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Design of Low Cost CNC Controller Using Raspberry PI

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Abstract: ***This project aims at the design of a Low cost hardware used for controlling CNC machine which overcomes the disadvantages such as cost and software complications. The movement of the three axes: x, y and z of the CNC machine are controlled through three stepper motors. The stepper motors are connected to the motor drivers which are connected to raspberry pi. Pi gives the direction and step input to the stepper motor driver. The image to be etched is given through CAD software which is converted into G-code and used in linux platform. As Raspberry pi works in Linux platform, linuxcnc software is used for dumping G-codes into pi. G-code is used to give instructions to the CNC regarding the movement of the machine. The parameters passed to the x, y and z axes are continuously monitored using a 7 inch touch LCD display connected to the Raspberry pi.***

Keywords: Low cost hardware, CNC machine, stepper motors, Raspberry pi, CAD software, linuxcnc software, LCD display

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. 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.

2. Parts Involved

2.1 CNC Etcher

Computer Numerical Control – Taking digitized data, a computer and CAM program is used to control, automate, and monitor the movements of a machine. The CNC controller works together with a series of motors and drive components to move and control the machine axes, executing the programmed motions. 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 by use of a post processor, and then loaded into the CNC machines for production.

Figure 1: CNC Etcher

2.2 CAD-CAM Software

CAD-CAM software provides the ability to create complex 3 Axis machine tool paths quickly and efficiently. Without CAD-CAM, programming complex parts is practically impossible as there are multiple tool paths required from advanced roughing, semi-finishing and multiple finishing tool path strategies. This allows existing CAD users to create the necessary machining for the part, simulate everything and create the NC programs for them. This is highly beneficial, as the CAD users do not have to completely re-learn a new CAD-CAM system; they only need to learn the machining side.

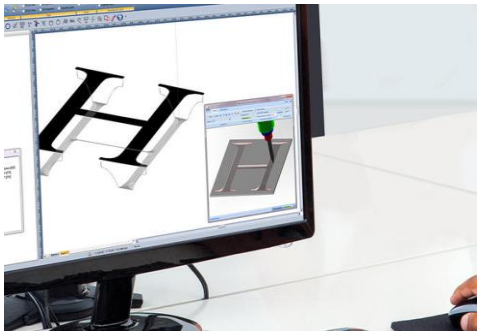


Figure 2: CAD Software image to be etched

2.3 Instructions VIA G-CODE

G00 Positioning(rapid traverse)
G01 Linear interpolation (feed)
G02 Circular interpolation CW
G03 Circular interpolation CCW
G04 Dwell
G07 Imaginary axis designation
G09 Exact stop check
G10 Offset value setting
G17 XY plane selection
G18 ZX plane selection
G19 YZ plane selection
G20 Input in inch
G21 Input in mm
G22 Stored stroke limit ON
G23 Stored stroke limit OFF

G-code is one of a number of computer code languages that are used to instruct CNC machining devices what motions they need to perform such as work coordinates, canned cycles, and multiple repetitive cycles. It is the most popular programming language used for programming CNC machinery. Industry has standardized on G-Code as its basic set of CNC machine codes.Some G words alter the state of the machine so that it changes from cutting straight lines to cutting arcs. Other G words cause the interpretation of numbers as millimetres rather than inches. Some G words set or remove tool length or diameter offsets.

2.4 Raspberry PI as a Controller

The raspberry pi board comprises a program memory (RAM), processor, graphics chip, CPU, GPU, Ethernet port, GPIO pins, Xbee socket, UART, power source connector and various interfaces for other external devices.

Former CNC machines had minicomputers bolted onto their frames. Now the bulky Electronic brains are replaced with a credit card sized computer- Raspberry pi.

Figure 3: Letters being etched by a CNC header

2.5 Stepper Motor Drivers

Driving a stepper motor is a bit more complicated than driving a regular brushed DC motor. Stepper motors require a stepper controller to energize the phases in a timely sequence to make the motor turn on. So we use 3 stepper motor drivers to control 3 stepper motor movements in x, y and z directions.

