Development of CNC Plotter Machine for Printing Application

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***Abstract*: This paper presents the design, development, and application of a CNC (Computer Numerical Control) plotter machine specifically developed for printing applications. The research focuses on the integration of modern CNC technology with printing processes to enhance precision, automation, and versatility in various printing tasks. The paper discusses the hardware design, software control, and operational principles of the CNC plotter, along with the potential applications, challenges, and future trends in the field of printing.**

Keywords: CNC, CNC Plotter.

I. INTRODUCTION

The field of printing technology has evolved significantly over the years, moving from manual to more automated systems. One of the recent innovations is the CNC plotter, a machine that combines CNC technology with printing mechanisms to achieve high precision, consistency, and flexibility. CNC plotters are widely used in industries for applications such as digital printing, 3D printing, packaging, and sign making. This paper investigates the development of a CNC plotter machine that incorporates printing functionalities, providing an in-depth analysis of its design and potential impact on the printing industry.

II. LITERATURE REVIEW

Numerous studies have been conducted on the evolution of CNC technology and its applications in various domains. CNC technology was originally developed for machining processes such as milling and turning, but its integration into other fields, including printing, has gained significant attention. Recent developments in CNC plotters have led to the creation of machines that can handle both traditional printing techniques as well as modern digital printing. The research highlights different types of CNC plotter machines, the software used for controlling them, and the challenges faced in integrating these technologies into printing applications.

In this paper, we are designing a low-cost three axis Mini CNC Plotter using stepper motor, Arduino microcontroller, and motor manipulate software program. In 1775 for operations like slicing, shaping and many others., a Canon the boring machine or Lathe became invented but it may do best one paintings at a time and additionally other dangers just like the requirement of ordinary tracking, professional labors and much less accuracy. In 1947, John parsons attempted to govern device tool movement the usage of 3-axis curvature data which changed into further developed for the discovery of CNC system [3]. But this one is of high value and its production is very tough. In our venture, we are looking to create a low value CNC plotter of small or medium length and an open structure.

Based on CNC principle, 2D Robotic Plotter will work. The software program used for programming the Arduino board are namely Inkscape (0.48.5), Processing (3.0.2), CAMOTICS, Arduino IDE. The accurate and efficient association and proper use of the programs along with the circuit make up an efficient 2D Robotic Plotter (CNC).

The fabrication of low-value CNC gadget is used to lessen price and complexity of the machine. This paper is address the layout of a low-price automated CNC gadget for PCD drawing and drilling [4]. The objective of this project is to design and drill PCB based on a low-cost CNC machine, it will be achieved by incorporating features of PC with ATMEGA328 controller in an Arduino. G-code is used for the operation of whole system G code nothing but a language for making computerized machine tool to understand 'How to make something' and to define instructions like where to move & how fast to move.

Designed and implemented a CNC plotter using spare parts on a solid surface to draw a PCB layout or an image [5]. Inkscape software is used to feed G code to the gadget the usage of processing software program. Arduino UNO with an ATmega328P microcontroller is used because the manage device. The microcontroller converts G-code into a fixed of system language practice to be sent to the motor driving force of the CNC plotter.

The machine basically works with three stepper motors (two for X-axis & one for Y-axis) and micro servo controller (for Z-axis). Where in Arduino Circuit plots the input given from the pc through 'INKSCAPE Software' on the sheet that's positioned on the drawing board using micro-controller. The plotter has 4 axis manage (2 X-axis and 1 Y & Z axis resp.) and a micro-servo controller for movement of the pen. This system reduces human effort and also reduces the chances of error. The efficient and correct mounting of all the parts and proper use of software and correct alignment of the circuit makes the system more efficient.[1]

III. OBJECTIVE

The primary goal of this research is to develop a CNC plotter machine capable of performing various printing tasks with high precision and efficiency. Specifically, the objectives include:

- Design of a CNC plotter machine that is adaptable to different types of printing mediums (e.g., paper, fabric, and plastic).
- Development of a software interface to control the printing process, including calibration, plotting, and media handling.

- Exploring the potential for reducing material wastage, improving quality, and reducing labor costs in the printing industry.
- Identifying the future prospects and limitations of CNC plotters in the printing industry.

