International Journal of Advance Engineering and Technology
Volume 1 Nomor 1 May 2025
e-ISSN: 3089-767X; p-ISSN: 3089-8439, Page 79-90
DOI: https://doi.org/10.63956/ijaetech.v1i1.20
Available online at: https://ijaetech.org/index.php/ijaetech/article/view/20

Computer Based Control System for the Development of an Automatic Drilling Machine

Belinda Ayuningtyas[1], Sulistyo Widodo[2], Randy Rahmanto[3], Riesa Syariful Akbar[4], Ganjar Febriyani Pratiwi[5]
[1,2,3,4,5]Electronic Engineering, Technic and Informatics, Dian Nusantara University, Indonesia

Abstract. *This study aims to design and develop an automatic drilling machine controlled by a computer-based system via a parallel port interface. The machine is intended to improve precision and efficiency in repetitive drilling tasks such as PCB fabrication and pattern-based production. Tests were conducted on repeatability, accuracy, working area dimensions, movement speed, and the performance of the electronic circuit. Results indicate that the machine achieved ±0.05 mm precision and a maximum feed rate of 500 mm/min. The system also demonstrated stable control signal behavior and consistent stepper driver performance in accordance with component specifications. This research proves that legacy computer hardware can still be effectively utilized in low-cost automation systems to support technical tasks requiring moderate precision.*

Keywords: *Automatic drilling machine, computer-based control, parallel port, stepper motor, accuracy.*

INTRODUCTION

The rapid advancement of science and technology has significantly influenced modern human lifestyles, leading to an increased demand for automation in various aspects of daily life. As manual operations gradually transition toward automation, the integration of computer-based control systems with mechanical devices has emerged as a promising solution to improve efficiency and precision. One such application of automation is in the drilling process, which traditionally requires repetitive manual labor and is often prone to inconsistencies, especially when precision is critical.

Tasks such as drilling Printed Circuit Boards (PCBs) or crafting specific hole patterns—like those required for birdcages—demand high accuracy and uniformity. When performed manually and in large quantities, these operations are vulnerable to dimensional variations that compromise quality. Automating such tasks through the implementation of computer-controlled systems offers a reliable solution by ensuring consistent performance and reducing human error.

In this context, the use of stepper motors as mechanical actuators controlled via a computer interface presents an effective means of automating drilling processes. Unlike traditional Programmable Logic Controllers (PLCs), which require specialized knowledge, personal computers offer a mode accessible and flexible platform for system

Received: August 04, 2025; Accepted: July 28, 2025; Published: August 10, 2025
*Corresponding author, belinda.ayuningtyas@undira.ac.id

control. Despite the declining use of parallel port connections in modern computing, such legacy interfaces can still be repurposed effectively for industrial applications. Moreover, with appropriate circuit adaptations, modern interfaces such as Universal Serial Bus (USB) can also be employed.

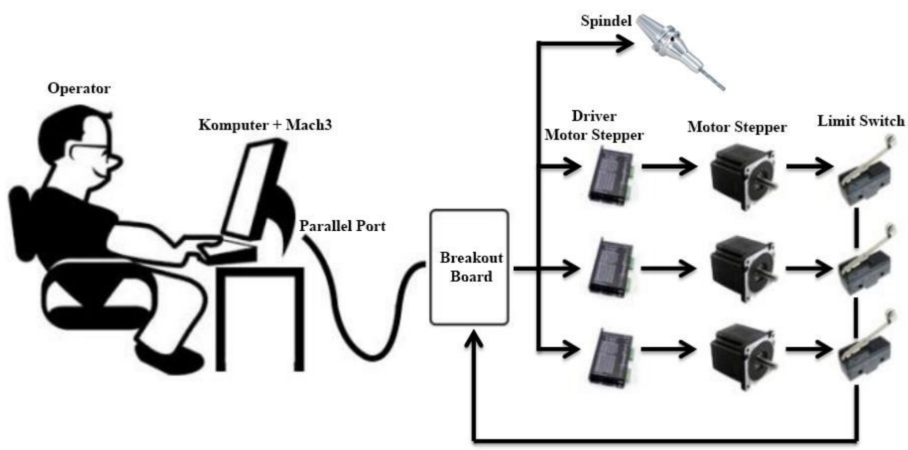
This paper presents the design and development of an automatic drilling machine powered by a computer-based control system. The proposed system aims to enhance drilling accuracy, minimize processing time, and repurpose outdated computer hardware for industrial functionality. The resulting automation not only improves productivity but also contributes to consistent and repeatable manufacturing outcomes..

