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Optimization and Modification of Mini CNC Plotter and Engraving Machine

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Abstract: ***CNC Machines are Computerized Numerical Control Machines that are familiar with drawing anything or design any mechanical part according to the design program fed into their controller unit. The controller unit is often either a computer or a microcontroller. CNC machines have stepper and servo motors to draw the planning as per the fed program. After researching different kinds of mini CNC machines, we found that they were either costly or had an outsized size. So to beat this problem we designed a mini CNC plotter machine with laser as its engraver. Our machine will be able to draw and engrave all the compatible materials. It would be faster and precise as compared to some of the machines available in the market.***
Index Terms: Arduino UNO, Bluetooth, Controller, Stepper Motor, SolidWorks, Wireless

I. INTRODUCTION

The first Numeric Control machines were built around the 1950s. These machines had servomechanism were rapidly increased with all types of computers-analog and digital. This rapid increase made a huge impact resulting in the making of our modern CNC machine and its tools. In the modern world, the increase in population is leading to produce large quantities and quality products with low production and installation cost.

CNC machine helps us achieve this operation due to its high accuracy and less human interference. Now there are various types of CNC machines. The most common machines are 2-axis and 3- axis CNC machines.

In this expanding and increasing world, we came up with an idea of Mini CNC Plotter and Engraving machine which is a computerized machine that is made to operate through programmed commands. The principal function of the machine is to draw and engrave the images that are fed into the software. The usage and working of the machine are much similar to that of a CNC machine. The various parts used in this machine are stepper motor, Arduino UNO ATmega328P microcontroller, HC-05 Bluetooth module, servo-motor, etc.

This machine will run on G-codes and various other software will be used to manage its working. The parts and software that are being used in the machine will be easily available at a low price and some of the e-waste spare parts will also be used.

II. LITERATURE REVIEW

A. *"Wireless communication using hc-05 bluetooth element interfaced with arduino" mrs. Anisha cotta, miss naik trupti devidas, april 2016 [1]*

This paper discusses wireless communication using the HC-05 Bluetooth module. It also describes the Bluetooth network topology and its interfacing with Arduino. Wireless communication is the transfer of information or power from two or more points that are not connected by any conductor.

B. *"Wireless base CNC mini plotter three axis control machine" Ghulam Dastgeer, Prof. Muhammad ASAD, saad. S.s. Ali, july 2018 [2]*

This paper describes the methodology of the Mini CNC plotter machine. It also discusses various sorts of motor drivers and about the machine's future scope.

C. *"CNC Machine PCB Plotter" A S Patil, S R Kakade, M B Lad, D D Saste, D N Homkar, March 2018 [3]*

This paper describes a CNC Pen Plotter machine with a three-axis movement. This machine mainly consists of two stepper motors and one servo motor as a linear actuator on the X, Y, and Z-axis. This paper also defines the process of executing the work and codes. It also informs us about the various applications of the CNC machine PCB plotter.

D. "A Dynamic Analysis of An Industrial CNC Plotter" D. Cekus, D. Skrobek, T. Zajac May 2016 [4]
In this paper, a dynamic analysis of a CNC plotter machine has been explained. The procedure has been completed in the SolidWorks program. The outcome of the process has been used to design an industrial plotter for a Polish company which produces CNC machines.

E. "Arduino Based Cost-Effective CNC Plotter Machine" Puja Ghire, Shubham Yenkar, Arpita Chirde, February 2018 [5]
This paper describes the technique to design a PCB based on a low-cost CNC system incorporating with ATmega 328 controller in an Arduino.

III. OBJECTIVE

With the fast increase of the demand of the product within the society, there's a necessity for a reasonable and transportable CNC machine that can be utilized in the industrial areas. Additionally, there's a necessity to teach scholars about the changing trend so that they are future prepared and have smart information regarding the machines. Hence, our objective is to style a Mini CNC Plotter and Engraver machine so it may be utilized in academic establishments and small scale industries.

