and innovate new thing without any fear of high costing .

This mini CNC PCB plotter, designed with affordability and functionality in mind, caters not only to cost-sensitive environments but also to those seeking hands-on educational tools. The integration of commonly available components like stepper motors from DVD or CD ROM drives and the utilization of a straightforward Arduino Uno and CNC shield setup underscores the project's approachability and ease of assembly. The software side is equally user-friendly; converting designs into G-code via the open-source "Inkscape" software, which then interprets these designs for precise machine operation, allows even beginners to start producing their own PCBs or other small-scale engravings with minimal learning curve. The versatility of the device extends beyond PCB fabrication. Its capability to adapt various tools, such as pens for sketching or lasers for engraving, makes it a multi-purpose machine suitable for a wide array of applications—from educational projects in schools to crafty undertakings in home workshops. The small footprint of the machine does not limit its potential; rather, it provides a compact solution that fits well in limited spaces while still offering substantial functionality. This CNC plotter also opens up avenues for experimentation and innovation, particularly in academic settings where engineering students can explore the realms of

mechanical and electronic design. By enabling the rapid prototyping of PCBs and other materials, it encourages iterative design processes, critical thinking, and creativity, all of which are essential skills in the modern engineering landscape. Moreover, the DIY aspect of building the plotter from scratch using recycled components is in line with sustainable practices, adding an element of environmental consciousness to the project. It demonstrates that high-tech innovation doesn't necessarily require expensive resources and can be achieved with a blend of simple yet effective technology and a creative reuse of materials. This aspect is particularly appealing to hobbyists and educators who advocate for sustainable engineering solutions. In summary, the development of this mini CNC PCB plotter not only addresses the demand for low-cost PCB production but also fosters a broader engagement with technology, from individual tinkerers to institutional educators, thereby contributing to a culture of innovation and self-reliance in various sectors.

### Mini CNC PCB Plotter



## II. RELATED WORK

The field of mini CNC PCB plotters has seen considerable development, spurred by advancements in digital fabrication and the increasing accessibility of CNC technology. Several related works have contributed to this progress. Notably, various DIY and open-source projects have democratized the technology, with platforms like Instructables and GitHub hosting numerous designs and modifications that enhance the functionality and user-friendliness of these devices. Academic research has also played a pivotal role, focusing on improving the precision and efficiency of CNC machines specifically tailored for PCB milling. Studies often explore the optimization of parameters such as spindle speed, feed rate, and cutting depth to minimize errors like overcutting and ensure the integrity of the delicate traces and pads on PCBs. Commercially, companies have developed compact and more affordable CNC machines that are suitable for desktop use in small workshops or educational environments. These units frequently incorporate software improvements, such as integrated CAM (Computer-Aided Manufacturing) tools, which simplify the process of going from PCB design to physical board. Furthermore, enhancements in hardware, like the incorporation of more robust and precise stepper motors and the use of durable milling bits, have significantly increased the reliability and lifespan of these plotters. Additionally, the expansion of supportive ecosystems around these tools, including forums, online tutorials, and dedicated software, reflects a comprehensive approach to not just developing a product but fostering a community that can use and improve upon it. This holistic development in the realm of mini CNC PCB plotters illustrates a trend not only towards technical innovation but also towards creating more inclusive and accessible technology platforms.

The surge in innovation and accessibility in the mini CNC PCB plotter domain is further complemented by the integration of advanced sensing technologies, which provide real-time feedback and adjustments during the milling process. This incorporation enhances precision by dynamically compensating for any potential inaccuracies or material inconsistencies, which is crucial for achieving the high tolerances required for modern PCB designs. Additionally, the emergence of hybrid models that combine traditional milling with additive manufacturing techniques, such as ink deposition or solder paste application, represents a significant step towards more versatile desktop fabrication tools. This convergence of technologies not only broadens the scope of applications for these plotters but also offers users the ability to execute multiple fabrication steps with a single machine, streamlining the PCB production process. Environmental considerations are also becoming increasingly important. Developers are focusing on reducing the noise and dust generated by these machines, making them more suitable for indoor use without requiring extensive safety or ventilation systems. Furthermore, the use of recycled or biodegradable materials for machine components and consumables is beginning to be explored, reflecting a growing commitment to sustainability within the industry. The educational impact of these tools cannot be overstated. By providing students and hobbyists access to affordable, yet powerful, fabrication tools, mini CNC PCB plotters serve as practical learning platforms for engineering, robotics, and electronics. Educational institutions are increasingly incorporating these tools into their curricula, thereby nurturing a new generation of engineers and designers who are well-versed in the intricacies of digital fabrication technologies. Thus, the evolution of mini CNC PCB plotters not only reflects technological advancements but also a broader cultural shift towards more sustainable, accessible, and integrated approaches to engineering and design. This shift is likely to continue driving innovation in the field, as users and developers together push the boundaries of what these compact yet powerful machines can achieve.