IV. METHODOLOGY

The development of the CNC plotter machine involves several key steps:

1. **Hardware Design:** The CNC plotter machine is built with a robust frame, precision motors, and a suitable printing head capable of applying ink or toner. The machine uses stepper motors or servo motors to control the movement along the X, Y, and Z axes with high accuracy. The design also incorporates a material feeding mechanism, depending on the type of printing medium used.
2. **Software Development:** A custom control software was developed using G-code, the standard programming language for CNC machines, which enables the user to input design files (e.g., vector graphics in SVG or DXF formats). The software converts these designs into movement commands for the CNC plotter. Additionally, a graphical user interface (GUI) allows users to control the speed, resolution, and positioning of the print.
3. **Integration with Printing Technology:** The printing head is integrated with the CNC machine and is capable of handling various printing technologies, including inkjet and toner-based printing methods. The printing mechanism is calibrated to ensure that each line and curve of the design is accurately transferred onto the material.
4. **Testing and Calibration:** Once the machine was assembled, rigorous testing was performed to calibrate the plotting mechanism and printing quality. Factors such as resolution, color accuracy, and print consistency were evaluated.

Mini CNC Machine is the small CNC Machine that can operate same likes as CNC machine. This machine is designed for the specific dimension. The CNC machines can be divided into two groups, which are turning machines and milling machine. A turning machine is generally made up of a device that spins a work piece at high speed and the tool is moved back and forth and in and out until the desired shape is achieved. A milling machine is a machine that has spindle which is same as the router, with a special tool that spins and cuts in various directions and moves in three different directions along the X, Y, and Z axis. A CNC machine with several unique features, such as simplicity and reliability, was developed for studying computerized numerical control and its associated software. The machine is especially useful for educational and research purposes, and it is easy to integrate with other manufacturing systems. It can also be used to introduce the CNC aspect of CAM systems without involving too many complexities that are present in commercial systems.

The three-axis machine is capable of continuous path movement. Its design is carried out with the following considerations in mind:-

1. Intended as an instruction or research kit, it should be small in size and Light weight.
2. The worktable must have sufficient movement.
3. The spindle head must be restrained to a single degree of freedom.
4. A reduction must be given to the Z-drive for higher torque.

METHOD ADOPTED

In these four modules, he elaborates the part one by one which is module by module. First module is about the mechanical design. Mechanical design of the machine involves conceptual of overall configuration of the machine, drafting and design analysis made to satisfy geometrical and force constrain. The second module is the drive module. This module shows that the controller of the machine which is microprocessor that is receive the command signals. Drive module is consisting of motors, amplification units, and a power supply. The control signals are the first generated by the microprocessor to determine the direction of rotation of the motor. The third module is system software. The system software can be defined as an instruction set required executing the functions of the system through a set physical component. The software system is designed to generate automatic stops for the tool and work piece movements. This is done because the unit operates in the open loop mode.

From the book CNC Machines by B. S. Pabla, M. Adithan, they state that there are

some features in CNC machine tools (B. S. Pabla, 1994).

The features are: -

1. The part programmed can be input to the controller unit through key-board or the paper tape can be read by the tape reader in control unit
2. The part programmed once entered in to the computer memory can be used again and again
3. The part programmed can be edited and optimized at the machine tool itself
4. The input information can be reduced to a great extent with the use of special sub programmed developed for repetitive machining sequence
5. The CNC machines have the facility for proving the part programmed without actually, running it on the machine tool
6. CNC control unit allows compensation for any changes in the dimension of cutting tool
7. With the CNC control system, it is possible to obtain information on machine utilization which is useful to management

We have supply the current in Arduino with USB data cables to transfer data from computer to Arduino board we have used to stepper drivers to supply G-codes in sequence in stepper motor. In X direction stepper motor will move left and right, Y direction stepper motor will move front and back direction, Z direction servo motor will move in up and down so we have used in industry to reduce cost of design printing and maintain accuracy drafting of CNC machine is very precious

The combined characteristics of the machine tool and the control determine the precision of positioning. Three critical measures of precision are resolution, accuracy and repeatability. Control resolution (BLU) is the distance separating two adjacent points in the axis movement (the smallest change in the position). The electromechanical components of the positioning system that affect the resolution are the lead screw pitch, the gear ratio, and the step angle in the stepping motor (open loop) or the angle between the slots in the encoder (closed-loop). Accuracy of a CNC system depends on the resolution, the computer control algorithms, and the machine inaccuracies.[2]

To complete the task of entire project two software is used-

1.Ink space V 0.48.5

2.Processing P3.

A. Ink space 0.48.5

Ink space is used to design the plotted diagram or text. In this project by using this software G-code file of a selected image or text is created. G-code is a commonly used numerical control programming language which includes X, Y, Z coordinates.

B. Creating G-Code File Using Ink space

The CNC plotter of our project will work within 20cm×20cm area. Fig. 3 Conversion of text to G-code So we choose the document properties of the Inkscape 40cmx40cm (Width × Height) which is four times the working area of the plotter because the plotter can draw only in the first quadrant. So we have initially kept the axes at the nearest end of the motors which is considered as origin to easily modify the design. In Fig. 3 the working area of CNC plotter is shown with the text written in the pre-defined area. The text is selected using cursor and then select "object to path" from the drop down window to save the G-code form of the selected text.

