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Design and fabrication of 3-axis mini–CNC Milling Machine using Mach3 for Educational purpose

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ABSTRACT:

The development of machining systems with integrated CNC machines enables the manufacturing industry to produce complex products quickly and efficiently. Numerical control technology has become a core course for mechanical engineering majors in higher education institutions. CNC machine tool training should develop students' ability to learn about design and manufacturing. However, the cost of purchasing a CNC machine is not cheap. An important factor in the development of technical education is to give students experience in the laboratory, and small machines can complement education that requires students to learn processing skills. The purpose of this article is to design and build a 3-axis CNC milling machine with a PC-based micro CNC milling machine that performs machining using G-code. This machine is not suitable for production and precision machining. It can also replace high-cost CNC machines and be used in any university offering technical training.

INTRODUCTION

CNC software is a computational tool that performs movement by specifying the coordinate system using computercontrolled programs. The appropriate objects are drawn into any CAD system in CNC application and translated into system coordinate commands, commonly known as G-codes. The configuration of CNC computers consists of several systems, such as mechanical, electrical, and a combination of highly complex software. Mechanical systems are the most important for developing CNC machines, such as frame, drive, and guidance. Conversely, the electrical system includes several main components, such as handhelds, control panels, and electronic motor-driven devices. Hence, this paper aims to develop the CNC machine and design and fully manageable CNC milling machines.Maintenance costs of machines are reduced by using inexpensive and off-the-shelf components to construct the machines. The lower cost is achieved by integrating standard PC-based interfaces with open-source software and supporting off-the-shelf hardware components. The ArtSoft Mach3 Software is used as the motion controller for this machine. All related machine accuracy processes and procedures from literature reviews are used as reference or guidance to determine workflow and predict operation.

CNC machine tools are controlled using a special type of code called G-code. CNC machine tools can be programmed directly through the keyboard and screen integrated on the machine or CAM software and then transferred to the computer via USB or other connections [10-12]. Today, integrated with many new and modern features, CNC machinesincreasingly play an essential role in machine manufacturing technology.

The main aims of the present work are the development, analysis, manufacture, and assessment of a cost-effective,easy-to-use, flexible, small-scale prototype 3-axis vertical CNC laboratory milling machine developed, which wasdeveloped for student experiments in CNC and CAD/CAM programming areas.

