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DESIGN OF 3-AXIS COMPUTER NUMERICAL CONTROL (CNC) ROUTER USING STEPPER MOTOR

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Abstract

This paper will present the design of 3-axis computer numerically-controlled (CNC) using stepper motor which comprise the use of a graphical-user interface (GUI) and 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 simple mini 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 techniques this machine tool is portable and it's controlled by computer (PC). Design and Fabrication of mini CNC with workspace of 130mm x 130mm using a precision Stepper motors that combined with belt & pulleys help in moving the axis smoothly on linearity bearings that increases a more precisely results obtained.

Keywords: Drilling, milling, circuit board design, Drawing.

1. INTRODUCTION

In modern CNC systems, end-to-end component design is highly automated using computer-aided design (CAD) and computer-aided manufacturing (CAM) programs. The programs produce a computer file that is interpreted to extract the commands needed to operate a particular machine via a post processor, and then loaded into the CNC machines for production. Since any particular component might require the use of a number of different tools – drills, saws, etc., modern machines often combine multiple tools into a single "cell". In other installations, a number of different machines are used with an external controller and human or robotic operators that move the component from machine to machine. In either case, the series of steps needed to produce any part is highly automated and produces a part that closely matches the original CAD design. With the on-going development of technology and economy, new industrial requirements such as high precision, good quality, high production rates and low production costs are increasingly demanded. Most of such requirements, including dimensional accuracy, conformance to tolerances of finished products and production rate can be met with better machine tools. With the help of CNC technology, machine tools today are not limited to human capabilities and are able to make ultra-precision products down to nano scales in a much faster manner. The traditional design philosophy of machine tools is multi functionality and highest precision possible.

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2. EXISTING SYSTEM

The complete system of 3-axis using stepper motor can be shown in the fig.

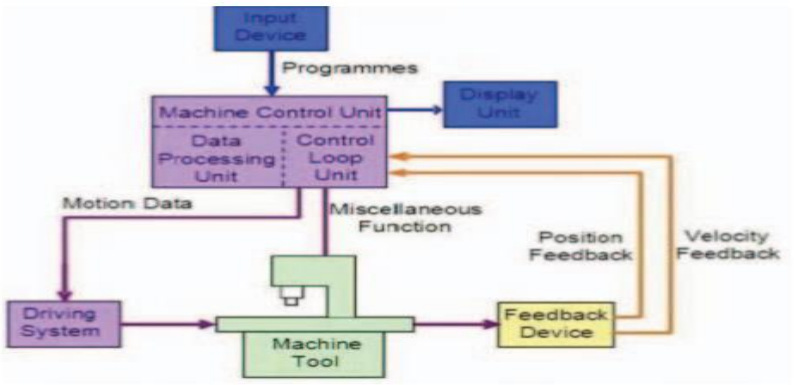

Fig.1. Hardware architecture of CNC Machine

3. PROPOSED SYSTEM

The complete system of 3-axis CNC using stepper motor is divided into 8 major parts: (1) power supply, (2) structure and configuration of 3-AXIS CNC machine, (3)Arduino UNO and PIN diagram, (4) GRBL Shield, (5) limit switches, (6) A4988 stepper motor , (7) speed controller, (8) spindle dc motor.