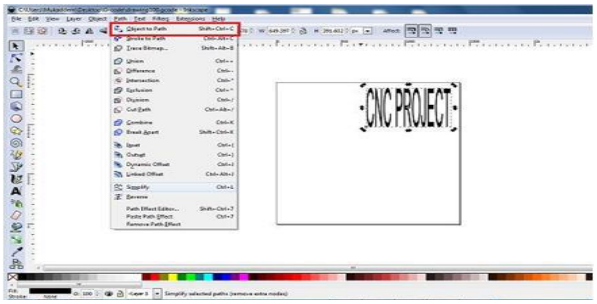


Fig. 1. Conversion of text to G-code

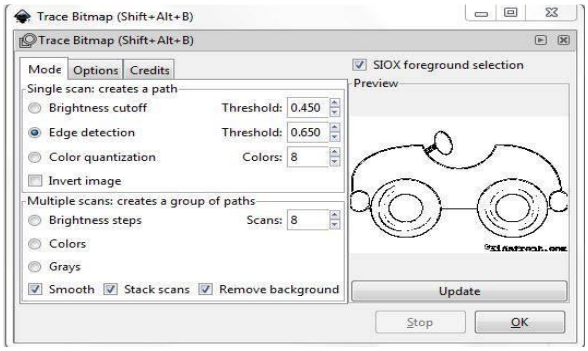


Fig. 2. Creating transparent image (a) original image (b) transparent image.

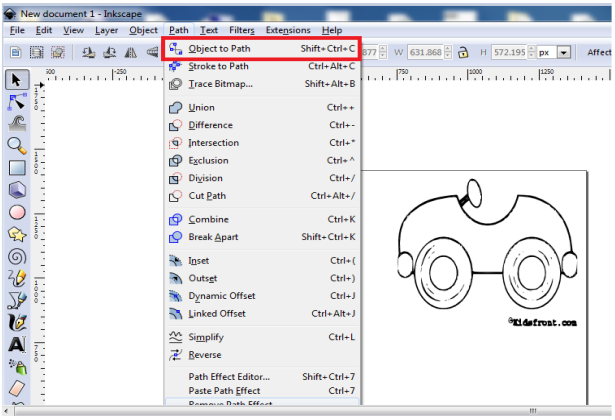


Fig. 3. Conversion of transparent image to G-code

C. Processing: -

Processing is open source programming language software which is used for electronic drawings. GTCRL processing program is used to send G-code file from user interface to CNC plotter. The Fig. 6 shows the user interface of processing 2.2.1 software after running GTCRL program.

The port of Arduino Uno is selected by pressing „P" button on keyboard hence „G" button is used to upload our desired G-code file. Immediately CNC machine will start sketching selected G-code file. Sketching can be stopped by pressing „X" button.

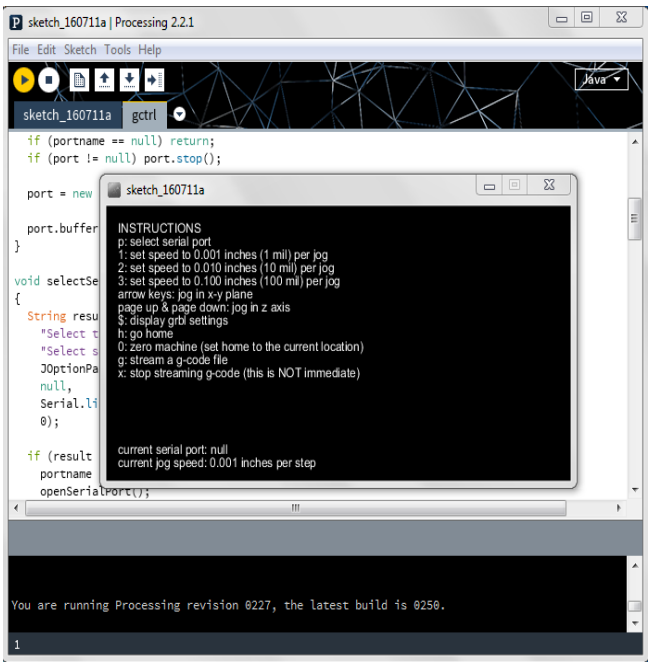


Fig. 4. Uploading G-code file

D. Coding

Bradenham's Line Algorithm is used for plotting in the CNC plotter. A part of this algorithm is shown below-

void line (int x0, int y0, int x1, int y1) { int dx = abs(x1-x0), sx = x0<x1 ? 1 : -1; int dy = abs(y1-y0), sy = y0<y1 ? 1 : -1; int err = (dx>dy ? dx : -dy)/2, e2; for(;;){

set Pixel(x0,y0); if (x0==x1 && y0==y1) break; e2 = err; if (e2 >-dx) { err -= dy; x0 += sx; } if (e2 <dy) { err += dx; y0 += sy; }

