Design and fabrication of 3-axis CNC Milling machine

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Abstract— Nowadays with a digital control it's became more and more useful to use such a machine tools with a coded software. This paper will present the design and fabrication of 3-axis milling machine. computer numerically-controlled (CNC) machine which comprise the use of Arduino micro controller to produce pulse-width modulation (PWM) outputs in order to run the stepper motors that will be used in this work. A milling 3-axis CNC is previously used precisely surfaced designed for snapping of wood, plastic sheet and thin sheet of metal alloy by using a rotating drill bit which its accuracy is much lesser than using a lesser cutter technique this machine tool is portable and it's controlled by computer (PC). Design and Fabrication of CNC with precision Stepper motors that contacted with the lead screw moment along 3 -axis.

Keywords— Stepper motor, spindle motor, leadscrew, ball bearings, flexible coupling, and control system by Arduino micro controller in Easel software.

INTRODUCTION

Computer Numerical Control or CNC machine is a conventionally machine where an operator decides and adjusts various machines parameters like feed, depth of cut etc. depending on type of job, and controls the slide movements by hand. It also is a specialized and versatile form of a Soft Automation and its applications cover many kinds, although it was initially developed to control the motion and operation of machine tools. A CNC machine takes codes from a computer 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 over and over again. The 3-axis CNC machine; these machines nowadays have range size in the open market

Over decades, industrial technology has transformed many aspects of daily life. Several studies have been carried out for the development of such a (CNC) machine on smaller thinner, lighter weighted and budget cost. From the related journal and research, the main idea in carrying out this work of CNC development. As the technology of CNC machine characterized by accessible price and technology so rip that even individuals can design and construct CNC controlled machine [2]. Advanced facility and precision of control of CNC tools, if it's compare with usual machine, has had a significant influence on the development of function components, frame body, stepper motors, and control circuits. Construction and evaluation of Low-cost table CNC milling machine by using low-price milling cutter for the main spindle due to a low voltage supply of the main cutting forces it is possible to use the tools of smaller dimension to machine materials like wood, aluminum and plastic materials. Design and Implementation of Three-Dimensional CNC Machine [3] where it discusses the design of low cost three dimensional CNC. The main function is a microcontroller-based CNC machine and its communication between personal computer (PC) and CNC machine by Software sub system that gets a set of commands and fetch it to the mechanical sub system in order to be control the 3-axis. Software sub system that is a PC that provides easy to use interface for user to program commands in such a language that microcontroller accepts.

RESEARCH METHOD

The first step in the operation of CNC machine was calibrating the tool, it was aimed to know whether the stepper motor and any other system were working according to the program that has been configured. Followed by setting the starting position of the spindle drill on the CNC machine using Universal G-code Sender software both automatically and manually by hand spinning. Spindle drill speed can be set up to a maximum speed of 12000 rpm (rotation per minute). After the CNC machine is calibrated, the design with the
 *G-code extension format was uploaded using Universal G- code Sender to Arduino Uno with serial communication. The microcontroller will read the data as a command and provide logic to the A4988 motor driver. The data received by the motor driver was used to drive 4 Nema 23 X, Y and Z axis stepper motors, so that a pattern will be formed on the object.

OBJECTIVE

The idea behind fabrication of low cost CNC Milling Machine is to full fill the demand of CNC machines from small scale to large scale industries with optimized low cost. A major new development in computer technology is the availability of low-cost open source hardware, such as the Arduino microcontroller. An advantage of open source hardware is that a wide variety of ready-to-use software is

available for them on the Web; therefore, the prototyping and development times are drastically reduced. Moreover, a wide range of low-cost interfaces and accessories such as Arduino shields are also available. However, for the development of low-cost models of CNC machines, such tools may be quite adequate from the viewpoint of machine control. In this project, the development of a prototype 3-axis CNC Milling Machine using Arduino-based control system is presented with the following specification.

- Low cost
- Easily operable
- Easy interface
- Flexible
- Low power consumption

METHODOLOGY

The structural design of the machine including to wiring connection and the software adopted to generate codes and C+ language. Finally, but not last is 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 initial design will be drafting or sketching then when the design satisfied. 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. Travel length that is to be designed is X axis 3.5 foot and Y axis 2.5 foot and Z axis will be 0.984 foot. This structure comes with less materials hence it's very less expensive to build which it's designed to cut wood plastic and aluminum.

