NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY
[IJIERT] ISSN: 2394-3696 Website: ijiert.org
VOLUME 8, ISSUE 8, Aug. -2021

DESIGNING A C. N. C PLOTTER MACHINE

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ABSTRACT
The Computer Numerical Control plotter is a machine that is industrially useful in the production of various drawings, writings and sketches. Basically, it consists of the input port, a micro-controller, a motor and a moving pen. The input port is connected to a computer system for input while arduino is used as the micro-controller. If any other output device apart from a pen is attached to the arm, the machine can be used for a wide array of applications. For example, if a cutter is attached, the machine can be used for cutting shapes as pre-designed. The machine constructed in this work has been used to produce a text as output.

Keywords: Arduino, micro-controller, input port.

INTRODUCTION
The world today has become highly industrialized. Therefore, there is the constant need to design and develop various items ranging from diagrams/designs to machine parts and equipment. Hence, there is the need to have a device which can accept input in form of design and then print or plot same on a given surface as output. The Computer Numerical Control (CNC) plotter machine is one machine that can be used for such tasks (Jayachandraiah et. al., 2014, Haitao et. al., 2007). In other words, the CNC plotter machine accepts input as soft copy designs from a connected computer system and produces an output as drawings on the supplied surface. In specialized cases, when attached to laser, the CNC plotter machine can be used to produce 3D objects.
Basically, the CNC plotter machine comprises of the input port, the micro-controller, three axes stepper motor and the moving pen as the output.
In this research work arduino is used as the micro-controller which senses the input, interprets it based on pre-configured instruction set and produces the output in form of drawing.

LITERATURE REVIEW
Numerical control started in the year 1947 when John C. Parsons invented a way of coupling computer equipment with a jig borer to make faster templates of helicopter rotor blades.
By 1951, Massachusset Institute of Technology (M.I.T) became involved, and in 1952, the prototype of today's NC machine- a modified Cincinnati Hydrotel Milling Machine, was successfully demonstrated. The term numerical control was originated at M.I.T.
As CNC machines increased, there arose the need for non-proprietary standards. Some of such standards which were often based around vector- graphics markup languages, supported by plotters were introduced at various times. One of such standards has since become very common- the "G-code" that was originally used on Gerber Scientific plotters and then adapted for CNC use (Jayachandraiah et. al., 2014, Haitao et. al., 2007).
While the G-code is the predominant language used by CNC machines today, there is an ongoing effort to replace it with STEP-NC. The major reason is that STEP-NC, being a system that was deliberately designed for CNC will perform better compared to the G-code which was adapted from an existing plotter standard (Zhu et. al., 2012).
Also, some machine tool/control manufacturers have invented their own proprietary interactive methods of programming, trying to make it easier to program simple parts and make set-up and modifications at the

machine easier. Such programming methods include Mazatrol by Mazak, 1GF by Okuma, and Hurco (Zhu et. al., 2012, Espalin, 2014). These have met with varying degrees of success.
In recent times, advancement in CNC interpreters is seen in terms of support for logical commands known as parametric programming (William, 1986). Parametric programs include both device commands as well as a control language similar to BASIC. The programmer can now make "if/then/else statements", loops subprogram calls, perform various arithmetic functions, and manipulate variables to create a large degree of freedom within one program.

ARDUINO PROGRAM

An arduino program is used to program the microcontroller to perform the desired function. It is an open source project that creates microcontroller based kit for building digital device and interactive objects that can sense physical quantities and control devices (Espalin, 2014).
The project is based on micro controlled board design, produced by several vendors using various microcontrollers. These systems provide sets of digital and analog input/output (I/O)pins that can interface with various expansion boards and other circuits. The board features a serial communication interface or a universal serial bus (USB) on some models, for loading program from personal computers to program the microcontrollers. The arduino project provides an integrated development environment (IDE) based on both the C and C# languages. The first arduino program was introduced in 2005 aiming to provide a low cost, easy way for novice and professionals to create devices that interact with their environment using sensor and activators. In this work, it was used to program the microcontroller to drive the CNC plotter in response to external feed (Adeloye et. al., 2017).