Two stepper motor is used to control X and Y axis, and a servo motor is used to control the Z axis. The test code of Y axis stepper motor is shown below-

```
#include <Stepper.h>

constant steps Per Revolution = 20;

// Connection pins: Stepper myStepperY(stepsPerRevolution, 2,3,4,5); void setup() { // Set speed: MyStepperY.setSpeed(100);

// max 250 steps for dvd/cd stepper motor My Stepper Y. step (160); delay (100); void loop
```

The code for X axis stepper motor is also same except the pin numbers. The Z axis is represented by a servo motor controlled by the PWM pin of the Arduino. The full CNC code is uploaded in the Arduino then the Arduino will wait for G-code file from processing software. When the processing software send command to Arduino it will start plotting the G-code.

E. G-code: -

To draw a text file or design a circuit layout by the CNC plotter firstly the files need to be converted into G-Code. G-Code is a set of instruction that contains number of X, Y, Z, coordinates depending on the file. G-Code instructs X axis of the machine to travel from X1 to X2 points with a specific speed and same is true for Y axis, but for Z axis the coordinates are fixed because only vertically up & down movements are involved.

DESIGN OF CIRCUITS

Circuit design

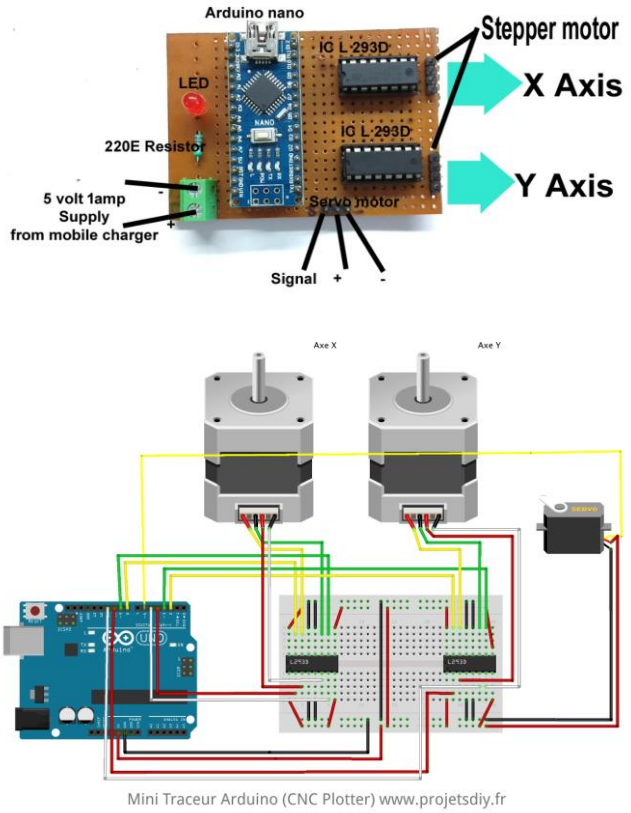
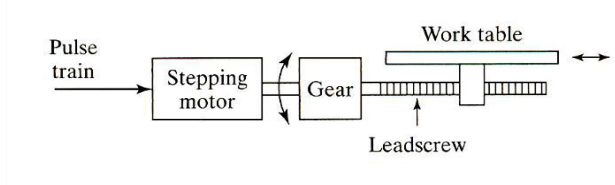


Fig. 5. Circuit Diagram

WORKING OF MINI CNC/2D PLOTTER



Open loop system

Our CNC machine consists of three axes x, y, z axis for three-dimensional motion of tool. The numerical data required for working of the plotter is provided by a program called part -program which in turn converts the numerical data to electrical signals. These electrical signals are then given as input to stepper motors. Each signal specifies a specific point in the coordinates and according to the point the tool moves. As mentioned earlier input device used is serial communication port DB9. Machine control unit (MCU) consists of data processing unit (DPU) and control loop unit (CLU). On receiving part program DPU interprets and encode it into internal machine codes. Then intermediate position of the motion in Basic length unit (BLU) is calculated by interpolator of DPU. Then it is passed to CLU for further process [2]. To control driving system and to perform required motion data from DPU are converted in to electrical signals in CLU. Machine tool can be of any type, machine slide should be of high accuracy and repeatability and also coated with anti-frictional material.[3]

