Bangladesh University of Engineering and Technology (BUET)

CNC PAPER CUTTER

Course Name : Instrumentation and measurement Sessional

Course No: ME 366

Group No: C15

Project partners:

Rahat Chowdhury (1610122)

Sayeda Islam Emu (1610134)

Sazid Noor Rabi (1610126)

Somlata Dev Sharma (1610133)

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Introduction:

Our project is a CNC machine which can be used to cut paper and other thin sheets of plastic and other materials. The word CNC stands for Computer Numerical Control. Which implies that the machine is controlled by a computer.

It is used to process a piece of material to meet the required specifications by following a coded programmed instruction and without a manual operator.

Instructions are delivered to a CNC machine in the form of sequential program of machine control instructions such as G-code and then executed. The program can be written or generated by Graphical CAD software.

So our goal was to cut a paper in any shape using a micro-controller with the structure we built.

Components of the project:

Mechanical Parts:

1. X- axis clamps:

    These clamps were 3D printed using PLA filaments. These clamps hold the stepper motor and pulley respectively and with a belt chain they are connected to each other and with the platform. It enables movement in x-axis. It also holds the rods.
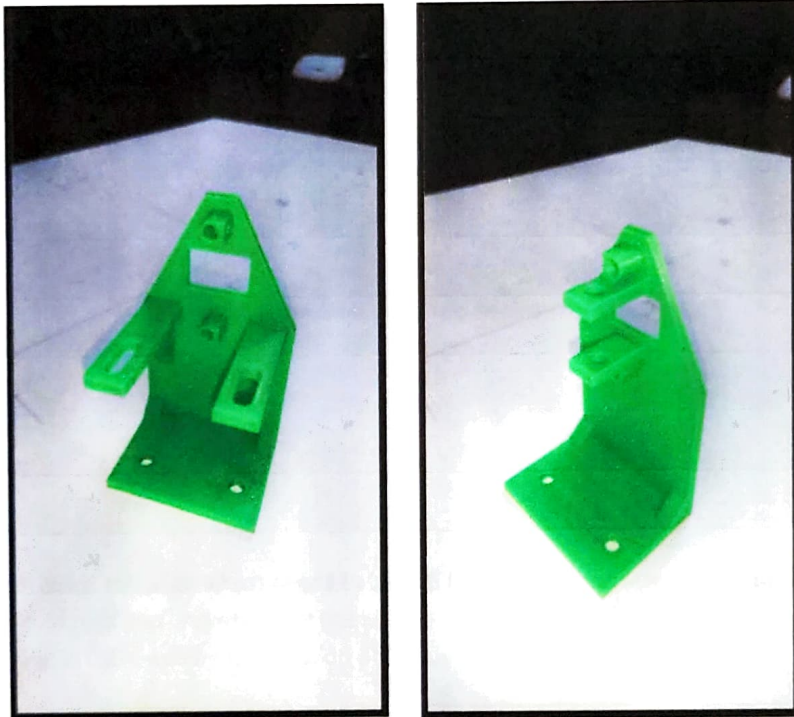
2. Y- axis clamps:

    These clamps are also 3D printed. They hold the other stepper motor and pulley. The stepper is connected to the pulley with the belt chain. Between them there is the cutter holder connected with rods from one clamp to another with the belt pulley, motor is connected to the holder which moves in the y-axis direction.
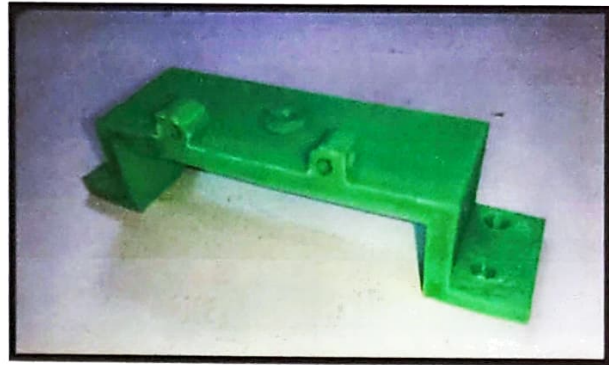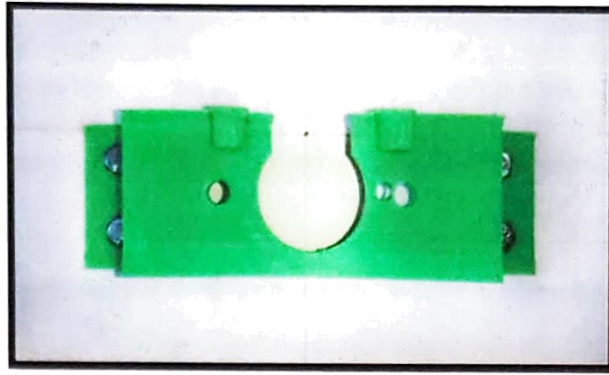
3. Platform:

The platform holds the page which needs to be cut. It is positioned between the x-axis clamps with the help of rods and underneath it the pulleys are connected with belts. This belt helps the platform move in the x-axis by the rotation of motor.

4. Belt-pulley:

The belt pulley is used to connect the motor with the idler pulley. The motor rotates and the belt transmits the motion towards the other pulley. In the x-axis this belt is glued with the platform for it's movement. In the y-axis the belt is connected with the cutter holder to make it move. The pulleys were connected with a single belt chain to enable proper movement.
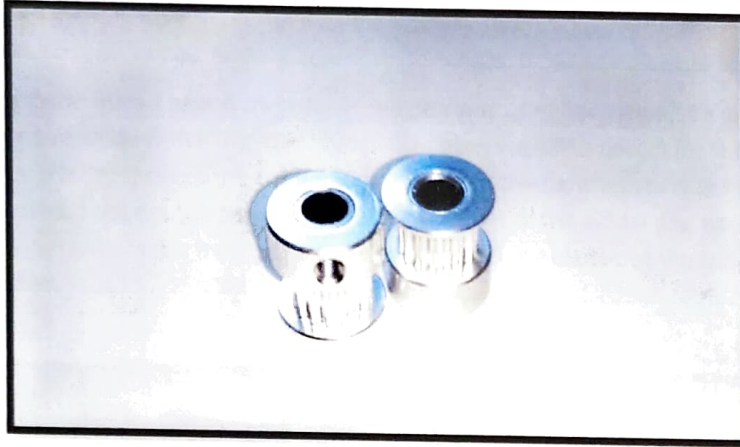
5. Cutter holder:

The holder consists of 4 parts. The back portion is connected to the y-axis clamps with rods. The front portion has 2 rectangular pieces glued to the top and bottom of the back portion. Also there is a z-axis motion given by the main holder which is connected to the back portion with rods. This moving part holds the cutter.

6. Stainless steel rods:
    The rods are 3mm diameter made of stainless steel. They connect the x-axis clamps to the platform and y-axis clamps with the cutter holder. The holes in the parts were made 3.5 mm in diameter to keep some clearance and enable smooth movement of the parts over the rod. There rods were cut into 14 inches and 3inch sections for the purpose of our project.

7. Cutter:
    The cutter is made from a pen. A matador i-teen pen was used because of it's uniform diameter and it being compatible with the cutter holder diameter, we had a design for the holder so that we can adjust the tightness of the cutter. So we adjusted the tightness to make it firm, otherwise it would not cut the paper easily. The front part of the actual pen was cut off and we made a hole vertically in the front portion. Then we glued the blade out the top part of the pen with super glue.
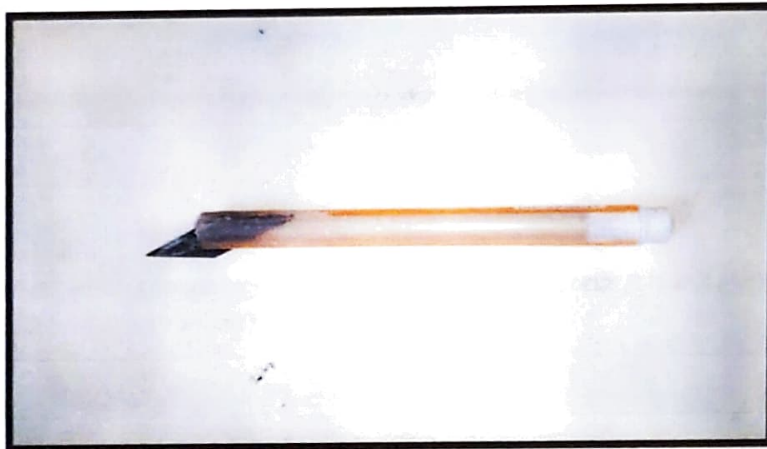
8. Nuts and Bolts:

Nuts and bolts were used to hold the clamps down on the board. 12 of them were used directly on the board. Some were used to fix the motors to the clamps. To position the pulley we also used nut bolts. To fix the rods to the clamps we used nut bolts. There were bolts in the pulley which were screwed to the motors to fix them with the motors. 18 nuts and 22 bolts were used.
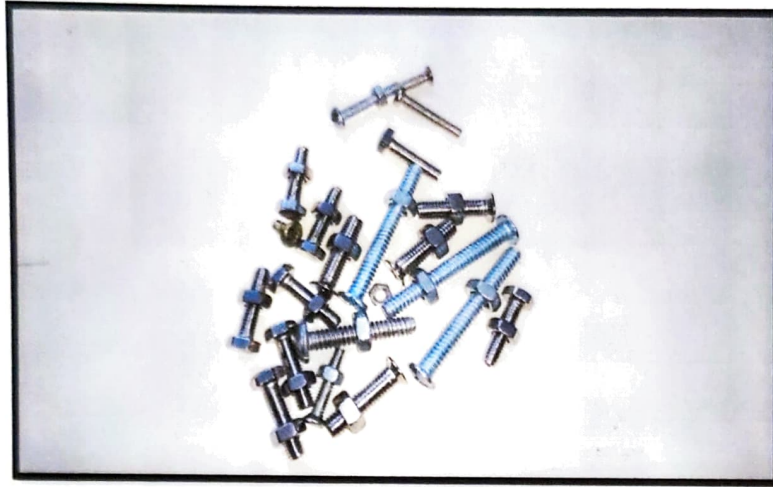
9. Plastic wood board:

The main board which contains everything is made of plastic wood. It is 2' X 2' or 4 sqft. It is 8 inches in thickness. It was drilled to put the bolts in.
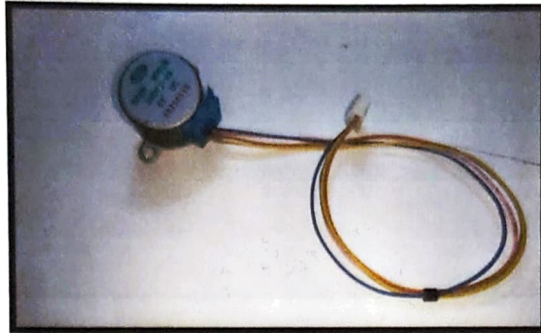
10. Zip-tie:

Zip-ties were used to connect the belt chains together. One end was connected with the other end. This resulted in the formation of a continuous belt.

Electrical Parts:

1. Stepper Motor

2. Servo Motor
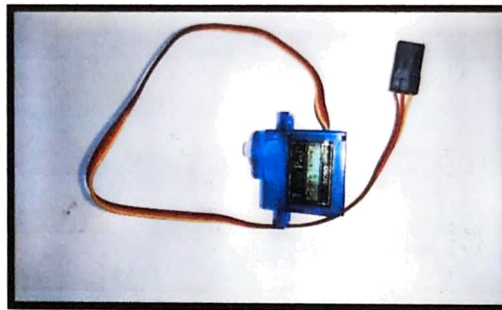
3. CNC Shield
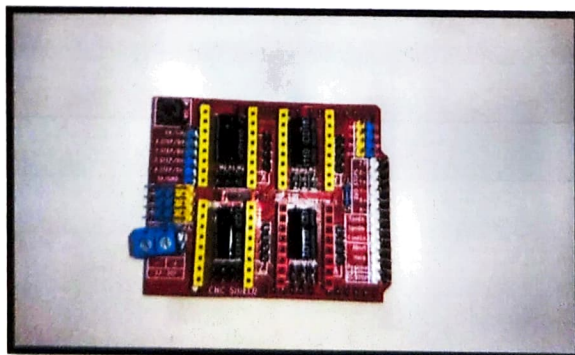
4. Motor Driver A4988
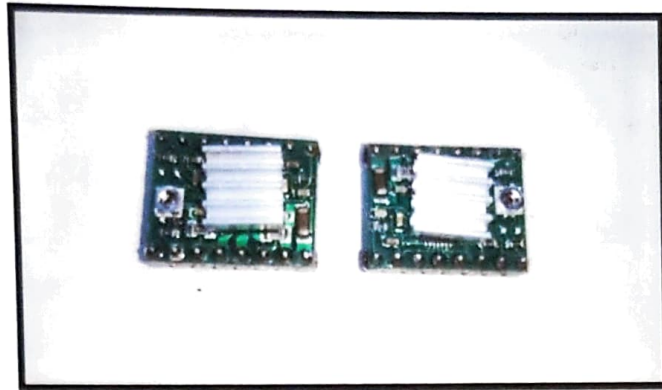
5. Arduino Uno
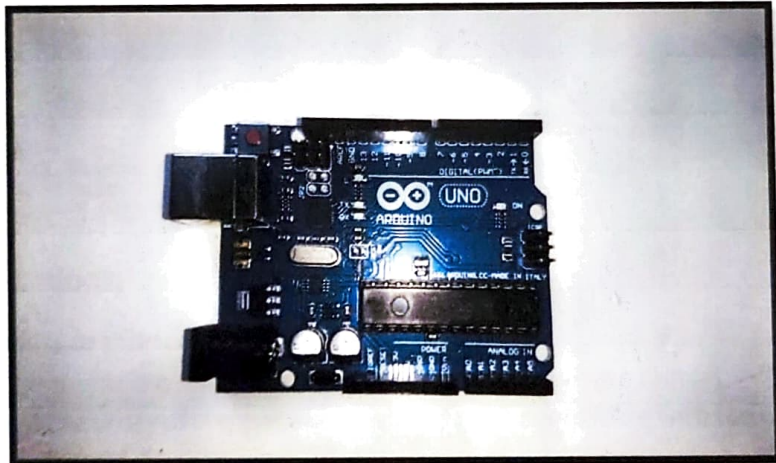
6. Adapter (12v, 0.5A)
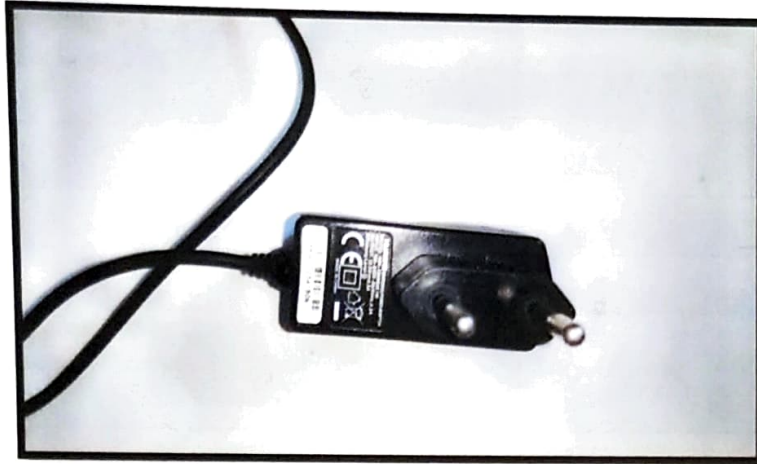
7. Laptop