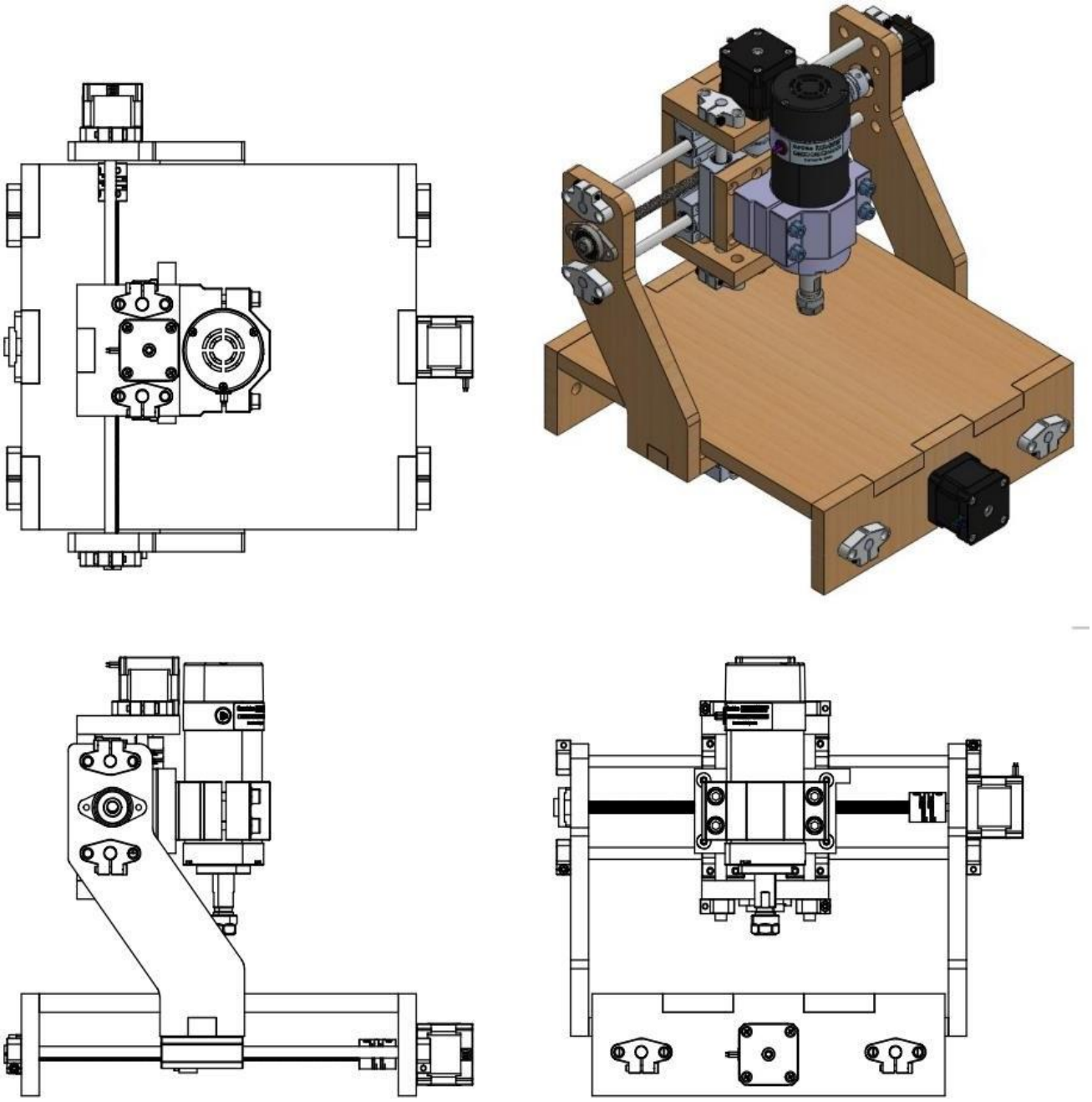
LITERATURE REVIEW

[1] Mr. Saad Mahmood Ali and Mr. Haider Mohsin (2020) - High-performance, cost-effective compact 3-axis vertical with a simple interface using a Mach3 controller in the project "Design and Design of a Tri-Axis Small NC Milling Machine", which aims to explore theoretical and technical methods for the design, construction, assembly and testing of electromechanical systems CNC milling machine. The new Mach3mill G-Code CAD/CAM software package runs on a PC and turns it into a powerful and economical machine. [2] Mr.Tran Thanh Tung, Mr. Nguyen Xuan Quynh and Mr. Tran Vu Minh (2021) - The main purpose of their work is to propose a process for the design and manufacture of alow cost but high performance small vertical 3-axis CNC milling machine. for industrial CNC machines. The model machine shown in this article can be used as an educational tool for mechanical engineering majors. CNC machine tooltraining should develop students' ability to learn about design and manufacturing.[3] B.Jayachandraiah ,O.Vamsi Krishna、P.Abdullah Khan、R.Ananda Reddy (2014) - Worked on the "Development of Low-cost 3-Axis CNC Routers" project where they came up with the idea of developing low-cost CNC routers to reduce the cost and complexity of the CNC machine. This article discusses the development of a low-cost CNC router capable of 3-axis simultaneous interpolation operations. [4] Bikram Bihari Barik, Arindam Mahanty, Soumyadeep Datta Majumder, Arindam Roy Goswami (2023) - Due to the rapid development of technology, the application of CNC machine tools inmany industry presses has been

very popular for years. However, because these machines are so large and expensive, CNCs are not available to the general public, especially students. So the project "Manufacture of affordable three-axis portable micro CNC milling machine" can solve this problem.[5] Mr. Professor Placid M. Ferreira (2013) - Assistant assistant in "Design and Evaluation of Small CNC Milling Machine", which aims to explore the thinking and ideas behind the design, acting on high precision and cost-effective dimensions. CNC milling machine milling machine. This newly developed machine is widely used in the electronics and medical industries for processing small products and small works of art. [6] Zhou Ruiren, D.C. H. Yang (1991) - Creating a work guide for three-axis CNC machining. In CAD and CAM integration, it is necessary to link the mechanical and control tools in the CAM process with the geometric information in the CAD model.

