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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.

I. 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.

II. HARDWARE DESCRIPTION

A. 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.

Fig.1: CNC Etcher

B. 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.

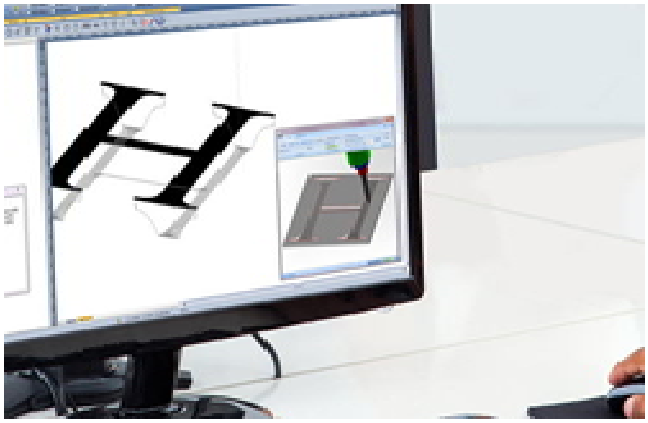

Fig.2: CAD Software image to be etched

C. 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.

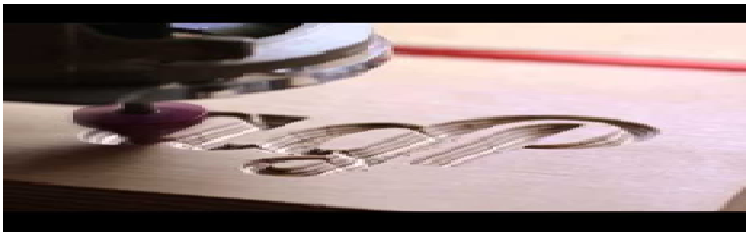

Fig.3: Letters being etched by a CNC header

D. ATMEGA-328 Controller

The Atmel 8-bit AVR RISC-based microcontroller combines 32 kB ISP flash memory with read-while-write capabilities, 1 kB EEPROM, 2 kB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channel in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. The device achieves throughput approaching 1 MIPS per MHz.

E. GRBL Code

GRBL is a no-compromise, high performance, low cost alternative to parallel-port-based motion control for CNC milling. It will run on an Arduino as long as it sports an Atmega 328. It accepts standards-compliant g-code and has been tested with the output of several CAM tools with no problems. Arcs, circles and helical motion are fully supported, as well as, all other primary g-code commands. Macro functions, variables, and most canned cycles are not supported, but we think GUIs can do a much better job at translating them into straight g-code anyhow. GRBL includes full acceleration management with look ahead. That means the controller will look up to 18 motions into the future and plan its velocities ahead to deliver smooth acceleration and jerk-free cornering.

III. STEPPER MOTOR

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.

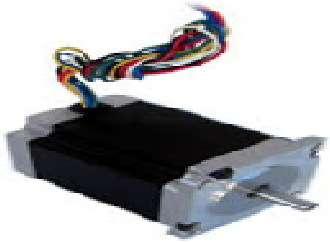

Fig.4: Stepper motor

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.

