DESIGN AND CONSTRUCTION OF A MINI CNC PLOTTER MACHINE

A Thesis

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DECLARATION

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We hereby ensure that the works that has been prevented here does not breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

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ABSTRACT

A Mini CNC plotter machine is a compact, computer-controlled device designed for precision drawing, and prototyping tasks on various flat surfaces. Utilizing stepper motors and a microcontroller, typically an Arduino, the machine interprets G-code instructions to control the X, Y, and Z axes, enabling accurate two-dimensional or shallow three-dimensional plotting. It commonly employs servo motors or solenoids to handle the pen or tool head for movement and engagement with the work surface. These machines are widely used for educational, DIY, and small-scale design applications due to their affordability, portability, and ease of customization. They are compatible with open-source software like GRBL and Inkscape, allowing users to create vector-based designs easily. Mini CNC plotters support various materials such as paper, cardboard, wood, and plastic, making them ideal for circuit design, label marking, and artistic works. Their simplicity and functionality make them a valuable tool for hobbyists and educators alike.

CHAPTER 1

INTRODUCTION

1.1 Introduction

A CNC XY Plotter Machine is a 2D plotting machine which uses a pen to draw text or image, continuous or discontinuous drawings on any given solid surface. CNC plotting is one of the most common plotting processes used in various applications. Since the introduction of Computer Numerical Control in the 1960s, CNC machines have become an integral part of industrial & commercial manufacturing processes. Computer Numerical Control is a process that uses computers to control tools to create different types of products. These machines require specialized software and consoles for operation. A computer program is customized for an object and the machines are programmed with CNC machining language (G-code) that essentially controls all features of the final product like coordination, location & speeds.

Computer Numerical Control (or CNC) [1] is an advanced form of automatic machine that used widely to control the motion of these machine tools. Numerical control machine was first invented around in 19th century to minimize the load of the work [2]. Its advantage ensures higher efficiency, higher flexibility, and low production cost, a little working time and a little loss in production. It mainly follows three steps that are receiving data, interpreting them and react accordingly [3].

To direct the machine function, a special codes and numbers form sequential commands (instructions) that are used to operate the machine automatically and to produce a specific part with specific dimension. These instructions (program) are then converted in to an electrical signal and act as input to the motors which run the machine and do the basic movements [4].

A machine control unit (or MCU) decides the tool depth of draw, drawing speed etc. Motion of tool is based on Right hand coordinate system. Three axis of rotation (x, y & z) for three dimensional motion of tool and for specific role plus an axis of rotation. The x-axis serves as height stands and uses two pieces one for front and one for back. The y-axis acts as motor

mount to move z-axis in addition with slide mechanism whereas the z-axis controls the depth by allowing the movement of router in up and down direction so it is very important axis [5][6].

1.2 CNC Plotter

The plotter is a computer printer for printing vector graphics. In the past, plotters were used in applications such as computer-aided design, though they have generally been replaced with wide-format conventional printers. A plotter gives a hard copy of the output. It draws pictures on a paper using a pen. Plotters are used to print designs of ships and machines, plans for buildings and so on.

1.3 Background History of CNC

The concept of numerical control began when an automated device incorporates certain concepts of programmed sense [7]. Originally, the first cars were built in 1940. But in the 1950's, better cars began to appear. It is based on devices with new NC machines, which have been modified by engines designed to transfer machine control. These initial methods were rapidly improved with analog and numerical calculations [8] [9]. After World War II, especially in 1949, John Parsons found ways to improve airplanes by making solid leather. This led to important air force research projects conducted at the Massachusetts Institute of Technology (MIT). After the research phases, a test mill was developed at MIT. In this project, Professor J. In the 1960s and 1970s, a common type of CNC machine began to emerge. Digital technology then entered the struggle, and automation in production systems was more efficient than ever [10].

1.4 Problem Statement of CNC Plotter

Nowadays CNC XY plotters are being made all over the world using the CD drive for the scanner mechanism which provides the requires motion along X-direction & Y-direction. So, this manufacturing process is not suitable for mass production of plotters. Again, the price of the plotters in the current market is quite high too. So, in order to solve these limitations, we designed a CNC XY Plotter suitable for mass productions which is cheap as well.

1.5 Objective

The objectives of this project are:

- To study about **Mini CNC Plotter**.
- To design and construct a **Mini CNC Plotter**.
- To create a platform for further development in CNC and robotic systems.
- To convert digital vector designs into accurate physical drawings.
- To put the whole system into action so that we can observe its practical effects and verify our work.
- To study the system performance for future reference and improvement purpose.

1.6 Methodlology

Methodology the method used in this study is as follows:

- Creating an idea for design and construction of An **Mini CNC Plotter**. And designing a block diagram & circuit diagram to know which components we need to construct it.
- Collecting all the components and programming the micro-controller to control the whole system.
- Setting up all the components in a PCB board & then soldering. Lastly, assembling all the blocks in a board and to run the system & for checking purposes.

1.7 Work Flow Diagram

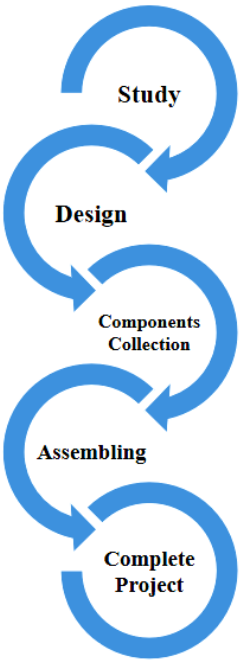


Figure 1.1: Working Flow Diagram

1.8 Research Outline

This project book consists of Six chapter. The first chapter contains the statement of the Introduction,Background history, Problem Statement, Work Flow Diagram, objectives of the study and Methodology. Chapter two contains system Literature Review details. Chapter three System Architecture, Discussed in Block Diagram, Diagram, Working principle and Cost analysis .Chapter Four describes the hardware implementation with component details and the software which we have used for our work. Chapter Five deals with the result Analysis ,shows the complete prototype ,Advantage, Application and Limitation of the project that we have built. In the final chapter, we have discussed the , Future Scope, conclusion of the project.

