Design And Development of CNC Based Laser Engraver

Major Project Report Submitted in Partial Fulfilment of the Requirements for the Degree of

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in

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Acknowledgement

The major project opportunity we had in mechatronics was an excellent chance for learning and professional development.

We would like to thank Dr Praveen Pawar ,Dr Manvendra Tiwari , Mr Subham(Major Project guide) for providing us with the platform and right skillset to grab such an opportunity, and only under his guidance, was the project such a great success.

TABLE OF CONTENTS

TABLE OF FIGURES

List Of Tables

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 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 and what engraving is. We got a brief introduction on laser, how it works, what are its properties, how to generate it and how to control its intensity. The machine is made using a ~200mW red laser. It might not cut through chunks of wood but surely burn the top layer.

Simulation analyses are performed in CAD software 'WOK WI" 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 engraving machine.

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.

Diode Lasers. Laser diodes are made by sandwiching negatively(n-type) semiconductor with positively(p-type) semiconductor. The laser beam generated is only in boundary layer of the forward biased semiconductor diode. This layer is only few micrometers in size, mirrors are fixed to make very compact diodes. Different colours of diode can be made by varying the choice of semiconductor and the dopant used. In p-type and n-type semiconductor the major component is gallium arsenite.

HISTORY

As barcodes spread, lasers weren't just utilized for the reading of product information, but also in this information's creation. With new advances in technology, lasers began to be able to mark or engrave materials to create barcodes, serial numbers, 2D codes, UDI codes, logos, designs, and more.

Let's take a look at the key points in the history of laser engraving and marking to discover how we got to today.

- In the 1970s, in an effort to improve the then-popular computerized engraving machines, Bill Lawson of LMI began to experiment with the viability and possibilities for laser engraving.
- Prior to Lawson, a company called Laser Craft had developed some primitive laser engraving technologies, but their systems necessitated the use of stencils and in effect "sandblasted" the material with a laser beam. These stencils were also difficult to control.
- The system Lawson landed on, however, scanned black and white artwork, information, or designs, engraving either the white or black part, depending on operator desire, which greatly improved the end result.
- During the 1970s, Electrox emerged as the first laser company to develop and manufacture a commercial fast axial flow CO2 laser, helping to advance the field and establish Electrox as a key source for laser marking systems.
- Technology, and specifically computerized systems, significantly advanced by the 1980s and 1990s, which led to computers being directly integrated into laser engraving systems.
- In 2001, TYKMA Technologies is formed, eventually becoming TYKMA and merging with Electrox. The new company, TYKMA Electrox, stands as a fully integrated worldwide organization offering efficient and modern MOPA fiber laser systems.

LITERATURE REVIEW

The advances and characteristics on high power diode laser material processing . Lin li :	He had investigated wood engraving by Q-switched diode pumped frequency doubled Nd: YAG green laser. The aim of this work is to investigate the influence of the process parameters on the material removal rate by engraving panels made of different types of wood using a Q-switched diode pumped Nd:YAG green laser working with wavelength 532nm. The examined parameters like the pulse frequency, the beam speed and the number of laser scansions also called repetitions. The working parameters and engraved depth were related and energy based model was proposed in order to predict the laser. Experimental result showed that this type laser can be successfully used to machined different type of wood, obtaining decorative drawing and 3D engraved geometries without burning.

FX of fluid speed ratio and laser power on engraved depth and colour difference of mosso bamboo lamina. Cheng Jung Lin et al (2008) [6]	He had investigated AISI 304 stainless steel marking by a Q- switched diode pumped Nd: YAG laser. The aim was to determine the correlation occurring between working parameters like pulse frequency, beam scanning speed, and current intensity and resulting mark visibility. To characterize mark feature, its width and roughness were estimated and analyses optical and scanning electron microscopy coupled with energy were dispersive X-ray technique were carried out.
Study on holograms laser engraving process. **Mihaela Iliescu et al.**	Study on Holograms Laser Engraving Process" Holograms and holography become more and more important for nowadays life, specially because of their role in security and protection. Some research results on holograms laser engraving process parameters are evidenced by this paper. Application of holography and holograms is very wide, covering: security and product authentication, packaging - consumer goods brand protection, art and interactive graphics, etc. This paper is a study on hologram marks, more specifically, on hologram laser engraving process parameters. In order to obtain high resolution engraving results low speed, high frequency and small pulse duration of the laser beam should be used