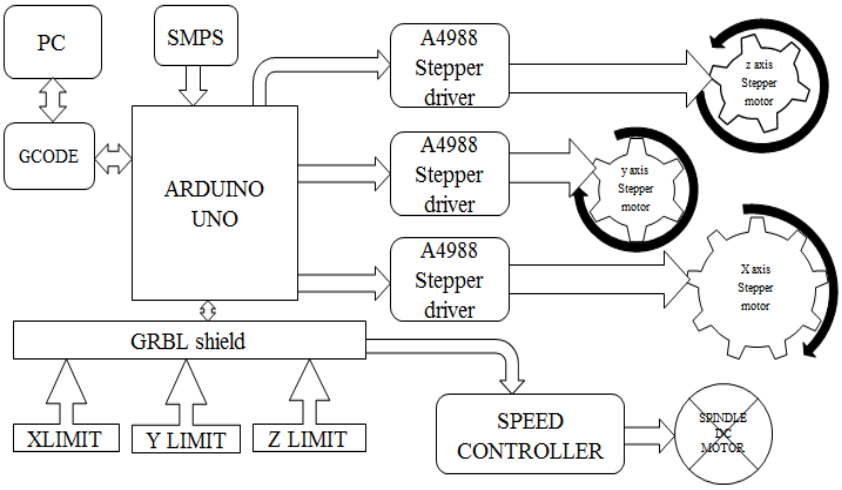

Fig.2. Over all Block diagram

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3.1 POWER SUPPLY

Power supply is a broad term but this lesson is restricted to discussion of circuits that generate a fixed or controllable magnitude dc voltage from the available form of input voltage. Integrated-circuit (IC) chips used in the electronic circuits need standard dc voltage of fixed magnitude. Many of these circuits need well-regulated dc supply for their proper operation. In majority of the cases the required voltages are of magnitudes varying between -18 to +18 volts. Some equipment may need multiple output power supplies. For example, in a Personal Computer one may need 3.3 volt, ±5 volt and ±12 volt power supplies. The digital ICs may need 3.3volt supply and the hard disk driver or the floppy driver may need ±5 and ±12 volts supplies.

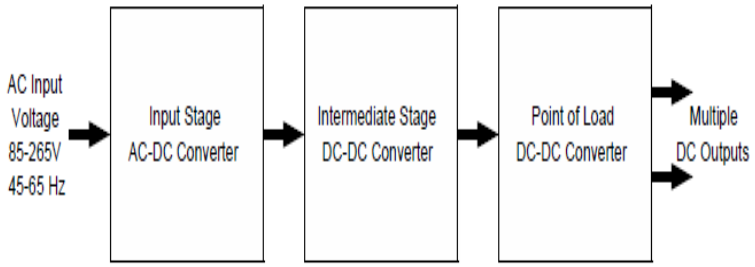

Fig.3. power supply block diagram

3.2 STRUCTURE AND CONFIGURATION OF 3-AXIS CNC MACHINE

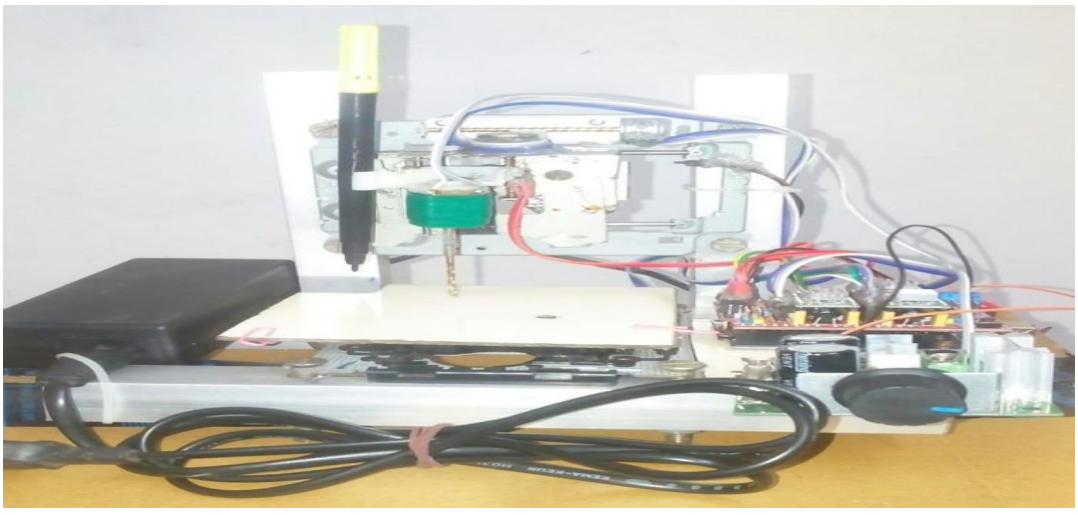

Fig.4. 3-axis CNC using stepper motor

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The structure of the machine is made of aluminums sizes 52x74x17 centimeters. The base of the center width is 30 x 30 millimeter. The prototype of the robot can be shown in Fig.

