

CNC Plotter Machine

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Abstract- The CNC machine which was introduced in the late 1970s has improved its utilization drastically over the years. The goal of the project is to design a cost-effective three-axis CNC plotter machine with multiple applications. The 3-axis plotter machine works with the use of a stepper motor, Arduino UNO and microcontroller software. Its framework involves mechanical system design, wiring and software tools. The principle behind the plotter machine is computer numerical control which gives input to the plotter from a computer program. The Arduino UNO and CNC shield drivers enable consistent and accurate step control of stepper motors. The Inkscape is utilised to transform any desired picture into a G-code file for the machine to work. The CNC plotter machine used in the project works within a plotting area of 8×9 cm.

Keywords- Arduino, CNC, stepper motors, Inkscape software, G-code file

I. INTRODUCTION

The computer numerical control (CNC) is majorly utilised to replace manpower, increase reliability, and precision, and reduce time consumption. The CNC is obtained by integrating a computer processor that enables the programs to be edited and stored in computer memory. The plotter machine executes its functions based on special instructions or commands known as the G-codes. The G-code gives the direction to the tool for the movement of all three axes. The tool can also be chosen based on the desired outcome. It can be a marker pen, laser cutting, milling etc., and it can be utilized for a diverse range of applications. The axes have the potential to create 3-D or 2-D images on plain surfaces or any other material. The plotter machine is so versatile that it can be used for everyday simple tasks to the most specialized, complex tasks as well. The position of the tool is controlled by a stepper motor to provide high accuracy in movements. The plotting area can be increased for commercial purposes as per requirement. The closed-loop control system is most preferable in providing the reliability, speed, and accuracy needed for commercial machines.

II. LITERATURE SURVEY

In this section, a brief summary of the research carried out by various authors on CNC plotter machines is mentioned. [1] R. R. Jegan, E. Gnanasundaram, M. Gowtham, R. Sivanesan and D. Thiagarajan 2018 "Modern Design and Implementation of XY Plotter". The objective of this research paper is to develop the XY Plotter, which is an accurate, and adaptable pen plotter that can write or draw.

This research paper gave an idea about the working of a CNC plotter machine using X-Y coordinates.

[2] Y. M. Hasan, L. F. Shakir and H. H. Naji 2018 "Implementation and Manufacturing of a 3-Axes Plotter Machine by Arduino and CNC Shield". The objective of this research paper is to construct a plotter and build open-source software to operate the machine. This research gave an insight about how to construct a cost-effective Arduino plotter machine with XYZ coordinates using open-source software and hardware.

[3] Rahul Somalwar², Namesh A. Kale³, Ashish J Nandeshwar⁴ and Antariksh V 2020 "Short paper on CNC PCB milling machine". The goal of the research paper is to reduce the cost of CNC machines and meet the growing needs of large-scale industries in minor applications. This research gave an idea on how to develop, assess, and install a low-cost CNC-based PCB milling machine that can be employed in small firms.

[4] Aneeta Pinhiero, Beljo Jose, Tinsemon Chacko, Nazim TN 2016 "Wireless CNC Plotter" The goal of this research paper is to develop a small three-axis CNC plotter machine. This research paper gave the clarity about the concept of a wireless CNC plotter that can be used for PCB layout and drilling.

[5] M.Bhavani, V.Jerome, P.Lenin Raja, B.Vignesh, D.Vignesh 2019 "Design and Implementation of CNC Router". The objective of this article is to develop and build a CNC plotter machine-based router machine for wood engraving. This research gave an idea about the design and fabrication of a mini-CNC Plotter Machine that can be used for engraving.

III. OBJECTIVE

The major purpose of the CNC plotter machine is to create 2-D, and 3-D images on a plain surface or any other material by using a 3-D printing mechanism and microcontroller. The machine is cost-efficient. The plotting operation can be replaced by any other tool like a laser cutter or milling cutter. The distinctive feature of this machine lies in its flexibility as it is capable to execute a wide variety of applications.