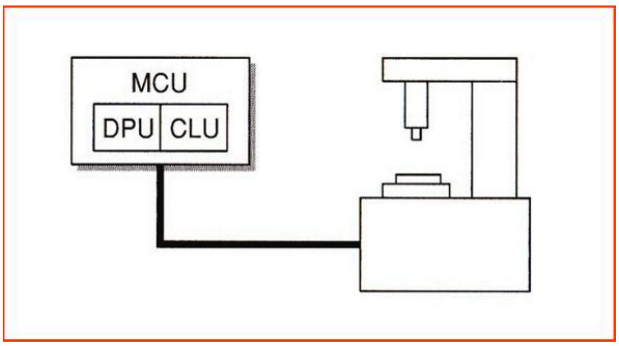


Fig. 6. Machine Control Unit

ELEMENTS OF MINI CNC MACHINE

STEPPER MOTOR: -

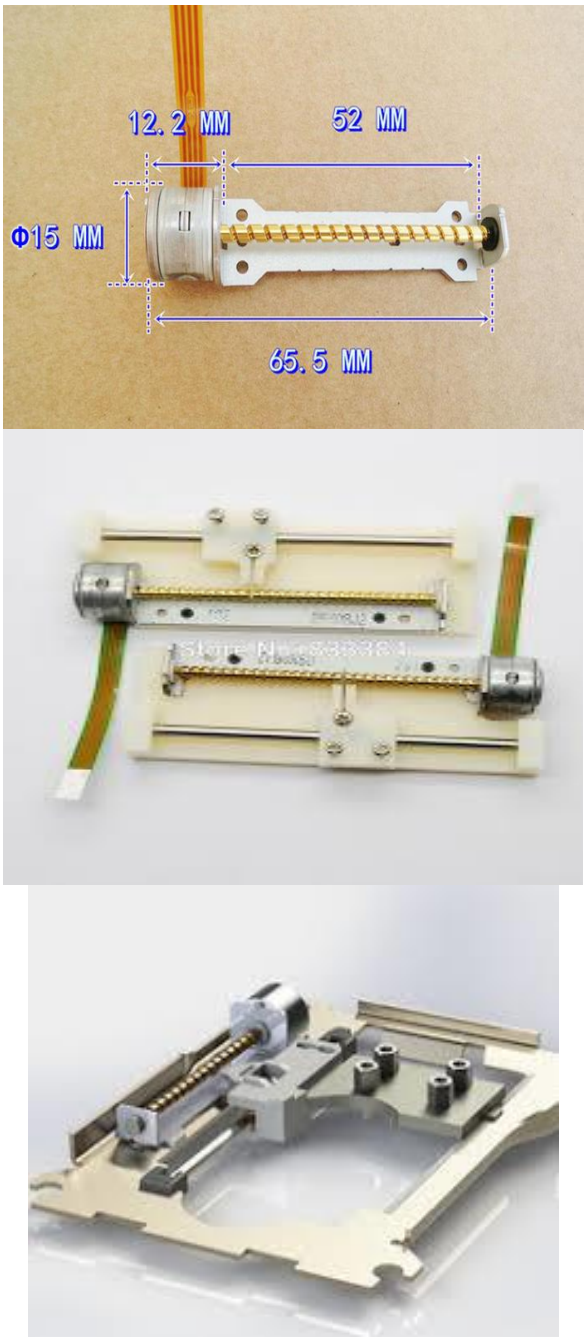


Fig. 7. Stepper Motor Illustration

A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation in a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller). A NEMA 23 stepper motor is a stepper motor with a 2.3 x 2.3-inch size is chosen to drive the motion of the axes. NEMA 23 stepper motors are high torque about 19KG-Cm holding torque. NEMA 23 stepper motors have 1.8-degree step angle with 2.5A rated current. The speed of rotation is directly proportional to the pulse frequency. The higher the output voltage from the driver, the higher the level of torque drive. [4]

TABLE I. PL15S-020-01 10MM STEPPER LINEAR STOPPER MOTOR

Model	Step Angle (Deg.)	No. of Phase	Rated Voltage (VDC)	Current /Phase(A)	Resistance /Phase (Ω)	Holding Torque(gf.cm)	Pull-out Torque(gf.cm)	Pull-in Torque (gf.cm)	Step Avail (mm)
PL15S-020-01	18	2	5	0.50	10	25	15(300PPS)	10(300PPS)	0.15

Highlights

- Excellent open loop control - No encoders necessary
- Digitally controlled - Easy to use with a micro processor
- Cost effective - compact design, lower integration cost
- Maintenance free - motor is brushless
- Winding possibilities - Bipolar

Application

- HVAC/R: Valve Actuation
- Office Automation: Printers, Copiers, Data storage
- Medical Applications: Pill Dispensing, Analysers
- Telecommunication: Antennae Positioning Switching lines
- Other Industries & Applications: Robotics

TABLE II. GENERAL SPECIFICATION:

Item	Specification
Step Angle Accuracy	±8%(full step, no load)
Resistance Tolerance	±10%
Inductance Tolerance	±20%
Temperature Rise	80.C Max. (rated current,2 phase on)
Ambient Temperature	-20. C~+50.C
Insulation Resistance	100MΩMin. ,500VDC
Dielectric Strength	600VAC 1s , 3mA