3.3 ARDUINO UNO

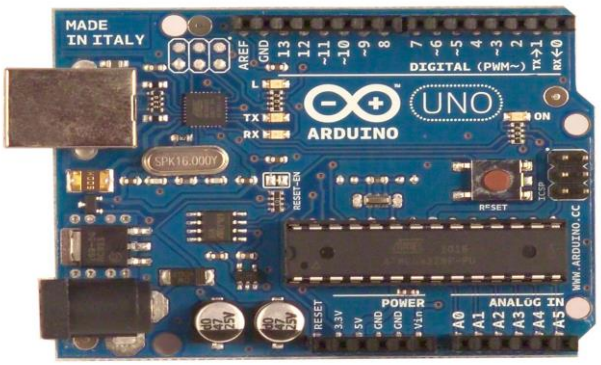

Fig.5. Arduino UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input and output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, aUSB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to supportthe microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapteror battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

3.4. PIN DIAGRAM

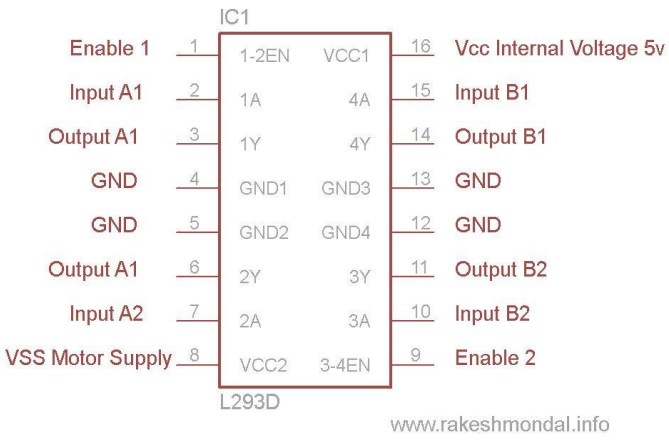

Fig.6. Arduino pin diagram

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3.5. GRBL SHIELD

GrblShield is a shield that plugs onto the Arduino development platform transforming it into a CNC controller using the grbl CNC firmware. Skills: CNC, Embedded C, Hardware. The ArduinogrblShield is a complete hardware solution for Dank's CNC motion control system called grbl.

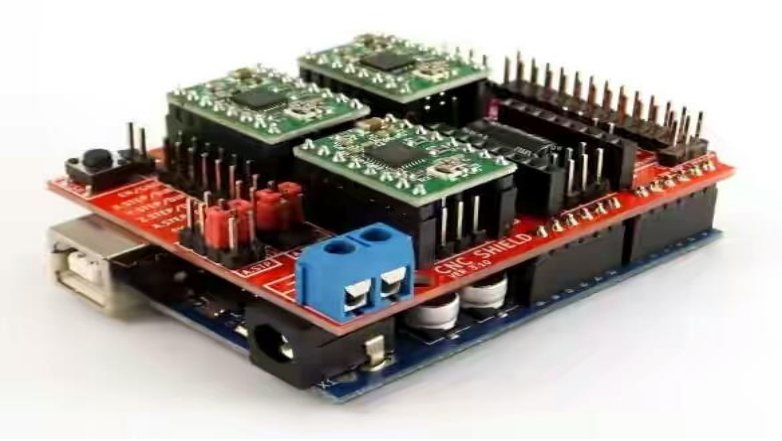

Fig.7. GRBL Shield

The Arduino CNC Shield makes it easy to get your CNC projects up and running in a few hours. It uses open source firmware on Arduino to control 4 stepper motors using 4 A4988 Stepper drivers,, with this shield and the Arduino you can build all kinds of robotics or CNC projects including CNC routers, laser cutters and even pick place machines. Grbl is a free, open source, high performance software for controlling the motion of machines that move, that make things, or that make things move, and will run on a straight Arduino. If the maker movement was an industry, Grblwould be the industry standard.Most open source 3D printers have Grbl in their hearts.

