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# Design and Development of a CNC Mill Trainer by using Modern DDCSV1 CNC Motion Controller

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**Abstract:** CNC machine tools are currently predominating in the machine-building industry. Generally, these machine tools are equipped with control systems supplied by the world's leading manufacturers, such as Siemens and Fanuc are very expensive. In parallel, many cheap amateur and semi-professional CNC machine tool solutions are being developed. One of the biggest challenges today is how to make the CNC technology affordable, simpler and available to an extent that even occasional user can think of owing such technology. The main standard components required for developing the prototype of machine tool structure has been selected following the approach of kind of loading the machine tool will be subjected. A systematic study has been done for the selection of the drive motors, controllers and spindle drive. The objective of maximizing the tool traverse in X,Y and Z direction so to enable to cutting tool to approach the maximum machining volume for material removal subject to the constraint of sizes of standard available machine components used in CNC machine.

## I. INTRODUCTION

With the on-going development of technology and economy, new industrial requirements such as high precision, good quality, high production rates and low production cost are increasingly demanded. Most of such requirement, including dimensional accuracy, conformance to tolerances of finished products and production rates can be met with better machine tools. The traditional design philosophy of machine tools is multifunctional and highest precision possible. For example, a shank with spindle together with tailstock can be added onto a standard three axis vertical milling machine to become a multifunction drilling-milling-turning machine, meaning the machine tool is design to be used for multiple purposes instead of single purpose. However with the dramatic increase of industry varieties and the growing demand of miniature products, these general purpose machine tools are not efficient, either in term of machine time or cost, in manufacturing products with special sizes and precision requirements.

## II. LITERATURE REVIEW

With the development of computer and information technology, computer numerical control (CNC) machine tools have undertaken more complicated machining tasks. Because of its highly automated machining ability and high performance, CNC machine tools have gradually became the main choice to process mechanical products than other common machine tools. [1] Nowadays, with the development of the equipment manufacturing industry toward an open generic type, it is necessary for us to propose a reconfigurable CNC system to match different industrial manufacturing needs. [2] CNC controllers, working as a brain for manufacturing automation, are high value added products accounting for over 30% of the price of machine tools. CNC technology is generally considered as a measure of the level of manufacturing technology of a nation, and is currently led by major advanced countries such as USA, Japan, and Germany. [3]. With the help of CNC technology machine tools are not limited to human capabilities and are able to make ultra-precision products down to nano scale in a much faster manner. Rapid growth of technology significantly increased the usage and utilization of CNC systems in industries but are considerable expensive. As the technology of CNC machine characterized by accessible price and technology so rip that even individuals can design and construct CNC controlled machine [4]. In many Indian engineering educational institutions the CAD/CAM and Manufacturing Technology Laboratories are equipped mainly with large commercial CNC machines which are prohibitively expensive and moreover are overdesigned considering the needs of students. They come with costly annual maintenance contracts and are time-consuming and expensive to repair in the case of breakdowns. [5]

This project consist of development and replacement of a CNC mill trainer which was operated by PLC circuits by modern new innovative CNC controllers. This Development of CNC mill trainer came forward to reduce the cost and complexity in CNC systems. A CNC machine takes codes and converts the code using software into electrical signals. The signals from the computer are then used to control motors. Since the motors can turn very small amounts the machine is able to move in highly precise movements. The 3-axis CNC machine nowadays have range size in the open market. [6] CNC milling is a specific form of computer numerical controlled (CNC) machining.

Milling itself a machining process similar to both drilling and cutting, and able to achieve many of the operations performed by cutting and drilling machine. This paper discuss the development of low cost CNC mill trainer machine components which is capable of 3-axis simultaneous interpolated operation. Each axis of the machine moved by stepper motor, the motor is driven by sending pulses.

**A. Objective**

The objectives of this project are:

- 1) To design and develop the machine component and assemble as a complete CNC mill trainer.
- 2) To replace old PLC circuits with modern CNC controllers.
- 3) To assemble the CNC mill trainer.
- 4) To provide easy interface.

To reduce the size of machine by eliminating the big size PLC circuit board and replacing it by compact size controllers.

**B. Scope of the Project**

The Scope of this project includes:

- 1) To produce a vertical portable CNC milling machine
- 2) Should be operating as milling machine process
- 3) Should use G-code to construction the milling cutting testing.
- 4) Use Mach 3 software as machine interface
- 5) Produce a Mini CNC milling machine that suitable for small industry.
- 6) Machine test material used wood and the tool bit from solid carbide.

Below Figure showed the flow chart scope of this project. This scope used to guide the implementation of the project.

