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AUTOMATIC MINI CNC MACHINE FOR PCB DRAWING USING ARDUINO

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Abstract - *Computer Numeric Control Machines are an important part of the manufacturing industry. These machines are fast, accurate and adaptable. The project's objective is to design and implement a low cost three dimensional computerized numerical control (CNC) machine for PCB drawing. The primary function of this CNC machine is to draw the PCB layout and thus to connect PC to a numeric control machine. As there is a high demand in market for accurate and low cost CNC machine for PCB drawing so our main objective of project is design low cost computerized numerical control (CNC) for PCB drawing. To achieve cost effectiveness, our system based on Arduino microcontroller and also it maintains the accuracy and reliability required for complex shapes. The backbone of the system is a smart mechanical system with the integrated system that provides precise results. Full form of the CNC machine is computer numerical controlled machine. Movement of CNC machine can be controlled by the instruction such as coordinate position which is generated by computer.*

***Key Words*: CNC, PCB, G-Code, Inkscape, Processing 3, USB, Drivers, Engrave.**

1. INTRODUCTION

The term "CNC" is a general term which describe many types of devices such as drills, wood cutters, 3D printers, milling machines. Basically "CNC" stands for computerized numerical controlled and physical movement of the machine is controlled by the instruction such as coordinate position which is generated by computer. Computer Numerical Controlled (CNC) machines are very different in design and construction from conventional machine tools. This difference arises due to the requirements of higher performance levels.

The quality and reliability of these machines depends on the different machine elements and subsystems of the machines. Some of the important components and aspects of CNC machines are to be considered in their design, for example machine structure, guide ways, feed drives, spindle controls, software and operator interface, tool monitoring. Computer Numerically Control can be applied to milling machines, lathe machines, grinding machines, plasma cutters, laser cutters, surface grinders, etc.

CNC is basically a machine whose working is commanded by a computer.

1.1 Objectives

- To study various types of CNC machines, their purpose and applications.
- To convert PCB design file into hex file for Arduino Microcontroller.
- To develop and implement low cost mini CNC machine for PCB drawing using Arduino microcontroller.
- To test the developed low cost mini CNC machine using Arduino IDE software.

1.2 Problem Statement

To develop a low cost automatic mini CNC machine for PCB drawing using Arduino.

2. METHODOLOGY

2.1 Block Diagram

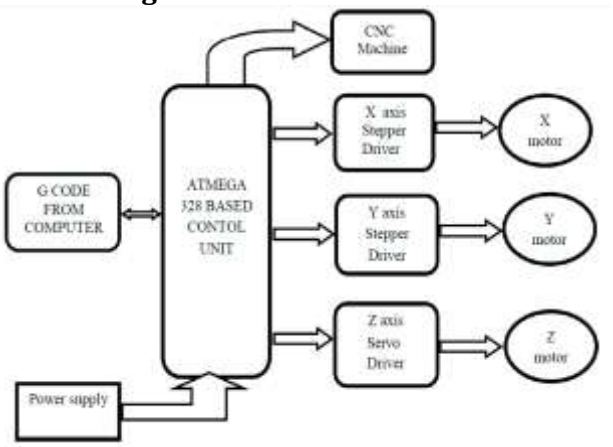

Fig-1: Block diagram

Arduino Uno microcontroller core platform is used in this project. It can be easily interfaced with computers, drivers and stepper motors as well.

The Arduino Uno microcontroller needs 12V power supply. Program will be dumped to the Arduino IDE software and then converted to the compiler of Arduino. The driving

circuit is designed to control the mechanical setup and to communicate through software with the computer.

This project will explore a CNC machine's ability to create its own components. CNC PCB machine is a drawing machine where a computer controls the individual axes of the machine through a motor.

2.2 Working

The two stepper motors are driven and controlled by two drivers. These two stepper motors are connected to the X-axis, Y-axis and one Z-axis to servo motor line.

- **G code from PC**

G-code is a programming language for Computer Numerical Control (CNC) in computer aided-design and manufacturing (CAD/CAM). The g-code used in the computer tells the CNC machine how far to move and at what speed.

- **Conversion from G-Code to C-Code**

To make the G-code interface with the microcontroller, each piece of the G-code line will be treated as a different character, composing a reasonable C-code to display the G-code after a few executable C-code instructions are executed.

The G-code is interfaced with the Arduino microcontroller used to convert the code to a USB converter, i.e. serial. Furthermore, this code is passed to three motors by easy drivers converting the code and moving the three motors according to the instructions. We need three axis X, Y, Z which operates as follows:
-- X motor move left and right,
-- Y motor moves front and back, and
-- Z motor moves up and down.

3. SPECIFICATIONS

3.1 Stepper Motor (28byj-48)

A stepper motor is an electromechanical device that converts electrical power into mechanical power. It is also a brushless, synchronous electric motor that can divide a complete rotation into a wide range of steps.

The stepper motor uses magnet operation theory to turn the motor shaft into an accurate distance when an electrical pulse is provided. There are eight poles in the stator, and six poles in the rotor. To make one complete revolution, the rotor will require 24 pulses of electricity to move the 24 steps.