3.6. LIMIT SWITCHES

Fig.8. Limit switches

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Rugged zinc die-cast construction and full epoxy encapsulation make this limit style switch ideal for the harshest industrial applications Viton gaskets ensure a positive seal and offer high resistance to chemical attack. Modular head, switch body, and receptacle design makes machine change outs simple. Sensor head design can be rotated for maximum application flexibility. Sensor heads and bodies feature captive screws to eliminate loss. Sensor bodies feature bifurcated engagement prongs for a reliable connection when plugged into receptacle stabs. Engagement key between sensor body and receptacle prevents improper assembly. Factory-assembled models with tamper-proof screws offer a lasting seal.

3.7. A4988 STEPPER DRIVE

The A4988 stepper motor driver carrier is a breakout board for Allegro's easy-to-use A4988 Micro stepping bipolar stepper motor driver and is a drop-in replacement for the A4983 stepper motor driver carrier. The driver features adjustable current limiting, overcurrent protection, and five different micro step resolutions. It operates from 8 – 35 V and can deliver up to 2 A per coil.

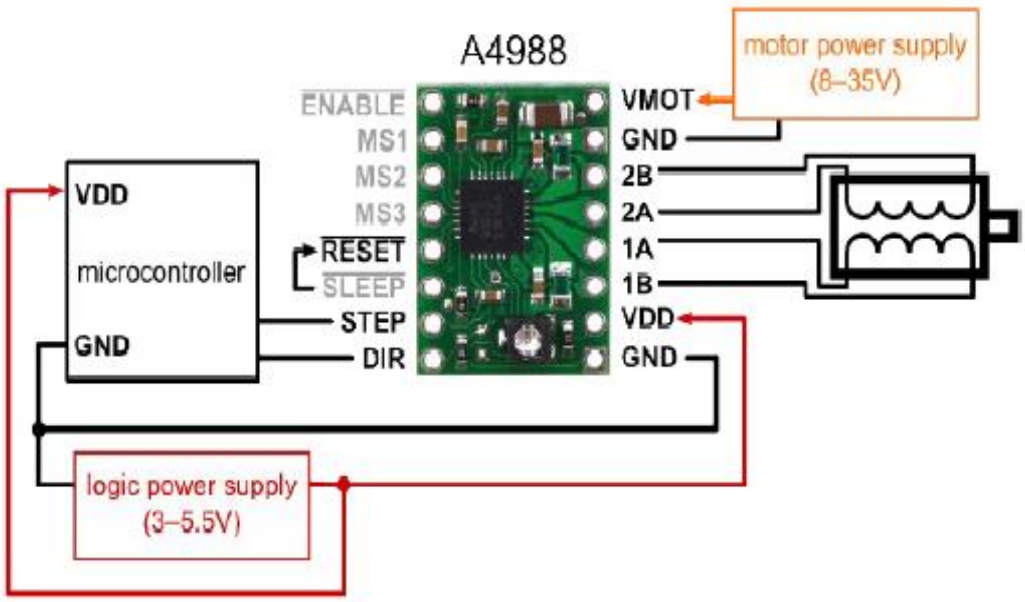

Fig.9. A4988 drive controller

3.8. SPEED CONTROLLER

An electronic speed control or ESC is an electronic circuit with the purpose to vary an electric motor's speed, its direction and possibly also to act as a dynamic brake.

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Fig.10. speed controller

3.9. SPINDLE DC MOTOR

A stepper motor consists of two main parts, a rotor and a stator. The rotoris the part of the motor that actually spins and provides work. The stator is the stationary part of the motor that houses the rotor. In a stepper motor, the rotor is a permanent magnet. The stator consists of multiple coils that act as electromagnets when an electrical current is passed through them. The electromagnetic coil will cause the rotor to align with it when charged. The rotor is propelled by alternating which coil has a current running through it.Stepper motors have a number of benefits. They are cheap and easy to use. When there is no current send to the motor, the steppers firmly hold their position. Stepper motors can also rotate without limits and change direction based on the polarity provided.