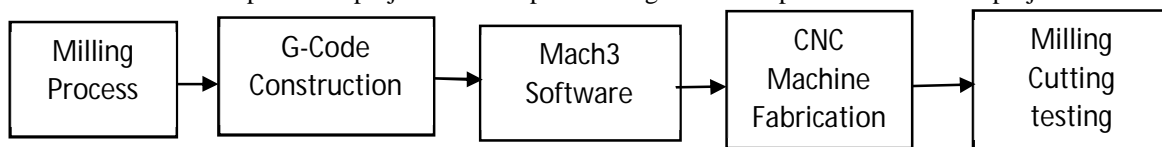


Figure .1. Flow chart for Scope of the Project

**III. METHODOLOGY**

The structural design of the machine including to wiring connection and the software adoption. Finally, development the base of the design that has been achieved.

**A. Structure Design**

The machine structure is the vital part of the machining tool. It merges all machine components into a single complete system. The machine structure is vital to the efficiency of the machine since it's directly affecting the total dynamic stiffness and also affecting the damping response. Perfectly designed structure can afford high stiffness, which leads to precise operation. Mini scaled machine tool required more precise stiffness than the regular large-scale machine tool as shown in Fig. 2. The next level will be deciding the criteria required which is firstly the length travel. The length travel is the length of the X, Y and Z axis that travels from one point to another. The X axis move left & right, Y axis move front & back, Z axis moves Up and Down.

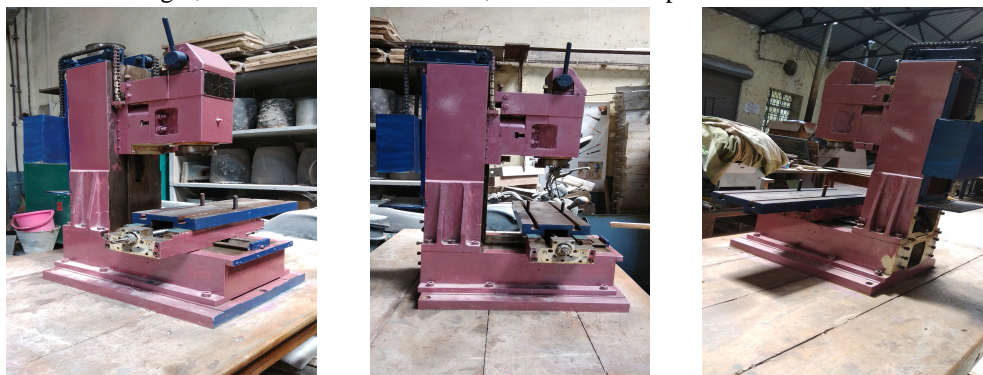


Fig. 2 structure of CNC machine

**B. Components**

1) **DDCSV1 CNC motion controller:** The Digital Dream CNC has engaged in the numerical control industry for 7 years, specializing in the research, development and production work of various CNC (Computer Numerical Control) systems with high quality, high reliability. It can produce the common Brushless DC motor, Stepper motor driver as well as the 1 axis CNC system to 6 axes CNC system. The DDCSV1 is the 4 axis and 4 axes motion controller which has been researched and developed by Faster CNC for four years. The control period of each position is only 4 milliseconds, with a high control precision. The highest uniaxial output pulse is 500 KHz and the pulse width can be adjusted. It supports the common stepper motor and servo motor. The DDCSV1 numerical control system adopts the ARM+FPGA design framework. The ARM can finish the part of human-computer interface and code analysis and the FPGA can finish the part of underlying algorithm and control pulse generate, with the reasonable design, reliable control and easy operation. The panel layout structure of DDCSV1 is rational. The common off-line operation can be finished only by 17 keys and it supports the FANUC with high universality to be compatible with G code set. This specification introduces the operation method of caving machine’s special off-line CNC system, DDCSV1 and the machine tool connection as well as operation specification. By lots of graphical representation and examples, the uses can quickly learn to use the DDCSV1 CNC system. Ordinary digital input interface of 16-circuit optocoupler coupling isolation Ordinary digital input interface of 3-circuit opt coupler coupling isolation Output interface of 0-10V spindle control port with analogue quantity (can be modified as PWM output); Support the 4 axis stepper motor control, the highest control pulse output of single axis is 500KHz; ARM9 main control chip; FPGA core algorithm chip. [7]



Fig.3. DDCSV1 3 Axis CNC motion controller

2) **Stepper Motor: Stepper motor & Accessories:** It’s a combination of stepper motor drive connected with pillow bearing with lead screw that is mechanical linear bar and linear bearings that drives rotational motion into liner motion with minimum friction. The stepper motor as represented in Fig. 2 the speed is directly proportional to the pulse frequency where it stands of the higher the output voltage from the easy driver the more level of torque drive.



Fig. 4. Stepper motor NEMA 23 10.1 kg.cm RMCS-1001



- 6) *PMDC motor Controller*: The controller comes with Heavy-Duty Line Suppressors for Mains Power Fluctuations and Noise In-Built Soft Start Motor Overload Protection by adjustable Current Limit & Current Trip Adjustable Min and Max speed Front Panel Motor On Indication Front Panel ON-OFF switch and Speed set Potentiometer Front panel Digital Display, Other Display on Request Easily Replaceable Fuses and Terminals for Easy Connections Remote On-Off provision for frequent Motor On-Off operation Available in capacities 0.5hp 180V DC for PMDC Motors.