ARDUINO NANO:

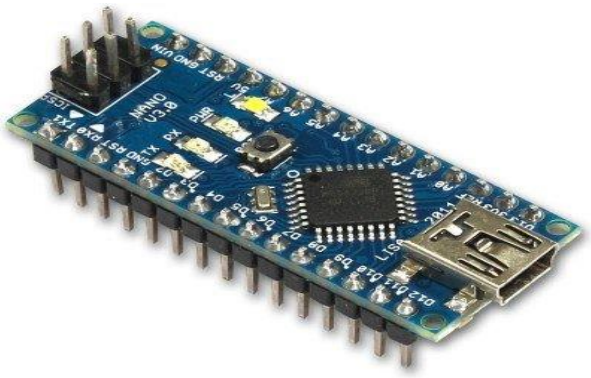


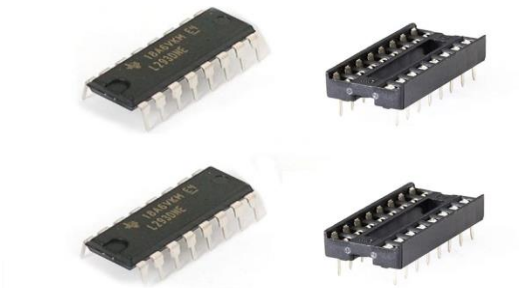
Fig. 8. Arduino Nano

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x) or ATmega168 (Arduino Nano 2.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package.

Technical Specifications: -

1. Microcontroller: Atmel ATmega168 or ATmega328
2. Operating Voltage (logic level): 5 V
3. Input Voltage(recommended): 7-12 V
4. Input Voltage(limits): 6-20 V
5. Digital I/O Pins: 14 (of which 6 provide PWM output)
6. Analog Input Pins: 8
7. DC Current per I/O Pin: 40 mA
8. Flash Memory: 16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by bootloader
9. SRAM: 1 KB (ATmega168) or 2 KB (ATmega328)
10. EEPROM: 512 bytes (ATmega168) or 1 KB (ATmega328)

L293D IC



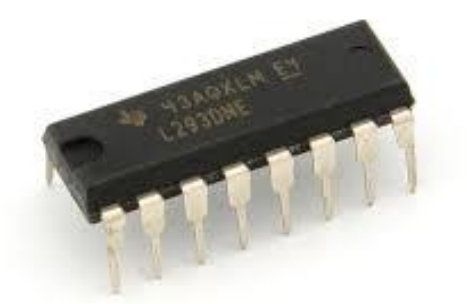


Fig. 9. IC L293D Motor Driver

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. In a single L293D chip there are two h-Bridge circuit inside the IC which can rotate two dc motor independently. H-bridge is a circuit which allows the voltage to be flown in either direction. H-bridge IC are ideal for driving a DC motor. Due its size it is very much used in robotic application for controlling DC motors.[5]

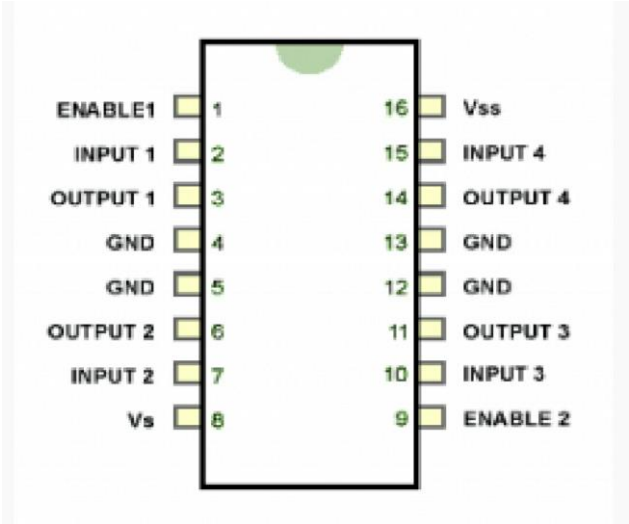


Fig. 10. L293D Motor Driver IC

Working of L293D

1. There are 4 input pins for l293d, pin
2. 2,7 on the left and pin 15 ,10 on the right as shown on the pin diagram. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right-hand side.
3. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1. For rotating the motor in clockwise direction, the input pins has to be provided with Logic 1 and Logic 0.
4. Enable pins 1 and 9 (corresponding to the two motors) must be high for motors to start operating. When an enable input is high, the associated driver gets enabled.
5. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state.