MATERIALS AND METHODS

The CNC plotter machine is made up of three sub systems has shown in figure 1 below

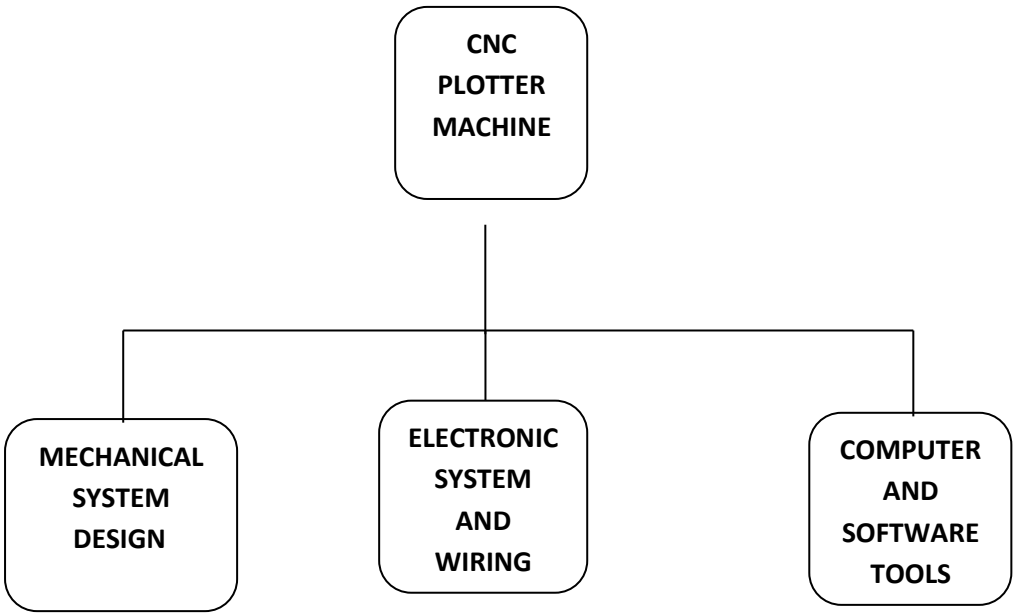

Fig.1 Sub-systems of CNC plotter machine

The mechanical sub component consists of various moving parts such as the stepper motors that control motion in the X, Y and Z axes. The left-right motion is controlled by X axis stepper motor, front-back motion controlled by Y axis stepper motor and the pen goes up and down by Z axis stepper motor controller.
The left-right motion is controlled by X axis stepper motor, front-back motion controlled by Y axis stepper motor and the pen goes up and down by Z axis stepper motor controller.
The components required include Stepper Motor (2 pieces), Stepper Motor Driver Module (2 pieces), Power supply, Arduino-uno, Bearing, Pen, hose clamp, connectors and cables.

The wiring of the various components of electronics system is shown in the figure below. The micro-controller of arduino board is connected to the computer system through the USB serial port. The Stepper Motors of three axes(X, Y and Z) are connected with CNC shield driver board as shown in the figure below. D. C. Power supply is provided for all the components of electronics system.

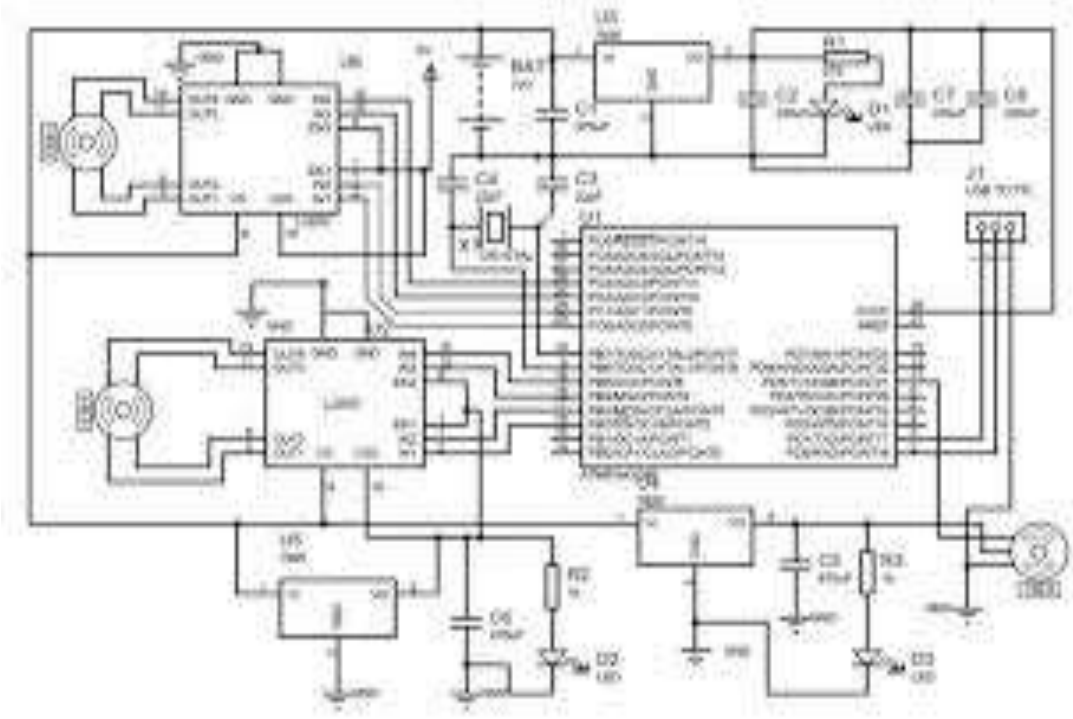

Fig.2. CNC plotter machine wiring (http://doi.org)