METHODS

The development of the computer-based automatic drilling machine follows a structured engineering design approach consisting of several key stages: problem identification, system design, hardware and software integration, testing, and evaluation. The following describes each phase in detail.

System Design

The system is designed as a combination of mechanical components and an electronic control unit. The mechanical framework includes a movable platform with X and Y axes for positioning and a vertical Z-axis mechanism for the drilling operation. The movement in each axis is actuated using stepper motors to ensure precision and repeatability.



Figuria 1. Overall System Configuration

A key part of the design is the use of a computer as the central controller. The computer sends digital signals through a parallel port interface to a stepper motor driver circuit. These signals determine the direction, steps, and timing of the motor movements, which in turn control the drilling head's position and operation.

Hardware Implementation

- Mechanical Components: The main frame is constructed using aluminum profiles for stability and low weight. A drill chuck is mounted on a vertically sliding mechanism operated by a Z-axis stepper motor.
- Actuation System: Three stepper motors (one for each axis) are used for motion control. These motors are connected to lead screws or timing belts to translate rotational motion into linear displacement.
- Driver Circuit: A custom-built or commercially available stepper motor driver circuit receives pulse and direction signals from the computer and powers the motors accordingly.

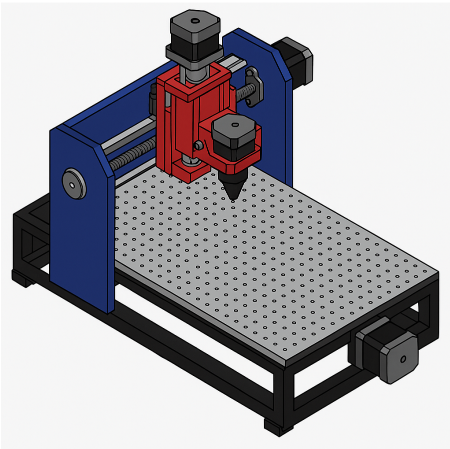


Figure 2. Mechanical Hardware Design

Control System Development

The computer is programmed to control the stepper motors using a dedicated software interface. This interface is developed using a high-level programming language such as C++ or Python, capable of accessing and controlling the computer's parallel port. The software allows users to input drilling coordinates, sequence patterns, and repetition cycles.

- Signal Interface: The parallel port is used to transmit control signals. Although this port is outdated in modern systems, it is still reliable for simple control tasks and is utilized here to reduce system complexity and cost.
- User Input: Users can input drilling patterns via a graphical user interface (GUI) or by loading predefined coordinates.