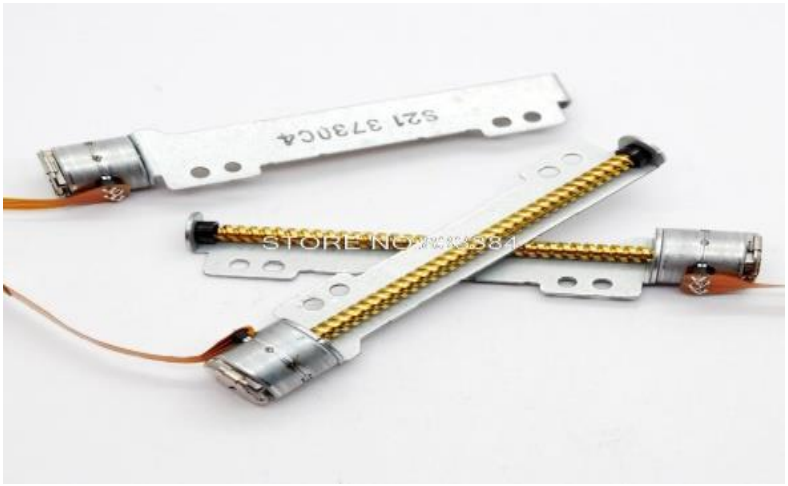

Fig.11. stepper motor

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4. SOFTWARE DETAILS

4.1. PROTEUS 7.10 SIMULATION

Proteus 7.10 is a Virtual System Modeling (VSM) that combines circuit simulation, animated components and microprocessor models to co-simulate the complete microcontroller based designs. This is the perfect tool for engineers to test their microcontroller designs before constructing a physical prototype in real time.This program allows users to interact with the design using on-screen indicators and/or LED and LCD displays and, if attached to the PC, switches and buttons. One of the main components of Proteus 7.10 is the Circuit Simulation -- a product that uses a SPICE3f5 analogue simulator kernel combined with an event-driven digital simulator that allow users to utilize any SPICE model by any manufacturer. Proteus VSM comes with extensive debugging features, including breakpoints, single stepping and variable display for a neat design prior to hardware prototyping. In summary, Proteus 7.10 is the program to use when we want to simulate the interaction between software running on a microcontroller and any analog or digital electronic device connected to it.