An experimental study of laser assisted machining of hard to wear white cast iron S.H. Masood et al.	"An experimental study of laserassisted machining of hard-to-wear white cast iron" Laser-assisted machining has been considered as an alternative for hard-to-wear materials such as metallic alloys and ceramics. This paper presents the results of research conducted on laser-assisted machining of one such hard-to-wear material, high chromium white cast iron, used in making heavy duty mineral processing equipment for the mining industry. Results show that laser-assisted machining causes more frequent shearing of material, less uniform surface formation, and the heat penetration increases as the distance between laser spot and tool increases
Relation of laser parameters in colour marking of stainless steel. P. Laakso et al.	"Relation of laser parameters in color marking of stainless steel". Color marking of stainless steels as a process is known for some time but still it has not been used widely in the industry. Marking quality was evaluated by visual examination. The processing results show that the main limiting factors for producing high quality markings are the pulse energy and pulse peak power. A larger spot size makes it possible to use higher pulse energies still maintaining a feasible intensity on the surface.

Deep engraving of metals for the automotive sector using high average power diode pumped solid state lasers. Arkadiusz J. Antonczak et al	He had investigated the influence of process parameters on the laser induced coloring of titanium. This paper presents the result of the measurement and analysis of influence of laser process parameters of the color obtained. The study was conducted for titanium grade 2 using a industrial pulsed fibre laser. The process parameters like laser power , the scanning speed of material, the temperature of the material, the size of marked area, and the position of sample, relative both the focal plane and centre of working field of the system affecting the repeatability of the color created. The objective assessment of color changes, an optical spectrometer and CIE color difference parameter were used. Based on this analysis , a number of necessary modification are proposed to laser system commonly used for monochrome marking in order to improve repeatability in color marking.
"Rapid and flexible laser marking and engraving of tilted and curved surfaces" Janez Diaci et al.	Rapid and flexible laser marking and engraving of tilted and curved surfaces" Author present a novel method for rapid and flexible laser marking and engraving of tilted, curved and freeform work-piece surfaces. A low power CW laser regime is used to measure the 3D shape of a work-piece surface while a high-peak power- pulsed laser regime is used for processing. This paper discusses key issues concerning an implementation of the method and presents typical examples of markings and engravings. A novel method is presented that allows rapid and flexible laser marking and engraving of tilted, curved and freeform work- piece surfaces. The measurement phase takes typically less than 10 seconds.

Effect of Laser Parameters on Semiconductor Micromachining Using Diode - Pumped Solid-State Lasers" Mingwei Li et al.	Effect of Laser Parameters on Semiconductor Micromachining Using Diode - Pumped Solid-State Lasers" Laser micromachining of semiconductor materials such as silicon and sapphire has attracted more and more attention in recent years. In the current study, two Q-switched and one modelocked diode-pumped solid-state (DPSS) 355 nm lasers have been used to scribe grooves on silicon and sapphire wafer substrates at different pulse widths (10 ns, 32 ns, and 10 ps) and pulse repetition rates (30 kHz, 40 kHz, 50 kHz, and 80 MHz). Experimental results have been compared between different pulse widths, power levels, and pulse repetition rates. It has been found that at the same average power and same repetition rate, the grooves scribed by the longer pulse width laser are deeper, while the shorter pulse width laser produces better quality cuts.
Cutting flexible printed circuit board with A 532NM Q-switched diode pumped solid state laser Matt Henry et al."	Cutting flexible printed circuit board with A 532NM Q-switched diode pumped solid state laser" The authors investigate the high-speed laser cutting of flexible printed circuit boards (PCBs) using a 532nm laser to create features 120mm/s are reported with a high quality kerf It is concluded therefore that a 532nm Q-switched Diode Pumped Solid State Laser can cut Flexible PCB at high speed, with high quality kerfs and minimal thermal input.[10]