### III.METHODOLOGY

The methodology for operating a mini CNC PCB plotter typically involves several key steps, starting with the design and setup, followed by the actual plotting process, and concluding with post-processing. Initially, users design their printed circuit board (PCB) layouts using specialized software, such as Eagle CAD or KiCad. This design software enables the creation of the schematic and board layout, which are essential for defining the electrical connections and physical dimensions of the PCB. Once the design is finalized, it is converted into a standard Gerber file format, which serves as a blueprint for the CNC plotter. The next phase involves setting up the mini CNC plotter. This includes securely mounting a blank copper-clad board onto the machine's work area and ensuring that the plotter's tools, typically a sharp, fine-pointed V-bit or an engraving bit, are properly installed and calibrated for precise depth control. The machine's software then imports the Gerber files and translates them into commands that guide the CNC plotter's movements. During the plotting process, the CNC machine meticulously mills the copper layer of the PCB, removing unwanted copper to leave behind only the traces that form the circuit layout. This is done with high precision to avoid any errors that could cause short circuits or breaks in the traces.

The control software also plays a critical role in monitoring and adjusting the spindle speed and feed rate according to the board's material density and the complexity of the circuit patterns. These adjustments are essential to prevent damage to the thin copper traces during milling and to achieve the cleanest cuts possible. In addition to this, the software can utilize probe sensors to map the surface of the copper-clad board. This surface mapping allows the CNC plotter to adjust the cutting depth dynamically, compensating for any irregularities in the board's surface, which is crucial for maintaining uniform trace depths across the entire PCB. After the milling is complete, the mini CNC plotter often performs a second pass to clean up any residual copper particles that might have been left behind, ensuring the traces are clearly defined and isolated. This step enhances the reliability of the PCB by minimizing the risk of electrical faults. Post-processing includes carefully removing the milled PCB from the plotter and cleaning it to remove any copper shavings or debris. Users then typically inspect the board for any errors or imperfections, using magnification tools if necessary. Final steps may involve drilling holes for through-hole components and applying a protective coating to prevent oxidation of the copper traces. This coating also helps to improve the solderability of the PCB during component assembly. This comprehensive approach not only ensures the production of high-quality PCBs but also enhances the user's ability to consistently produce complex electronic circuits with precision and efficiency using a mini CNC PCB plotter.

### IV.EXPERIMENTAL RESULTS

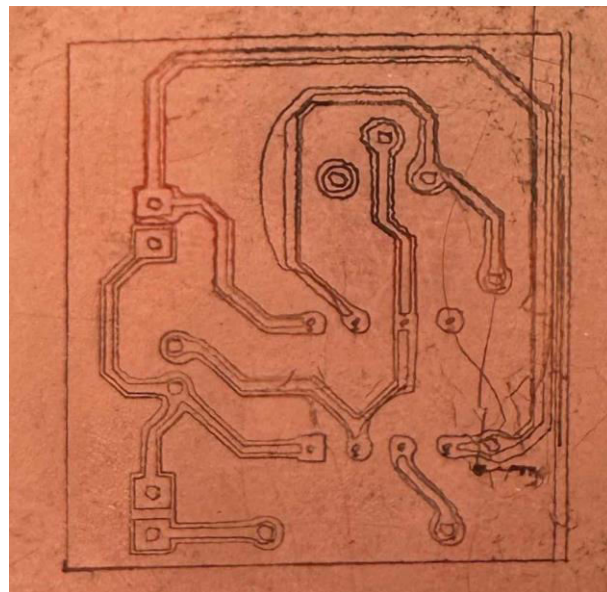
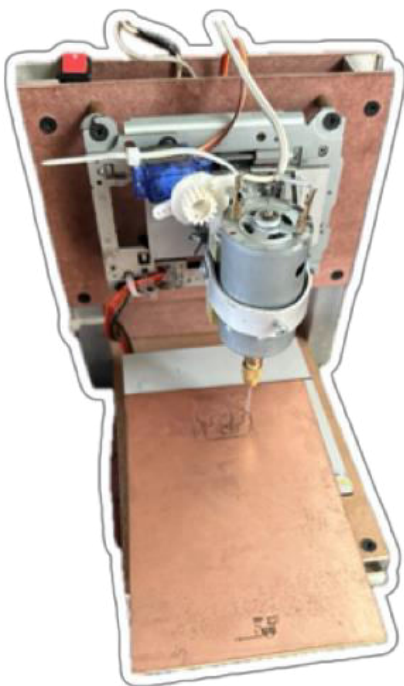
In this project the development of an Arduino-Uno-based, portable, dependable, three-axis tiny CNC PCB plotter is described. The CNC machines now on the market come at a heavy cost. Maintaining it takes a highly experienced operator and is rather challenging. The CNC machine solves this issue since it is affordable, dependable, portable, and it does not require a highly skilled person to run the apparatus. The equipments are very simple to maintain and reasonably priced. Compared to other machines on the market the working hours of this machine is extended. As the machine can be alter to suit the demands, it becomes more flexible. More features can be added to the CNC PCB plotter. A precise and accurate PCB with fine traces and