SERVO MOTOR

A servo motor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

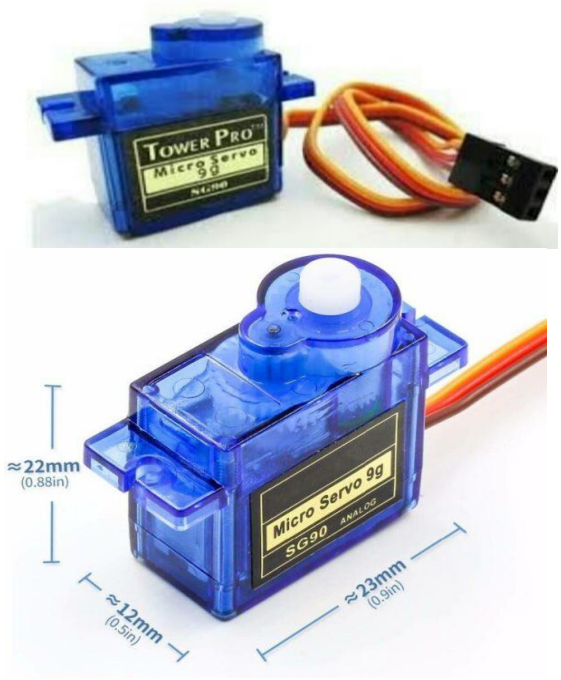


Fig. 11. Servo Motor SG90

HARDWARE IMPLENATION: -

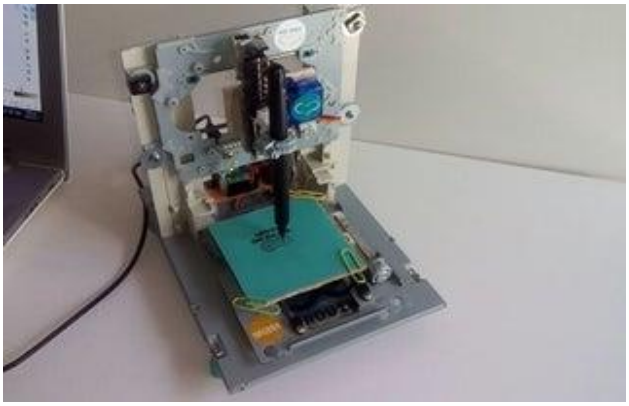


Fig. 12. Assembly of Parts

This setup of hardware with a combination of G-code gives better accuracy and reduces the work load. G code make easy to find the information of locations of all stepper motor moving, as the status of our moving motor are directly seen on computer hence we can start or stop the machine whenever we are needed. Making a small machine brings a flexibility to do work. Frame - A clamp is a mechanical tool used to preserve an object in a fixed role. The metallic rod of period 410mm, diameter 5mm are supported and used as guide methods to the X and Y axes tables. The timing belt is a non-slipping mechanical power belt and it can seek advice from both toothed belt, a bendy belt with enamel long-established onto its internal floor. Timing pulleys are purposeful pulleys that have either enamel or pockets across the out of doors diameter of the pulley frame. Timing enamel interact holes within the metal belt, while timing wallet engage pressure lugs on a belt's inner circumference. These teeth or wallet are used only for timing, no longer for energy transmission. CNC defend v3.0 can be utilized as force growth board for inscribing device, 3D-printers, and other devices. There are 4 slots within the board for stepper motor drive modules, can pressure 4 stepper vehicles, and every stepper motor most effective need IO port, that's is to mention, 6 IO ports can pretty nicely to manipulate three stepper motors, it's very handy to apply. After inserting Arduino CNC defend v3.0 into Arduino UNO and hooked up GRBL firmware then you can quick DIY a CNC engraving gadget. [6]

V. RESULTS

The developed CNC plotter was capable of printing high-quality designs on various materials with exceptional precision. The key findings of the study include:

- **Precision and Accuracy:** The CNC plotter achieved a high degree of accuracy, with printing resolution of up to 600 dpi, suitable for most printing applications.
- **Versatility:** The machine was capable of printing on a variety of surfaces, including paper, cardboard, and textiles, making it adaptable to different industries.
- **Efficiency:** The CNC plotter significantly reduced material wastage compared to traditional printing methods by precisely managing ink distribution and print area.
- **Software Control:** The software interface provided users with full control over the printing process, from design input to execution, ensuring smooth operation and reducing human error.
- This section deals with the fabrication procedure and calculation of the Mini CNC plotter machine. Fabrication part includes marking, cutting, grinding, welding, drilling, modeling for 3D printing, Assembly. For every fabrication process, marking is the first step followed by every individual. Indicating is a process to mark the required dimension on the workpiece to carry out further mechanical processes like cutting, drilling, welding etc.

