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Design and fabrication of Computer Numerical drawing Machine

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ABSTRACT: This presents the design of Mini CNC Machine. This machine has 2 axes, namely the X and Y axis. Mini CNC machine is a small CNC machine that can operate like a normal CNC machine with a limited area of the machining. The objectives of this project are to develop the mini CNC Machine and to develop the software to control the machine. This describes the development of the machine and the criteria needed to build the machine. The Mini CNC Machine is initially sketched by referring to the criteria that was decided. The criteria are the travel path length, type of linear motion, type of linear drive, motor and controller, and type of material that used. This machine's travel on the X axis is 15cm and Y axis is 15cm. The linear motion used is a round linear rail and the linear drive used was a sliding element, lead nuts and lead screws. The motor used is a stepper motor with specification 2.1V and 3.0A. We are fabricating low cost CNC machine to reduce cost and complicity of machine we have used G-code for all the system operations. This paper will present an affordable model of a CNC plotter machine which is able to draw a circuit layout on PCB or any other solid surface using simple algorithm and available components. At first the user needs to convert any image file or text file into G code using Ink space software and then feed it to the machine using Processing software. Arduinonano with an ATmega328P microcontroller is used as the control device for this project. The microcontroller converts G-code into a set of machine language instruction to be sent to the motor driver of the CNC plotter.

KEYWORDS: Computer Numerical Drawing (CND), Printed Circuit Board (PCB), Gcode, Micro controller Unit (MCU), Plotter.

I. INTRODUCTION

A Plotter is a special type of printer that uses a pen to draw images on solid surfaces. In Computer Numeric Drawing(CND), 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 project 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. Mini CNC machine is the machine that is similar to the usual CNC machine. Mini CNC machine is the small CNC machine that can operate like usual CNC machine but the area of the machining is limited. CNC machine is all about using the computer as a means to control machines that carves useful objects from solid block to material. For example, a CNC machine might begin with a solid block of aluminium, and then carved away just the right material to leave with a door handle. There are many types of CNC machine. The common CNC machines are two-axis and three-axis CNC machine. The two- axis machine can move on vertical and horizontal only which are X and Y axis. Three-axis machine can do movement starting with three primary axis which are X, Y and Z axis. The Z axis is being parallel with the spindle (Micheal W. Mattson, 2010).The CNC machine operation starts with the collecting the data from the programming that extract from the computer-aided design (CAD) and computer-aided manufacturing. The programs produce the computer file and then will extract the command to operate the machine. The program will be transfer via post-processor and then be loaded into the CNC machine to start the machining. The CNC machine is a system. To complete the system of CNC machine, there are 4 components which are mechanical design, drives module, system software and Automatically Programmed Tool (APT) post processor. For the mechanical design system, this part is the part of hardware of machine which is the part body. For the drive system, the command signal was received from microprocessor. Microprocessor is consisting of motors, amplifier units and a power supply. For the software system, it is generate the program to the CNC machine to start the movement of tools and work piece. For the APT postprocessor, it was developed to produce the G-code and Mcode that can be used by the CNC machine. Besides that, CNC machine also include of wiring in order to connect the power to the machine. To complete the whole CNC machine, all the elements must be in the good condition and must put at the right place.



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II.METHODOLOGY

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. In this module, the machine specification is identified and the power for machining aluminium is calculated. The second module is the drive module. This module show 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. Lastly, the fourth module is the Automatically Programmed Tool (APT) postprocessor. APT is a language that is used to control a variety of operations in machining and that is generating from the CAD/CAM software system. The APT postprocessor was developed to produce G-codes and M-codes that can be used by CND machine constructed from the APT files produced by commercial CAD software. From the book CND Machines by B. S. Pabla, M. Adithan, they state that there are some features in CND machine tools (B. S. Pabla, 1994). The features are:-

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

1. The part programmed once entered in to the computer memory can be used again
2. The part programmed can be edited and optimised at the machine tool itself
3. The input information can be reduced to a great extent with the use of special sub programmed developed for repetitive machining sequence
4. The CND machines have the facility for proving the part programmed without actually running it on the machine tool
6. CND control unit allows compensation for any changers in the dimension of cutting tool
5. With the CND control system, it is possible to obtain information on machine utilisation 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 CND 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 CND system depends on the resolution, the computer control algorithms, and the machine inaccuracies

III. AIM OF PROJECT

The main aim for develop a low cost automatic mini CND machine for PCB drawing and drilling. This system reduces the cost of machine and increases the flexibility. The objective of project is to design and implement a CND machine (30 cm by 30 cm) which will be able to draw a PCB layout on a surface.

IV. INFORMATION ABOUT PROJECT

To complete the task of entire project three software is used

1.Ink space 2.Processing

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.