Study on Holograms Laser Engraving Process" Mihaiela Iliescu et al	. "Study on Holograms Laser Engraving Process" Holograms and holography become more and more important for nowadays life, specially because of their role in security and protection. Some research results on holograms laser engraving process parameters are evidenced by this paper. Application of holography and holograms is very wide, covering: security and product authentication, packaging - consumer goods brand protection, art and interactive graphics, etc. This paper is a study on hologram marks, more specifically, on hologram laser engraving process parameters. In order to obtain high resolution engraving results low speed, high frequency and small pulse duration of the laser beam should be used
Investigated Co2 laser engraving of stainless steel 304. Mohd Ashraf B. Mohd Fauzan (2008)	He has investigated Co2 laser engraving of stainless steel 304. This research is to study the effect of parameter on the characteristic of the engraving and the width size using conventional C02 laser machine on 304 grade stainless steel. In this study, engraving is done on 304 grade stainless steel that are done using eight experiments that involves eight parameters combination. In this study, process parameters that are identified are assisting gas, gas pressure, cutting speed, focal height and focusing lens. The experiment is done with three replications to have a better result. The work piece is than analyzed and measured using metallurgical microscope. The results are than analyzed qualitatively and quantitatively.

CHAPTER 1:

PROJECT REPORT AT A GLANCE

This chapter covers the laser engraver introduction, design, goals, and a quick description of the project's operation. As a result, with the help of this chapter, the project's primary goal will become evident.

Definition:

The laser marking process is used to engrave permanent marks on different types of materials. In this process, a laser engraving machine vaporizes a specific area of the desired part or material in a given pattern made by lasers, including CO2 or fiber lasers. This results in a high-contrast physical modification of the surface that is easily visible to the naked eye.

Design :

This project aims is a making of CNC based laser engraver based on Fused deposition modelling and IoT integration of 3D printers.

Problem statement : At present there are laser engraver which is too large in size and it is not easily movable. In this project the main motto is to convert large size laser engraver into small scale lab equipment and make it mobile.

Possible Solution :

Small scale laser engraver can be achieved by reducing the dimensioning of the parts and cost can be reduced by using making the mechanical frame by low cost iron.

Block Diagram

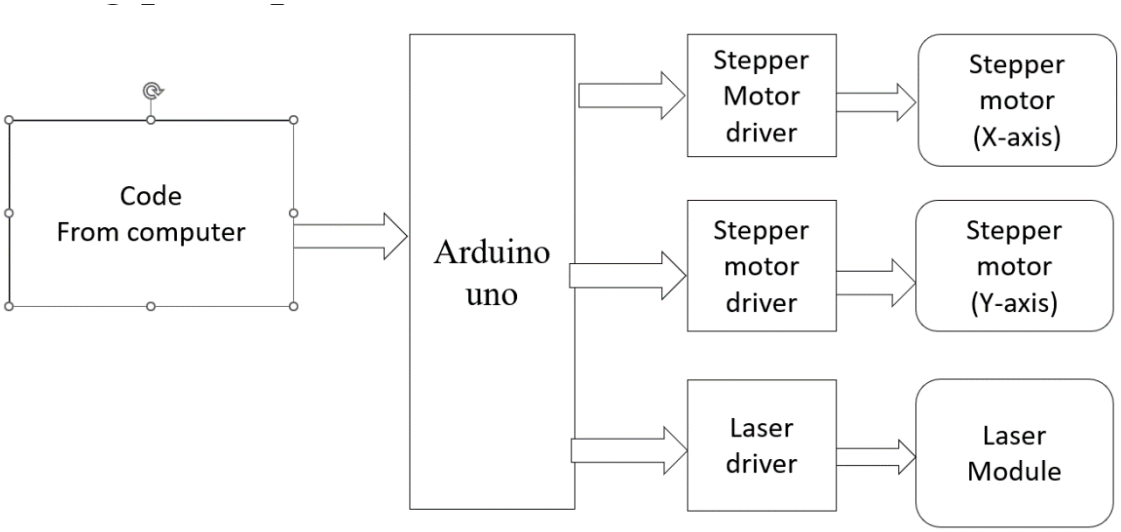

Figure.1 Block diagram of the process flow

This above block diagram describes the basic working of this project.