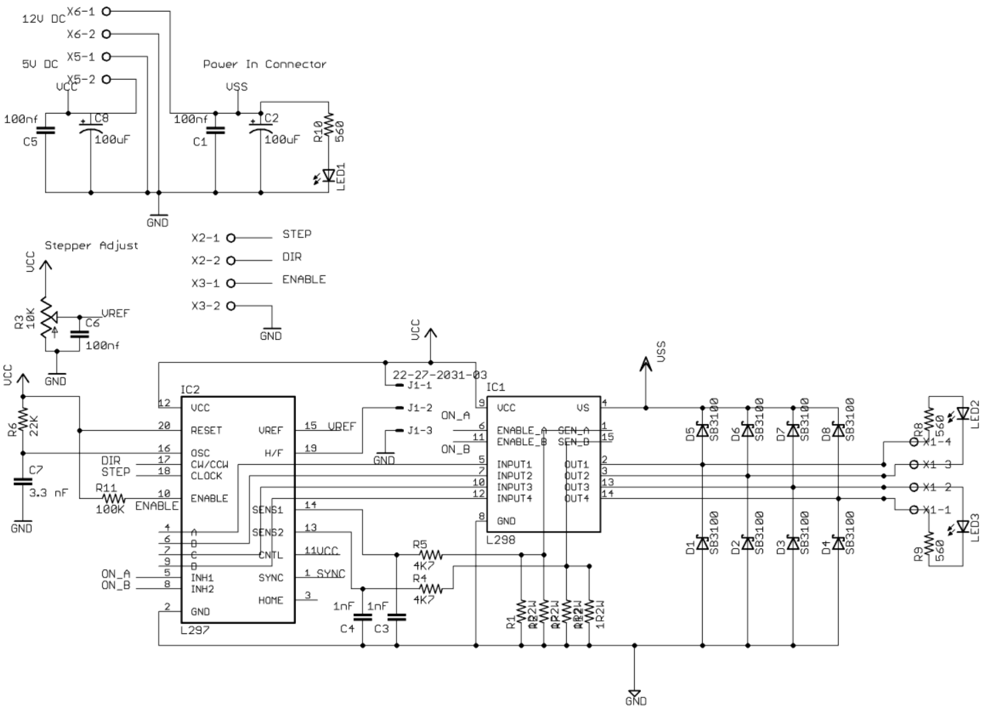


Figure 3. Stepper Motor Driver Circuit

Testing and Calibration

Once the system is assembled, testing is conducted in stages:

- Initial Calibration: Ensuring that each axis responds accurately to software commands and that motion is smooth and synchronized.
- Drilling Accuracy Test: Conducting repetitive drilling tasks on a test material (e.g., acrylic or PCB board) to assess position accuracy and hole uniformity.
- System Reliability: Evaluating system stability during prolonged operation and testing the consistency of results over multiple cycles.

Evaluation and Improvement

The final phase includes evaluating the system's performance against key indicators such as:

- Positional accuracy
- Repeatability
- Drilling time per cycle
- Ease of use

Feedback from the testing phase is used to fine-tune both hardware alignment and software timing, aiming for improved system responsiveness and drilling precision..

RESULTS

Repeatability Test

Repeatability testing was conducted to evaluate the system's ability to return to the same reference point after repeated motions. The test was performed on the X, Y, and Z axes using an outside dial gauge.

- The average deviations for the X-axis were 0.007 mm (20 mm), 0.004 mm (40 mm), and 0.004 mm (60 mm).
- The Y-axis showed slightly larger variation with average deviations of 0.009 mm, 0.008 mm, and 0.01 mm respectively.
- The Z-axis repeatability was excellent with average deviations of 0.002 mm, 0.005 mm, and 0.004 mm.

Conclusion: The machine exhibited excellent repeatability performance, supporting its intended application for high-precision tasks such as PCB and birdcage drilling.

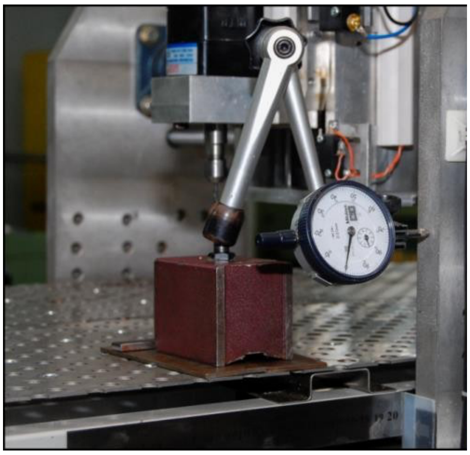


Figure 4. Repeatability Test Setup

Accuracy Test

Accuracy testing involved measuring the deviation between the commanded and actual displacement using a dial indicator during repeated incremental movements of 1 mm, 3 mm, and 5 mm.

- Maximum deviation for X-axis: ±0.04 mm
- Maximum deviation for Y-axis: ±0.05 mm
- Maximum deviation for Z-axis: ±0.01 mm

The system achieved a tolerance level of ±0.05 mm, which is acceptable for light-duty automated drilling operations.

