

Arduino Based Cost Effective CNC Plotter Machine

Puja Girhe

Student, EXTC Department, DES's COET Dhamangaon Rly, India.

Shubham Yenkar

Student, EXTC Department, DES's COET Dhamangaon Rly, India.

Arpita Chirde

Assistant Professor, EXTC Department, DES's COET Dhamangaon Rly, India.

Abstract – Due to the rapid growth of technology the usage & utilization of CNC machine in industries are increased. The fabrication of low cost CNC machine is used to reduce cost and complexity of machine. This paper deals with the design of automatic mini CNC machine for PCB drawing and drilling. The Idea behind our project is to design and drill PCB based on low cost CNC system the lower cost is achieved by incorporating features of PC with ATMEGA 328 controller in an arduino. We have use an G code for whole system operation G code is nothing but a language in which people tell computerized machine tools 'How to make something'. The How is defined by instructions on where to move & how fast to move.

Index Terms – CNC, Arduino microcontroller, part program, interpolator.

1. INTRODUCTION

The computer numerical control is an advanced form of soft automation developed to control the motion and operation of machine tools. Numerical control machine was invented around in 19th century to reduced work load, it is a method in which the manufacturing machine uses coded format, digits and letters.

CNC Machining is a process used in the manufacturing sector that involves the use of computers to control machine tools. Tools that can be controlled in this manner include lathes, mills, machines and grinders. The CNC stands for Computer Numerical Control. Inspiring from this CNC technology and revolutionary change in the world of digital electronics & Microcontroller, we are presenting here an idea of CNC pen plotter using custom built PLC. The idea behind this project is to make a small CNC machine which can draw images or pictures on surface which can be a paper or anything. It uses three stepper motors as linear actuators on each axis X, Y & Z. While printing / drawing, the proper synchronization of all this three axis i.e. stepper motors, is most challenging task. At present the data to draw is given programmatically i.e. hardcoded in program in binary format. A pen touches the surface & prints the pixel for logic 1 and lifts up in air for logic zero & actuator changes it position for next commands execution. As in future plan, it can access the G-Code directly

from supporting software like inkscape. Presented plotter is one dimensional 1D plotter.

The Idea behind this technique is to design PCB based on low cost CNC system the lower cost is achieved by incorporating features of PC with ATMEGA 328 controller in an arduino. We have use an G code for whole system operation G code is nothing but a language in which people tell computerized machine tools 'How to make something'. The How is defined by instructions on where to move & how fast to move.

A Plotter is a special type of printer that uses a pen to draw images on solid surfaces. In Computer Numeric Control (CNC), microprocessor is used which is capable of processing logical instructions interfaced with a computer. The logical instructions are provided by using a computer in the form of code or text or image which is then transformed into a machine language by microprocessor to be executed by the machine. A CNC plotter machine is a 3D controlled 2D plotting machines which uses a pen to draw text or image on any given solid surface. It can be used for the purposes such as PCB Design, logo design, etc.

This technique is based on CNC plotter machine. With the increasing demand for the use of CNC plotters in universities and laboratories, a cheap and less complex design is an absolute need. The parts used for the plotter in our project are easily available at a very low price and spare parts are also used. The construction is very simple and robust.

2. RELATED WORK

2.1 Block Diagram of CNC Plotter Machine:

“In this idea of technique, Arduino microcontroller platform with ATMEGA 328 core is used. It can be easily interfaced with PC using FTDI module where as also with the easy drivers and stepper motors to. The basic block diagram is as shown in the explanation is given as follows:

The G code is interfaced with ATMEGA 328 CNC based controller by FTDI module which is used to convert the code in convenient controller code i.e serial to USB converter.

Hence it acts like interfacing module between PC to Controller. This code is further passed to stepper motor by easy drivers which converts the code and as per instructions the stepper motor moves. We need three axes X,Y,Z which operates as follows X stepper motor move left and right Y stepper motor moves front and back and Z stepper motor up and down as per given dimensions these axis's will move on.