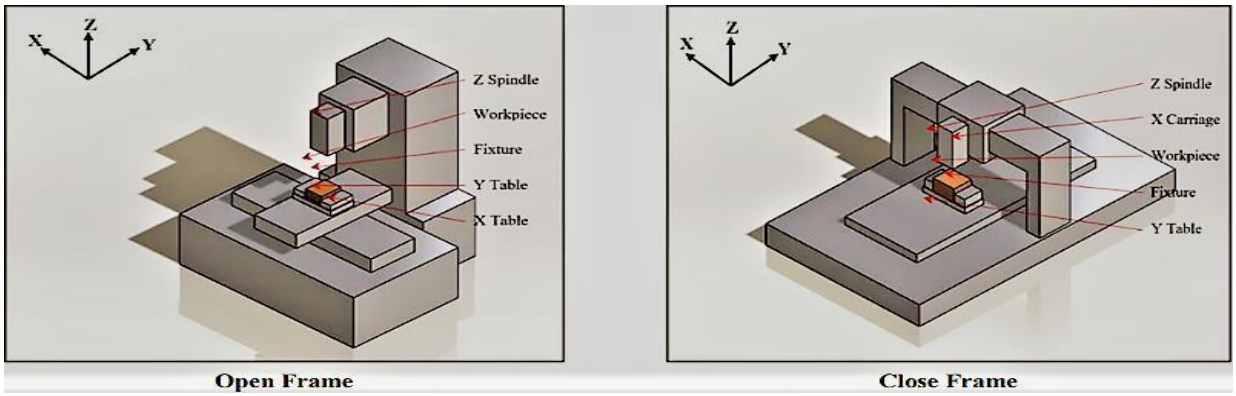
Basic Design of MINI CNC MILLING MACHINE

3D DESIGN



METHODOLOGY

Machine construction is divided into open frames, closed frames and lattice forms. The most common type of industrial structure is open and closed frames, as shown in Fig. 1. An open frame structure is often referred to as a C or G frame. This configuration is used in most common machine tools. After comparing the two designs and weighing the advantages and disadvantages of each, a tight frame design with a vertical tool position was chosen for the design of the small machine. Enclosed frames provide excellent tool access, while vertical milling machines are much easier to build than horizontal milling machines in terms of configuration. The component provides convenient access to the workspace and is usually compact and lightweight. The materials required for this construction are much cheaper and less used than open frame construction.



COMPONENTS of PROJECT

Mechanical system

Its structure had the Z-axis fixed in the study and the workpiece was controlled to move up and down. The fixed part consists of the machine base and the Z axis drive extension. The workpiece is placed on the machine table and can move freely in the direction of the X and Y axes in the horizontal plane using standard actuators. The motor is attached to the lead screw. The tool holder carries the machining tool to perform movement in the Z axis (vertical axis). To create a cost-effective model of a CNC machine, we choose the possibility of movement of the workpiece in the Y direction.

Its advantage is easier production and also a relatively compact machine part used mainly for study and institutional university courses. The workpiece plane moves along the Y axis, and the tool moves along the X and Z axes. The fixed part includes the machine frame (or platform), the sliding axes, the motor and the gear mechanism of the X and Y axes. The machine frame set consists of the X axis and the Y axis mounted on sliders fixed to the structure, the Z-axis slides along the X-axis, so there is a slider, a motor, and a gear mechanism for the machine. Z-axis. On the Z axis is the tool holder mechanism.

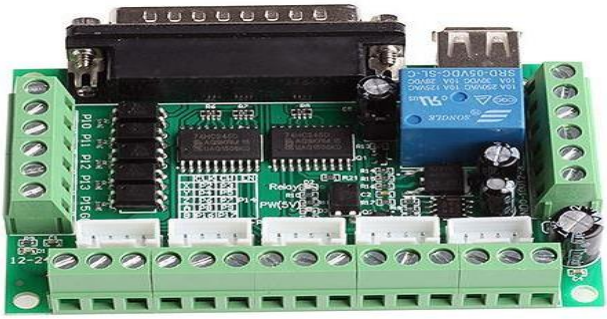
Electrical system

The electronic system includes a power supply, a microcontroller board, and a stepper motor driver board. The power supply converts alternating voltage to direct current and supplies the necessary voltages to the corresponding devices. The microcontroller board accepts 12V while the stepper motor board accepts 12-48V. 48V, 2.5A switching power supply (SMPS) adapters were used for the stepper motors mounted in the X and Z directions. 24V, 2.5A adapter for SMPS used for stepper motor for machine spindle mounted in Z direction and 12V, 1A adapter for SMPS used for driving microcontroller board. The circuit diagram of 3-axis 48V/10A is shown in figure 10. To control the movement of the system, a 3-axis CNC driver microcontroller development board of Kit TB6560 is selected here, as shown in figure 11. It is the brain of the CNC system that receives commands from the software system from the computer connected via USB serial port.

