Arduino Based CNC Drawing Machine

Shubham Agarwal[1], Pradyumn Ratnaparkhi[1], R P kori[2]

[1]Student, Dept. of. Mechanical Engineering, MITS, MP, India.
[2]Professor, Dept. of. Mechanical Engineering, MITS, MP, India.
Corresponding Author: pradyumn56@gmail.com

Abstract: - "Arduino Based CNC Drawing Machine" is a machine that works based on the rule of Computer Numerical Control (CNC). CNC Plotter typically works with two CD-drives for Z and Y axes and one CD-drive for X axis, where the CNC PLOTTER plots the input which is given from the system from the drawing board using an open-source physical computing platform called Arduino Uno. The CNC PLOTTER has two CD-drive axis control and one single CD-drive to lift and lower the pen. Each axis is given power and driven by using an Arduino Uno compactable driver A4988. The X and Y axis mainly contains step- per motors taken from CD-drives. The software used for programming the Arduino board is Grbl software. The right and efficient arrangement and proper use of these programs besides the circuit makes up an efficient CD-ROM CNC PLOTTER.

Key Words— *CNC Machine, CNC Plotter, Arduino Uno, GRBL software.*

I. INTRODUCTION

CNC stands for "Computer Numeric Control" and generally refers to a system whose operation is being controlled by a computer. The most common use of CNC, and the one useful to us, is the name which is given to these devices that, under the control of computer are able to cut, etch, engrave, build, turn and perform manufacturing operations on many materials. Movement is controlled along multiple axis, generally at least two (X and Y) and a tool spindle that moves along Z (depth) direction. The movement of the tool is done by direct-drive stepper motor or servo motors in order to give very high accurate movements, or in older designs, motors by a many step down gears. Open-loop control works until forces are small enough and speeds are not very great. On commercial metalworking machines, closed loop controls are standard and necessary in order to provide the required accuracy, speed, and repeatability required.

Generally, a CNC system has the ability to operate a cutting or a 3D printing head in 2 to 6 axes, which means that it can hold that tool head at a precise location in or on the material to make the cut or operation desired at the point. On moving the head along many points, the cutting head can make the design which is represented by a stream of data of positioning points which are being sent by the computer. By operating a CNC machine through a computer it is possible for the operator to design a thing which is on-screen, convert it to a CNC-readable code and then send the data to the CNC machine for it to make a physical copy of the item.

It operates on the G-codes made by MakerCam software and then which are simulated by the Grbl software. The simulation operates the stepper motors of CD-drives resulting in to a mechanical output at the cd-drives where carriage moves as per signal given by program.

Advantages:

1. It's an open source software and thus it's free, it supports many kinds of hardware and configuration and it's very simple to use.
2. The stepper motor never forgets a single step. Hence the complete operation is highly reliable.
3. By MakerCam the process can be done in 3D. Hence 3D modeling can also be done by this software.
4. The whole operation is cheaper and can be easily made through old parts of hardware from computers.

II. TECHNICAL SPECIFICATION

A. Arduino Uno R3

Arduino is the main part of the project; hence it should be selected properly. In our project we have selected Arduino Uno R3 which only operates using G-codes. The Uno is a microcontroller board which is based on ATmega328P. It has a 14 digital input or output pins (of which 6 can be for PWM output), 6 analog inputs, a 16 MHz quartz crystal, an USB connection, a power jack, a ICSP header and a reset button. It has everything needed to help the microcontroller; connect it

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with a computer using a USB cable or give it power using adapter or battery to start.

The board consists of an Atmel ATmega328 microcontroller operating at 5 V with 2Kb of RAM, 32 Kb of flash memory for remembering programs and 1 Kb of EEPROM for storing parameters. The clock speed is 16 MHz, which executed about 300,000 lines of C source code per sec. The board has 14 digital I/O pins plus 6 analog input pins. There is also an USB connector for interacting with the host computer and a DC power jack for connecting an outer 6-20 V power source.

B. CNC Shield

CNC shield contains 4 axis control drives on it i.e. **X-Y axis** for movement and **Z-axis** for the cutting tool vertical motions, whereas the last axis that is **A-axis** is optional to give the rotational motion to the cutting tool such as rotational movement used for the drilling motion etc. Every axis contains 3 jumpers that can be used to configure the micro stepping of the axis.

C. Stepper Motor drive

The stepper motor is used for obtaining correct positioning by using digital control. The motor operates by correctly moving with the pulse signal output from the controller to the driver. Stepper motors, by their unique ability to give high torque at a low speed while lowering vibration, are good for applications which use quick positioning for a short distance. Stepper motors allow correct positioning easily. These are used for many types of equipment for correct rotation angle and speed control by using pulse signals. Stepper motors generate high torque for a small body, and are best for fast acceleration and response. Stepper motors also maintain their post after stopping, due to design. Stepper motors contains a driver.

A4988 stepper drive is Used in Pololu stepper driver boards and G3D driver. Full, half, fourth-, eighth and sixteenth step modes.

D. CD-ROM Carriage

CD-ROM contains a stepper motor which has lead screw which moves the carriage ahead or backward.