IV. METHODOLOGY

The methodology of our undertaking project is simple. First, the machine's HC-05 Bluetooth module must be wirelessly linked with the controlling computer. Then after the successful connection, the G-codes are transferred to the Arduino ATmega328P using Arduino IDE software. Then the all the connections of motor driver, stepper motors and servo motors are made and is then linked to the final power output source.

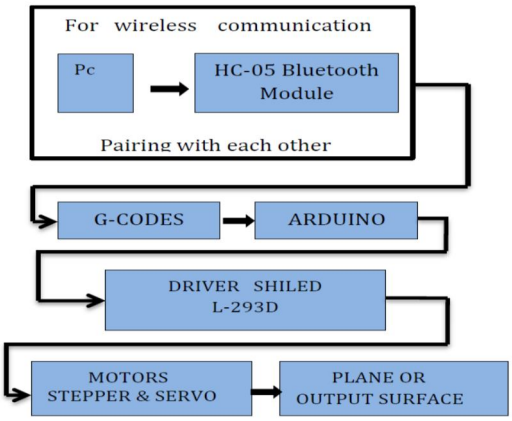

Figure 1: Block diagram of wireless base CNC machine.

V. SCHEMATIC ARRANGEMENT

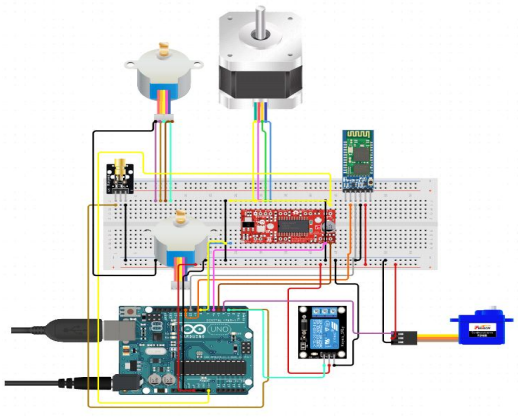

Figure 2: Circuit diagram

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VI. WORKING

Below are the main components and their working that are used in the machine:

A. Mechanical Body Explanation

1) HC-05 Bluetooth Module: This module is an SPP (SERIAL PORT PROTOCOL) module. It helps in a clear wireless serial affiliation setup. This module contains 2 sorts of operations- Command mode and Information mode. In command mode, we are ready to send the module. In information mode, we are ready to transmit or receive information to different Bluetooth modules. This module will be connected to our machine so that the data can be transferred wirelessly from the source computer to the microcontroller.

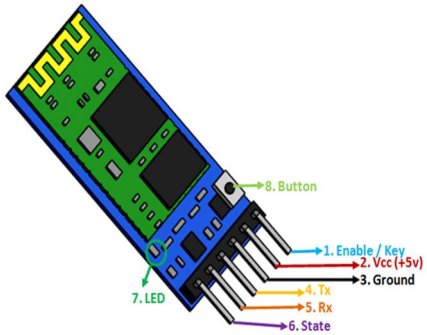

Figure 3: HC-05 Bluetooth Module

2) Pins Description

The pin description for the module shown in the figure are as follows:

a) Enable/Key= Used to toggle between Data mode and AT command mode.
b) Vcc= Powers the module.
c) Ground= Ground pin module.
d) TX= Transmits serial data.
e) RX= Receive serial data
f) State= this pin is connected to an onboard LED, it is used as feedback to check if the wireless connection is properly.
g) LED= Indicates the status of the module.
h) Button= Used to control the Key/Enable pin to toggle between Data and Command mode.

3) A4988 Stepstick Stepper Motor: This motor driver has an output capacity of 35V. This also helps us in controlling bipolar stepper motor at up to 2A. This driver also has an in-built translator which reduces the number of pins to 2.

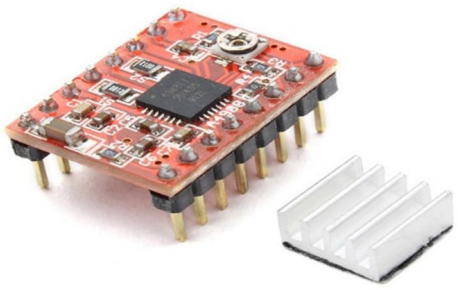

Figure 4: A4988 Stepstick stepper motor driver

This driver will help us to regulate the motors individually and it will help us in controlling the speed of the motors. This driver also consists of a relay switch which will help us in controlling the laser.