Circuit Diagram :

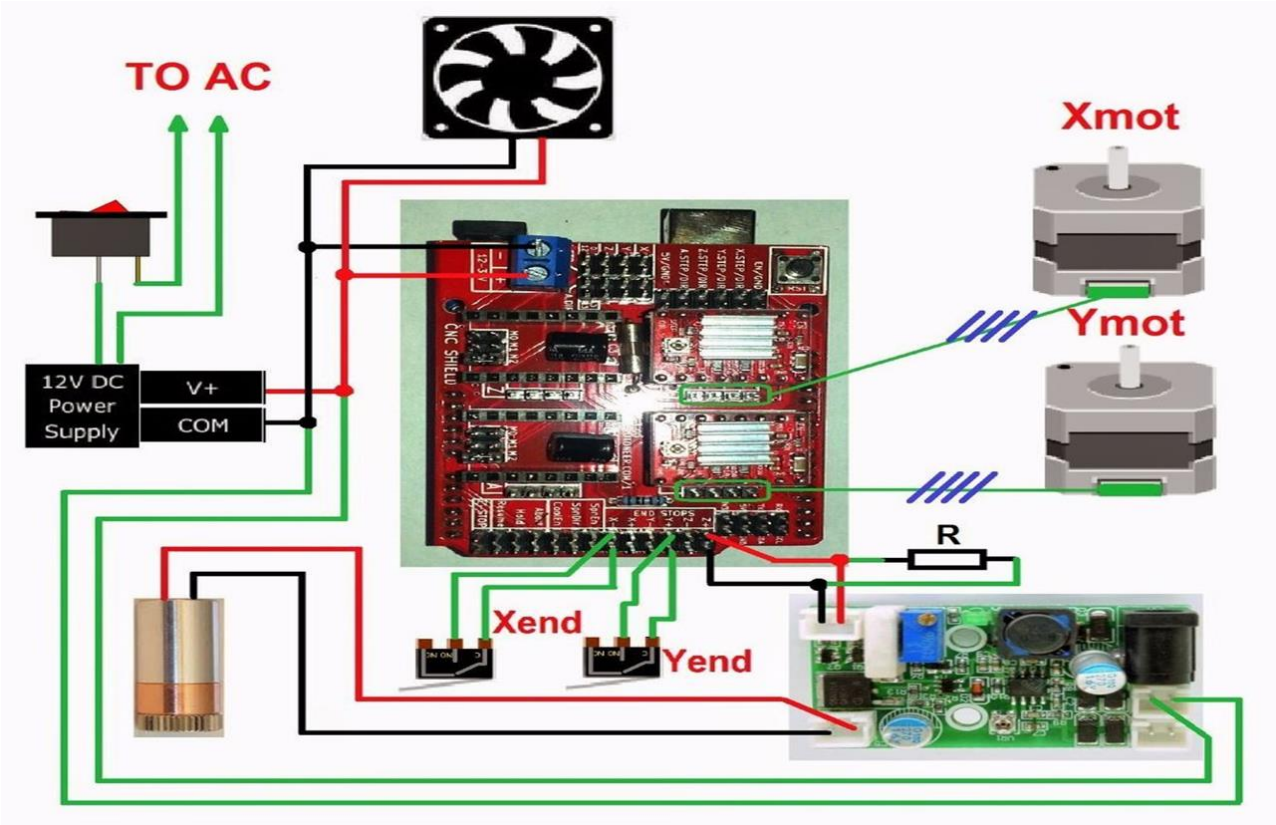

Figure.2 Circuit Diagram

Using CNC shield ,stepper motor drivers ,stepper motors ,limit switch ,power supply connect them as shown in the figure 2.