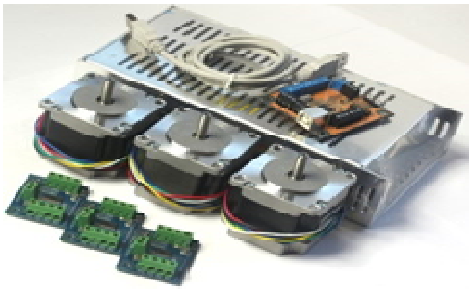

Fig.5 Stepper motors with Driver boards

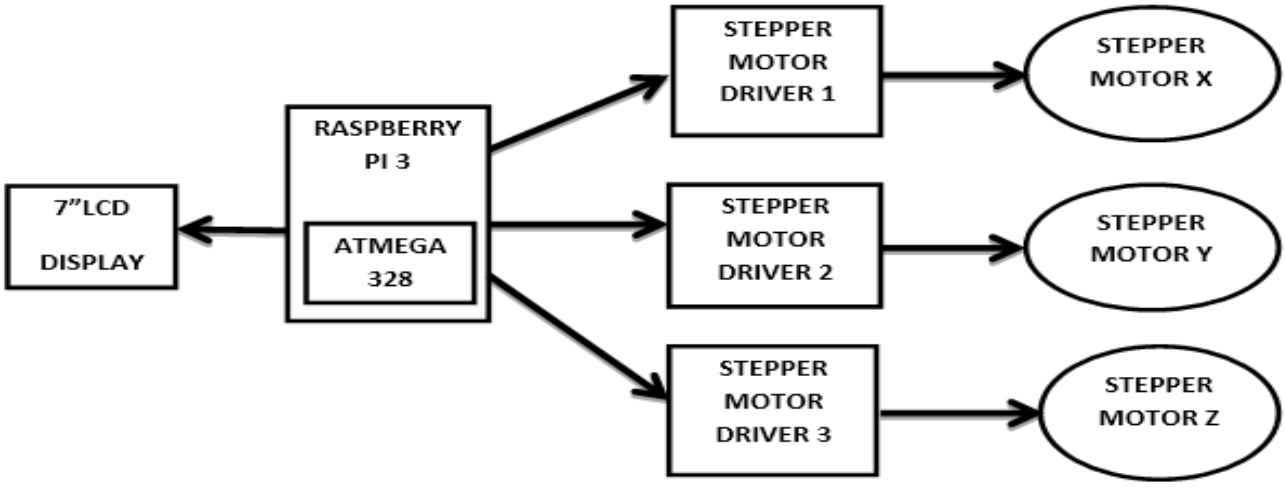

Fig.6 Installation flow chart

A. Working Algorithm

Step1: CAD image is converted into G-code via CAM software
Step2: G-code is fed to raspberry pi through linux CNC.
Step3: Direction and step inputs are given to the stepper motor driver
Step4: Stepper motors are controlled through drivers.
Step5: The control to the CNC is given via an AT-MEGA 328 controller and the raspberry pi.

IV. RESULTS AND DISCUSSIONS

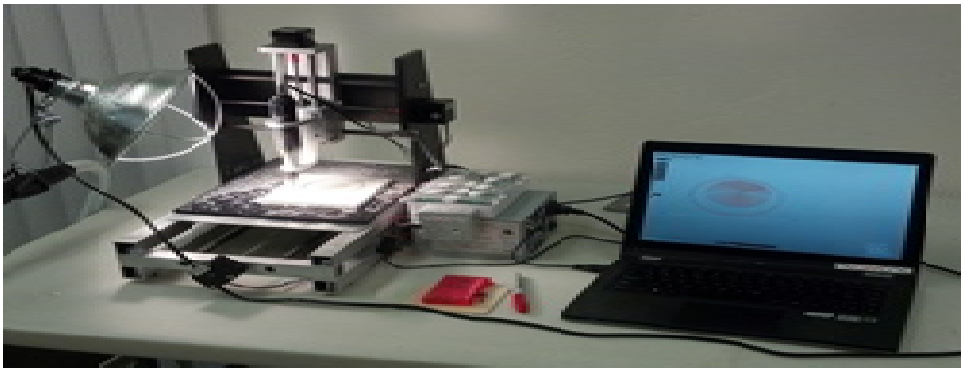

Fig.7: Former CNC's controlled via Computers

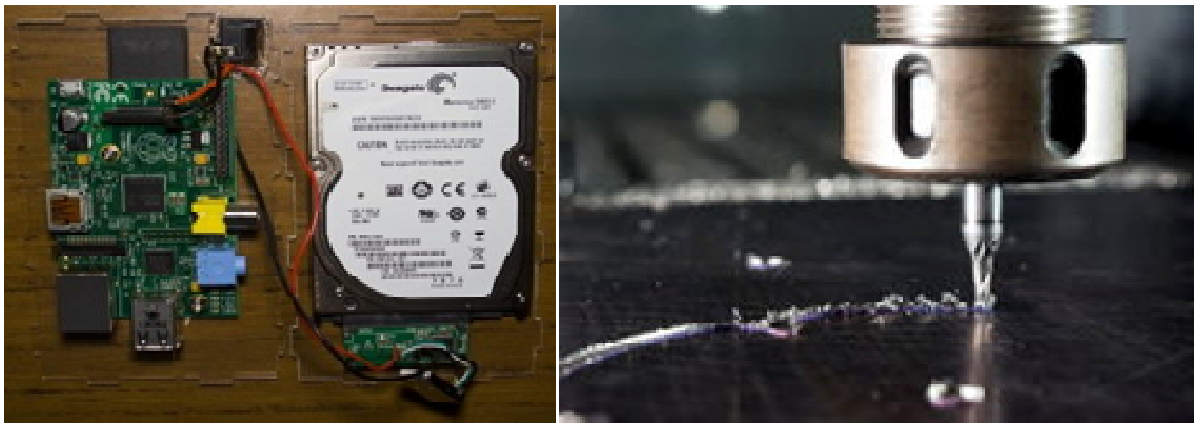

Fig.8: Computers being replaced by Raspberry pi

AutoCAD diagram which is converted into g code is given to the raspberry pi which is then given to the CNC and the etching process takes place. CNC's so far have used computers to control their operations which are now replaced by a credit card sized computer Raspberry pi.

