

# Design and Development of CNC Based Laser Engraver

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## ABSTRACT

Basically in laser engraving the laser beam burns the top layer of the surface to be engraved. The burnt area is left uncolored which makes it appear different from the surrounding surface. While in laser cutting laser beam has to penetrate through the surface. This can be achieved by prolonging the beam on a particular area for a long period of time, duration being decided on the strength of material to be cut. We are still collecting data from different resources to know this topic more in depth.

In our project we have decided to develop working model of laser cutting and engraving machine. This machine is very useful in our department since it's a kind of rapid prototyping machine. It can cut out paper patterns and thermoplastic sheets to produce desired shape and patterns. Till now we have collected information on laser cutting, laser and what engraving is. Laser cutting is different from laser engraving, in case of engraving very low intensity laser torch is used as compared to laser cutting. We got a brief introduction on laser, how it works, what are its properties, how to generate it and how to control its intensity. It might not cut through chunks of wood but surely burn the top layer. Simulation analyses are performed in CAD software 'SOLID WORKS' in order to simulate each part of the machine. It was helpful for remodeling the moving bed or the job holder, if any errors found during the simulation. Additionally, experiments are performed for the develop laser cutting engraving machine.

**Index Terms-** CNC Shield, G-code, Arduino, Stepper motor, SMPS

## 1. INTRODUCTION

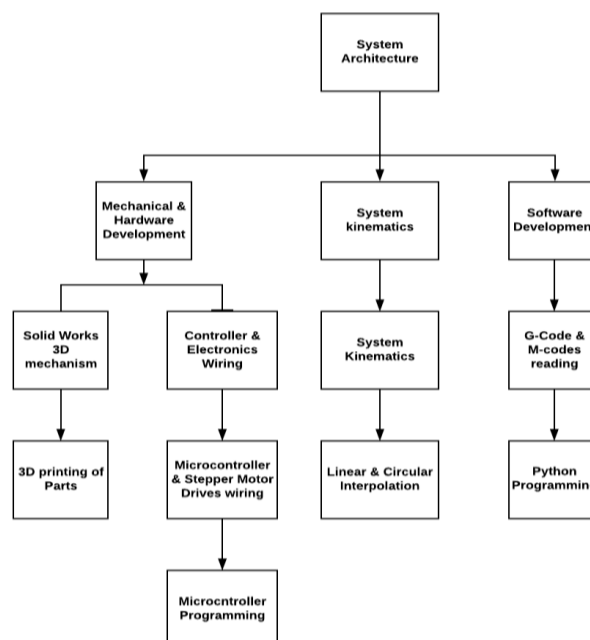
Laser stands for Light Amplification by Stimulated Emission of Radiation, was discovered in 1960. Laser light beam is different from normal light beam because of its high temporal and narrow spectral bandwidth. Here amplification of light is achieved by a laser active medium (gain medium). This medium is obtained by stimulated emission of photons from a lower energy state to a higher energy state previously populated by a pump source. In order to start the lasing active in the medium it must be in nonthermal energy distribution known as population inversion. Wavelength of photon is changed according to the need of active medium. The wavelength represents the colour and the amount of energy stored.

It is important to feed back the generated photon into the active medium using a resonator, so that a large amount of identical photons builds up for further stimulated emission. Pumping action is required which ensures continuous feeding of energy into the laser active medium. This helps in sufficient emission is generated on a continuous basis. Lasers are classified into different ways i.e. according to their mode of operation or type of laser-active medium.

Engraving is a process of design onto a hard surface by cutting grooves into it, basically on flat surface oriented perpendicular to the processing beam axis.

## 2. METHODOLOGY

The CNC machine is constructed in three stages: (a) build mechanical frame, (b) assemble electric system and (c) install control and computing system. Mechanical system gets necessary control signals from electronics system which ultimately results in desired actuation of motors. Electronics system gets command or a set of commands from software system and generates controls for mechanical system.



### 3. Design

The CAD software which has been used for designing and virtual analysis of the model is "solid works 16" which is a very versatile and flexible CAD software. By using solid works the conceptual idea of the design is converted in to virtual detail design, the below figures i.e. fig 1 shows the isometric view of the shredder machine.



Fig 1: Isometric view

### 4. Mechanical System

The mechanical system is assembled in such a way that the 3-axis movement is achieved by using the linear bearings and guide rods. Stepper motors are mounted to the each axis which is the source of motion acted according to the control signal generated from the electronics circuit. Each stepper motor is coupled to the screw rod which carries nut with the help of coupling bush. This screw rod and nut arrangement is responsible for converting the rotational motion of the stepper motor to linear motion. The linear motion of each axis is carried away smoothly by the linear bearing and guide rod assembly connected to the each axis which is capable of load carriers and allows linear motion in each axis. The controlled motion in each axis is achieved directly by controlling the rotation of the stepper motor. The speed of the motion in each axis can also be controlled by direct control of the speed of the stepper motor by giving required control signals. Thus the tool path of the spindle fixed to the end effector is controlled in each axis for smooth carving or cutting action of work piece.