CHAPTER 2

LITURATURE REVIEW

2.1 Introduction

In this chapter we discuss our system overview. In this paper they also work about **Mini CNC Plotter**. In below section we will describe some previous literature review. From previous literature we gather more knowledge to build this project and we successfully made it .

2.2 Literature Review

Various authors have studied the development of such machines. '**Mini CNC Plotter Machine Using DVD**."

Sundar Pandian 2014: "develop low cost 2 axis CNC machine". It is low cost and it is used currently in the laboratory. Stepper motors with drivers, Arduino open source, and microcontroller and open-source motor control software. Author used ready to assemble kit from Zen Tool works, USA. Kit provided stepper motor, lead screw, guide rod, anti-backlash flans and spring. He made the Body with high density PVC. The machine has fix gantry and mobile bed so there is restriction in working area. The model provides more scope for hands-on learning by the students and therefore better learning outcomes. It is developed for only educational purpose.

Venkata Krishna Pabolu et al. Nov 2010: "Design & Implementation of a two-Dimensional CNC Machine". It increases the demand for flexibility and cutting with respect to edge quality. It maintains the accuracy and reliability for complex shapes. In this system they used visual C# as a language on .NET platform. In this there are three main kinds of computerized numerical controllers:

1. Multiprocessor with ASIC,
2. PC front end,
3. Motion control card with PC.

The design of this system is user-friendly one which give accurate results and also flexible to users. RTOS is very costlier and not user friendly and also with such system it is not possible to implement on any general PC, where user has to purchase the operating system.

Kajal J. Madekar, Kranti R. Nanaware, Pooja R. Phadtare, Vikas S. Mane Feb 2016 "Automatic mini–CNC Machine for PCB drawing". To develop low-cost automatic mini-CNC machine for PCB drawing. This system reduces the cost of machine and increases the flexibility. In this G code is interfaced with ATMEGA 328. CNC based controller by FTDI module which is used to convert the code in convenient controller the code i.e. serial to USB converter, x moves to left, Y moves to right and z moves to up and down. It gives better accuracy and reduces the work load. G code mark easy to find the information of locations of all stepper motor moving. In the GRBL support 3 axis of motion X, Y and Z but does not support rotation axes (X, Y).

2.3 Summary

From the literature discussed above, we gained a lot of knowledge and we inspired to do this project. We were able to do it with everyone tireless work.

CHAPTER 3

SYSTEM ARCHITECTURE

3.1 Introduction

The project objectives, methods, literature evaluation, and other details were all clarified in the preceding chapter. The block diagram, circuit diagram, Working principle,Project final Image and cost analysis will all be covered in this chapter.

3.2 System Proposed

This mini-CNC plotter machine system is so effective and safe process. It is mainly used in factory and industrial area. After it used, we reduce the manpower and time. That's way we get good efficiency. Where very difficult to do this draw manually, but using this machine this work makes so easy. This machine is very easy to use and it works very effectively. A relevant picture is added below –

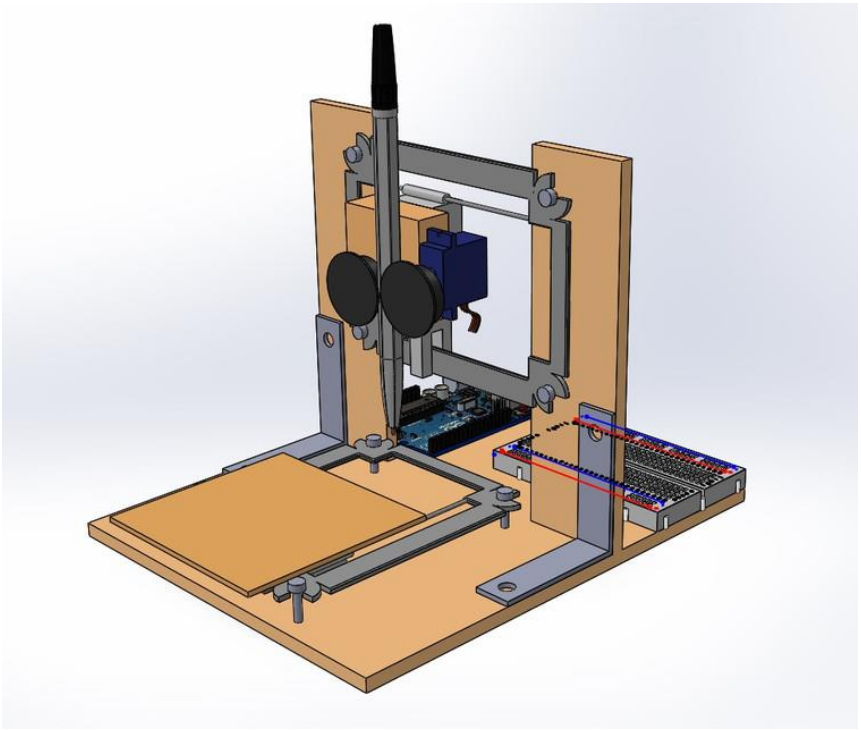


Figure 3.1: Structural View of Mini CNC Plotter.