Working Area Dimension Test

This test verified the machine's maximum travel range using linear rulers and limit switches. The actual working dimensions exceeded the design specifications:

- X-axis: 280 mm
- Y-axis: 367 mm
- Z-axis: 73 mm

These values confirm that the design goal of 250 mm × 300 mm × 20 mm (X, Y, Z) has been successfully achieved.

Table 1. Working Area Dimensions

Axis	Position Point (mm)			Length
	Left Limit	*Home*	Right Limit	Step (mm)
X	56	276	336	280
Y	28	316	395	367
Z	31	96	104	73

Maximum Feed Rate Test

Feed rate tests were carried out for all axes using program commands from 50 mm/min to 600 mm/min. Maximum consistent motion without timing loss was achieved at 500 mm/min.

The Mach3 software's axis calibration feature (see Figure 4.8) was used to correct discrepancies between programmed and actual displacement.

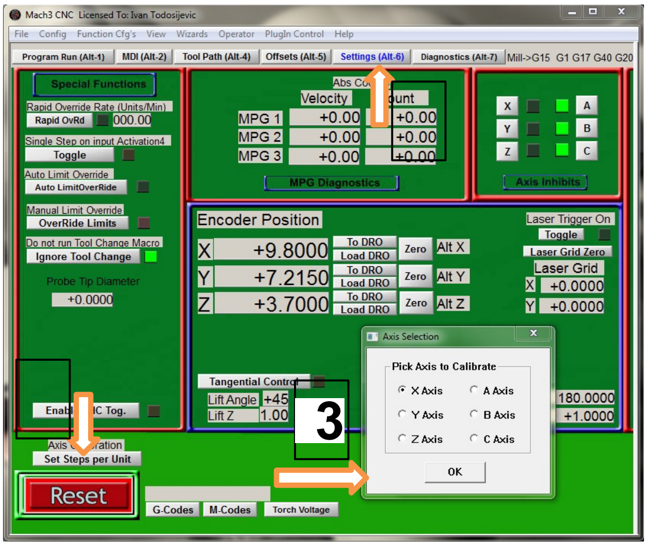


Figure 5. Axis Calibration

Drilling Test

To validate functionality, a drilling test was performed on real workpieces:

- Left test: uniform spacing in X-axis, varying in Y-axis.
- Right test: uniform spacing in both X and Y axes.
- Deep drilling was also successful, achieving depths >20 mm with a 2 mm drill bit.

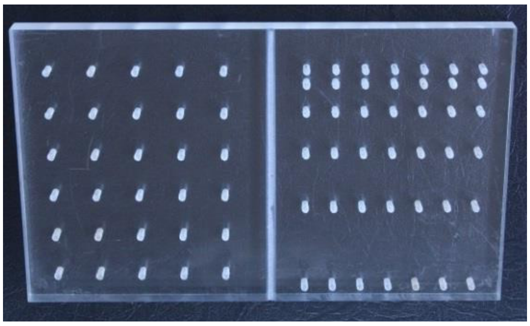


Figure 6. Drilling Pattern Test

Breakout Board and Signal Testing

Pin configuration testing of the parallel port (Table 4.11) confirmed that the output voltage of the pins was close to 5V when active and near 0V when inactive—aligning with digital logic levels.

Frequency testing confirmed a linear relationship between axis speed and signal frequency. For example, at 300 mm/min, frequency reached approximately 384–478 Hz depending on the axis.

Table 2. Parallel Port Configuration.

Pin 1	*Enable*	Pin 10	*Limit Switch* + Estop
Pin 2	Step X	Pin 11	*Home* X
Pin 3	*Direction* X	Pin 12	*Home* Y
Pin 4	Step Y	Pin 13	*Home* Z
Pin 5	*Direction* Y	Pin 14	–
Pin 6	Step Z	Pin 15	–
Pin 7	*Direction* Z	Pin 16	–
Pin 8	*Spindle On*	Pin 17	–
Pin 9	–	Pin 18 - 25	*Ground*

Table 3. Voltage Output

No. Pin	Voltage (V)	Description
1	4,935	aktif
	0,086	non aktif
3	4,939	*Clockwise*
	0,088	*Counter clockwise*
5	4,940	*Clockwise*
	0,087	*Counter clockwise*