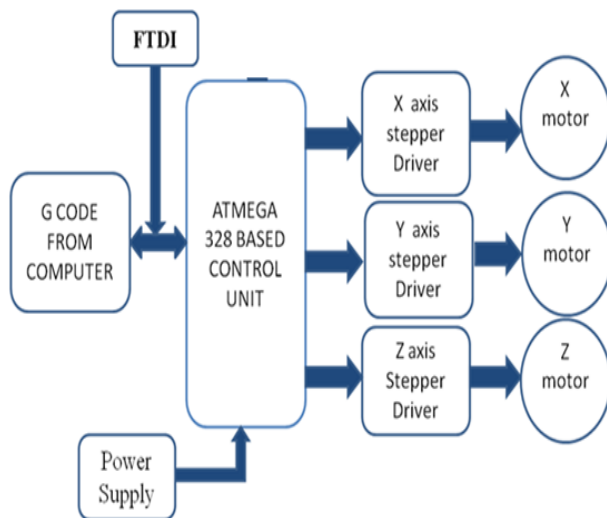


Fig. 1 Block Diagram of CNC Plotter Machine

2.2 G code

G code is nothing but a language in which people tell computerized machine tools 'How to make something'. The How is defined by instructions on where to move, how fast to move, & through what path to move.

G-code (also *RS-274*), which has many variants, is the common name for the most widely used numerical control (NC) programming language. It is used mainly in computer-aided manufacturing to control automated machine tools. G-code is sometimes called G programming language, not to be confused with views G programming language.

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.

G-Code is one of a number of computer code languages that are used to instruct CNC machining devices what motions they need to perform such as work coordinates, canned cycles, and multiple repetitive cycles. Industry has standardized on G-Code as its basic set of CNC machine codes.

2.3 Plotter

Pen plotters print by moving a pen or other instrument across the surface of a piece of paper. This means that plotters are vector graphics devices, rather than raster graphics as with other printers. Pen plotters can draw complex line art, including text, but do so slowly because of the mechanical movement of the pens. They are often incapable of efficiently creating a solid region of color, but can hatch an area by drawing a number of close, regular lines.

Plotters offered the fastest way to efficiently produce very large drawings or color high-resolution vector-based artwork when computer memory was very expensive and processor power was very limited, and other types of printers had limited graphic output capabilities

A plotter is a printer that interprets commands from a computer to make line drawings on paper with one or more automated pens. Unlike a regular printer, the plotter can draw continuous point-to-point lines directly from vector graphics files or commands. There are a number of different types of plotters: a drum plotter draws on paper wrapped around a drum which turns to produce one direction of the plot, while the pens move to provide the other direction; a flatbed plotter draws on paper placed on a flat surface; and an electrostatic plotter draws on negatively charged paper with positively charged toner. Plotters were the first type of printer that could print with color and render graphics and full-size engineering drawings. As a rule, plotters are much more expensive than printers. They are most frequently used for CAE (computer-aided engineering) applications, such as CAD (computer-aided design) and CAM (computer-aided manufacturing). Hewlett-Packard is the leading vendor of plotters worldwide.

3. PORPOSED MODELLING

Main blocks of this system consists of power supply, FTDI module, ATMEGA328, 3 Easy drivers each connected to stepper motors X, Y, Z. From power supply we get two voltages i.e. +5volt and +12 volt. 5volt which is required to ATMEGA328, Easy drivers whereas +12volt supply is required to stepper motors. RESET is connected to 5v supply through 10k ohms resistors to pull up the voltage thus it act as a pull up resistors. We have used here 16MHz crystal oscillator connected to ATMEGA with two capacitors of 22pF.

The GRBL code from computer is interface with controller using FTDI 232 module i.e. serial to USB converter. The output of FTDI is given to pin no.2 and 3 i.e. RXD and TXD pins of ATMEGA328. The output of ATMEGA328 is given to three Easy Drivers.

Easy Driver consists of 16 pins from which we are using in our project only 9 pins. Four pins are used for two stepper motor coil i.e. coil A and coil B. Two pins for input 5volt supply i.e.

VCC and GND. Three pins are used for STEP. Third pin is directly grounded.