3.3 Block Diagram

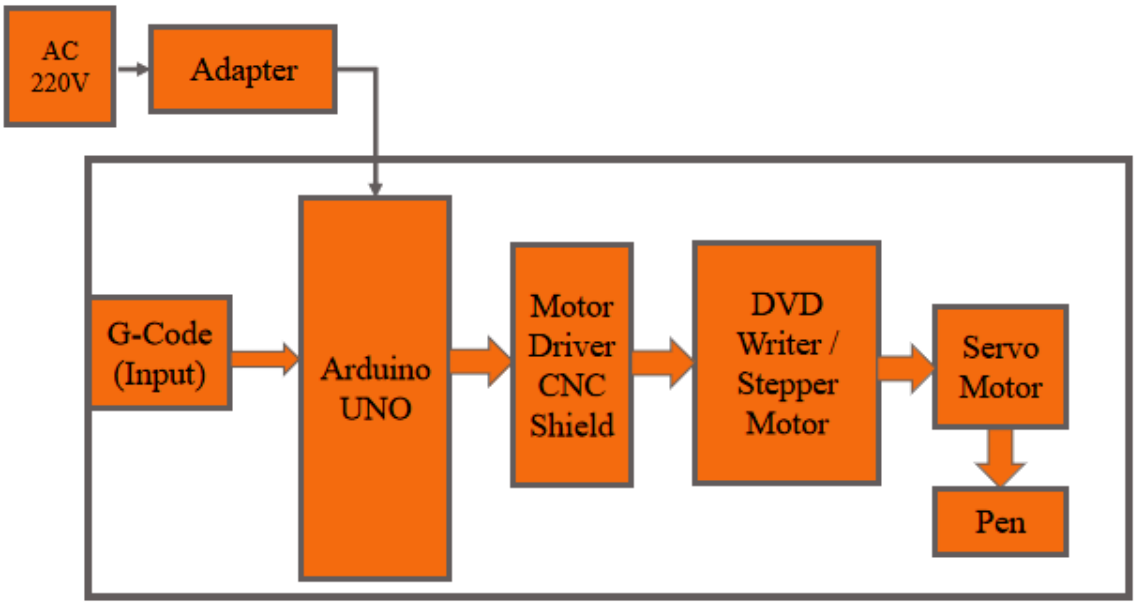


Figure 3.2: Block Diagram of Mini CNC Plotter

3.4 Circuit Diagram

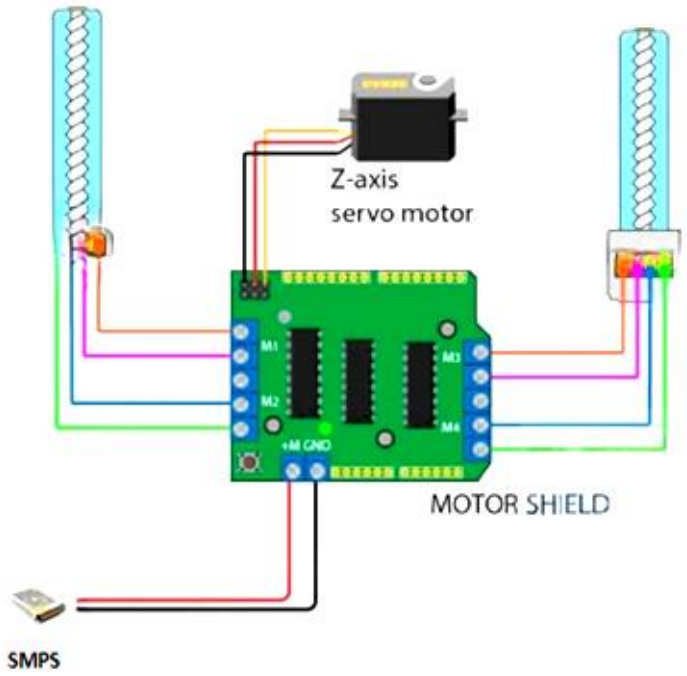


Figure 3.3: Circuit Diagram of Mini CNC Plotter

3.5 Working Principle

The Mini CNC Plotter Machine operates by converting digital drawing commands into precise mechanical movements. The SMPS (Switched Mode Power Supply) provides stable DC power to all components. The Arduino Uno, loaded with GRBL firmware, acts as the central controller, receiving G-code commands from a computer. These commands are passed to the CNC Shield, which interfaces with motor driver ICs (like A4988) to control the stepper motors salvaged from old DVD writer mechanisms. These motors move the pen along the X and Y axes. A servo motor is used for Z-axis control, typically to lift and lower the pen. The CNC Shield simplifies wiring between the Arduino and drivers. As the G-code is processed, the Arduino sends direction and step signals to the motor drivers, allowing the DVD stepper motors to precisely follow the path. This enables the machine to plot images or text on paper or light materials accurately.

3.6 Cost Analysis

Table 1: Cost Analysis

No	Product Name	Specification	Qty.	Unit Price	Total Price
01.	Arduino	UNO	1	1000	1000
02.	UNO Motor Driver CNC Driver	L293D	1	450	450
03.	Steeper Motor		2	350	700
05.	Servo Motor	SG90	1	380	380
06	SMPS	5V 7A	1	550	550
07.	Others			1200	1200
Total					4280/=

CHAPTER 4

HARDWARE ANALYSIS

4.1 Introduction

In this section, we will discuss elaborately about " Mini CNC Plotter Machine" and the component description, features, working procedure of our all equipment. The system hardware fabricates composed of micro-controller unit, power unit, source unit, power store unite, sensor unit and many more related components.

4.2 Components List

- Arduino Nano
- Uno Motor Driver CNC Shield
- Motor Driver IC
- SMPS
- Steeper Motor
- Servo Motor

4.3 Arduino Uno

The Arduino nano is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.



Figure 4.1: Arduino Nano

Arduino Nano Pinout Configuration

Table 2: Arduino Nano Pin Out

Pin Category	Pin Name	Details
Power	Vin, 3.3V, 5V, GND	Vin: Input voltage to Arduino when using an external power source. 5V: Regulated power supply used to power microcontroller and other components on the board. 3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA. GND: ground pins.
Reset	Reset	Resets the microcontroller.
Analog Pins	A0 – A5	Used to provide analog input in the range of 0-5V
Input/Output Pins	Digital Pins 0 - 13	Can be used as input or output pins.
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.
External Interrupts	2, 3	To trigger an interrupt.
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output.

SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication.
Inbuilt LED	13	To turn on the inbuilt LED.
TWI	A4 (SDA), A5 (SCA)	Used for TWI communication.
AREF	AREF	To provide reference voltage for input voltage.