4) *Stepper Motor:* A stepper motor is a brushless DC motor that divides a full rotation into several equal steps. These motors are generally used for precise positioning. These motors are not high-speed motors but have a high holding torque.

Figure 5: 5V Stepper motor

This motor will be used in the positioning of the x-axis and y-axis.

5) *Servomotor:* A servomotor is nothing but a linear or rotatory actuator that helps us in gaining precise control of linear or angular position, acceleration, and velocity. This motor is controlled with the help of servomechanism.

Figure 6: 4.8V Servomotor

This motor will be used in the movement of the tool i.e., a pen or a laser. This motor has 3 pins:

a) Power
b) GND
c) Signal pin

6) *Arduino Uno R3 ATmega328P:* This microcontroller is a high-performance controller that is based on AVR RISC architecture. The 328P indicates that it has 32KB of code space and 8-bit architecture. P stands for pico power. Pico power is defined as the power that is generated under 5kW.

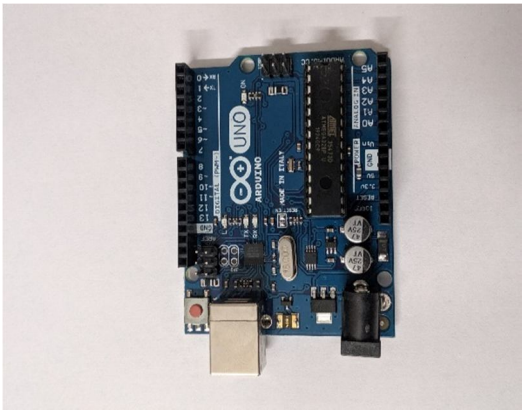

Figure 7: Arduino UNO ATmega 328P board

This board will be used in our machine because it has a low power consuming capacity.

VII. DESIGN

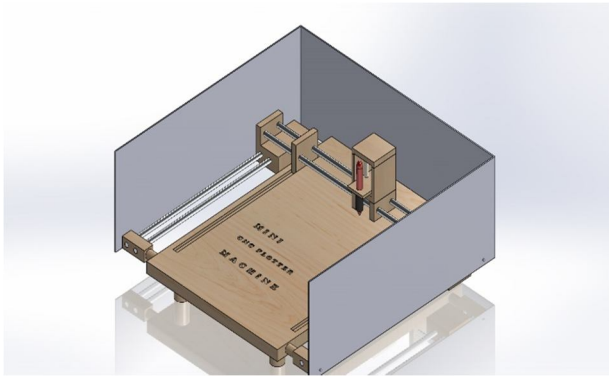

Figure 8: Mini CNC Plotter and Engraver designed in SolidWorks

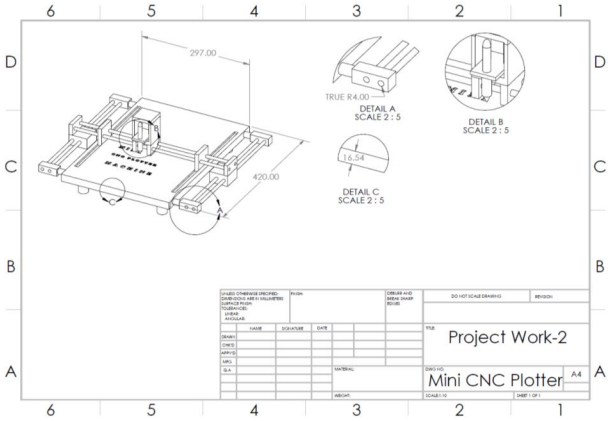

Figure 9: Dimensions of the machine

VIII. RESULT AND DISCUSSION

In the modern CNC machine, all the components design is highly automated using CAD and CAM programs. The programs produce a file that is interpreted to extract the command to work a specific machine by the use of post-processing. After the post-processor, the code is then loaded in the CNC machines for production.