IV. BLOCK DIAGRAM

The CNC machine works with input as a G-code file. The G-code file is obtained from Inkscape software and further, the G-code file would be sent to the Arduino controller over Universal Serial Bus (USB) by the Processing IDE. The

input functions as an electrical signal to the stepper motor and servo motor. The X, Y, and Z axes work according to the instructions given to the control unit. The controller unit also determines the drawing speed and the tool cutting and depth speed.

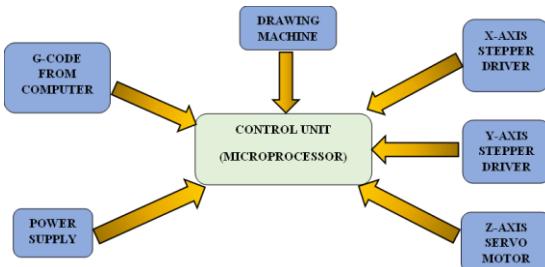


Fig 1. BLOCK DIAGRAM OF CNC PLOTTER MACHINE

V. SOFTWARES

A. INKSCAPE SOFTWARE (version 0.92.4)

The Inkscape software will convert any desired image or text into a G-code file. It is a free and open-source vector editor. The main purpose of the software is to trace the images or text. The tracing of the image is carried out by the following steps, open the Inkscape software version 0.92.4 and set the document properties. Further, select the size of the page accordingly millimeter or centimeter (mm or cm) according to your page size, then drag and drop or import the particular image needed. The image can be resized according to the paper size. Now go to Trace bitmap. After trace bitmap, two photos will be available, delete the original one and keep the traced one. After that select go to Path- object to path. Hence, the traced image is obtained which indicates that when will pen or the tool will go up and pen down. The G-code file obtained can be saved in the desired location.

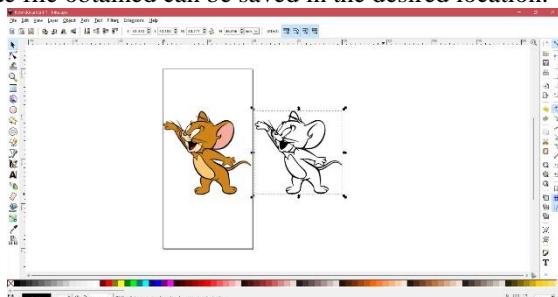


Fig 2. CONVERSION OF IMAGE TO G-CODE FILE

B. ARDUINO IDE 1.8.16

The open-source Arduino Software (IDE) allows us to write code and upload it to the board in real-time. Arduino IDE works within Windows, Mac and Linux operating systems. The Arduino IDE acts as a channel between the computer and the motor drive. The CNC shield and motor shield are used to interface the motor drive.

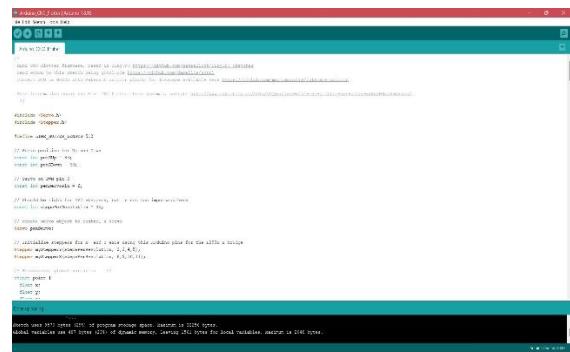


Fig 3. ARDUINO SOFTWARE IDE

C. PROCESSING IDE

Processing is an open-source software specifically created to be used by electronic artists and visual designers. The G-code file is sent from the user interface to the CNC plotter machine using the software. This will allow the plotter machine to operate. To send the G-code file to the system following steps are carried out, open GTCRL (processing software) and RUN the GTCRL program. After Running the program, a small pop-up command window is displayed. Further, Press (P) to select the port, on which the Arduino board was previously connected. Then press (G) to extract the G-code file from the PC. The command window of processing software is displayed that indicates that the CNC plotting machine is active and it is ready to take the G-code file from the PC. Hence the CNC machine will begin to function.