Arduino nano Technical Specifications

Table 3: Arduino Nano Specification

Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz

How to use Arduino Board

The 14 digital input/output pins can be used as input or output pins by using pinMode(), digitalRead() and digital Write() functions in arduino programming. Each pin operate at 5V and can provide or receive a maximum of 40mA current, and has an internal pull-up resistor of 20-50 KOhms which are disconnected by default. Out of these 14 pins, some pins have specific functions as listed below;

- Serial Pins 0 (Rx) and 1 (Tx): Rx and Tx pins are used to receive and transmit TTL serial data. They are connected with the corresponding ATmega328P USB to TTL serial chip.
- External Interrupt Pins 2 and 3: These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- PWM Pins 3, 5, 6, 9 and 11: These pins provide an 8-bit PWM output by using analog Write() function.
- SPI Pins 10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK): These pins are used for SPI communication.
- In-built LED Pin 13: This pin is connected with an built-in LED, when pin 13 is HIGH – LED is on and when pin 13 is LOW, its off.
- Along with 14 Digital pins, there are 6 analog input pins, each of which provide 10 bits of resolution, i.e. 1024 different values. They measure from 0 to 5 volts but this limit can be increased by using AREF pin with analog Reference() function.
- Analog pin 4 (SDA) and pin 5 (SCA) also used for TWI communication using Wire library.
- Arduino Uno has a couple of other pins as explained below:
- AREF: Used to provide reference voltage for analog inputs with analogReference() function.
- Reset Pin: Making this pin LOW, resets the microcontroller. Arduino Uno to ATmega328 Pin Mapping

When ATmega328 chip is used in place of Arduino Uno, or vice versa, the image below shows the pin mapping between the two.

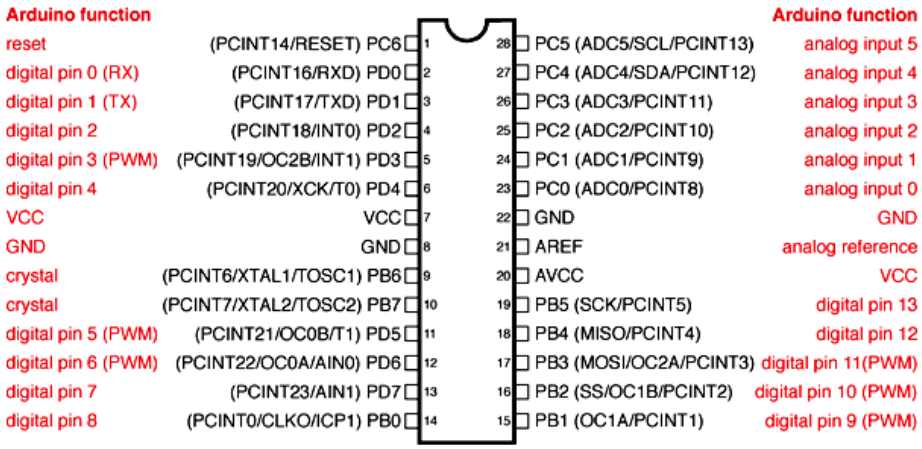


Figure 4.2: Arduino Nano Pin Out

The Arduino Nano can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- 3V3. A 3.3volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.

4.4 ULN2003 Motor Driver IC

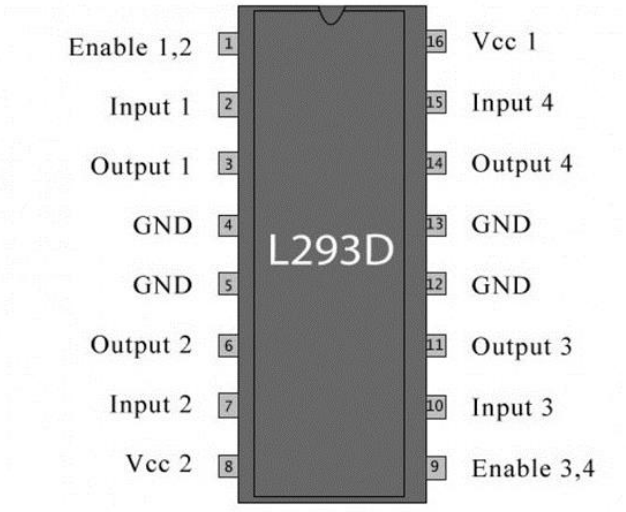


Figure 4.3: ULN2003 Motor Driver IC

- ULN2003 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 ULN2003 IC Dual H-bridge Motor Driver integrated circuit (IC).
- It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction. As you know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, hence H-bridge IC are ideal for driving a DC motor.
- In a single ULN2003 chip there are two h-Bridge circuit inside the IC which can rotate two dc motor independently. Due its size it is very much used in robotic application for controlling DC motors. Given below is the pin diagram of a ULN2003 motor controller.
- There are two Enable pins on ULN2003 . Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge you need to enable pin 1 to high. And for right H-Bridge you need to make the pin 9 to high. If anyone of the either pin1 or pin9 goes low then the motor in the corresponding section will suspend working. It's like a switch.
- There are 4 input pins for ULN2003 , pin 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. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.
- In simple you need to provide Logic 0 or 1 across the input pins for rotating the motor.

ULN2003 Logic

Let's consider a Motor connected on left side output pins (pin 3, 6). For rotating the motor in clockwise direction the input pins has to be provided with Logic 1 and Logic 0.

• Pin 2 = Logic 1 and Pin 7 = Logic 0 | Clockwise Direction

• Pin 2 = Logic 0 and Pin 7 = Logic 1 | Anticlockwise Direction

• Pin 2 = Logic 0 and Pin 7 = Logic 0 | Idle [No rotation] [Hi-Impedance state]

• Pin 2 = Logic 1 and Pin 7 = Logic 1 | Idle [No rotation]

In a very similar way the motor can also operate across input pin 15, 10 for motor on the right hand side.

Circuit Diagram for ULN2003 motor driver IC controller.