As we know the increase in population is increasing the demand for small scale high precision parts in various industries. So these types of small scale machines will be beneficial for those types of industries as they can provide both flexibility and efficiency in production. This will also reduce the investment but will ensure high profit for small scale business people.

We have modified our machine in such a method that it will be able to draw and engrave on all the compatible surfaces like wood, paper, cork, and plastics. It will also be helpful in etching on surfaces like aluminum, marble, stone, tile, glass, etc. The salient feature of our machine will be that the parts will easily be replaceable and can easily be found in the markets. The maintenance cost of our machine will be low as compared to the other machines present in the market. We tried to keep our design minimal and simple so that a normal worker with basic knowledge would be able to operate it with ease.

Below is the final tool path that has been obtained by our machine:

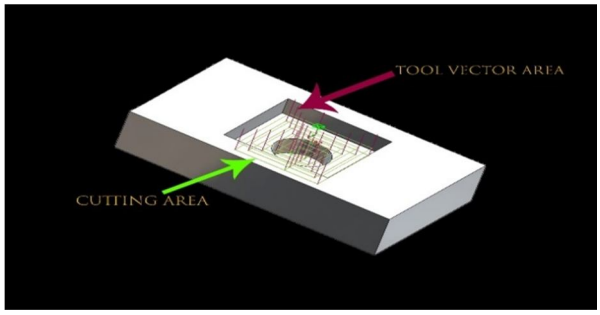

Figure 10: Tool path obtained on an Aluminum Block

The green arrow shows the area that will be cut with the assistance of the tool or laser engraver. The red arrow shows the tool vector area that will be covered by the tool.

The required codes that were generated by the Solidworks software is given below:

N6 (Rough Mill1)	N119 (Rough Mill2)	N198 (Contour Mill1)	N295 (Center Drill1)	N304 (Drill)	N313 (Rough Mill3)	N360 (Contour Mill2)
N7 G90 G54 G00 X7.75 Y-7.75	N120 X39.75	N199 G90 G54 G00 X-1.449 Y-46.4	N296 G90 G54 G00 X0 Y0	N305 G90 G54 G00 X0 Y0	N314 G90 G54 G00 X0 Y0	N361 Z-17.
N8 G43 Z2.5 H05 M08	N121 Z2.5	N200 G43 Z3. H01 M08	N297 G43 Z25. H13 M08	N306 G43 Z25. H14 M08	N315 G43 Z-17.5 H04 M08	N362 G01 Z-28. F122.323
N9 G01 Z-10. F185.687	N122 G01 Z-10. F185.687	N201 G01 Z-3. F411.48	N298 G82 G98 R-17. Z-25. P1000 F1712.611	N307 G83 G98 R-17. Z-40. Q2. F799.983	N316 G01 Z-28. F122.323	N363 G41 D24 X-9.942 Y7.984 F366.969
N10 G17 Y7.75 F742.749	N123 Y-29.5 F742.749	N202 G41 D21 X-1.024 Y-46.824 F1234.44	N299 G80 Z25. M09	N308 G80 Z25. M09	N317 X3.95 F244.646	N364 X-16.352 Y2.68
N11 X-7.75	N124 G02 X29.5 Y-39.75 I-10.25 J0	N203 G03 X-.6 Y-47. I.424 J.424	N300 G91 G28 Z0	N309 G91 G28 Z0	N318 G03 I-3.95 J0 F489.293	N365 G03 X-16.925 Y1.598 I1.02 J-1.233
N12 Y-7.75	N125 G01 X39.75	N204 G01 X47. F1645.92	N301 (16.0mm JOBBER DRILL)	N310 (16MM CRB 2FL 32 LOC)	N319 G01 X10.35	N366 X-17. Y0 I16.925 J-1.598 F489.293
N13 X7.75	N126 G00 Z2.5	N205 Y47.	N302 T14 M06	N311 T04 M06	N320 G03 I-10.35 J0	N367 I17. J0

Table 1: G-codes that will be uploaded in our CNC machine.

The above results show that all the required things will be provided to us by the software. We will just have to upload the required data via wireless transmission.