Stepper motor and Stepper motor driver

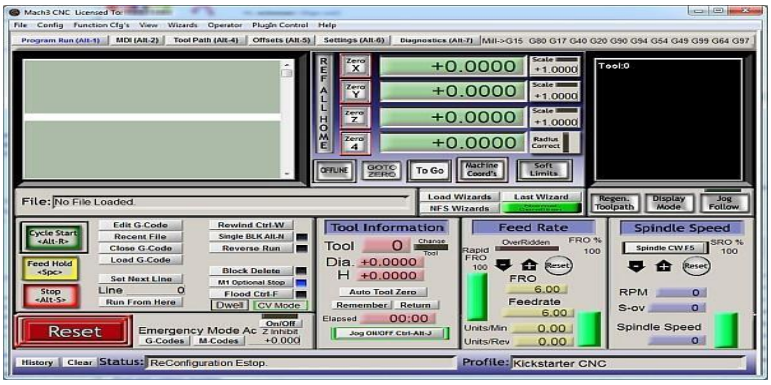
Mach3 interface controller board

MACH3 Interface Board CNC 5 Axis with Optocoupler latest upgrade 5 axis breakout board is specially designed for the CNC stepper/servo driver controller, such as TB6560, M542, M542H, MA860H, 2M542, 2M982, DM542(A), DM860(A) and other STEP/DIR input drivers. With this 5 axis breakout board you can drive any 1-5 axis machine used with stepper/servo driver controllers, it can be directly controlled by the PC via the MACH3, EMC2, KCAM4, and others by using DB25 port output



Software system

The Mach3mill software package runs on a PC and turns it into a very powerful and economical machine control system, as shown in Figure 14. Mach3 needs Windows 7 to run, ideally running on a 1 GHz processor with a resolutionof 1024 x 768 pixels. screen. A desktop computer will provide much better performance than most laptops and will be significantly cheaper.



MACHINE SPECIFICATION

No	Technical Criteria	Value of Selection
1	Frame structure type	Close frame
2	Machine configuration	Vertical tool position with 3-Axis
3	Frame material	Cast iron profile
4	Machine base Area	450mm (L) × 320mm (B) × 350mm(H)
5	Working Zone	X-230mm, Y- 190mm, Z-100mm
6	X, Y & Z travel length	230 mm x 190 mm x 100 mm of the linear axis
7	Spindle motor	High-speed BLDC motor
8	Spindle max-speed	26,000 rpm
9	The motor of each axis	Single shaft bipolar stepper motor
11	Controller system	Mach3 Interface controller 5 axis
12	Power Supply	Input: Single phase AC 220V /60hz,
13	tool dia	5mm

APPLICATION AND FUTURE SCOPE

- This machine can be for practical training on CNC.
- This is most suitable for use institutional learning programmes.
- This machine can be used in small handicraft industry.
- It will be more adaptable rather than going directly to heavy machinery.
- The portability of a machine can be increased as needed.

ADVANTAGES

- The setup of this machine is lightweight and smaller in size.
- This mini machine is easy to handle and interface.
- It is easy to use and programmed.
- This machine is easily customizable accordingly**.**

RESULT AND DISCUSSION

A complete model of the machine is shown in Figure 5. The machine is in good working order; there is no error in operation. The machine is easily disassembled, suitable for replacing machine parts. When the machine is in operation, the noise is not too loud, does not affect the surrounding environment and does not cause pollution. The machine has allthe basic functions of an industrial 27 CNC machine (it adopts G-code to start machining from CAM software) to fully meet the educational and research needs of students**.**

CONCLUSION

The article presented a model of a mini CNC milling machine for the production of visual aids for training in universities, colleges and vocational schools. In essence, the study proposed a plan to design a mini milling machine model and carry out the processing. The machine model presented in the article can be assembled and disassembled according to the intended use to increase the mobility of the machine and can be easily transported. Therefore, training institutions and production facilities with limited financial resources that cannot afford conventional milling can purchase this CNC milling machine to efficiently carry out training and production activities**.**

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