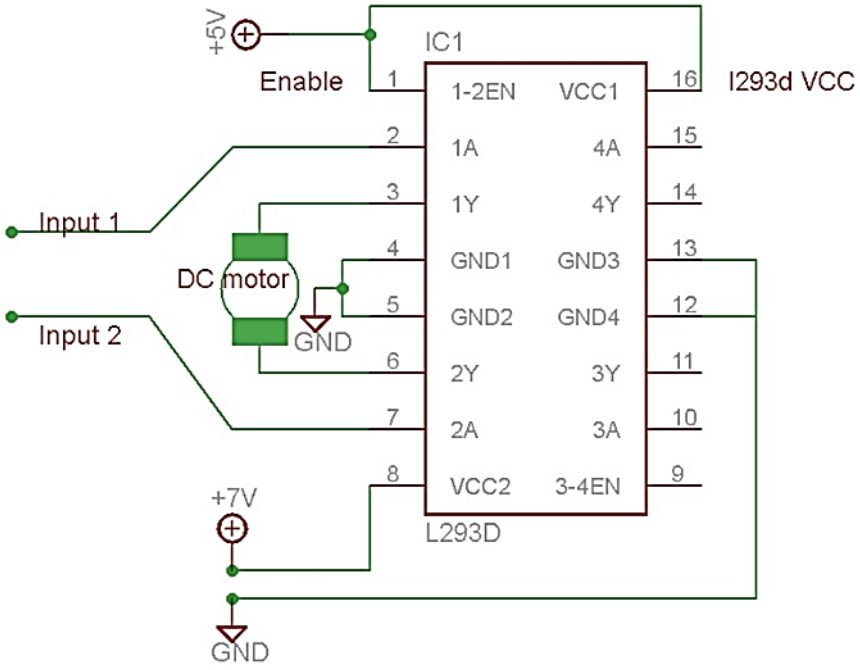


Figure 4.4: ULN2003 circuit diagram

4.5 Servo Motor

The servomotor is a closed-loop mechanism that incorporates positional feedback in order to control the rotational or linear speed and position. The motor is controlled with an electric signal, either analog or digital, which determines the amount of movement which represents the final command position for the shaft. Servo motors or “servos”, as they are known, are electronic devices and rotary or linear actuators that rotate and push parts of a machine with precision. Servos are mainly used on angular or linear position and for specific velocity, and acceleration.



Figure 4.5: Servo Motor

Specification

- High Quality Micro Servo
- Torque: 1.8kg/cm (4.8V)
- Operating Speed: 0.1sec/60degree (4.8V)
- Operating Voltage: 4.8V
- Dead Band Width: 10usec
- Temperature Range: 0-55ºC
- Cable Length: 25.5cm
- Servo Type: Analog Servo

Description: This is Tower Pro SG-91R Micro Servo for helicopter, 3D-flyer, and F3A. It is very light. It comes with a 3-pin power and control cable and mounting hardware.

4.6 Arduino Nano Motor Driver

ULN2003 is a monolithic integrated, high voltage, high current, 4-channel driver. Basically, this means using this chip you can use DC motors and power supplies of up to 16 Volts, that's some pretty big motors and the chip can supply a maximum current of 600mA per channel, the ULN2003 chip is also what's known as a type of H-Bridge. The H-Bridge is typically an electrical circuit that enables a voltage to be applied across a load in either direction to an output, e.g. motor.



Figure 4.6: ULN2003 Motor Driver Shield

The ULN2003 is quadruple high-current half-H drivers. It is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo- Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

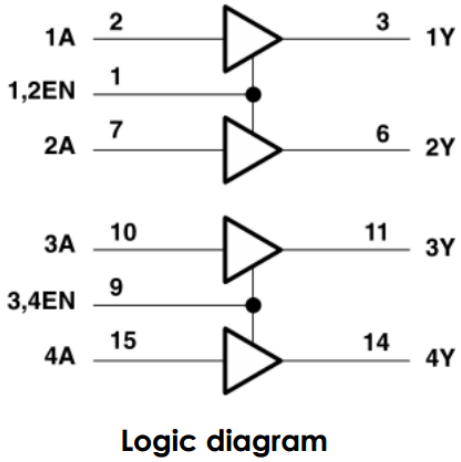


Figure 4.7: Logic Diagram

Pin Function:

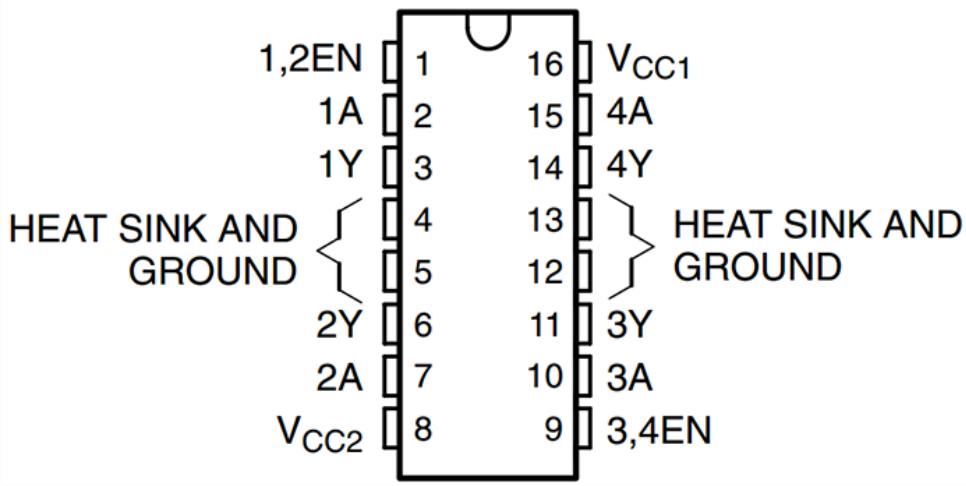


Figure 4.8: IC Pin Out

Table 4: IC Pin Out

Pin	Name	Function
1	Enable1,2	Enable pin to control 1,2 driver
2	Input 1A	Input to control 1Y
3	Output 1Y	Output, connect to motor
4	GND	Ground and heat sink
5	GND	Ground and heat sink
6	Output 2Y	Output, connect to motor
7	Input 2A	Input to control 2Y
8	Vcc2	Output supply voltage
9	Enable3,4	Enable pin to control 3,4 driver
10	Input 3A	Input to control 3Y
11	Output 3Y	Output, connect to motor
12	GND	Ground and heat sink
13	GND	Ground and heat sink
14	Output 4Y	Output, connect to motor
15	Input 4A	Input to control 4Y
16	Vcc1	Supply voltage (7 max)

Features

- Wide Supply-Voltage Range: 4.5 V to 36 V
- Separate Input-Logic Supply
- Internal ESD Protection
- Thermal Shutdown
- High-Noise-Immunity Inputs
- Output Current 600 mA Per Channel
- Peak Output Current 1.2 A Per Channel

4.7 Stepper Motor

A stepper motor, also known as step motor or stepping motor, is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can be commanded to move and hold at one of these steps without any position sensor for feedback (an open-loop controller), as long as the motor is correctly sized to the application in respect to torque and speed.