5. RESULTS

5.1 SIMULATION TEST

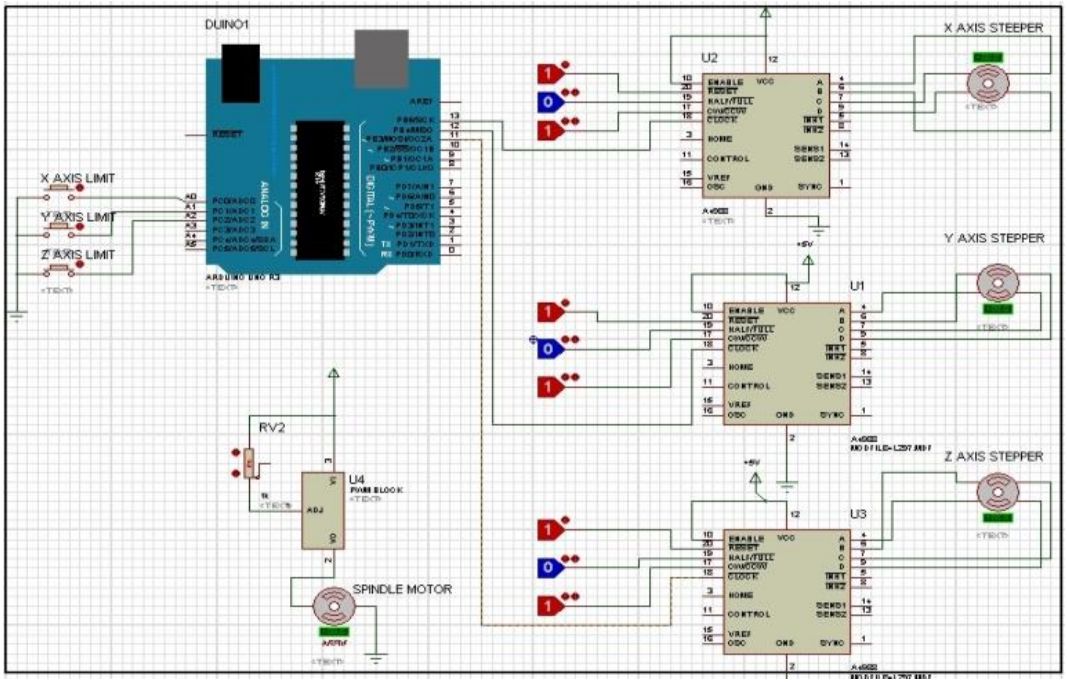

Fig.12. Simulation output

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5.2 CNC Machine output and Results

MACHINE OUTPUT

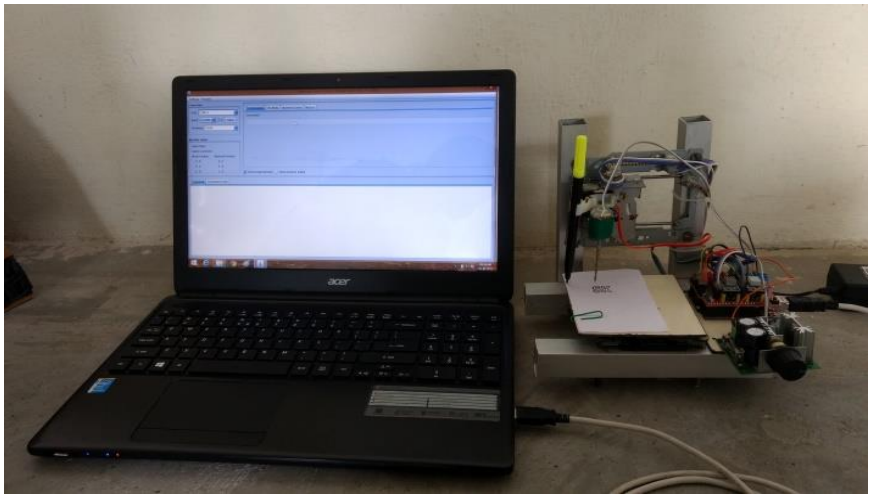

Fig.13. Machine output

SOFTWARE RESULTS

The machine process is using a graphical user interface (GUI) e.g., "Inkscape" which is graphical software that runs into a PC for creating and desiging an image to be convert itinto G-Code .nc file which used to run the design into GRBL Controller.

MECHANICAL RESULTS

Being a Mechatronics engineer I have some difficulties in testing the CNC machine mechanically which it required a surface flatness test and perpindicularity test as well as the repetation accuracy of the axis movment. It is clearly to understand the accuracy of the geared stepper motor selected in this project to run the axis is by using a quick calculation in order to obtain the accurate results.

CONCLUSION

A model of a CNC machine is assembled inhouse using and in the lab to perform a testing cratiria of the machine componantsbeforassemblin it. The steps of building a wooden stucture are followed in detail from a cnc structures company has been followed to meet the accuracy while merging it into an electronic as well as mechanical parts together. The configuration and calibration steps are clearly given with all details. The complete machine functionality verified using a various of tests which flows from softwares test into a mechanically tests, the errors has been initially clarified and determaind to ensure relaibility of the machine.

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FUTURE WORK

It is planned to scale up the prototype CNC machine in terms of size, use more powerful motors, strengthen the frame and worktable with materials like aluminum or cast iron, and augment the CNC control software with software for simulation ahead of actual run. For instructional purposes as well as for more precise operation, it is preferable to build CNC machines with DC or AC servomotors and encoder feedback using PC-based motion controllers. It is planned to implement the multi axis about 4 to 6 axis CNC router. The implementation of 3D printing (Rapidprototyping) technology to the same hardware abstract is ongoing plan for printing 3D models.

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