Fig.8.PMDC motor controller Digital type

#### IV. CONTROLLER CONNECTIONS AND DISCUSSIONS

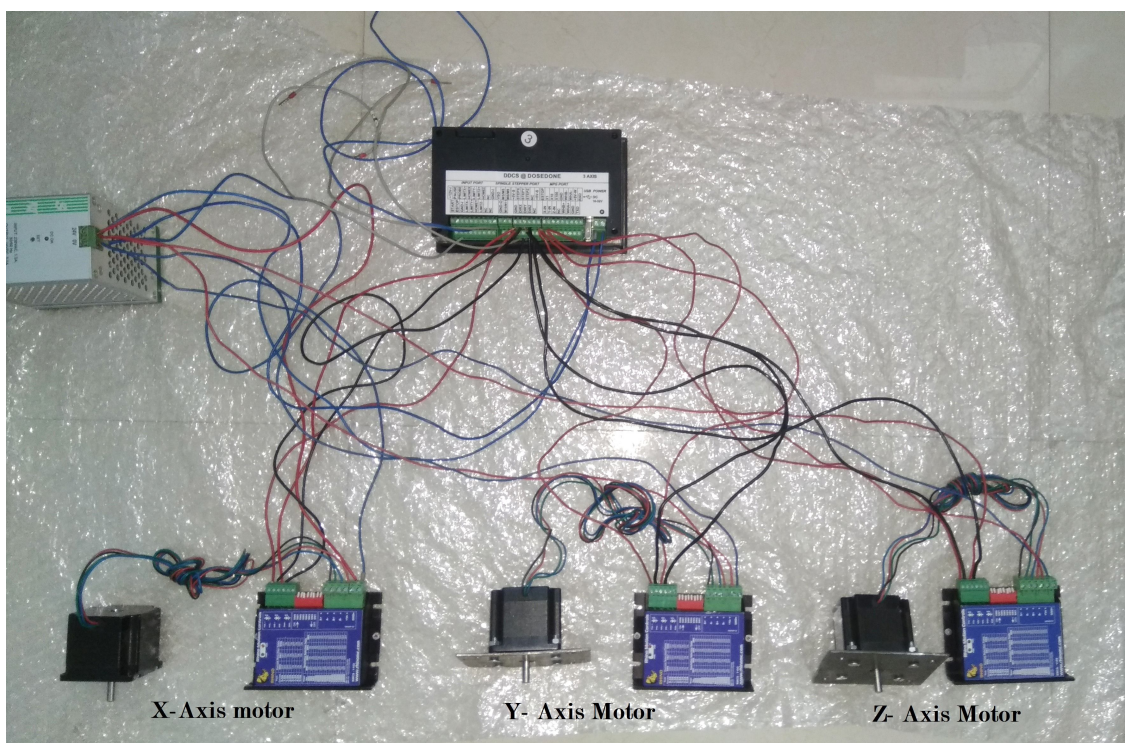


Fig.9. Connection of DDCSV1 CNC motion controller with Stepper motors and drivers

CNC mill trainer machine consist of three axes x, y, z axis for three dimensional motion of tool. The numerical data required for working of the plotter is provided by a program called part - program which in turn converts the numerical data to electrical signals. These electrical signals are then given as input to stepper motors. Each signal specifies a specific point in the coordinates and according to the point the tool moves. Machine control unit consists of data processing unit. On receiving part program data processing unit interprets and encode it into internal machine codes. Driving system includes stepper motor, which converts electric pulses into discrete mechanical rotations of motor shaft. These pulses are provided by the machine control unit. Stepper motor would be the best simple device that can be applied to CNC as it converts digital data to actual mechanical displacements. They are mainly used because of slow speeds, low torque, and low resolution and easy to slip in case of over load.

## V. CONCLUSION

The principle of CNC milling machine and gained better understanding in the modes of operation of CNC machine. There is various type of modern CNC machines use in industry. Automatic generation of different preparatory (G codes) and miscellaneous function (M codes) is used in CNC part programming for completing a successful CNC program. Specifically, CNC milling machine works with a computer numerical control that writes and read G-code instructions to drive machine tool to fabricate components with a proper material removal rate. G-codes are commands for CNC machines to follow so that they can operate on their own without human control. In this work, a small-scale 3 axis CNC milling machine was designed and fabricated with a low price. This proposed machine is easy to implement, inexpensive and comparable to the commercially available machines. The components of CNC machine are selected to provide accuracy and simplicity with-in limited budget. The accuracy of the CNC machine body parts assembly has succeeded to achieve the objectives in precisely and repeatability goal. From this project, we would conclude that it gives an idea for the beginners to understand on how the CNC machines work virtually.

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