Figure 4.9: Stepper Motor

Stepper Motor Working Principles

As all with electric motors, stepper motors have a stationary part (the stator) and a moving part (the rotor). On the stator, there are teeth on which coils are wired, while the rotor is either a permanent magnet or a variable reluctance iron core. We will dive deeper into the different rotor structures later.

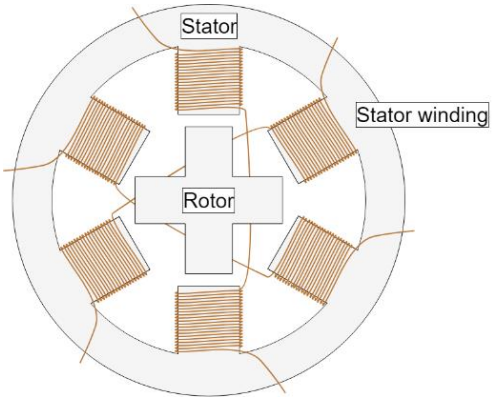


Figure 4.10: Motor Structure Inside

The basic working principle of the stepper motor is the following: By energizing one or more of the stator phases, a magnetic field is generated by the current flowing in the coil and the rotor aligns with this field. By supplying different phases in sequence, the rotor can be rotated

by a specific amount to reach the desired final position. At the beginning, coil A is energized and the rotor is aligned with the magnetic field it produces. When coil B is energized, the rotor rotates clockwise by 60° to align with the new magnetic field. The same happens when coil C is energized. In the pictures, the colors of the stator teeth indicate the direction of the magnetic field generated by the stator winding.

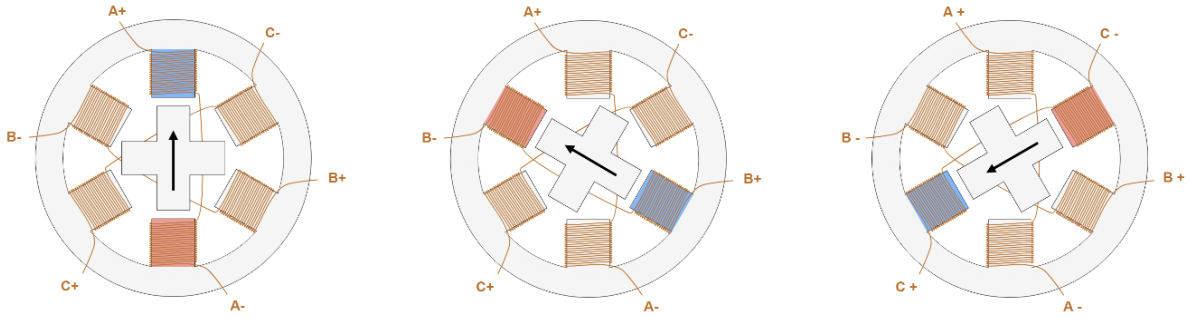


Figure 4.11: Stepper Motor Steps

Stepper Motor Control

We have seen previously that the motor coils need to be energized, in a specific sequence, to generate the magnetic field with which the rotor is going to align. Several devices are used to supply the necessary voltage to the coils, and thus allow the motor to function properly. Starting from the devices that are closer to the motor we have:

- A transistor bridge is the device physically controlling the electrical connection of the motor coils. Transistors can be seen as electrically controlled interrupters, which, when closed allow the connection of a coil to the electrical supply and thus the flow of current in the coil. One transistor bridge is needed for each motor phase.
- A pre-driver is a device that controls the activation of the transistors, providing the required voltage and current, it is in turn controlled by an MCU.
- An MCU is a microcontroller unit, which is usually programmed by the motor user and generates specific signals for the pre-driver to obtain the desired motor behavior.

4.8 Switch Mode Power Supply (SMPS)

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads,

such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.



Figure 4.12: SMPS

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor. Switched-mode power supplies are classified according to the type of input and output voltages. The four major categories are:

- AC to DC
- DC to DC
- DC to AC
- AC to AC

A basic isolated AC to DC switched-mode power supply consists of:

- Input rectifier and filter
- Inverter consisting of switching devices such as MOSFETs
- Transformer

- Output rectifier and filter
- Feedback and control circuit

The input DC supply from a rectifier or battery is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.

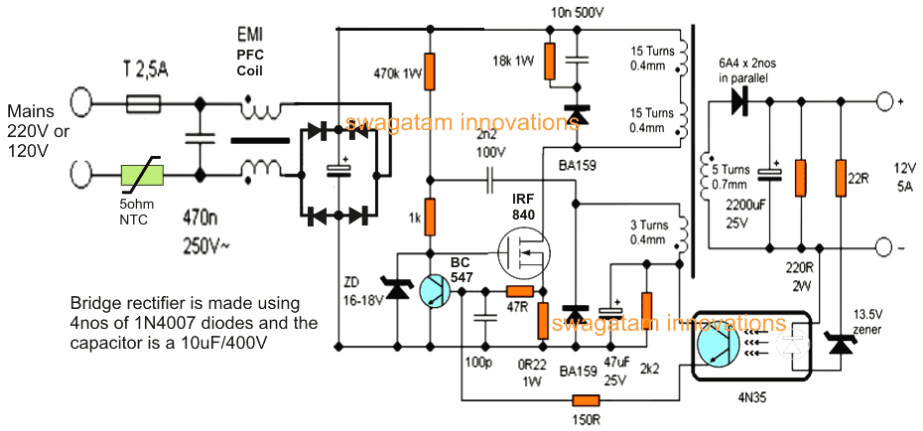


Figure 4.13: SMPS Circuit

Basic working concept of an SMPS

A switching regulator does the regulation in the SMPS. A series switching element turns the current supply to a smoothing capacitor on and off. The voltage on the capacitor controls the time the series element is turned. The continuous switching of the capacitor maintains the voltage at the required level.