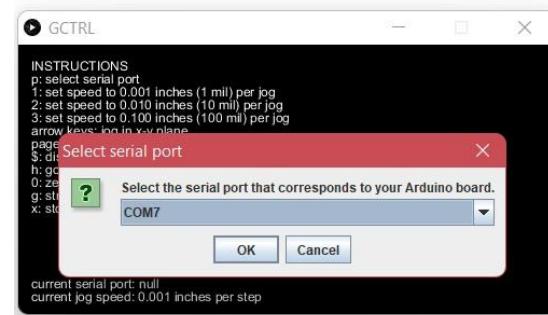


Fig 4. SELECTION OF PORT IN PROCESSING IDE SOFTWARE

VI. HARDWARE COMPONENTS

A. ARDUINO UNO

The Arduino UNO is a microcontroller board that uses the ATmega328P microcontroller. There are 14 digital input/output pins, six analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button on the board. The Arduino utilises the input program to control the movement and the position of the stepper motors.

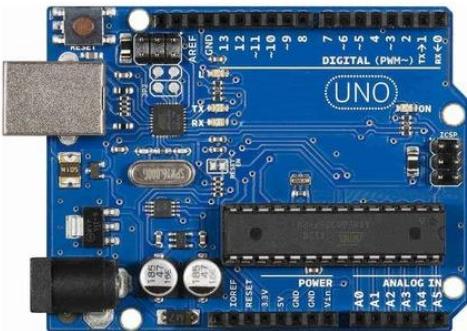


Fig 5. ARDUINO UNO

B. STEPPER MOTOR

The stepper motor is an integral component in a CNC plotter machine as it controls the precision and speed of the system. It is a brushless and synchronous electric motor. The stepper motor helps to control the precise and accurate movement of the X and Y axes. The movement and position of the stepper motor are carried out without any feedback mechanism i.e., it is based on open-loop control system.

C. SERVO MOTOR

The servo motor is an electrical device that allows the object to rotate with high precision. It is very commonly used in remote-controlled toys, drones, robots, printing machines, etc. The application of a servo motor in a CNC plotter machine is to control the up and down movement of the pen. This action is implemented by sending pulse width modulation. The pulse value of 90 degrees enables the pen to go up otherwise if the value is as low as 0 degree, the pen goes down. The up and down movement of the pen is in the Z-axis direction.



Fig 6. SERVO MOTOR

D. STEPPER DRIVER

The stepper driver receives a pulse signal and causes the motor to rotate at an angle in a certain direction. In the project, a l293D motor driver has been utilised.



Fig 7. L293D MOTOR DRIVER

E. CD ROM

CD ROM consists of a stepper motor that moves back and forth. This stepper motor in CD ROM can be used in a CNC plotter machine. There are 3 CD ROM used in the project. The stepper motor in each CD ROM can be used for the movement of axes. It can be used for the back-and-forth

movement for the Y-axis, side to side movement for the X-axis and the up-down movement of the Z-axis.

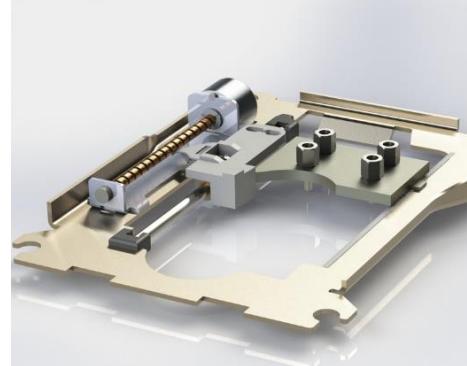


Fig 8. CD-ROM

VI. RESULTS

Any input can be given for the CNC machine to execute. The input can be either image or text. Here, image (college logo) is given as an input and the tool used here is a gel pen. The tool can be replaced as per the requirements.