Software:

1. Arduino
2. Inkscape
3. GRBL Controller

Hardware modifications:

1. The CNC shield is to shorted for microstepping.
2. 5-wire unipolar motor is needed to be modified to bipolar (4-wire motor)
3. We rearranged the order of stepper motor wire to get it compatible with the GRBL shield.
    Orange and pink = coil-1
    Yellow and blue= coil-2

Mechanism:

```
┌─────────────────────────┐
│   Drawing in Inkscape   │
└─────────────────────────┘

┌─────────────────────────┐
│   Converting to G-Code  │
└─────────────────────────┘

┌─────────────────────────┐
│  Opening G-Code in GRBL │
│        Controller       │
└─────────────────────────┘

┌─────────────────────────┐
│   Running code in GRBL  │
│        Controller       │
└─────────────────────────┘

┌─────────────────────────┐
│  Motors move according  │
│         to code         │
└─────────────────────────┘

┌─────────────────────────┐
│ Paper is cut by the cutter │
└─────────────────────────┘
```

Detailed mechanism:

At first, we have to download the GRBL code for CNC (it is readily available on the internet) and upload it to the Arduino. Again, we have to download 'MI grbl extension' folder from the internet, then copy this to the inkscape extension folder. This extension folder will control the z-axis - (servo). Basically it is a professional vector graphics software. There are some basic shapes like rectangle, circle, star, polygon, etc. Even we can use any traceable jpg, png file types in inkscape. After setting the suitable parameters and the adjustment of the drawing, we have to set 'object to Path' which will set the direction.

The entire mechanism of inkscape is when the pen/ cutter is going to touch the platform and in which direction it is going to draw or cut following the G-code. Then in the Grbl software we have to set the appropriate port name and baud rate. Then choose the G-code file. This will basically set a starting point and connect itself with the origin, the end point is also connected with the origin. That makes a full cycle, the pen or cutter will be back to the point where it started. When we can control the axis and zero position.

Cost Analysis:

No.	Name of the equipment/service	Quantity	Cost
1	Board	1	240
2	3D printed parts		1500
3	Stepper Motors	2	240
4	Servo Motor	1	100
5	CNC- Shield	1	400
6	Arduino Uno	1	360
7	Motor driver	1	360
8.	Belt	10	250
9	Pulley	2	200
10	Metal rod	1	240
11	Nuts and bolts	1	100
12	Super Glue	1	20
13	Misc.		300
	Total cost		4310

uture prospects and Limitations:

1. Due to problem in the structure and the software, we couldn't successfully cut the page in both axes.
2. Pressure was added to cut the page and without adding this pressure it cannot be done. If our structure was firm and strong, this would not be needed and we could have cut the page without additional pressure.
3. For future, this cutting machine may be used for milling, drilling and cutting similar objects to paper. We just need to make the structure stronger and use powerful motors. Like the NEMA 17 and bigger servos.
4. This machine is a miniature version of the CNC machines used in industries. This machine was aimed to be helpful at home made decorations and origami.
5. Can be converted into a milling machine by adding a motor on top of it that rotates the cutter continuously. A DC or a stepper motor may be used. Also for a milling machine structure, there needs to be more support material around it. A milling machine has a head or overarm which supports cutting.
6. We can also make a PCB printer if we make a stronger structure and change the cutter into a pcb printing cutter. It is used for making PCB.
7. We can also change the cutter and replace it with a laser to make a laser engraver. Laser engravers are useful for engraving plastic, wood, paper, fabric, acrylic, rubber and cardboard. Also glass, ceramic, stone and coated metals such as anodized aluminium.

Applications:

a. Art forms related to paper cutting:

1. Origami
2. Quilling
3. Kirigami
4. Card making
5. In-house decoration
6. Making papercut sculptures
7. Paper dolls
8. Papier mache
9. Pop up books
10. Decoupage

b. PCB Printer

c. Laser engraver

1. Plant labels
2. Custom Phone Cases
3. Leather engraving
4. Jewellery
5. Laser etched mirrors