



## **X-Y Pen Plotter Design Accomplished from Older Drives**

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*The paper describes the design and the implementation of a small, easily operable and flexible 2-axis CNC pen plotter (Computer Numerical Control). It is accomplished from two old and available CD-ROM (Compact Disc Read-Only Memory) drives using their stepper motors and the main hardware structure. The two stepper motors move the pen platform along X and Y axis. The plotter has been tested for printing different images and texts. Thus, the functional and graphical requirements were demonstrated, the conclusion being that this device is efficient and precise, and it can be easily achieved from available components.*

**Keywords:** 2-axis pen plotter, CD-ROM, CNC plotter, plotter design, stepper motor

### **1. Introduction.**

CNC machines are industrial process equipments that uses computers to control machine tools such as plotters, lathes, mills. Day after day, CNC expand its application to other tasks like in cutting, welding and assembling robots, which are used in manufacturing factories. Because of the great developments in the computer field, CNC becomes easy to add new features such as new sensors and actuators, and it becomes easy to change structurally and develop the control algorithms, these facilities being not previously observed in the design of the older CNC machines [1]. The CNC stands for Computer Numerical Control inspiring from this CNC technology and revolutionary change in the world of digital electronics & microcontroller.

Due to the high relative cost and versatility against the conventional CNC machine, it remains as a staple of industry and this makes difficult for the companies to manufacture large quantities of these CNC machines, especially when a high-quality is required [2].

On the other hand, many different projects have been implemented for small low cost CNC (i.e. [3]), where three-axis Mini CNC Plotter was implemented using stepper motor, microcontroller and motor control software. Another example is a low-cost three-axis vertical CNC mill suitable for adoption in undergraduate mechanical engineering laboratory [4]. Kajal J. Madekar et al showed that the used of G-code programming to control the motors for small CNC machines gives better accuracy such as in large CNC machines and reduces the work load [2].

The idea of this paper is to implement a small low cost CNC plotter machine, which can draw images or pictures on a small area. It uses two stepper motors as linear actuators on each axis X, Y and servo motor on axis Z for the pen-head. The Arduino Uno microcontroller controls the proper synchronization.

## 2. Design basics.

The device working way is on three axes X, Y and Z. X and Y axes controls the motion over the printable area, while Z axis controls the motion of pen-head. The PC program converts the text into G-code and sends it sequentially to the microcontroller. The Arduino starts to control the three motors according to the received G-code locations with a proper synchronization during printing [5].

Two stepper motors were taken from two older CD-ROMs together with other mechanical components, as shown in figure 1, they being employed with the motion over the worktable area. The Arduino Uno module is based on a microcontroller that is used to control the rotation of the motors. Arduino developing boards are open source based, easy to use, having a good number of input/output ports, suitable memory size and can easily interact with physical computing platform for creating interactive objects that stand alone or collaborate with software on the computer [6].

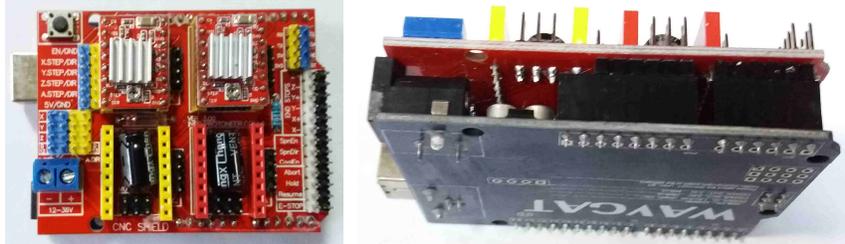
The drive electronic circuits receive PWM (Pulse Width Modulation) signals from Arduino ports to control the speed and direction of motors. The stepper motors are considered the heart of mini-plotter, figure 1, because the printing accuracy depends on them characteristics [7].



**Figure 1.** Mechanical parts and wire connections

Two L293 motor drivers [8] connect the two stepper motors to Arduino, because the current limitation of the Arduino output port pin is at about 40 mA, while

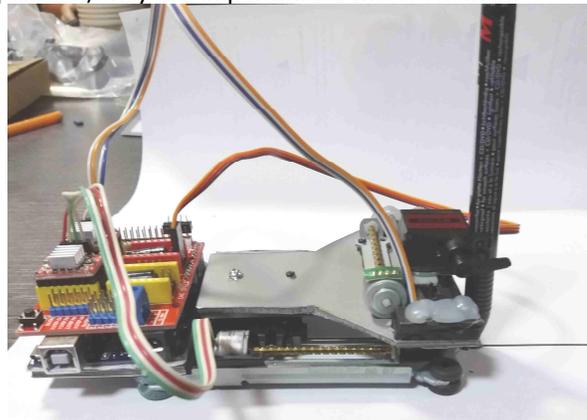
the stepper motor requires more than 150 mA. The way of electrical and physical coupling between Arduino and motor driver boards is shown in figure 2.



**Figure 2.** Electrical and physical coupling between Arduino and driver module

### 3. Pen plotter testing

During tests the voltage waveform was measured in the printing condition, resulting the ON/OFF switching, 1.5 ms ON pulse in 20 ms period, of the motor with a constant delay. The winding voltages of the stepper motor were measured also in a printing operation, they are important for motor rotation.



**Figure 3.** Experimental tests with the 2-axis CNC pen plotter

When the stepper motors switch ON cause a voltage drop in the supply voltage, while at the switch OFF the supply voltage rises. The rises and drops in the supply voltage cause the voltage fluctuations that was noticed.

### 4. Conclusion.

Existing CNC plotters are of high cost enough difficult to maintain and requires highly skilled operators, CNC pen plotter is of low cost and easy to control. Investigation shows static rigidity, positioning accuracy and repeatability.

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