No. Pin	Voltage (V)	Description
7	4,940	*Clockwise*
	0,088	*Counter clockwise*
8	4,938	aktif
	0,088	non aktif

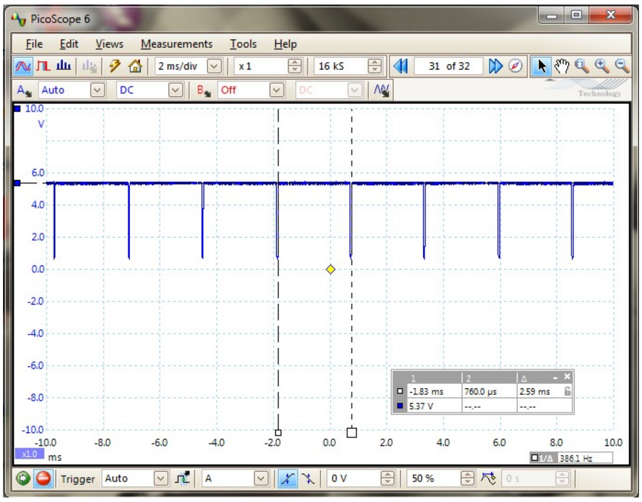


Figure 7. Signal Frequency Testing

Stepper Driver Output Test

Driver output current was measured under holding and running conditions:

- Peak current during holding was 1.9 A, which is consistent with the rated output of the L298-based driver.
- Running current was significantly lower, confirming proper power regulation.

Table 4. Stepper Driver Output Current

Driver	Cable	Current (A)	
		Holding	*Run*
Sb. X	1	1,7	-0,098
	2	1,9	-0,046
	3	1,7	-0,039
	4	1,9	0,035
	1	1,4	0,002

Driver	**Cable**	**Current (A)**	
		Holding	***Run***
Sb. Y	2	1,4	0,002
	3	1,5	0,002
	4	1,5	0,003
Sb. Z	1	1,3	0,008
	2	1,3	0,005
	3	1,3	0,008
	4	1,3	0,005

Relay Board Operation

The relay circuit controls the spindle and indicator lamps. During idle state, the green lamp (connected to NC terminal) remains ON. When the spindle is activated, the yellow lamp (connected to NO terminal) is triggered.

BD139 transistor was used for switching, and base resistance R_B was recalculated to approximately 1.2 kΩ using collector current assumptions.

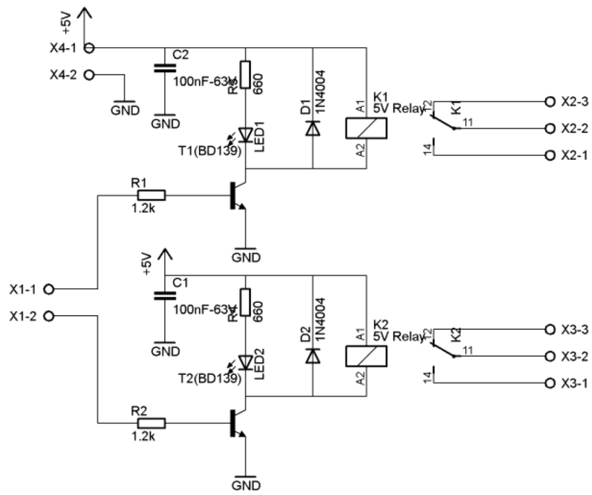


Figure 8. Relay Board Image

DISCUSSION

The testing results confirm that the computer-based automatic drilling machine performs reliably with good repeatability, accuracy, and feed rate consistency. The system achieved a precision of ±0.05 mm, suitable for applications like PCB drilling and repetitive pattern fabrication. Axis calibration via Mach3 software improved positioning accuracy, while the maximum feed rate of 500 mm/min was limited by the full-step mode of the stepper driver. Signal and power tests showed that the parallel port-based control and driver circuits functioned within expected voltage and current limits. Overall, the system successfully demonstrates that low-cost computer-based automation, even using outdated interfaces like parallel ports, can deliver reliable performance for semi-precision drilling tasks.