TABLE III. CALCULATED TIME VALUES FOR THE SPECIFIED FEED RATE

Sr, NO.	Feed rate (Mm/min)	Time (sec)
1	200	120
2	250	99
3	300	85
4	400	67
5	500	58
6	800	44
7	1000	40

- From Table 1, it has observed that irrespective of surface as the federate increases time is decreasing. On a base (wooden plank) the clamps of respected axes(x and y), i.e., C-clamps to hold y-axis and T-clamps to hold x-axis for drilling holes and firm the rods into it, plotting base for drilling holes and for fixing it on rods with the help of 3D printing holders, holes are made on the base plate on which VCD drive and a pen is to be placed to arrange this whole setup to x-axis rods by means of 3D printing clips.
- Hacksaw blades are made of high-speed steel which are used for cutting metal. This blade is locked in the frame. Typical hacksaw blade lengths are 10 to 12 in (250 to 300 mm). Blades can be as small as 6

in (150 mm). The pitch of the teeth can be from 14 to 32 teeth per inch (TPI) for a hand blade.

- A grinding machine is a type of tool that is advanced for grinding workpiece. It firstly uses an abrasive wheel as the cutting tool. The rough surface of the abrasive wheel fragments off minute portions of the workpiece as needed. It is named as a grinder.
- A grinder is largely performed to get absolute shape and complete the given materials with least surface roughness and high surface quality. It is primarily a finishing operation that removes relatively small quantities of metal, to deliver highly detailed
- products. However, some of the grinding processes also take swiftly removing high volumes of metal.
- Then welding process is carried out by joining two or more metal pieces together by heating the surfaces to the point of melting with an electric arc, or by other means.
- The Drilling operation that uses a drill bit to make a hole in solid materials. The drill bit is a multi-point rotary cutting tool. The bit is rotated at rates from hundreds to thousands of revolutions per minute. This penetrates the cutting edge against the work-piece, shearing off chips from the hole.

VI. APPLICATIONS

The CNC plotter machine can be applied in various fields, including:

- **Graphic Design and Advertising:** For producing high-quality custom prints on banners, signs, and posters.
- **Packaging Industry:** For printing labels, boxes, and packaging materials with complex designs and logos.
- **Textile Printing:** For printing on fabrics with fine detail, suitable for customized clothing or textile designs.
- **Prototyping and Customization:** The machine can also be used for rapid prototyping, where intricate patterns and designs are required on various substrates.
- **3D Printing Integration:** When combined with 3D printing technologies, CNC plotters can create intricate 3D prints with surface finishes that require additional detail work.

VII. CHALLENGES

The integration of CNC plotter technology into the printing process presents certain challenges, such as:

- **Complex Calibration:** Ensuring that the printing head is perfectly aligned with the CNC movement system is essential to avoid misprints.
- **Material Handling:** Different materials have different properties, and not all are compatible with standard printing heads or feeding mechanisms.
- **Maintenance and Upkeep:** Due to the precision components involved, regular maintenance of the machine is necessary to maintain performance.

VIII. CONCLUSION

The development of a CNC plotter machine for printing applications offers significant potential to transform traditional printing processes. The machine's precision, adaptability, and integration with digital control systems allow for more efficient, customizable, and cost-effective printing solutions. As industries continue to demand higher precision and flexibility, CNC plotter machines can become a core technology in the printing domain.

A CNC machine which can draw images or text on the surface like paper, softwood, metal sheet etc. is constructed which has two axes, namely X and Y axis. It uses two stepper motors and a servo motor for z-axis. The machine is operated by accesses of G codes directly using software called “INKSCAPE” microcontroller board, based on the ATmega328p microcontroller, which was developed by Aurdino.cc. Along with this, there are other electronic components like motor shield, stepper motor drive, GRBL controller reprogrammed for successful functions of the machine. Finally time is calculated for the specified feed rate is presented. It is observed that irrespective of surface as the federate increases time is decreasing.

In this paper we have presented the concept of a low cost three-axis mini CNC plotter. The existing CNC machines are of high cost, difficult to maintain and requires highly skilled operators. Our CNC plotter overcomes these problems. It is of low cost and easy to control and there is no need of highly skilled operators. It can be used for long hours at a stretch which is not possible in existing ones. It is hoped to extend this work for future development. The project is about building a mechanical prototype of CNC machine which is able to draw 30cm by 30cm on given solid surface it consumes low power and works with high accuracy due to precise controlling of steeper.

IX. FUTURE WORK

Future research should focus on:

- **Automation of Media Loading and Handling:** Introducing robotic arms or automated systems to handle different materials and reduce the need for manual intervention.
- **Advanced Printing Techniques:** Exploring the integration of advanced printing technologies, such as UV printing, to expand the types of printing mediums the CNC plotter can handle.
- **Cost Reduction:** Finding ways to lower the production cost of CNC plotters, making them more accessible to small businesses and individual users.

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