Figure 4: Stepper motor driver board

2.6 Stepper Motors

Stepper motors are DC motors that move in discrete steps. They have multiple coils that are organized in groups known as "phases".By energizing each phase in sequence, the motor will rotate one step at a time.With a computer controlled stepping you can achieve very precise positioning and speed control. For this reason, stepper motors are the motor of choice for many precision motion control applications.With a computer controlled stepping you can achieve very precise positioning and/or speed control. For this reason, stepper motors are the motor of choice for many precision motion control applications.

- **Positioning** – Since steppers move in precise repeatable steps, they excel in applications requiring precise positioning such as 3D printers, CNC, Camera platforms and X, Y Plotters. Some disk drives also use stepper motors to position the read/write head.

Figure 5: Stepper motor

- **Speed Control** – Precise increments of movement also allow for excellent control of rotational speed for process automation and robotics.
- **Low Speed Torque** - Normal DC motors don't have very much torque at low speeds. A Stepper motor has maximum torque at low speeds, so they are a good choice for applications requiring low speed with high precision.

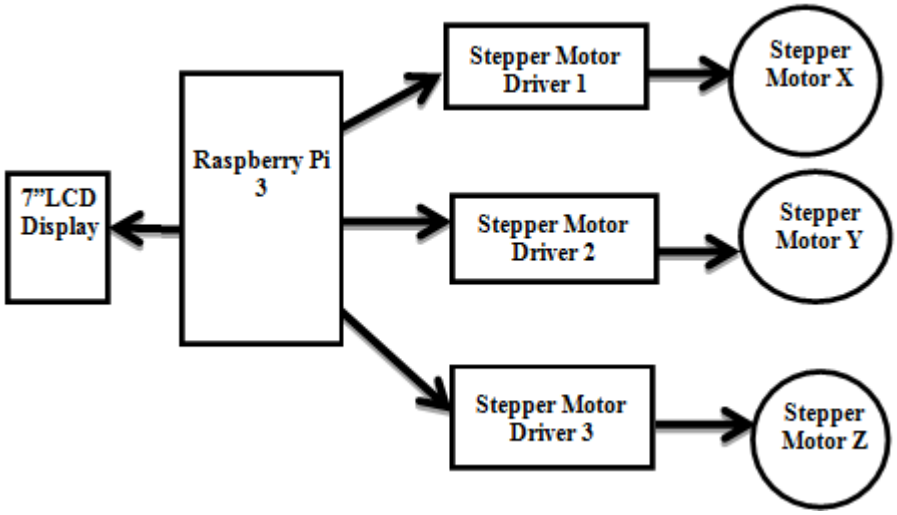
Figure 6: Stepper motors with Driver boards

2.7 7" LCD Display Interface With PI

Figure 7: Touch LCD Display connected to Raspberry pi

The parameters passed to the stepper motor drivers for the movement of the three axes of CNC are continuously monitored using a touch LCD panel by connecting it to the raspberry pi.

3. Installation Flow Chart



4. Working Algorithm

Step1: CAD image is converted into G-code via CAM software
Step2: G-code is fed to raspberry pi through linuxCNC.
Step3: Direction and step inputs are given to the stepper motor driver
Step4: Stepper motors are controlled through drivers.
Step5: The 3 axes of the CNC machine are controlled via Raspberry pi

5. Conclusion

Soon, CNC technology will evolve just as the Internet has done, and continues to do. It has expanded into the hands of millions of people and gives them the ability to do things that we might have only seen in science fiction movies. As the cost of CNC technology drops, we see a variety of uses that the original designers of the technology did not envision. It also will give rise to a world of convenience, efficiency, and precision for automated processes of projects previously done by hand. If a CNC can be controlled using a credit card sized computer like Raspberry pi then it is surely an added advantage.

6. Acknowledgement

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