Using Arduino uno we connect CNC shield in a way that all pins in CNC shield get fitted into the Arduino uno so ,no pins in Arduino are left unconnected

CHAPTER 2:
COMPONENTS USED

Name	Quantity
Arduino uno	1
CNC shield	1
Stepper motor	2
Stepper motor driver	2
Arduino cable	1
Limit switch	2
Power supply	1
Relay module	1
Laser driver	1
Male and female jumper wires	30
Laser module	1/

This chapter contains a description of the many parts that were utilised to create the 3D printer.

Arduino uno

Arduino uno has 20 pins, which are

1. Digital pins

   There are 14 digital pins.

   There are used to read the data from other components.

   In Arduino there are numbered from 1to 14.

2. Analog pins

   There are total 6 analog pins.

   There are used only to read 0 and 1.

   In Arduino they are numbered from A0 to A5.

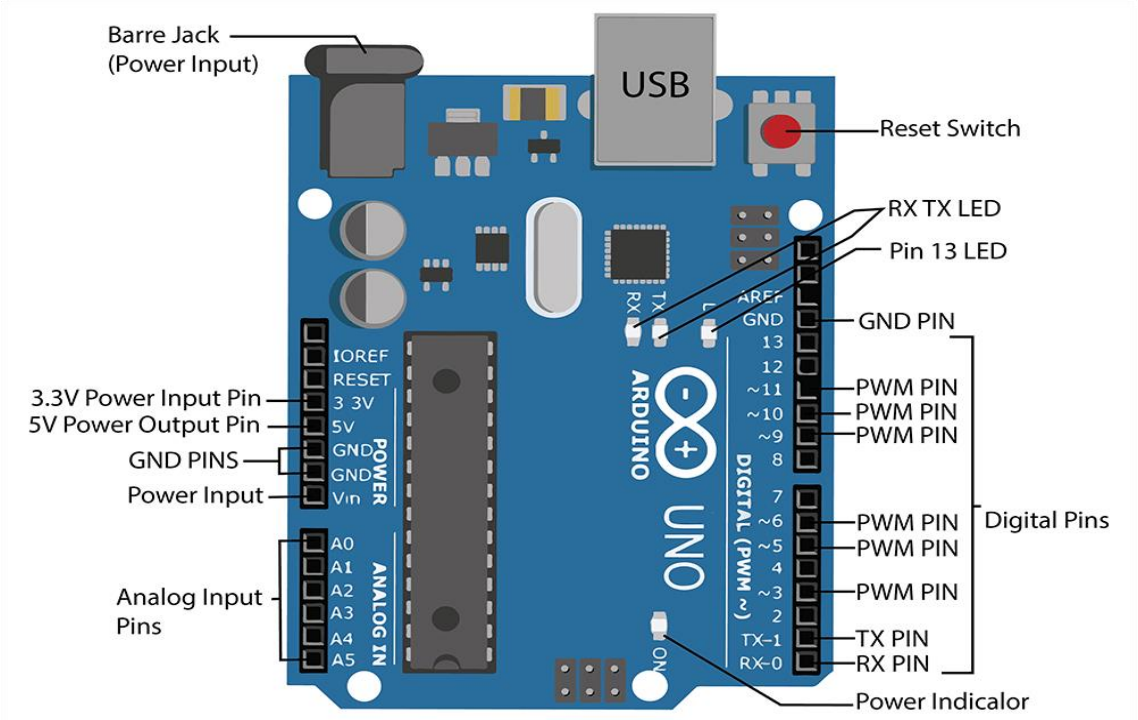

Figure.3 Arduino uno

II. CNC shield

- This CNC shield is designed to allow you to control a stepper motor from an Arduino board.
- It contains 4 driver sockets which allows compatible Pololu A4988/DRV8825 driver modules to be inserted providing the ability to drive 3 stepper motor axis (X,Y, & Z).
- CNC shield can take maximum voltage of 35v.

