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Study of CNC System for PCB Design using Proteus

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ABSTRACT

A Computer Numerical Control (CNC) system for Printed Circuit Board (PCB) design using Proteus Design Suite has been presented. A schematic diagram and single-sided PCB layout of a high voltage circuit for Geiger– Muller (GM) tube is designed using Proteus software. Subsequently, the PCB layout of the circuit is converted into Gerber files that are decoded into G-code through Flat CAM software. The G-code is introduced to the CNC system consisting of a computer, a CNC controller and a CNC machine. The code is stored in the memory of the computer and is uploaded to the CNC controller byMach3 software. The controller operates the CNC machine to perform isolation routing, drilling and milling for PCB as per the instructed design. It is noticed that the CNC system associated with Proteus makes the PCB designing process automated and easier by reducing the process of printing as well as etching. This study reveals that the proposed system can eliminate human error to achieve better accuracy and higher productivity as compared to the conventional methods of PCB design.

Key words: CNC, PCB, Proteus, G-code, FlatCAM

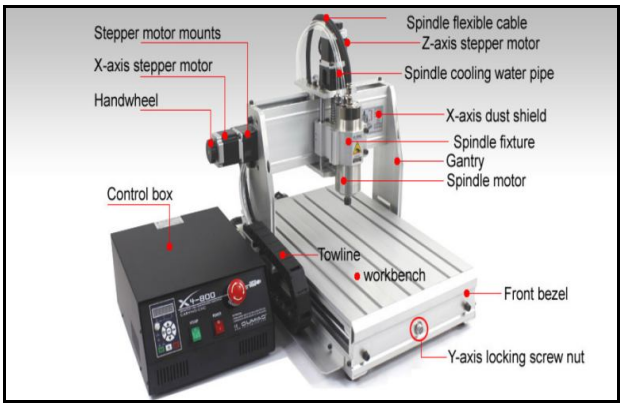
1. INTRODUCTION

The Printed Circuit Board (PCB) is the core component in almost all electronic appliances that are used for domestic applications and industrial or research purposes [1]. PCB connects electronic or electrical components using conductive tracks and offers mechanical support to the electronic components. It reduces electronics noise, minimizes the dimensions of electronics devices, and reduces possibilities of errors and chances of short circuit. There are three types of PCB boards categorized as single-sided, double-sided and multi-layered PCB boards [2]. Single-Sided PCBs contain only one layer of conductive material. In single-sided PCB, parts are layout on one side and also the circuit on the other side. Double-Sided PCB has two layers of conductive material and multilayer PCB has over two layers of conductive material. PCB can be manufactured by silk-screening (manually) and CNC (Computer Numerical Control) -milling. In the conventional method(silk-screening), we require longer time and energy for designing, printing, etching further as drilling, whereas CNC system reduces printing, etching likewise as makes the drilling automated [3]. For this reason, the CNC system can play an important role to chop back time and more effort [4]. CNC machines are automated operating machines which are supported code letters, numbers and special characters [5]. A CNC system controls machine tools automatically via programming codes under the control of a computer as another to somebody's operator [6]. Most of the standardized codes for CNC system are G and M codes. Theses codes associated with Proteus software have made the applications and learning processes of CNC system easier. Our laboratory CNC machine relies on the programming within the G-code. G code is one kind of language by which user instructs computerized machine tools 'How to make something'. It is well-defined by commands on where to move, how efficiently to move, and through what path to move [7]. G-codes can be generated by the PCB design software like Proteus with FlatCAM, TinyCAD, and Eagle. But Proteus is unlike others. It is a PCB layout designing software which is suitable to create PCB. In Proteus, it is suitable to make PCB layout as well as circuit schematic can be designed and simulated [8]. In this paper, we have designed a single-sided PCB by using Proteus software that converts the circuit schematic into G-code with the assistance of FlatCAM software to form the design understandable for the CNC system.