Creating G-Code File Using Ink space

The CND plotter of our project will work within 20cmx20cm area. Fig. 3 Conversion of text to G-code So we choose the document properties of the Inkscape 40cmx40cm (Width x 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 CND 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. To create G-code of an image, the file must have a transparent background. The image should be dragged into the selected area then select “trace bitmap” from drop down window to create a transparent image. Scans are selected as 8 and “Edge detection” is selected to create black & white image. After adding this transparent image in the predefined area we’ve used “object to path” command to create the Gcode file of the selected image by following the steps described earlier.

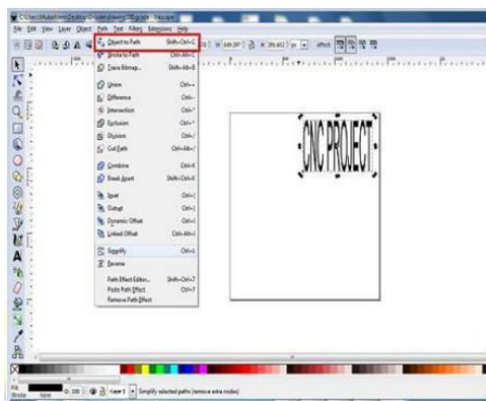


Figure No 1: Conversion of text to G-code

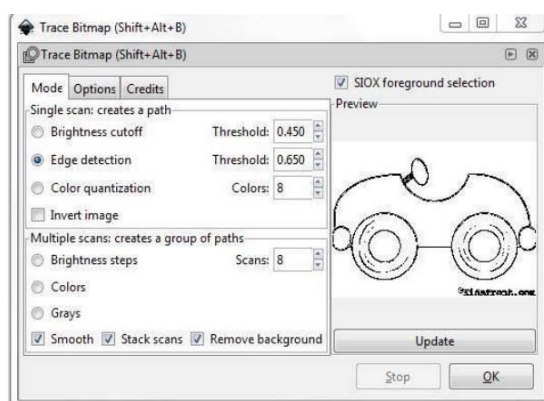


Figure no 2: Creating transparent image

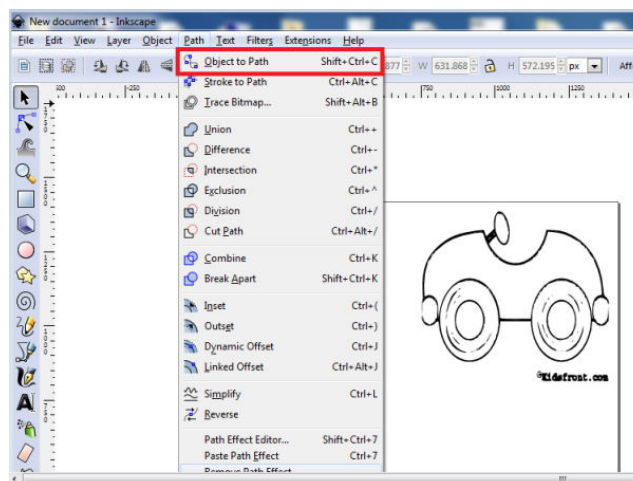


Figure No 3: Conversion of transparent image to G-code

B. 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 CND 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 CND machine will start sketching selected G-code file. Sketching can be stopped by pressing “X” button.

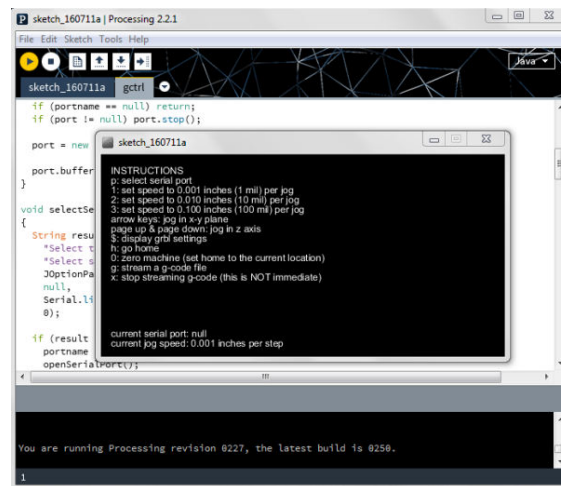


Figure 4: Uploading G-code file

C. Coding

Bresenham's Line Algorithm is used for plotting in the CND plotter. 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 CND 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.

D. G-code:-

To draw a text file or design a circuit layout by the CND 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.

V. WORKING

Our CND 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 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.