distinct features should be able to be produced using a well-designed and calibrated small CNC PCB plotter. The productivity of the CNC plotter, which includes traverse and cutting speeds, will affect how long it takes to finish a PCB. Productivity may be increased by using faster and more effective processes. The CNC plotter's resolution, ascertained Achievable detail will depend on variables like lead screw pitch and stepper motor accuracy during PCB design.

This project introduces a compact and affordable CNC PCB plotter based on Arduino Uno. Unlike many expensive CNC machines available, this plotter is designed to be easy to use, maintain, and transport. You don't need specialized skills to operate it, and maintenance is straightforward and inexpensive. Plus, it offers extended working hours compared to other machines. Being adaptable to various demands, it's highly flexible, allowing additional features to be incorporated. With precise calibration, it can produce intricate PCBs with fine traces and clear features. The speed at which it operates, both in traversal and cutting, affects productivity, which can be enhanced with faster processes. The level of detail achievable depends on factors like the precision of stepper motors and lead screw pitch during PCB design.

## V. CONCLUSION

A mini CNC PCB plotter represents a significant advancement for hobbyists, educators, and small-scale developers in the field of electronics manufacturing. Compact, precise, and highly adaptable, these plotters transform the process of PCB creation from a cumbersome, chemically intensive procedure to a streamlined, digital fabrication process. By allowing users to rapidly prototype PCBs with high accuracy directly from their digital designs, mini CNC plotters not only save time but also reduce waste and costs associated with traditional methods. The integration of such technology into workshops and educational settings promotes a deeper understanding of both design and manufacturing processes, empowering users to experiment more freely and



innovate. Moreover, the ability to iterate designs quickly enhances troubleshooting and optimization of electronic circuits, accelerating the development cycle and leading to better outcomes in projects. In conclusion, mini CNC PCB plotters stand out as transformative tools in electronics fabrication. They encapsulate the merging of digital precision with physical production, offering a gateway to sophisticated electronics manufacturing that is accessible even in a non-industrial setting. This technology is not just about creating more efficiently; it's about inspiring a new generation of inventors and engineers who can bring their ideas to life with unprecedented ease and speed.

This shift towards using mini CNC PCB plotters is revolutionizing how electronics are made, especially for those who work in small-scale settings or educational environments. These machines allow for quick and precise production of PCBs right from digital files, eliminating many of the traditional steps that were both time-consuming and hazardous due to the chemicals involved. This makes the process cleaner, faster, and much less wasteful, which is not only good for the environment but also lowers costs. With these plotters, students and hobbyists can see their projects come to life much faster, making it easier to test ideas and make improvements on the fly. This rapid iteration is invaluable for troubleshooting and perfecting electronic devices, significantly speeding up the learning and development process. Ultimately, mini CNC PCB plotters are more than just tools for

cutting circuit boards—they are enablers of innovation and creativity. They democratize access to advanced manufacturing techniques, making it possible for anyone with an idea to explore complex electronics projects. This is not only empowering but also encourages a whole new generation of tech enthusiasts to translate their visions into tangible, working prototypes without the barriers of traditional PCB fabrication techniques. This way, mini CNC PCB plotters are paving the way for future innovations in electronics by making sophisticated manufacturing accessible to all.

## VI. FUTURE SCOPE

By adding a 3D pen or heatend, this machine may be improved to become a 3D printer. Devices like pens, lasers, drilling machines, engraving machines, and so on, can have removable slots added to them. It is possible to include a camera sensor that will automatically translate an image or object into G-code for printing when it is detected. The bluetooth component or wifi module has wireless printing capabilities. It is possible to create a cloud-based printing project goal at any time and from anywhere. For this project, an android or web application that can automatically convert images to G-code and upload them to the machine may also be made. An auto sholdering device and an automated PCB component planter might improve this project. Workspace of the The machine can be scaled up without changing the algorithm. The method may be improved by using premium elements. The PCB printing time can also be lessen and make the printing more faster. Imagine upgrading a regular machine to a 3D printer by adding a special pen or a heating tool. You could also make slots for other tools like lasers or drills. Plus, you can add a camera that turns pictures into instructions for printing. With Bluetooth or Wi-Fi, you could print wirelessly, even from far away using a cloud-based system. You could even make an app that turns images into printing instructions and sends them to the machine. Adding devices for soldering and planting PCB components could make it even better. And you could make the workspace bigger without changing how it works. Using better materials could make it work even smoother and faster, especially when printing PCBs.

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