2. OVERVIEW OF A CNC SYSTEM

CNC comprises of a computer, a CNC controller, and a CNC machine. The total system is based on the programming in the G-code and the program is stored in the memory of the computer. After this, that code is uploaded to the controller and the controller operates the machine. Figure 1 shows an overview of the CNC system. The different parts of the CNC system have been described below

(a)



(b)

Figure 1: CNC System (a) Computer and (b) CNC controller with CNC machine

2.1 Computer

A computer used for CNC system consists of Intel(R) Core (TM) i5-7400 CPU @ 3.00 GHz processor, 4 GB RAM & 1 TB internal storage that operates on Microsoft Windows 10 Professional, 64-bit operating system platform. The computer is a major part of CNC which accepts the information of the design and store in the memory. This data is translated and transmitted into a specific position for CNC machine. Computer also controls the spindle movement [10].

2.2 CNC Controller

X 4 – 800L is controlled in software package of Mach3 as 3-axis CNC machine controller [9]. Mach3 is mostly known CNC Controllers software used for Laboratory and Industrial CNC machines. It is decent to work with WinXP, Win7 (32/64bit), Win10 (32/64bit) PC with USB 2.0 port (Does not support USB3.0 port) to regulate the motion of motors such as stepper and servo by using the processing G-Code [11].

2.3 CNC Machine

A CNC machine is a kind of mechanical tool which is controlled by a computer, in step with exact input commands. Those commands are delivered to a CNC machine within the sort of a consecutive program of machine control instructions like G-code and so executed. CNC programming is a method of defining machine movements through the appliances of numbers and corresponding coded letter symbols [12]. It uses two stepper motors and one spindle motor as linear actuators on each axis X, Y, and Z. It can access the G-code directly from Mach3 software.

3. APPLICATION SOFTWARE FOR CNC SYSTEM

3.1 Mach3

Mach3 is customizable software which operates on windows platforms. It can be used in many purposes such as motion control of motors by processing G- code, various relay control, the manual pulse generating, touch screen control etc.

3.2 Proteus

Proteus is circuit simulation software and it is applicable for circuit simulation, schematics drawing, PCB layout design and three-dimensional visualization of the PCB [13]. We have used Proteus 8 Professional software to design PCB and generate the Gerber file. Libraries with symbols of components are needed to design a schematic of any circuit using Proteus software.

3.3 FlatCAM

FlatCAM is software for preparing CNC jobs for making PCBs on a CNC router. It can convert Gerber file generated by Proteus 8 Professional software for Isolation routing, drilling, and milling [14]. To create G-code from Gerber file, a number of basic settings need to be specified at FlatCAM software. These features are discussed below.

- **Tool Dia**:Tool dia is the diameter of the end mill or engraving bit which is used for outlining traces or drilling.
- **Passes:** Single pass only dose one outline around traces and multiple passes dose multiple outlines around the traces
- C**ut Z:**Cut Z is the cutting depth for the trace isolation or drilling depth for PCB.
- **Spindle Speed:** .Spindle speed is the rotational speed of the end mill or engraving bit in revolutions per min.
- **Feed Rates:**Feed rate is the surface speed of the end mill or engraving bit in millimetres per min.

4. METHODOLOGY

In this paper, a single-sided PCB fabrication of high voltage circuit using CNC system has been discussed. A schematic diagram and PCB layout of the high voltage circuit for Geiger – Muller (GM) tube is designed via Proteus software. The PCB layout of the circuit is converted into Gerber files for Isolation routing, drilling and milling. Then the Gerber files are fed into FlatCAM software which converts Gerber into G-code. The G-code is interfaced with CNC controller [7]. This G- code is transferred to the stepper motor and CNC machine is instructed to perform Isolation routing, drilling and milling. All working steps are shown at a glance in figure 2.

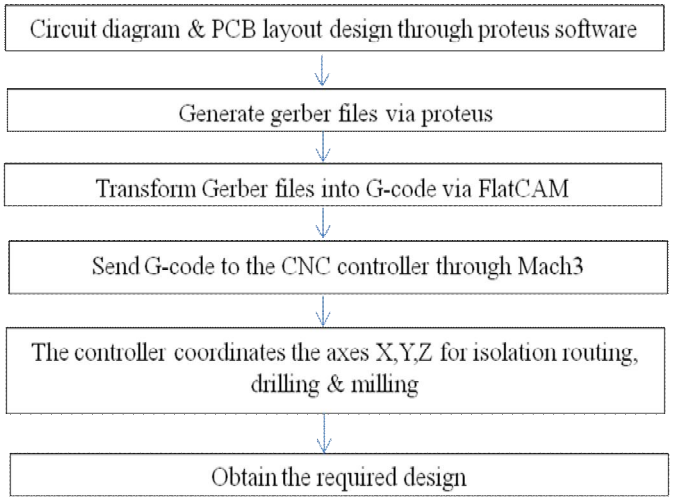


Figure 2: Working Flow Diagram

To create our PCB using CNC system, we set different values for different parameter in case of isolation routing, drilling and milling as shown in the table 1.