Fig 1 structure of CNC machine

B. Components

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. 5 have 1/30 step angle and 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. Microcontroller Board: Uno it's an Arduino Board it's selected to be the control unit in this project, which it's used as a motion control board. The Arduino Uno is a microcontroller board based as shown in Fig. 6. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.
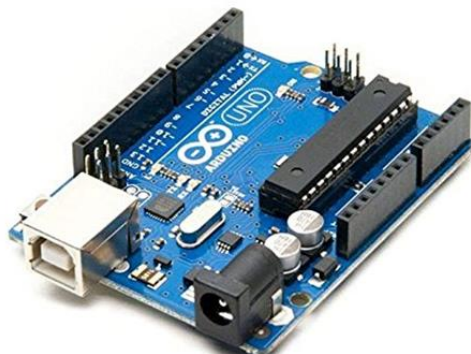
Fig 2. chromium rod and lead screw   Fig.3.stepper motor

. Power Supply: 12V SMPS (Switch mode Power Supply) is used for stepper motor driver. 2V SMPS is used to power the microcontroller board (Arduino Uno3). The microcontroller is flashed with GCODE interpreter firmware written in optimized 'C' language.
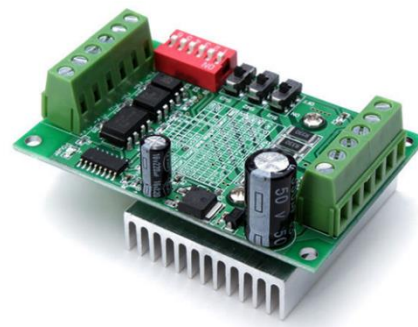

Fid 4. Arduino Uno board   Fig 5. stepper motor driver

Stepper Motor Drivers: It's kind of driver that receive steps signal from microcontroller and convert it into voltage electrical signals that turn the motor. This driver is called Easy Driver V4.5 as shown in Figure.4 that required 6V – 30V supply to power the motor which can power any type of step motors

C. Software development

The CNC machine uses easel software for motion control of the axis. Easel converts any design given or G-code, where certain commands are used that stepper motor driver will easily understand.
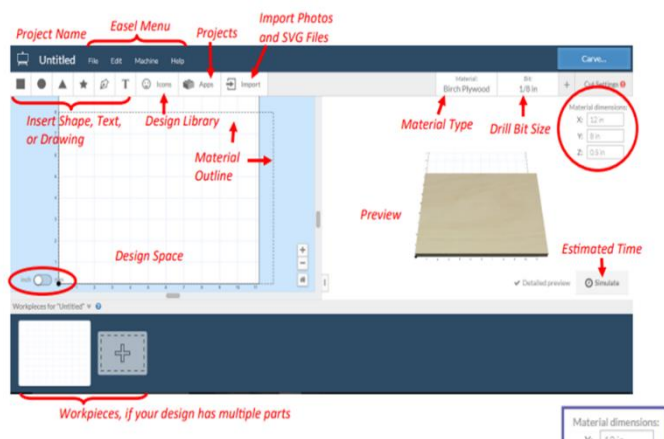

Fig 6. Easel software   Fig.7. circuit connections

In order to begin programming it's required for IDE Arduino software to make it easier and friendlier to generate G-code the best   way is to use "Easel" combined with laser engraver plug-in which is an open source graphical editor. There are three easy drivers in this

project electronic circuit each driver is connected individually to the Arduino PWM output on terminal number 3,5,6 which according to Arduino Uno datasheet and is shown in Fig. 9. Stepper motor that is used in X, Y and Z axis in this project uses with 4 wire connections that is each stepper motor are connecter to one easy driver respectively as shown in Fig. 10.

D. CNC Structure Assembly

After gathering all required parts and accessories for assembly, step by step procedure for making the CNC is noted below.
a) Start from lower-deck which is the base table.
b) Install 4 rubber bush lever
c) Assemble the upper-deck which is Y-axis base.
d) joining of aluminum extrusion of 40x40 rod
e) Assembly the Frame using aluminum stand.
f) Completion of the Frame.
g) Assemble the gantry which is X-axis support.
h) connecting c-channel
i) putting the sliding wheel in the c channel.
j) Assembly the Cutting-Head Slider which is a tool mount.

E. CNC Structure Assembly

To begin with the help of online source the EASEL controller to PC that it's used to send G-code to CNC it is user friendly and free open source to Arduino to give a virtual command to control moment of machine using easy driver, and the interface of the easel software connected to Arduino. For compilation the easel to Arduino it's don't required to download a software source code to be added into Arduino library folder by following the steps from easel website. After having easel library stetted up into Arduino IDE next is flashing the CNC .hex file Firmware to Arduino using X loader application which required to be download and open to select the COM port connected to Arduino with correct baud rate for Arduino Uno: 115200 to upload the hex file.

CONCLUSION

From this project, we learned the principle of CNC machine. We 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. Zero set up is very important step to obtain an accurate geometry of the work piece.
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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