Arduino Based Computer Numerical Control Plotter

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Abstract - *With the innovations in technology, Computer numerical control machines have revolutionized the machining processes. Modern industry uses the CNC Plotter not only for the reduction in production cost but also in saving the time and for increasing the profit and accuracy of the job. In this paper, we have discussed on how to make a low-cost Arduino based mini-CNC Plotter. Using a simple algorithm, a mini-CNC plotter can draw a layout of circuit on a PCB or any other surface of the solids. The control device for this project is an Arduino Uno with an ATmega328P microprocessor. To utilize Processing, the user must first use Inkscape software to convert any image file or any other text file into G code before Uploading it to the processor. G-code is converted by the microcontroller into a set of machine language instructions that are supplied to the CNC plotter's motor driver.*

Key Words: Computer Numerical Control(CNC), Printed Circuit Board, Microcontroller, G-code.

1. INTRODUCTION

Typically, two to six axes can be used to move a cutting or 3D printing head using a CNC Plotter, enabling it to precisely locate the tool head in or on the material to make the desired cut or action. A data stream of positioning coordinates sent by the PC can be used by the cutting head to cut or carve the design, by moving the head through multiple spots. It is feasible for a user to design a product on a computer, convert everything to CNC-readable data, and then transmit the data to a CNC machine to make a physical copy of the object designed using a computer.

The CNC plotter that is being discussed in this paper is based on an Arduino micro controller and a (CNC) shield. G codes are pre-defined functions related with machine axis movement. Only G codes are utilized in CNC plotter machines. G codes instruct the pen to travel in the X, Y, and Z directions. If the pen is constructed in a large size, it can be worked using drilling, laser cutting, and milling tools. The goal of this project is to build a mini-CNC plotter that is capable of sketching complicated designs on paper or on metal surfaces and cut them with remarkable precision. In Cartesian c, we used three stepper motors with lead screws.

1.1 Objective

The goal of this project is to build a low-cost mini- computer numerical Control machine that functions similarly to a real CNC.

- The project serves as a model for cutting operations that can be substituted with different cutting equipment such as a drilling machine, milling cutters, or even a laser cutter, among others.

- To give plotting/drafting as a replacement for traditional manual processes using a automatically operated device.

- Using low-cost models, teach college/school students about 3D printing and CNC machines.

1.2 Literature Survey

In the referred paper [1] the focus is to build, a low-cost, desktop prototype 3-axis vertical CNC mill. It is inexpensive, and it is also being used in the laboratories. Microcontroller and open-source motor control software, as well as stepper motors with drivers. Stepper motor, guide rod, lead screw, and spring were all included in the kit. He constructed the body of the Plotter out of PVC with high density. Because the system has a movable bed and a fixed spindle, the operating space is limited. The model allows students to engage in more hands-on learning, resulting in improved learning results. It was created solely for educational purposes.

[2] "Automatic mini– CNC Machine for PCB drawing". The goal is to create a machine, which is of low-cost, a fully automated mini-CNC machine capable of drawing on PCB. This approach lowers machine costs while increasing flexibility. The ATMEGA 328 is interfaced in this G code. The FTDI module is needed to turn the code into a useful controller, such as a serial to USB converter, where x shifts to the left, y shifts to the right, and z shifts up and down. It improves accuracy while also reducing workload. G code marks make it simple to retrieve information about the locations of all stepper motors that are moving. The GRBL supports movement in three directions: X, Y, and Z, but not axes of rotation in X and Y direction.

2. METHODOLOGY

Mini CNC Plotter Machine works by taking design G codes and converting them to lead screw rotation using Arduino, Stepper Drivers, CNC Shield, and Stepper Motor. It uses G-codes created by Inkscape's G-code plugin, which are then emulated by the software called GRBL software. The CD-drives' stepper motors are run by the simulator, resulting in a usable mechanical output at the CD-drives stepper motor arrangement, where the carriage acts in response to software signals.
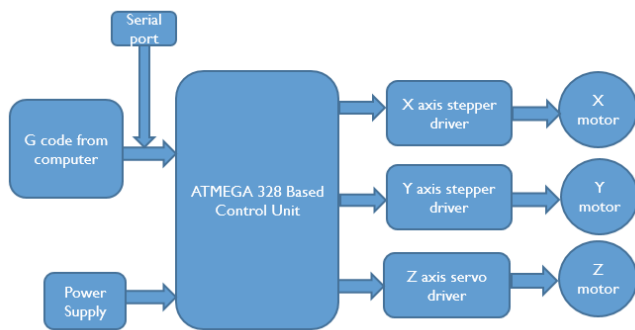