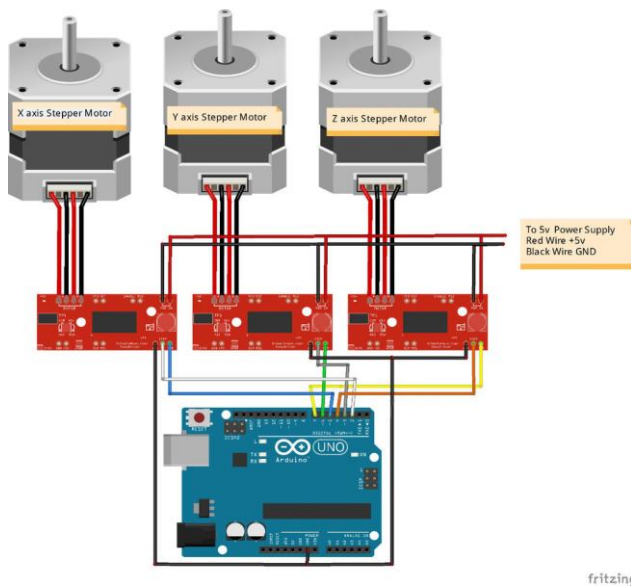


Fig. 2 Circuit Diagram of CNC Plotter Machine

According to the given dimensions Easy drivers or drilling machine will move. When working of motors is completed the dimensions on pc will roll of to again its initial value i.e zero.

3.1 Serial to USB Converter

It is used for making the communication between USB based computers and serial devices. We use here, FTDI (Future Tech Devices International) serial to USB converter is used. FT232RL IC is used. It is bidirectional converter. This converter is used to load the data which is coming from the PC system into the controller. This converter converts human interpretation language into its ASCII value which is understandable by the controller.

FT232RL is 28 pin IC. It has internal clock generator so that no external crystal is required. It works on FIFO i.e. First In First Out technique.

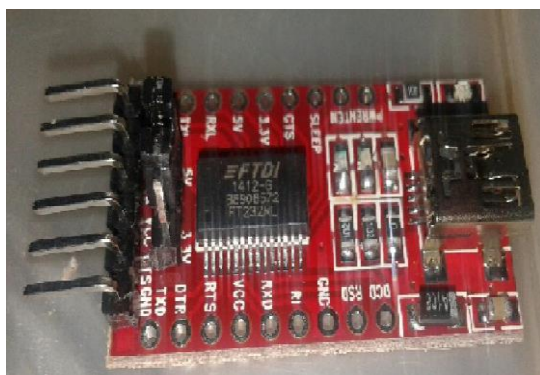


Fig. 3 FTDI Module

To interface the computer to the controller we use FT232RL IC which converts the USB data into serial data.

4. RESULTS AND DISCUSSIONS

A Our CNC machine consist 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 isserial 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].

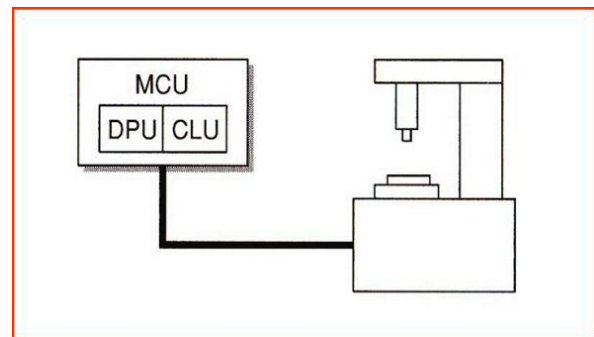


Fig. 4 Machine control unit

Driving system includes stepper motor, which converts electric pulses into discrete mechanical rotations of motor shaft. These pulses are provided by the machine control unit. Stepper motor would be the best simple device that can be applied to CNC as it converts digital data to actual mechanical displacements. They are mainly used because of slow speeds, low torque, and low resolution and easy to slip in case of over load.

5. CONCLUSION

We have presented the use of CNC machine for small scale application purpose due to the rapid growth of technology the usage & utilization of CNC machine in industries are increased. This project is about building a mechanical prototype of a CNC plotter machine which is able to draw a PCB layout on a given solid surface. It consumes low power and works with high accuracy due to precise controlling of stepper motors. This is a low cost project as compared to other CNC product. It is made with easily available components and spare parts. It is designed for private manufacturing and small scale applications in educational institutes. The machine is designed with a very simple construction scheme and can be carried anywhere without much effort. The algorithm used is simple. The pen can

be replaced with a pinhead or laser head or any other tool for different purpose of use. Software that has been used is open source and user-friendly.

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 an flexibility to do works.

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