(a)Acrylic

(b)Time Pulley

(c)Wheel

The Astro Industrial Duty Aluminum 2020H European Standard Anodized Profiles made of High Grade tempered Aluminum Alloy 6063 - T5. The dimensions are as per European Standard and the structural cross section thickness is minimum of 1.5 mm. The profile can be used for structural elements in automation machinery, laser cutting machines or 3d printers. Also many prototype CNC router machines, XY tables or camera sliders can be made using the same. The profile is anodized in natural aluminum color to provide a hard layer to prevent corrosion and wear. We have a number of accessories available to easily assemble various structures using the 2020 profile. Please check out the same in the Aluminum Profile Accessories Section.

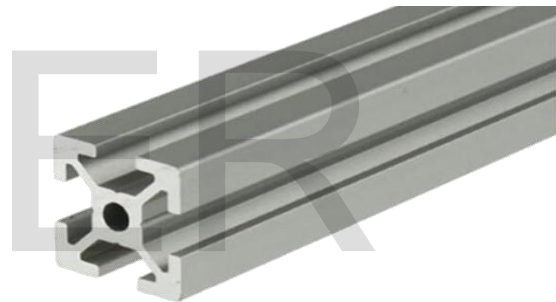


Fig 2: 20x20 Aluminum Profile

### 5. Electrical System

Arduino uno is selected to be the control unit in this project. The arduino uno is a microcontroller board based on the ATmega328 chip. The microcontroller board is flashed with G- code interpreter code which was written in the C language. The control board is responsible to generate the control signal for corresponding command signal from the computer to the stepper motors which is directly controls the motion of the tool path. Fig. 4. displays the functionality of the Arduino pins as used by GRBL. The driver called easydriver (Fig.6) is used as the stepper motor driver. It receives steps signal from microcontroller and convert it into voltage electrical signals that run the motor.



Fig 3: Arduino Uno

### 5.1 CNC Shield

The Arduino CNC Shield makes it easy to get your CNC projects up and running in a few hours. It uses opensource firmware on Arduino to control 4 stepper motors using 4 pieces of A4988 Stepper Motor driver breakout board, with this shield and ArduinoUno/Mega, you can build all kinds of robotics, linear motion project or projects including CNC routers, laser cutters and even pick&place machines.

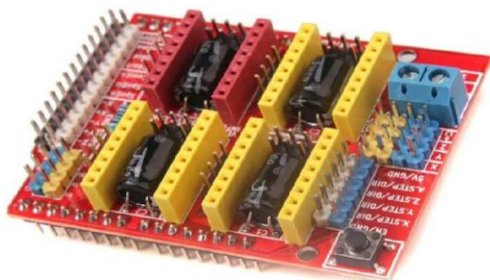


Fig 4: CNC shield

### Hooking Up the Stepper Motor to CNC Shield

Connect steppers motor to CNC Shield board as the below block diagram. of the CNC Shield connected to 3-stepper motor:

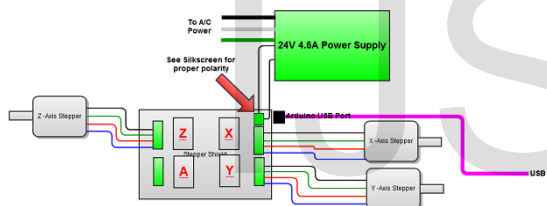


Fig 5: Line Diagram of Connection between Arduino Microcontroller and Stepper Motor

### 5.2 Stepper Motor Driver (A4988):

The A4988 is a complete micro stepping motor driver with built-in translator for easy operation. It is designed to operate bipolar stepper motors in full-, half-, quarter-, eighth-, and sixteenth-step modes, with an output drive capacity of up to 35 V and ±2 A. The A4988 includes a fixed off-time current regulator which has the ability to operate in Slow or Mixed decay modes.



Fig 6: Stepper Motor Driver (A4988)

### Connection Diagram:

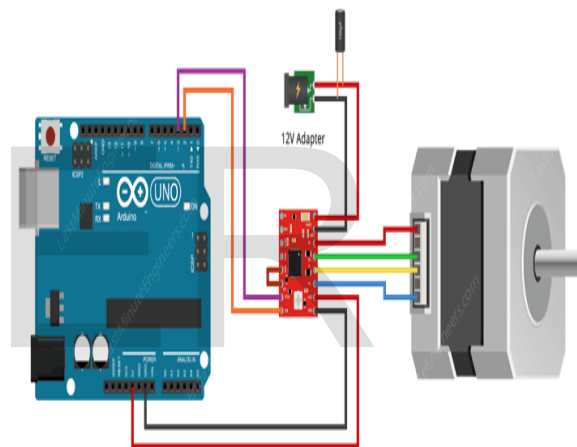
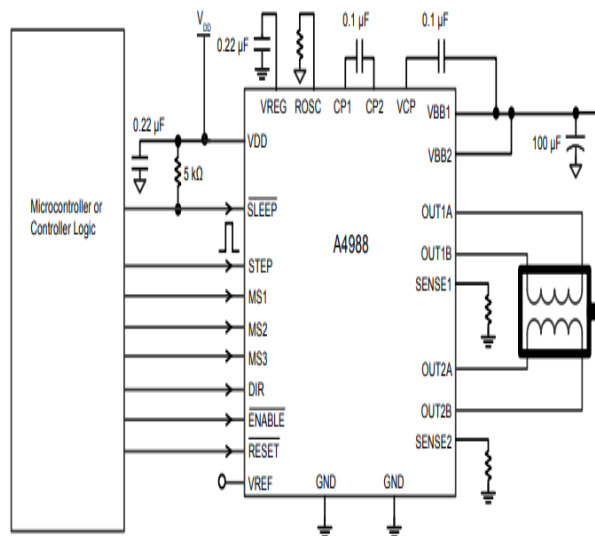