V. 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.

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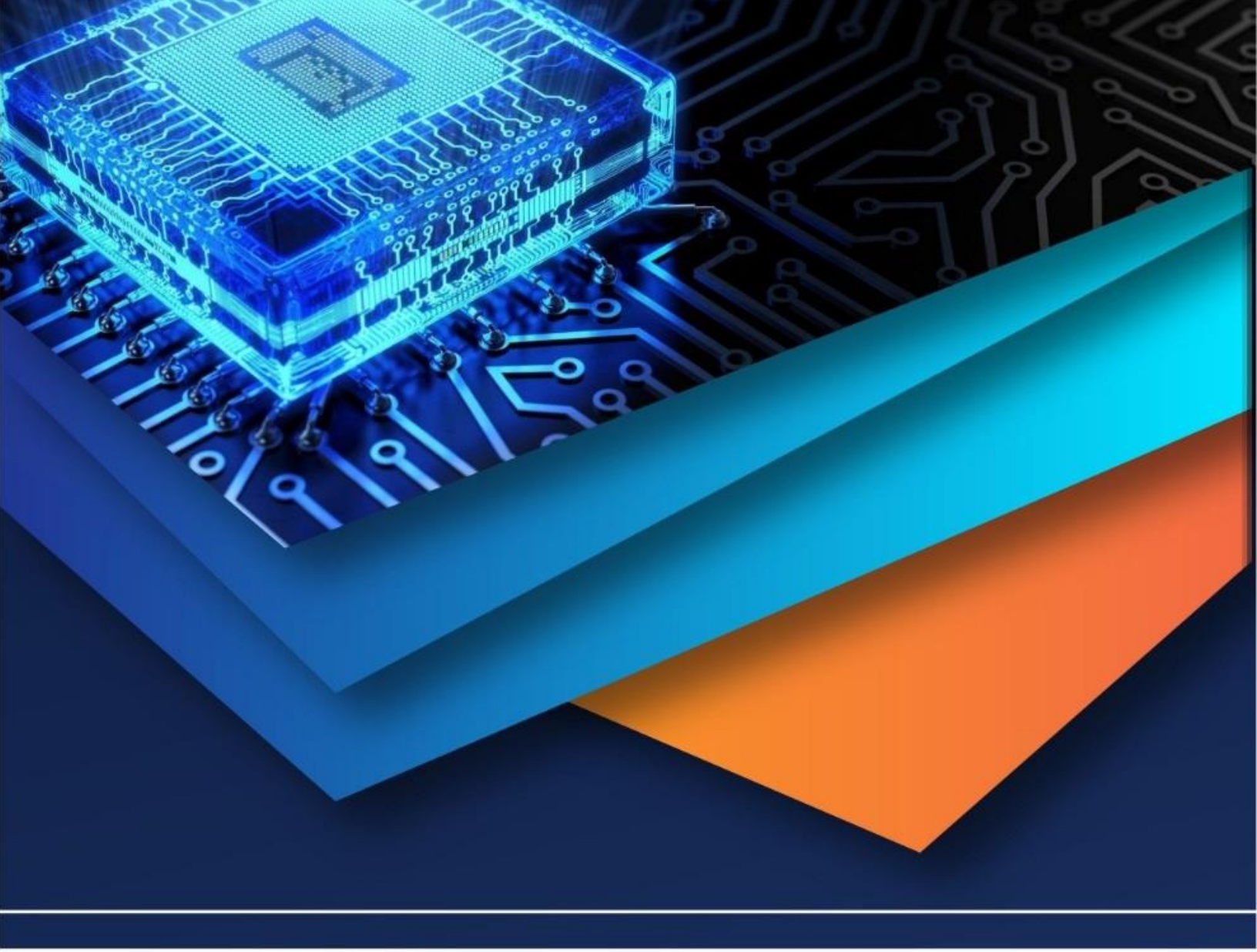

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