CONCLUSION

This research successfully developed a computer-based automatic drilling machine that integrates mechanical systems with a simple yet effective control mechanism via a parallel port interface. The system demonstrated high repeatability with deviations as low as 0.002 mm and accuracy within ±0.05 mm, making it suitable for repetitive drilling applications such as PCB fabrication and light manufacturing tasks. The working area dimensions exceeded the initial design targets, and the machine consistently operated at a maximum feed rate of 500 mm/min. Electrical and frequency tests validated the reliability of the control signals, while current output measurements confirmed the safety and compatibility of the stepper driver components. Overall, this project proves that repurposing older computing hardware for automation is feasible and cost-effective, offering a viable alternative to more expensive CNC systems for small-scale precision applications.

REFERENCES

Thompson, L. M. (2006). Basic electricity and electronics for control: Fundamentals and applications (3rd ed.). ISA—Instrumentation, Systems, and Automation Society.

Yu, Y. J. (2024). Developing an automatic drilling system by controlling proportional valves for automated drilling rigs. Journal of Mechanical Science and Technology, 38(3), 1141–1150. https://doi.org/10.1007/s12206-024-1141-6

Zhou, Z. (2023). Development of electric drive laboratory drilling system using PLC with PID control. Applied Sciences, 13(2), 1059. https://doi.org/10.3390/app13021059

Materials Today. (2025). State-of-the-art review on automatic vertical drilling tools (AVDTs). Materials Today: Proceedings, 79, 115–123. https://doi.org/10.1016/j.matpr.2025.03.012

AIP Conference Proceedings. (2024). Automated multi-axis depth-controlled drilling machine with Arduino interface. AIP Conference Proceedings, 3156, 050010. https://doi.org/10.1063/5.0153260

Ayyad, A., Halwani, M., Swart, D., Muthusamy, R., Almaskari, F., & Zweiri, Y. (2022). Neuromorphic vision-based control for precise robotic drilling with sub-millimeter accuracy. arXiv. https://arxiv.org/abs/2201.01626

Yan, H., Xu, H., Gao, H., Ma, F., Eben Li, S., & Duan, J. (2023). Integrated drill boom hole-seeking control via reinforcement learning. arXiv. https://arxiv.org/abs/2312.01836

Madani, A., Niaz, P. P., Guler, B., Aydin, Y., & Basdogan, C. (2022). Robot-assisted drilling on curved surfaces with haptic guidance under adaptive admittance control. arXiv. https://arxiv.org/abs/2207.13999

Guler, B., Niaz, P. P., Madani, A., Aydin, Y., & Basdogan, C. (2022). Adaptive admittance controller for collaborative drilling via deep learning. arXiv. https://arxiv.org/abs/2205.14457

Kumar, R. (2024, October 30). L298N motor driver specification, pinout and how it works. JAK Electronics Community. https://www.jakelectronics.com/solution/l298n-motor-driver-specification-features-pinout-how-it-works

Allelco Electronics. (2024, October 29). How the L298N motor driver powers DC and stepper motors. Allelco Electronics. https://www.allelcoelec.com/blog/How-the-L298N-Motor-Driver-Powers-DC-and-Stepper-Motors.html

Singh, A., & Sharma, V. (2025). A simple multi-axis stepper motor controller using a PC parallel port. ResearchGate. https://www.researchgate.net/publication/238073729

Li, W., & Chen, Y. (n.d.). Motion control with the parallel port on PC and its application. ResearchGate. https://www.researchgate.net/publication/251847052

Allen, S. (2022, December 28). Successful LinuxCNC stepper motor test—new screwdriver. New Screwdriver Blog. https://newscrewdriver.com/2022/12/28/successful-linuxcnc-stepper-motor-test

Tindie. (2025). 5 Axis CNC interface board for stepper motor driver Mach3 with USB cable. Tindie. https://www.tindie.com/products/mmm999/5-axis-cnc-interface-board-for-stepper-motor

IJRASET. (2025). Fabrication and automation of drilling machine by Arduino control. International Journal for Research in Applied Science and Engineering Technology (IJRASET). https://www.ijraset.com/research-paper/fabrication-and-automation-of-drilling-machine-by-arduino-control.