Fig 7: A4988 can also be interfaced with Arduino through CNC Shield:

### 6. GRBL Software:

GRBL is opensource software that runs on Arduino Uno that takes G-code commands via Serial and truns the commands into motor signals. GRBL source code is added to Arduino library and Arduino IDE is used to flash GRBL directly to the Arduino board.

Grbl Controller is software that is designed to send G-code to CNC machines, such as 3D milling machies. It just needs to give the user a nice way to get command down to whatever controller they are using. Grbl Contoller is written using the Qt crossplatform libraries. It also gets some help from the QextSerialPort library to simplify choosing the correct USB serial port.

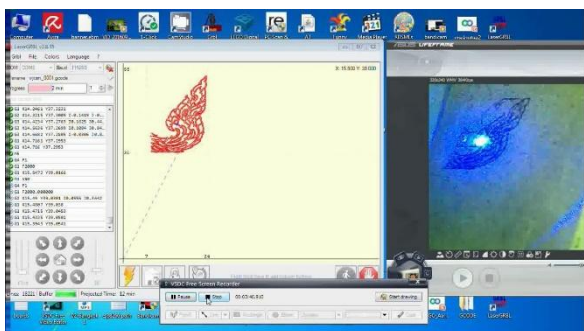


fig 8: GRBL Controller



Fig .9: Laser Engraver Modle

## 7.Objective of the Work

The objectives of the work are:

- To reduce the large scale industrial cutting machine to a small portable lab equipment.
- To decrease the cost of making prototypes
- To make it useable for cutting paper, polystyrene and thin sheets
- Make the machine mobile.
- Developing concept sketches and then reviewing it with the customers to find according to them what the shapes should be.

## 8.Machine Specification

The technical parameters of the machine are shown in table 1 and the complete assembly of the CNC machine is illustrated in Fig9.

TABLE 1  
TECHNICAL PARAMETERS

Machine dimension	600×460×180 (mm)(L*W*H)
Working area	300×380 (mm)
Z-axis travel	100mm
Driver motor	3 Stepper motor
Laser Power	2.5w/2500mw
Laser Wavelength	445nm
Controller	PC based GRBL Controller
Engraving Accuracy	0.01mm

## 9. Project Schedule:

Laser Engraver development cycle include three major phases. Very first stage is mechanical design using Solid works. 3Modelling of each part has been done which include X, Y & Z-axis and final assembly will be done in Solid works software and converting into 2D and BOM generation. After this we are going for the manufacturing of the different parts using 3D printing.

Second phase includes understanding the working area of the Laser engraver machine and Kinematics of the Cartesian coordinate systems is analyzed. In this phase, we are also going for type of microcontroller is used and different electronic components & their interface with Microcontroller and programming. We are going do the wiring of all electronic components has been done.

Third and final phase is understanding G-codes and M-codes & Interfacing software to do the Job by using G-Codes and M-codes.

### Result:

- Design of the Laser Engraver in which we do Engraving on Plywood, plastic, paper
- It should works by uploading G-codes & M-Code

### Future Plan of Action for Phase 2:

- 3D design of X, Y & Z axes in Solid works.
- 3D Printing & modeling
- Laser Module selection
- Electronics selection & wiring
- Microcontroller Programming

## 10. Conclusion:

By using CNC controllers, there is a remarkable increase in the quality of products as well as it offers high flexibility. It increases the productivity and reduces the lead time. This collaboration of hardware with G-code & M-code gives better productivity and reduces the work load. G-code & M-code make easy to find the information of locations of all stepper motor moving, as the status of our moving motor are directly seen on computer. Making a small machine brings a flexibility to do work and also decrease the cost of making prototypes, make it useable for cutting paper, polystyrene and thin sheets.

In this work, designed and fabricated with low-price. In conclusion the accuracy of the designed and fabrication of CNC based laser engraver body parts assembling has succeeded to achieve the objectives of this project in precision and repeatability goal.

## Advantage :

- Low weight
- Easily transportable
- Low cost
- Easy setup

## 10. ACKNOWLEDGEMENT

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