Fig 9. IMAGE INPUT

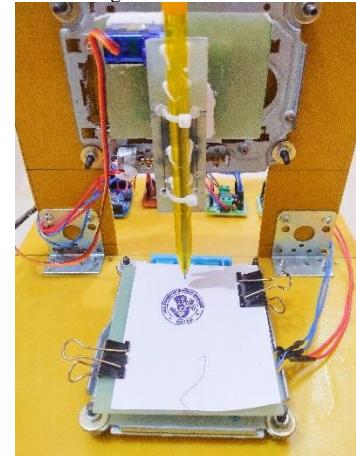


Fig 10. IMAGE OUTPUT

VII. CONCLUSION

In this project, a simple and cost-efficient CNC plotter machine has been curated. It can write, cut, and engrave according to the required needs with precision and accuracy. The machine is easy to use and occupies less area due to its size. It can be assembled and transported anywhere with ease. The plotting area in the project is small but that doesn't limit its applications. The area can also be extended.

VIII. FUTURE SCOPE

The machine can be improvised to a great extent to meet its commercial needs. The size can be enlarged and motors can be replaced with more powerful ones. Applications like laser cutting, woodcutting or milling are difficult when it is done manually, CNC machines can execute them with much ease.

The CNC machine will be able to execute its action with high precision and accuracy for a long period of time. The CNC machines have more scope in the automation industry since they can ensure high-quality products. With emerging advancements in technology, CNC machines will be a leading player in major industries. It will surely boost the global economy and will lead to rapid industrialization.

REFERENCES

- [1] R. R. Jegan, E. Gnanasundaram, M. Gowtham, R. Sivanesan and D. Thiagarajan, "Modern Design and Implementation of XY Plotter," 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), 2018
- [2] Y. M. Hasan, L. F. Shakir and H. H. Naji, "Implementation and Manufacturing of a 3-Axes Plotter Machine by Arduino and CNC Shield," 2018 International Conference on Engineering Technology and their Applications (IICETA), 2018
- [3] Shinde, Umesh & Somalwar, Rahul & Kale, Namesh & Nandeshwar, Ashish & Mendhe, Antariksh. (2020). Short paper on CNC based PCB milling machine considering human safety. Journal of Research in Engineering and Applied Sciences.
- [4] Aneeta Pinhiero, Beljo Jose, Tinsemon Chacko, Nazim TN, "Mini CNC Plotter" in international journal of innovative research in electrical, electronics, instrumentation and control engineering vol. 4, issue 4, April 2016.
- [5] M.Bhavani, V.Jerome, P.Lenin Raja, B.Vignesh, D.Vignesh, Design and Implementation of CNC Router, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 3, March 2017.
- [6] Mamilla, Venkata. (2016). Study on computer numerical control (CNC) machines. International Journal of Advanced Scientific Research.
- [7] Nsayef, Aman & Lateef, Anas. (2018). Microcontroller – Based Plotter Machine
- [8] T. Shivakumar, M. S. Sravan and K. Selvajyothi, "Python based 3-Axis CNC plotter," 2016 IEEE International Conference on Power and Energy (PECon), 2016
- [9] Pandey, Udit & Sharma, Swapnil. (2017). Model and Fabrication of CNC Plotter Machine, International Journal of Advanced Research in Computer and Communication Engineering
- [10] Nairutya Patel (2020) Study on Computer Numerical Control (CNC) Technology, International Research Journal of Engineering and Technology (IRJET)
- [11] Prince, Mohammad & Ansary, Muhsin-Al & Mondol, Abu. (2017). Implementation of a Low-cost CNC Plotter Using Spare Parts. International Journal of Engineering Trends and Technology
- [12] T. Andrei and I. Nae, "Designing and Building CNC Router Using Stepper Motors", Seria Technical, Volume-12, Page No- 55-62, 2010
- [13] <https://github.com/martymcguire/inkscape-unicorn>
- [14] M. Aditi, S. Karpagam, B. Nandini, B. S. Murugan, 2019, Automated Writing and Drawing Machine, International Journal of Engineering Research & Technology (IJERT) ETEDM
- [15] Raad, Sara & Mohammad, Haider & Falah, Mustafa. (2019). Accurate and Cost-Effective Mini CNC Plotter. International Journal of Computer Applications.