Table-1: Specifications of Stepper Motor (28byj-48)

Steps/revolution	2048
Voltage & Current	12V at 400 mA
Step angle	1.8° full step 0.9° half-step
Drive System	Unipolar
Max continuous power	5 W
Time taken to complete one rotation	4 sec

3.2 Servo Motor (SG90)

Servos are controlled through the control wire by sending a variable width electrical pulse, or pulse width modulation (PWM). There is a minimum pulse, maximum pulse and frequency of repetition.

For a total of 180 degrees movement, a servo motor can normally only turn 90 degrees in either direction. The neutral position of the motor is defined as the position in which the servo has the same amount of potential rotation in the direction of both clockwise and counter clockwise.

Table-2: Specifications of Servo Motor (SG90)

Voltage	4.8V-6.0V
Connector type	JR type (Yellow: Signal, Red: VCC, Brown : GND)
Speed	0.12sec/60degrees (4.8V) 0.10sec/60degrees (6.0V)
Size	32 × 11.5 × 24mm (Include tabs) 23.5 × 11.5 × 24mm (Not include tabs)

3.3 ULN2003A Driver

The ULN2003 is a high voltage monolithic transistor array with high current Darlington. It consists of seven NPN Darlington pairs with high voltage outputs for switching inductive loads with common-cathode clamp diode. A single Darlington pair's current collector rating is 500mA. For higher current capacity, the Darlington pairs maybe parallel. Applications include relay drivers, hammer drivers, lamp drivers, LED gas discharge display drivers, line drivers and buffers for logic. For each pair of Darlingtons, the ULN2003 has a 2.7k series base resistor for direct operation with TTL or 5V CMOS devices.

Features:

- 500mA rated collector current (single output).
- High voltage outputs: 50V
- Inputs compatible with different logic types.
- Application for relay driver.

4. SOFTWARE ARCHITECTURE

4.1 Flowchart

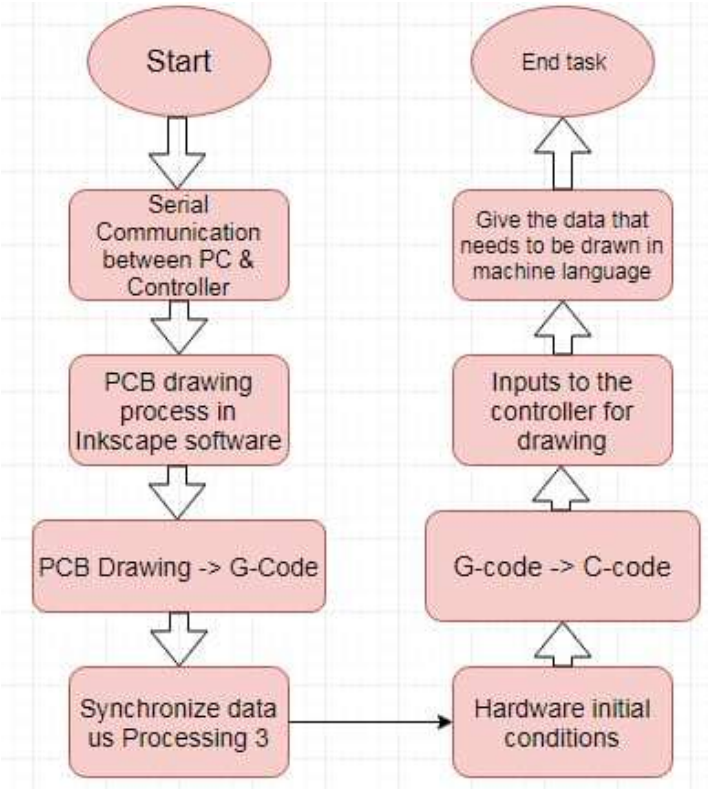

Fig-2: Flowchart

4.2 Algorithm

- Gets inputs of PCB diagram (gerber files)
- Convert gerber files to G-code
- Changes input into machine language of coordinates that is sent to AtMega328P.
- Serial communication between PC and ATMega328P.
- Coordination of servo motor and driver control position stepper motor.
- Checking current that is measured at servo motor
- Checking PCB drawing process.
- Setting initial parameter values by setting initial position values of two stepper motors.
- Drawing on the PCB board (automatic mode, steps per revolution, continue, pause & stop).

5. HARDWARE ARCHITECTURE

5.1 Mechanical Setup

Fig-3: Mechanical Setup

5.2 Details

- The instructions from the Arduino are fed to the CNC machine. We have connected the two Stepper motor driver ULN2003 on CNC shield. The output of the each Stepper motor driver ULN2003 are given to the respective stepper motor.
- Due to X axis stepper motor, the wooden board moves front side and backside. Due to Y axis stepper motor, the spindle moves left and right & due to Z axis servo motor, the tool moves up and down. The depth to the spindle is provided by the Z axis servo motor.
- The spindle requires a PCB engraver pen which will draw the actual image on PCB board.

6. CONCLUSION

We studied various types of CNC machines, its purpose and their applications. We studied different research papers, patents and found out their limitations. We created G-code of PCB design using Inkscape software and simulated it using CAMotics software. Automatic mini CNC machine is designed and developed for PCB drawing using Arduino for low cost and for better accuracy.

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