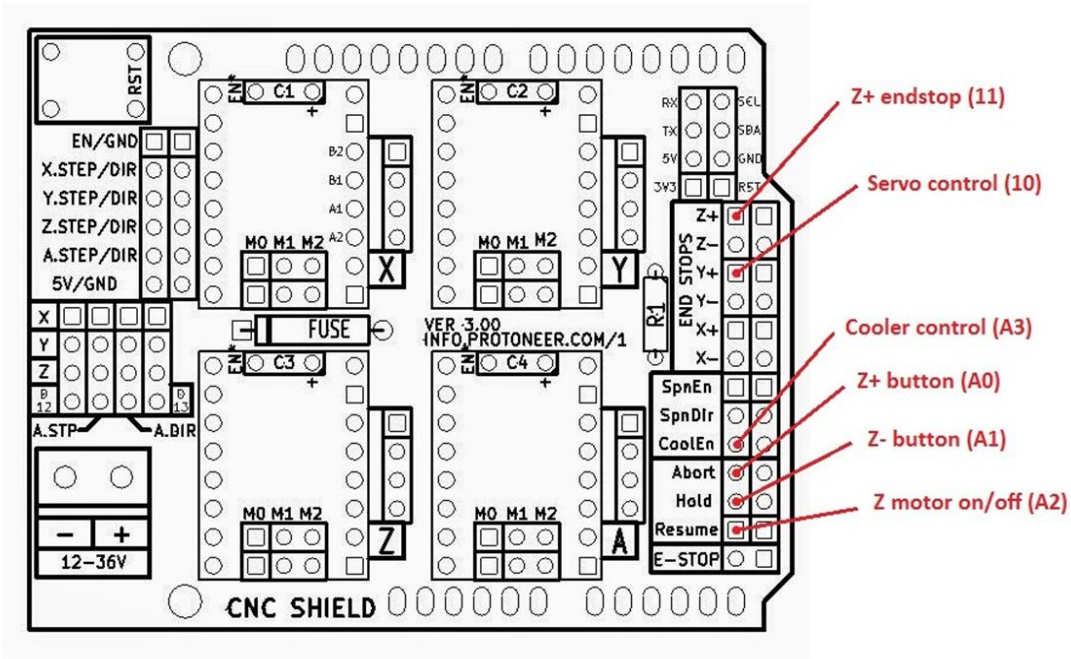

Figure.4 CNC shield

III. Stepper motor Driver A4988

- There are 9 types of stepper motors drivers (A4988,DRV8825,DRV8834..)
- The stepper motor driver are used for noise less operation of stepper motors.
- Stepper motor drivers are used to reduce resonance.