Fig -1: Block diagram of CNC Plotter

On the CNC shield, an Arduino will be installed. In response to an Arduino command, the CNC shield will distribute current. The stepper motor will transform G code into digital pulses using the CNC shield. The stepper motor of X-axis will move to the left and to the right, the stepper motor of that of Y-axis will travel in the forward and backward directions, and the Z-axis stepper motor is capable of moving in upper and lower directions. This machine can create a variety of challenging designs. The flow of the procedure across blocks is depicted in Fig -1.

2.1 Software Implementation

The list of software required for completing the project is listed in the below Table -1.

Table-1: Software Required

Sl. No	Software
1.	Arduino IDE
2.	Processing IDE
3.	Inkscape
4.	G-code converter Plugin for Inkscape

1. Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application, which can be used for Windows, macOS, and Linux. It is mostly used to write and upload programs to the boards that are compatible with Arduino, along with other vendor development boards that work with the support of cores of third-party.

The Arduino IDE uses the Arduino IDE program to convert programs that are executable into a text file(HEX code), which can then be uploaded into the firmware of Arduino board by a loader software. Arduino IDE is the uploading tool by default for flashing user code onto official Arduino boards.

2. Processing IDE

Processing is an open-source programming language software which can be used for e-drawings(electronic drawings). The processing tool "GTCRL" is used to deliver G-code files from the user interface to the CNC plotter. The Fig-2 shows the processing IDE's user interface.

The Arduino Uno's port is selected by hitting the "P" button on the keyboard, and therefore the "G" button is utilized to upload G-code file of user's liking. The CNC machine will immediately begin drawing the selected G-code file. The drawing can be stopped by hitting the "X" button.
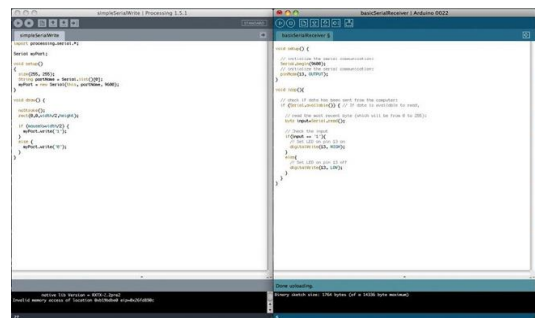

Fig -2: Processing IDE

3. Inkscape

Inkscape is an open-source and free of cost vector graphics editor that primarily works with the Scalable Vector Graphics (SVG) format to produce vector pictures. Inkscape is used to turn any image into graphics code, often known as G-code. G-code files are created by combining Inkscape with the required extension files.
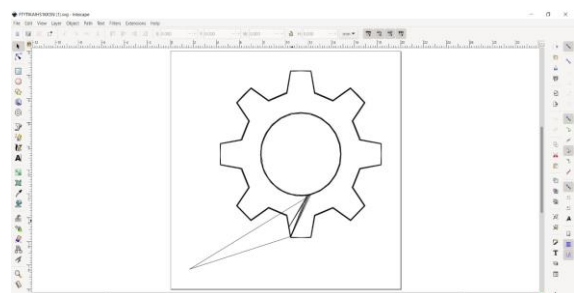

Fig -3: Inkscape Software

2.2 Hardware Implementation

Listed below is the list of hardware that we are going to use in our project model.

Table-2: Hardware Required

Sl. No	Hardware	Quantity
1.	Scrap DVD drive	2
2.	Arduino UNO	1
3.	L293D/L297 Motor Shield	1
4.	Mini Servo Motor	1
5.	5V 1A Power Adaptor	1

1. Disassembly of DVD/CD Drives:

To make this CNC plotter machine, first dismantle the 2 DVD/CD drives and remove the stepper motors from them. To open them, pry them open with a screwdriver and remove the rails. The next step is to choose a CNC machine base. We have used the DVD drive's surfaces. Finally, we will have to figure out how to connect one of the stepper-rails to our construction vertically.