Design basics

AC power first passes through fuses and a line filter. Then it is rectified by a full-wave bridge rectifier. The rectified voltage is next applied to the power factor correction (PFC) pre-regulator followed by the downstream DC-DC converter(s). Most computers and small appliances use the International Electrotechnical Commission (IEC) style input connector. As for output connectors and pin outs, except for some industries, such as PC and compact PCI, in general, they are not standardized and are left up to the manufacturer.

There are different circuit configurations known as topologies, each having unique characteristics, advantages and modes of operation, which determines how the input power is transferred to the output. Most of the commonly used topologies such as flyback, push-pull, half bridge and full bridge, consist of a transformer to provide isolation, voltage scaling, and multiple output voltages. The non-isolated configurations do not have a transformer and the power conversion is provided by the inductive energy transfer.

Advantages of switched-mode power supplies

- Higher efficiency of 68% to 90%
- Regulated and reliable outputs regardless of variations in input supply voltage
- Small size and lighter
- Flexible technology
- High power density
- Disadvantages:
- Generates electromagnetic interference
- Complex circuit design
- Expensive compared to linear supplies

Switched-mode power supplies are used to power a wide variety of equipment such as computers, sensitive electronics, battery-operated devices and other equipment requiring high efficiency. Linear voltage IC regulators have been the basis of power supply designs for many years as they are very good at supplying a continuous fixed voltage output. Linear voltage regulators are generally much more efficient and easier to use than equivalent voltage regulator circuits made from discrete components such a zener diode and a resistor, or transistors and even op-amps.The most popular linear and fixed output voltage regulator types are by far the 78… positive output voltage series, and the 79… negative output voltage series.

These two types of complementary voltage regulators produce a precise and stable voltage output ranging from about 5 volts up to about 24 volts for use in many electronic circuits.There is a wide range of these three-terminal fixed voltage regulators available each with its own built-in voltage regulation and current limiting circuits. This allows us to create a whole host of different power supply rails and outputs, either single or dual supply, suitable for most electronic circuits and applications. There are even variable voltage linear regulators available

as well providing an output voltage which is continually variable from just above zero to a few volts below its maximum voltage output.

Switch Mode Power Supply

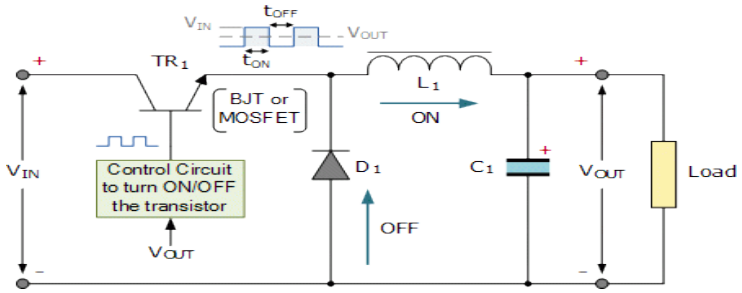


Figure 4.14: SMPS Circuit Connection

Most d.c. power supplies comprise of a large and heavy step-down mains transformer, diode rectification, either full-wave or half-wave, a filter circuit to remove any ripple content from the rectified d.c. producing a suitably smooth d.c. voltage, and some form of voltage regulator or stabiliser circuit, either linear or switching to ensure the correct regulation of the power supplies output voltage under varying load conditions. Then a typical d.c. power supply would look something like this

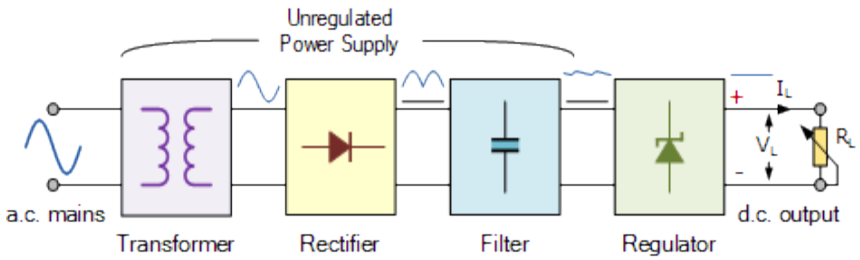


Figure 4.15: DC Power supply way

These typical power supply designs contain a large mains transformer (which also provides isolation between the input and output) and a dissipative series regulator circuit. The regulator circuit could consist of a single zener diode or a three-terminal linear series regulator to produce the required output voltage. The advantage of a linear regulator is that the power supply circuit only needs an input capacitor, output capacitor and some feedback resistors to set the output voltage.

CHAPTER 5

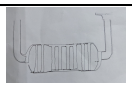
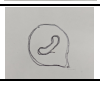
RESULT & DISCUSSION

5.1 Final Result

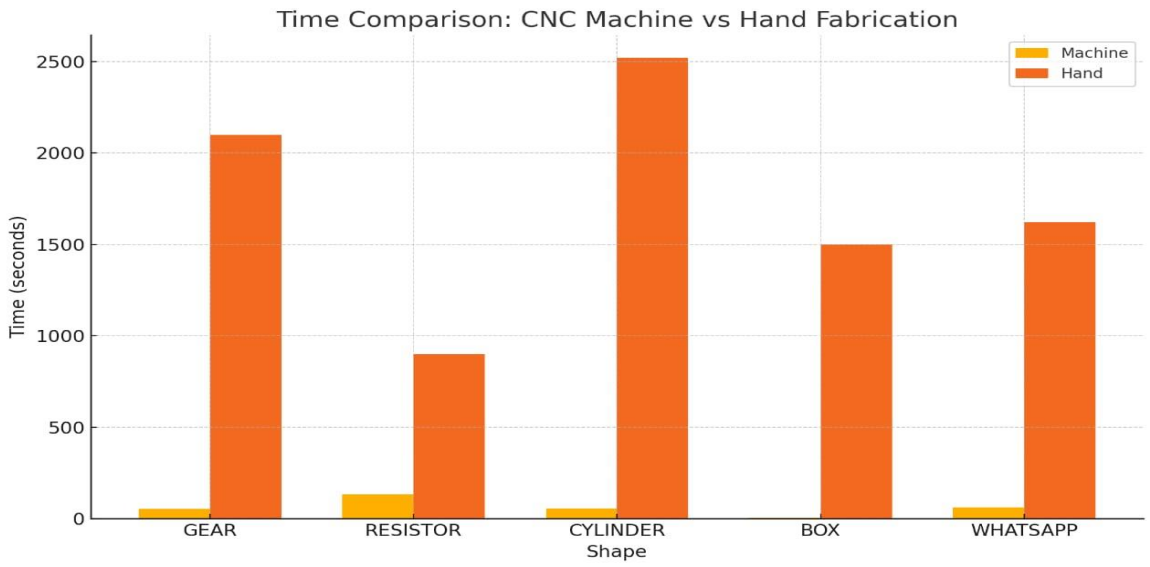
After finally completing this project, we ran it & we observed the output of this project. We can see that it is working well as expected. After making our project we observe it very careful. It works as we desire. Our project give output perfectly and all equipment are work perfectly. We check how much it works and we get perfect output from this project.