Table 1: Different tool diameter

Different working process	Bit diameter (mm)	No. of Passes	Cut Z(mm)	Spindle speed (rpm)	Feed Rate (mm/min)
isolation routing	0.2	1	-0.1	8000	50
drilling	0.8	1	-2	8000	50
milling	2	1	-2	6000	50

5. RESULTS AND DISCUSSION

A PCB of high voltage circuit for GM tube has been designed using a CNC system. The schematic diagram and PCB layout of the circuit is designed by Proteus Software as shown in figure 3(a) and 3(b) respectively. Consequently, the Gerber file, G –Code, Isolation routing, and drilling of the high voltage circuit is also demonstrated in figure 4(a), 4(b), 4(c), and 4(d) respectively.

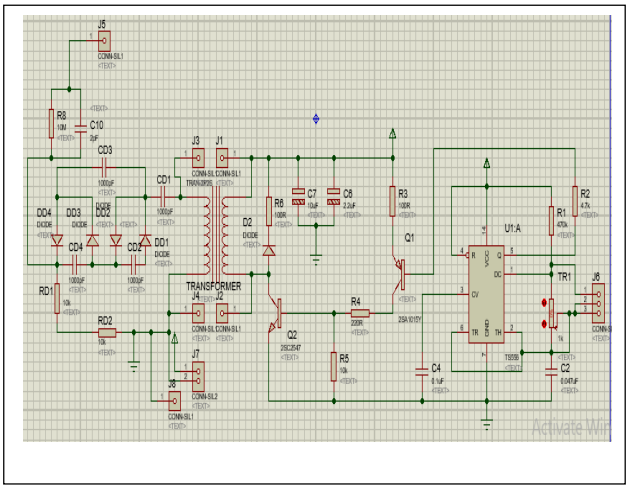


Figure 3(a): Schematic Design of GM tube high voltage

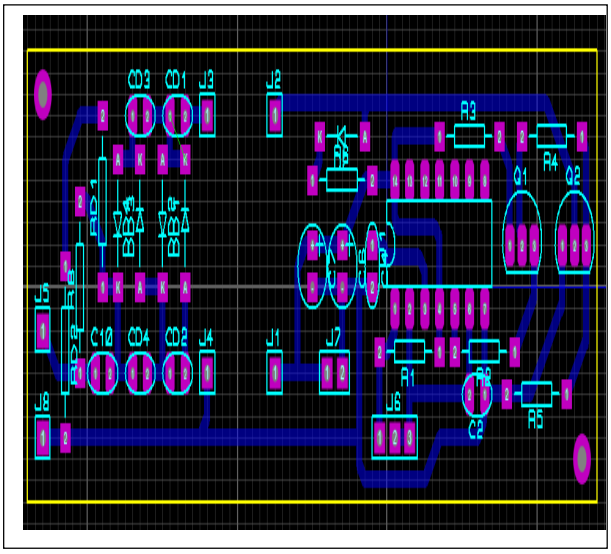


Figure 3(b): PCB Layout in Proteus circuit for GM tube in Proteus

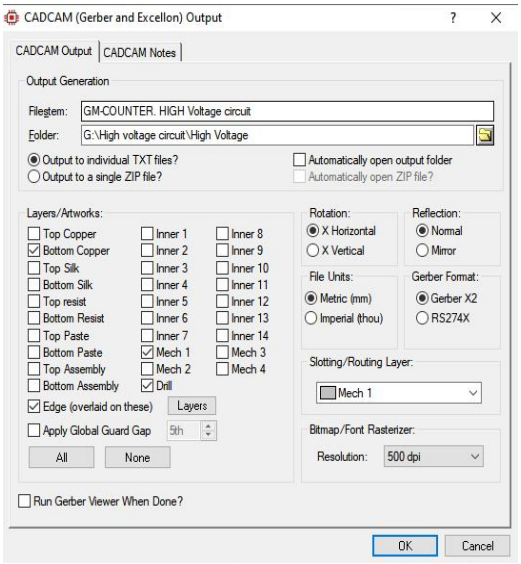


Figure 4(a): Generate Gerber File in Proteus

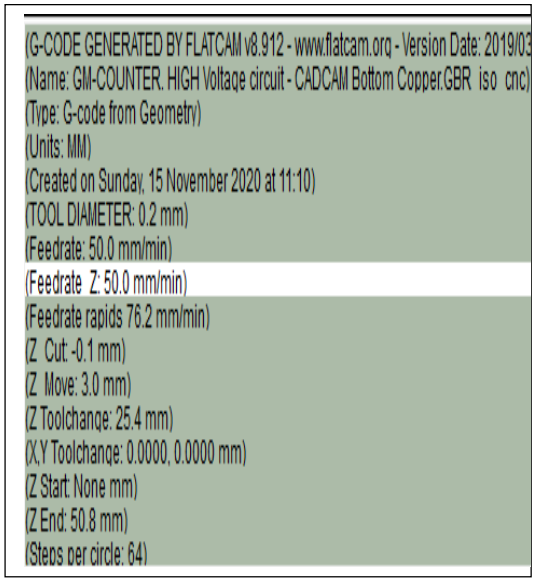


Figure 4(b): Transform Gerber file into G – Code

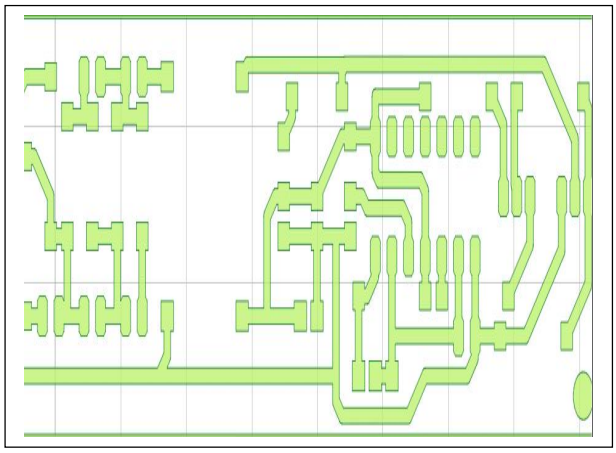


Fig 4(c): Isolation Routing in FlatCAM

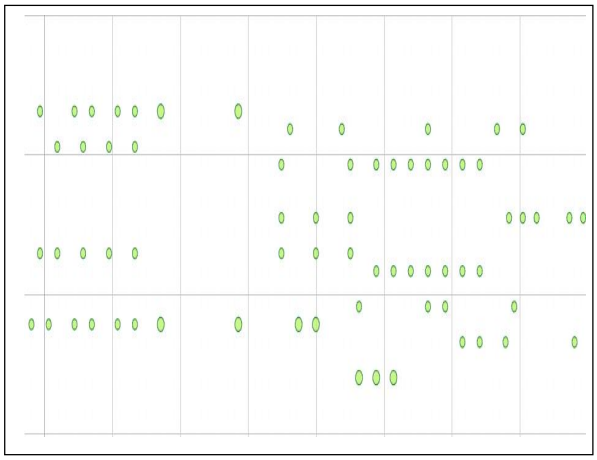


Figure 4(d): Drilling in FlatCAM

From Figure 4, it can be seen that the CNC system makes the PCB designing process automated and easier. This system reduces the process of printing as well as etching. The automatic machining process of CNC system eliminates human error and achieves better accuracy and higher productivity as compared to the conventional methods.

Since the CNC system operates automatically, it is very essential for the operator to know how to the read, write and adjust program codes. For successful operation, it is also vital to know the exact diameter of different bits [15].

6. CONCLUSION

CNC system plays a vital role in PCB designing process. The combination of Proteus and FlatCAM software associate with CNC system machine makes the PCB designing process flexible and also minimizes the working load. Location of all steeper motors and the status of the servo motor are directly seen on PC with the help of G-Code. So according to our necessity, we can start or stop the machine. The CNC system can be used for wood cutting, metal removing industries, plastic and metallic box cutting. In future, we want to make plastic & metallic box for proper packaging of our different customized electronic system using CNC system. Besides these, we also want to make various mechanical parts of robotic design using this system.

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