Fig - 4 : Disassembly of DVD Drive

2. Mounting X, Y and Z axes

For X axis:
Place one stepper motor (with rails) on a large sheet of plexiglass and use a pen to mark the (4) screw holes. Open the holes and use nut screws to secure the motor.
Place the four mounting angles on one side of it, then use a marker to mark the (8) holes needed for the screws. Make sure there is a 5mm gap between them.

For Y axis:
Place the other stepper motor between two plexiglass panels and use a pen to indicate the (4) screw holes.
Place the two pieces of plexiglass on the X axis (large plexiglass piece) and use a pen to mark the four holes needed to match the mounting angles.

Mounting of Z Axis
The most difficult component of our design is the Z axis. We would need a flat surface to connect it to on the X axis. The Z axis's servo motor and the base of the pen will be attached to that surface. The pencil must be able to move in upward and downward directions with the help of a servo motor.

3. Circuit Connections
It is now the time to make the circuit connections and test the X and Y axes stepper motors after the construction is complete. The wiring for the stepper motors has been completed. The servo is connected to the 3 pins on top.
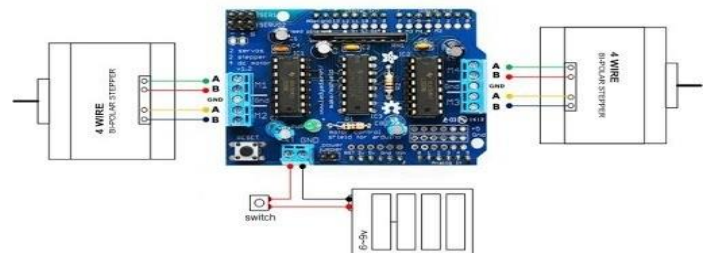

Fig - 5: Circuit diagram of CNC Plotter

4. Uploading the CNC code

In this stage, the primary CNC code, which was incorporated via code bender, is employed. It can be notice that the pencil starts moving in this section. Change the pencil coordinates that control the servo motor if necessary. Use your browser to program your board by pressing the "Run on Arduino" button.

5. Uploading of G code

Make the G code file using the Inkscape software to create G code command files that would be suitable with this mini-CNC machine. Now an add-on can be installed that allows the user to transfer the text or photos to g code command files.
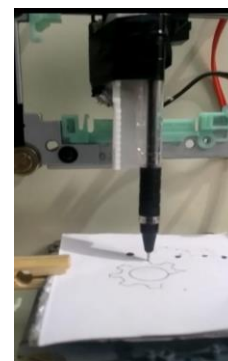
6. Results

Fig – 6: Image plotting by the CNC plotter

3.1 Advantages

- It's an open-source tool, so it's free, and it supports a wide range of hardware and setups. It's also quite simple to use.

- There are no steps missed by the stepper motor. As a result, the entire procedure is secure.

- The entire project is less expensive and can be readily produced with low-cost hardware.

3.2 Limitations

- Due to the project's size and capacity, it is unable to handle higher load applications or cutting pressures. It is unable to sustain larger cutting forces as well as the heavier weight of cutting instruments.

- The shapes that can be drafted are limited due to the circuit employed. Because of the GRBL software, the Arduino Uno's capacity is limited to a few forms.

- The CD-drive carriage's maximum height is limited to 50-60 mm

3.3 Applications

- **3D printing**: We can accomplish 3D modelling by swapping the pen with a 3-dimensional extrusion pen, which is now the most rapidly expanding technology.

- **Laser engraving**: By substituting a laser machine for a pen, we may do laser engraving operations to engrave various logos, trademarks, benchmarks, and other items.

- **Laser cutting:** For high-precision machining processes, we can utilise laser cutters instead of pens.

- **Milling operations**: With an overarm and arbour, we can do various milling operations such as slotting, grooving, and so on.

4. CONCLUSIONS

In this work, we have introduced the concept of a low-cost three-axis mini-CNC plotter. Existing CNC plotter machines are expensive, with complicated maintenance, and require experienced and trained personnel to operate. Our CNC plotter solves these issues and can be used in schools and colleges to teach students about the principles and operation of CNC machines and 3D printers. It is low-cost and simple to operate, and it does not require highly skilled personnel. The machine's pen can be replaced with a laser, allowing it to function as a laser cutting machine or for laser engraving purposes. Wood is also engraved with an engraving machine. The pencil can also be replaced with a strong drill to be used for both drilling and milling purposes.

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