Parameters	Specifications
Total size	15 x 9 cm
Reciprocating movement range	Max. 5 x 5 cm

III. ASSEMBLY

A. Dismantle the Cd-drives and Soldering

The first thing to do, that is usually overlooked, is to remove the front panel over the drive tray. To do this, force remove the drive tray by sticking a clip into an eject hole. As the tray is removed out, the front panel can snap off by pulling the bottom of it forward and after that push it above. When that's done, then unscrew the bottom plate of drive and remove the metal drive casing and the plastic front panel.

The reason we want the component of the optical drive is because it gives us a motor, track, and housing that can mechanically give a smooth backward and forward movement, which is ideal for a CNC axis. Being not used in the project, brush-fewer motors prove great motors for quad-copters.

Wire Colour	DC voltage	Used for
Yellow	+12 V	Motors
Black	GND	-
Black	GND	-
Red	+5 V	Logic circuit

It is required for extending the stepper motor wires. Mostly stepper motors have a ribbon cable that connects them to the main board. Cut them and solder the four new wires to the pin terminal. Colour code is used to find the path of every single wire.

The drive cases are put over the horizontal and vertical plane to get these axes movements. For this two of the drive case carriage over the vertical plane for getting the motion in Y-Z axis in which Z-axis is used for cutting and to plot depth. And at last one drive case on horizontal plane for getting the X-axis and the all three drive cases are placed on the wooden planks i.e. two drive case over vertical plank and one drive case over horizontal plank respectively. And thus we completed the hardware setup.

B. Joining the electronics

The Arduino Uno is the device that controls everything. It is essentially the "brain" of the system. But it itself, it has issues controlling the stepper motors directly. To solve all Arduino/Stepper motor issues, "Stepper Motor Drivers" are used for each motor. Then these stepper motors are connected with stepper drivers by using strip wires and jumper wires

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connected using bread board for connection and connecting stepper drivers using Arduino Uno by using CNC shield.

Now it comes to power supply. Here power is given by using SMPS (Switch Mode Power Supply) in which a 4-pin connector is used for giving power. For this a yellow wire (+12V) is small with the black wire (ground wire) to start the SMPS and to get the needed power supply.

IV. SOFTWARE INSTALLATION

Till now all hardware is joined and now only one thing is remaining i.e. installing softwares to run our project. The softwares that are used for our project are MakerCam.com or Grbl software.

CNC machine runs on programming language known as "G-codes". The MakerCam itself changes respective shape into G-codes but arduino has a difficulty in interpreting G-codes. Thus G-code interpreter software is essential called as Grbl.

A. Maker Cam

The Grbl Controller software makes use of G-Code converted photos. If we want to create your own photos, you will need to change your photo to SVG first. Then you need to go to the website makercam.com and upload it. Otherwise, the MakerCam website also allows you to insert some shapes by going to "Insert" and then selecting your required shape.

These are some steps to make a shape

1. By using of Arrow tool (from top left toolbar), select your entire photo.
2. Move it to the bottom left corner of the grid.
3. You can pan around the grid by clicking on Hand tool from toolbar. Use it to drag the photo back to the center of the screen. From the top right most corner of the page, change the measurement to cm.
4. Making use of the scale option from "Edit > Scaled Selected", scale down and then move it so that it fits inside the square that is in the side of the grid.
5. With the photo still selected, go at "Cam > Follow Path Operations". Change the target depth to -1, the safety height to 1 and step down to 0.1 and then enter OK
6. Then go to "Cam > Calculate Selected" to obtain the path.
7. At last, go to "Cam > Export G-code" to save the G-Code of the image.

B. Grbl software

CNC machine uses a programming language known as "G-codes". The MakerCam itself changes the shapes into G-codes but arduino has difficultly in interpreting G-codes. Thus G-code interpreter software is essentially called as Grbl.

These are the steps to install Grbl on Arduino:

1. Download the Grbl Hex files for our specific version of Arduino.
2. Download the X-Loader program.
3. Connect the Arduino to your PC.
4. Using the X-loader program, select the Grbl Hex file we downloaded, select Arduino from dropdown menu, and select the COM port that our Arduino is connected to.
5. Click "Upload" to upload the Grbl program to your Arduino.

V. CONCLUSION

In today's CNC systems, end part design is highly automatic using computer aided design (CAD) and computer-aided manufacturing (CAM) software. The programs make a computer file that is interpreted to find the commands required to operate a particular machine by using a post processor, and then given to the CNC machines for the production. Since a part might require the use of many number of tools, saws, etc.

With the increasing needs for small scale and large precision parts in many factories, the market for small scale machine tools has expanded substantially. Use small machine tools to make small scale parts will provide both flexibility and efficiency for manufacturing approaches and reducing capital cost, which is beneficial for small business owner. In this research, a small scale three axes "CNC PLOTTER" is designed and analyzed under very short budget.

VI. FUTURE SCOPE

A. Industrial CNC milling

It can be planned to scale up the prototype CNC machine in term of size, by using powerful motor, toughening the frame and worktable with materials as aluminum and cast iron, and replace the CNC program with software for simulation before actual run. The implementation of 3D printing technique to the same hardware abstract is used for printing of 3D models.

B. The PCB Mill

In manufacturing of precise PCBs (Printed Circuit Board) that is printing the conductive paths which connects the various electric components to one another over a board.

VII. ACKNOWLEDGEMENT

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