- Finally, we have completed our project successfully & check our project its run accurately according to our objective.
- At first, we start our system.
- Successfully converted digital designs into precise physical outputs.
- Servo motor worked well for pen up/down movements.
- Machine size was small and suitable for desktop use.
- Best suited for paper, cardboard, or soft surfaces.
- Following are the outputs of our project.

Table 1 : Time duration comparison for fabrication by mini CNC PLOTTER and hand.

SL No.	Shape	Time by machine	Time by hand
01		53 sec	35 min
02		2.22 Min	15 min
03		56 sec	42 min
04		4.52 Sec	25 min
05		1 Min	27 min

Figutre 1 :Time comparison chart



5.2 Hardware Implementation & Final Project

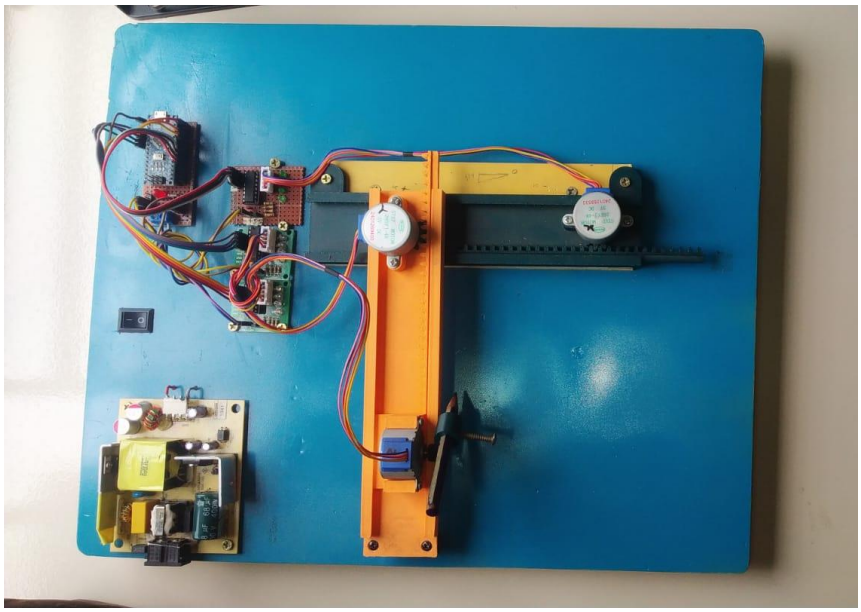


Figure 5.3: Complete Project Prototype

5.3 Advantages

There are certainly many advantages of our project and some of the major ones have been given below

- Cost-effective solution
- Stable power supply (SMPS)
- This project is easy to use
- Easy to draw image.
- Able to print 2D image.
- Time saving machine for industrial work.
- No Oil consumption.
- Time saving equipment.
- Installation is simplified very much.
- Less time and more profit.
- Simple construction

5.4 Limitations

Through the project has many advantages it has also some limitation, they are given below:

- This project can now be only used for small scale purposes
- No energy backup.
- Used cheap Chinese products for the prototype so there's some processing delay present in the circuit.

5.5 Application

The application areas for this project in this modern and practical world are huge and some of these are given below:

- Industrial work
- Garments factories for print
- Educational tool
- Prototype designing
- Handwriting simulation

5.6 Discussion

While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

The Mini CNC Plotter Machine is a compact, low-cost system designed for automated drawing and engraving using Arduino Uno, CNC Shield, stepper motors from recycled DVD drives, and a servo motor for Z-axis control. It interprets G-code instructions to produce precise sketches on paper or other light materials. The project showcases how simple components can be integrated to form a functional CNC system, making it ideal for students, hobbyists, and educators. It promotes hands-on learning in electronics, programming, and mechanical design. Additionally, it supports e-waste recycling, making it an environmentally friendly educational tool with practical real-world applications.

CHAPTER 6

CONCLUSION

6.1 Conclusion

The Mini CNC Plotter Machine project successfully demonstrates the integration of electronics, mechanics, and programming to create a functional and compact automated plotting system. By utilizing readily available and recycled components such as DVD writer mechanisms, stepper motors, Arduino Uno, CNC Shield, and a servo motor, the machine achieves accurate 2D drawing and engraving on paper and light surfaces. It operates based on G-code instructions, enabling precise control over movement and pen positioning. The project highlights the practical implementation of CNC technology in a simple and cost-effective manner, making it ideal for learning and prototyping purposes. It provides valuable hands-on experience in fields like robotics, automation, and embedded systems. Moreover, it encourages sustainable practices by reusing electronic waste. The Mini CNC Plotter serves as a great educational platform and can be further expanded or modified for more advanced CNC or engraving tasks. Overall, it is a useful, innovative, and eco-friendly project for beginners and enthusiasts.

6.2 Future Scope

We are thinking about adding many features to our project in the future to get more desirable out comes. Some of the steps that we are thinking about taking are given below:

- We will increase its working accuracy level.
- We will think about adding leaser cutting and PCB Design.
- The pen of the machine can be replaced by a laser to make it work like a laser engraving or cutting machine.
- In Future we will add extra power system.

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