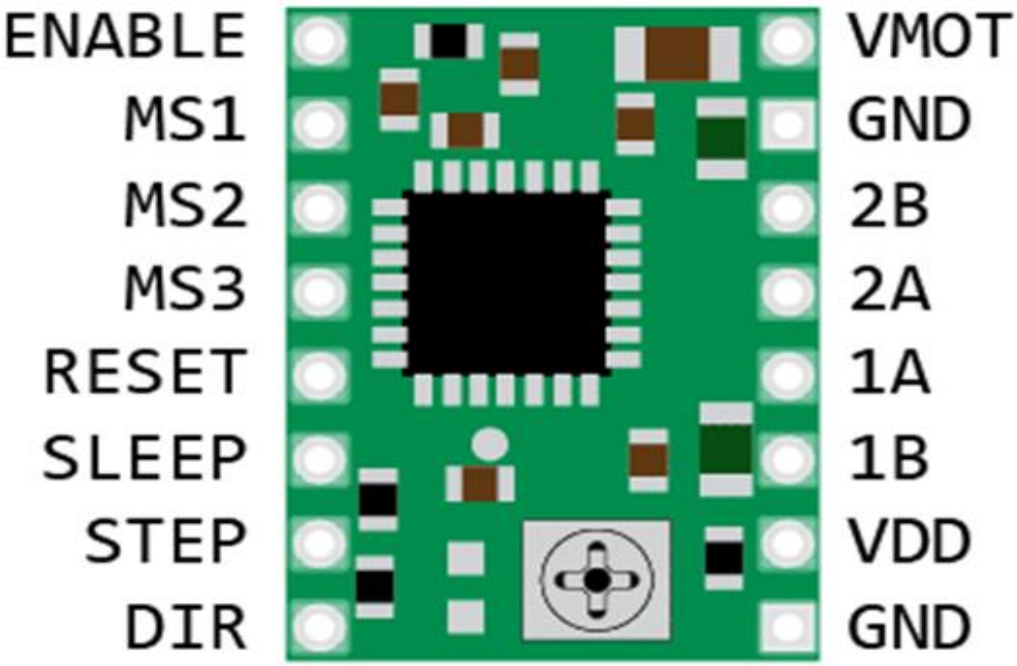

Figure.5 Driver A4988

IV. Relay module

- Relay modules (or power relay modules) are ubiquitous electronic components.
- They are an exceedingly significant component of any home automation project.
- You will require a relay module if you use a low voltage microcontroller such as an Arduino to control motors or lighting circuits.

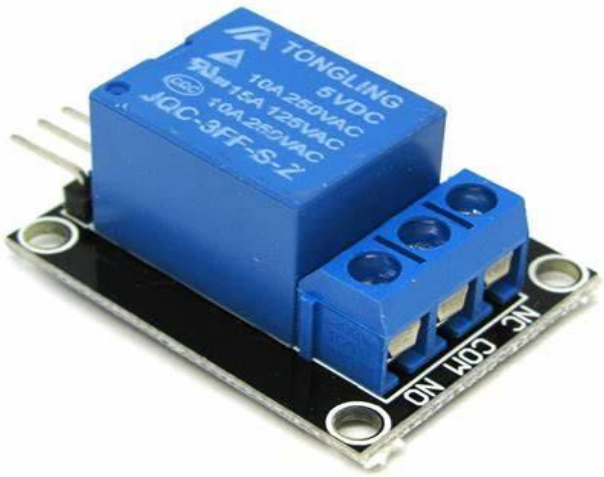

Figure.6 Relay module

V. Stepper motor

- NEMA17 Stepper Motor is commonly used in CNC machines, Hard Drives and Linear Actuators.
- The motor have 6 lead wires and rated voltage is 12 volt.
- It can be operated at lower voltage but torque will drop.
- These motors run on 12V and hence can provide high torque.

Figure.7 Stepper motor

VI. Power supply(AC to DC converter)

A power supply is used by SMPS, an electronic power supply system, to efficiently transmit electrical power. It is a PSU (power supply unit), and computers often utilise one to adjust the voltage to the right range for the machine.

Power Supply transforms a 240V AC source into a 12V-5A DC source. This power source is directly supplied to the extension shield's input, which is used by all of the 3D printers' components.