We have also modified our machine in such simplest way that by interchanging and replacing some parts of the machine we are able to use the machine as a 3D printer. So this feature will benefit the small scale industries and academic institutions and can also save their investment cost and their production time.

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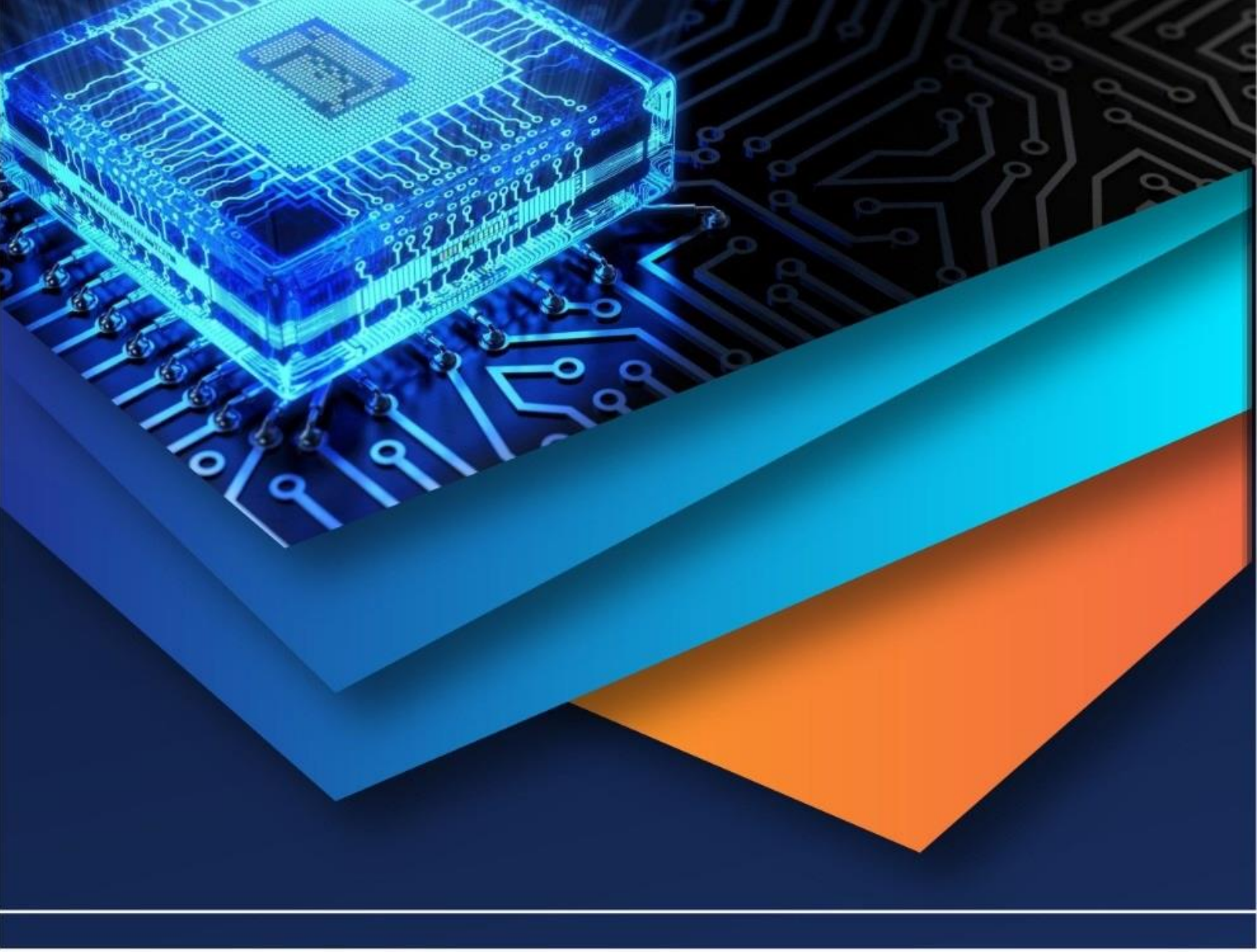

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