The software tool is divided into three stages namely:

- Arduino IDE
- Inkscape and G-code
- Processing IDE

The open-source arduino software (IDE) makes it easy to write code and upload it to the board. Also, inkscape is used to design the plotted diagram or text and to convert the diagram or text into G-code files.
To draw a text file or design a circuit layout by the CNC plotter, the files firstly need to be converted into G-Code using inkscape as stated above. G-Code is a set of instruction that contains number of X, Y, Z, coordinates depending on the file. It instructs the X axis of the machine to travel from X_1 to X_2 points with a specific speed and same is true for the Y axis. For Z axis, the coordinates are fixed because only vertical movements are involved. In this project inkscape is used to convert any transparent image to G-code.

TESTING AND IMPLEMENTATION

Upon completion, it is necessary to calibrate the movement of the axes. Test code for step per motor is used where steps per revolution of 200 steps is allowed for the motor to move. On running the code, it is found that the motor travels 40 mm, indicating that the stepper motor takes 5 steps to cover 1mm.This is calibration for both X and Y axes.
To run CNC plotter machine, the arduino IDE must be installed on the computer and the CNC plotter machine must be connected by USB. The COM port should be chosen on the console screen.
The following steps were taken to test-run the plotter machine

- The inkscape application was opened on the computer.
- The drawing or text was input into the inkscape workspace.
- The drawing or text was converted to outline.
- "Object to path 10" was clicked to make the drawing or text transparent

- The drawing or text was saved as "makerbotunicon G-code". Since inkscape does not have "makerbot" as an add-on, it is downloaded.
- After saving the drawing or text as "makerbotuniconG-code", the processing IDE was opened. Once opened, click run. A window appears with all the instructions. When 'p' is pressed on the keyboard, the system will request that a port be chosen and then, the COM port should be selected. Upon pressing the key 'g' and browsing to the folder where the G –CODE was saved, select the right-CODE and press enter. If everything was connected right, the device should start to plot on the paper. To terminate the process, just press 'X' and the device will stop operating.

Alter the testing and calibration, a plotter machine was ready to operate.
The machine collects data as files from Computer Aided Design (CAD) and Computer Aided Manifesting (CAM). The programs produce the computer file and will then extract the command to run the device. The program will be transferred via arduino and then loaded into the plotter machine to start plotting.
An example of the output from the machine is shown in figure 3 below

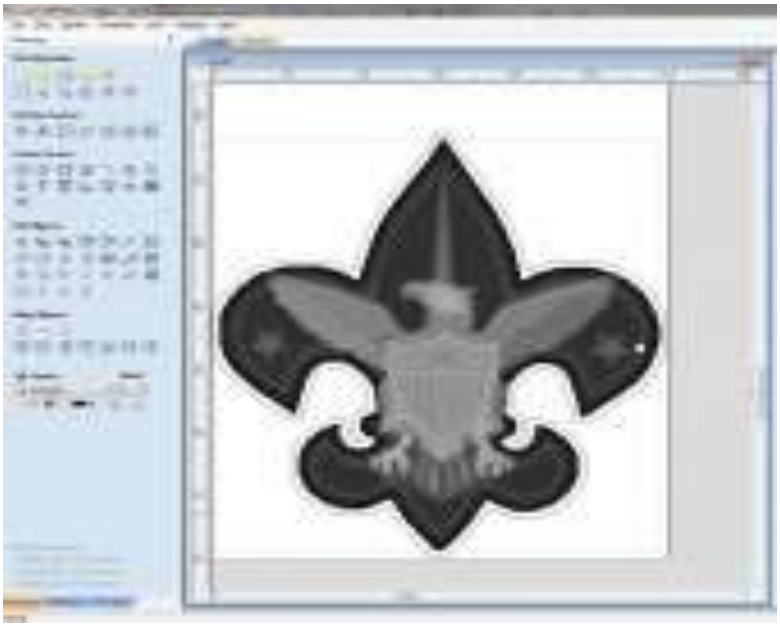

Fig. 3. A scout diagram output from CNC Machine

CONCLUSION AND RECOMMENDATION

In this work, we developed a low-cost plotter machine, which is easily controlled by a computer system. This small machine is portable as the board size of this device is 40X40 cm and can be assembled everywhere as needed. The design of computer numeric control can still be improved to get more efficient, portable CNC plotter machine. To achieve this, further research is needed in the fields of mechatronics and programming design. This can be done by exposing engineers and engineering students to the use of electronic components for practical work.
Lastly, it should be ensured that high quality components are used to avoid damaging the machine and for reliability.

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