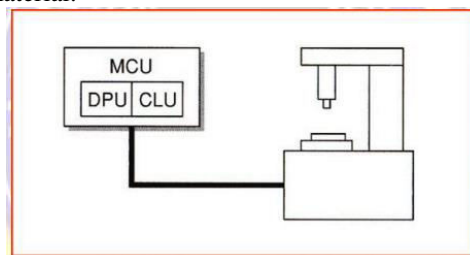


Figure No 5: Machine Control Unit



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VI. ADVANTAGES & DIS-ADVANTAGES

ADVANTAGES

1. The advantages of CND machines are reduced lead time.
2. Less elimination of operator errors, operator activity.
3. Lower labour cost, smaller batches.
4. longer tool life, elimination of special jigs and fixtures,
5. Flexibility in changes of component design, reduced inspection, less scrap and accurate costing and scheduling.
6. The simplicity, the operating principles of the machine and control system can be very easily Understood.
7. Since very few transmission elements are used, the reliability of the system is high, and not many instruction systems of this type are currently available in the market place

DIS-ADVANTAGES

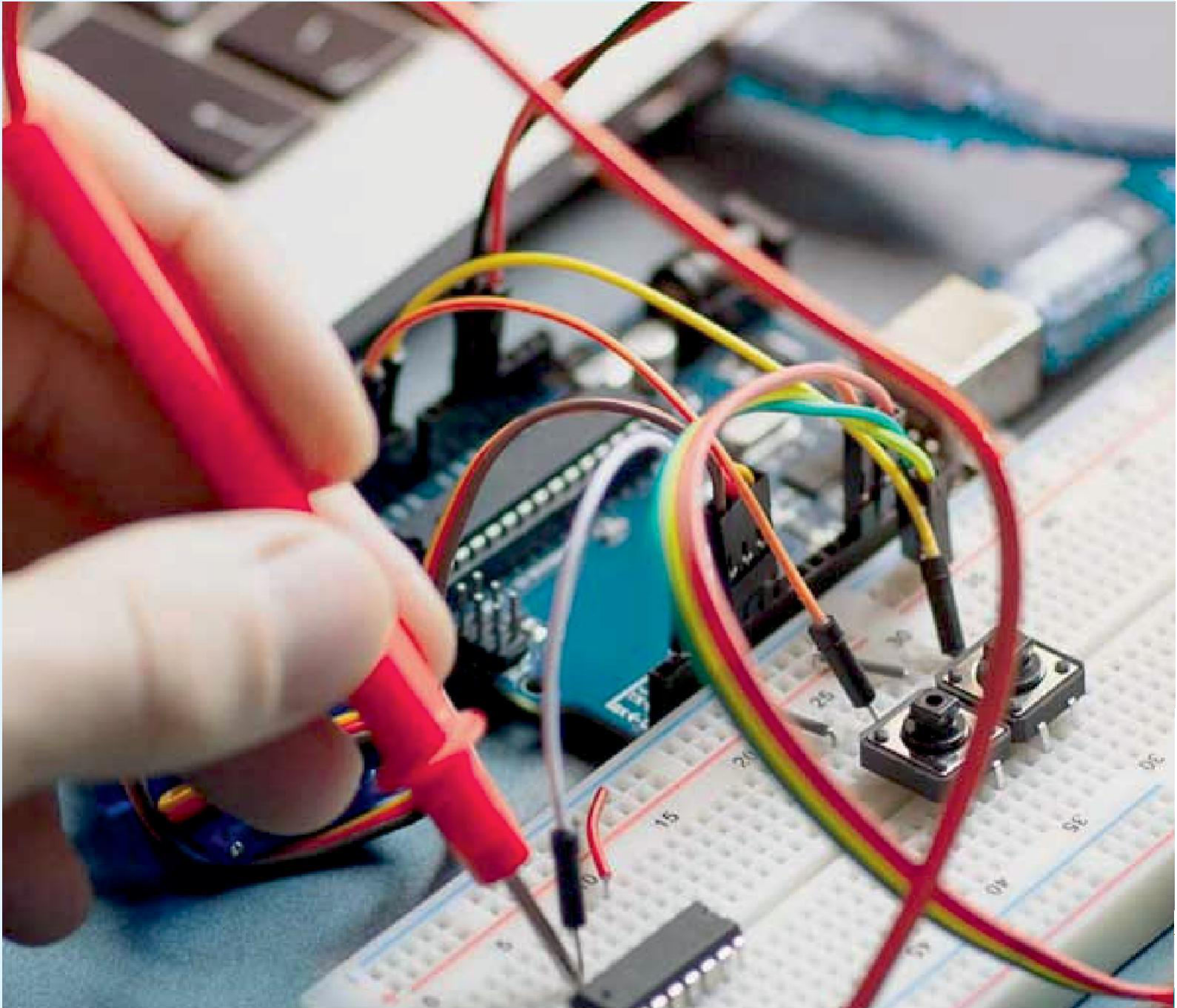
1. Higher investment cost.
2. Higher maintenance cost.
3. Costlier CND personnel and planned support facility.
4. Machine runs in slow pace and generates excess heats which causes heat sink to be heated quickly
5. The Z axis is not very rigid so it causes slight vibrations

VII. CONCLUSION

In this paper we have presented the concept of a low cost three-axis mini CND plotter. The existing CND machines are of high cost, difficult to maintain and requires highly skilled operators. Our CND 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 CND 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 stepper motor

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