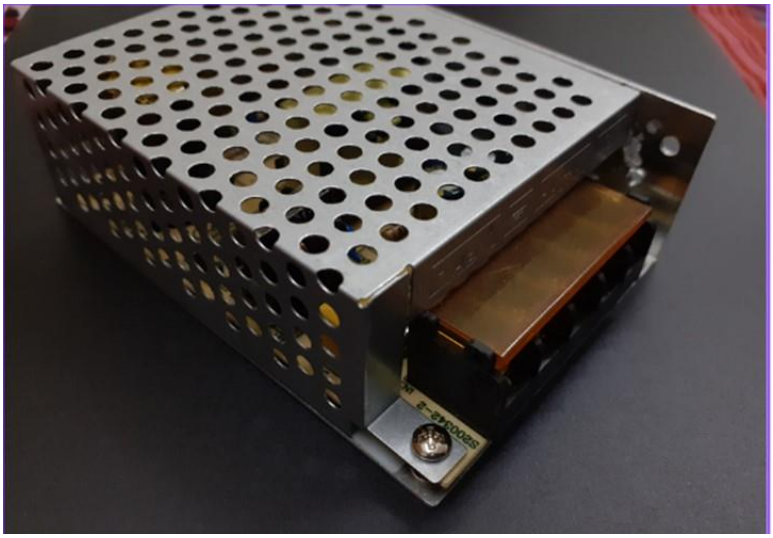

Figure.8 Power supply

VII. Limit switch

On 3D printers, the heated bed serves as a semi-warm surface where the early layers can fuse together and preserve strength and hardness. For excellent print quality and consistent layer adhesion throughout the process, heat beds are required. They function by maintaining the extruded material's ideal temperature. It is helpful in that it raises the surface temperature to a specific level so that print adheres more effectively.

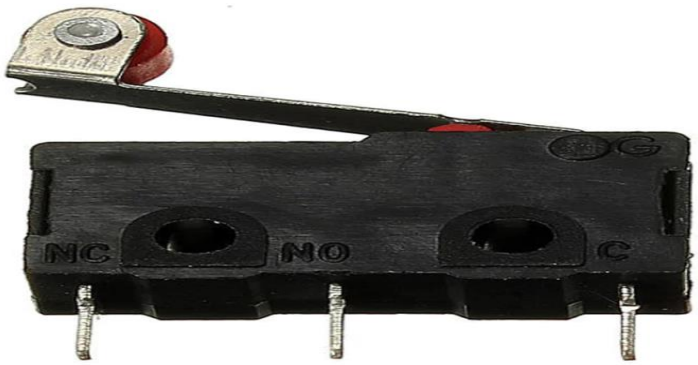

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Fig No 9 Limit switch

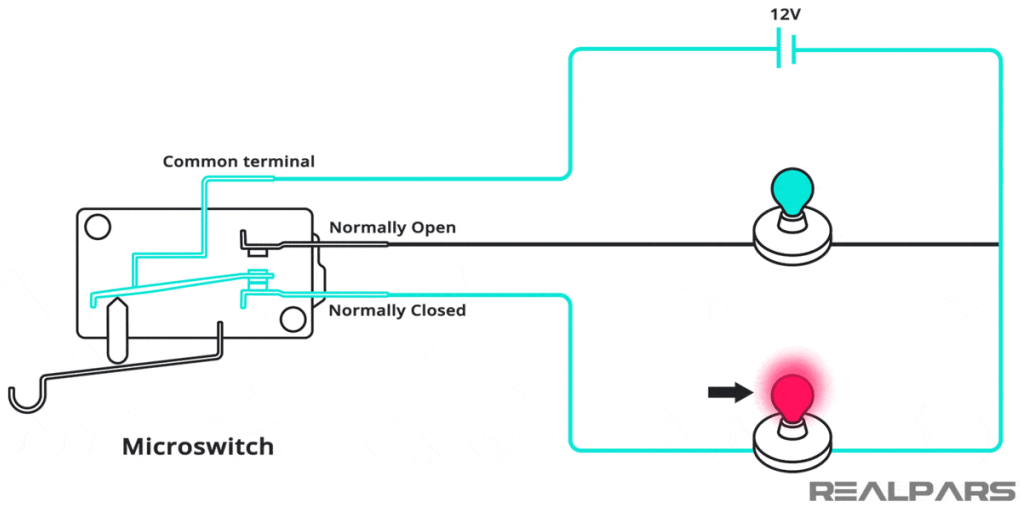


Fig No 10 Working of limit switch

CHAPTER 3:

SOFTWARE INFORMATION

I. RDworks v8

- *RDWorks is a powerful program that allows you to perform laser cutting engraving operations.*
- *The program has support for drawing points, lines (horizontal/vertical), polyline, ellipse/circle, rectangular/square, Bezier curve, text, and for CAD models such as DXF, AI and PLT.*

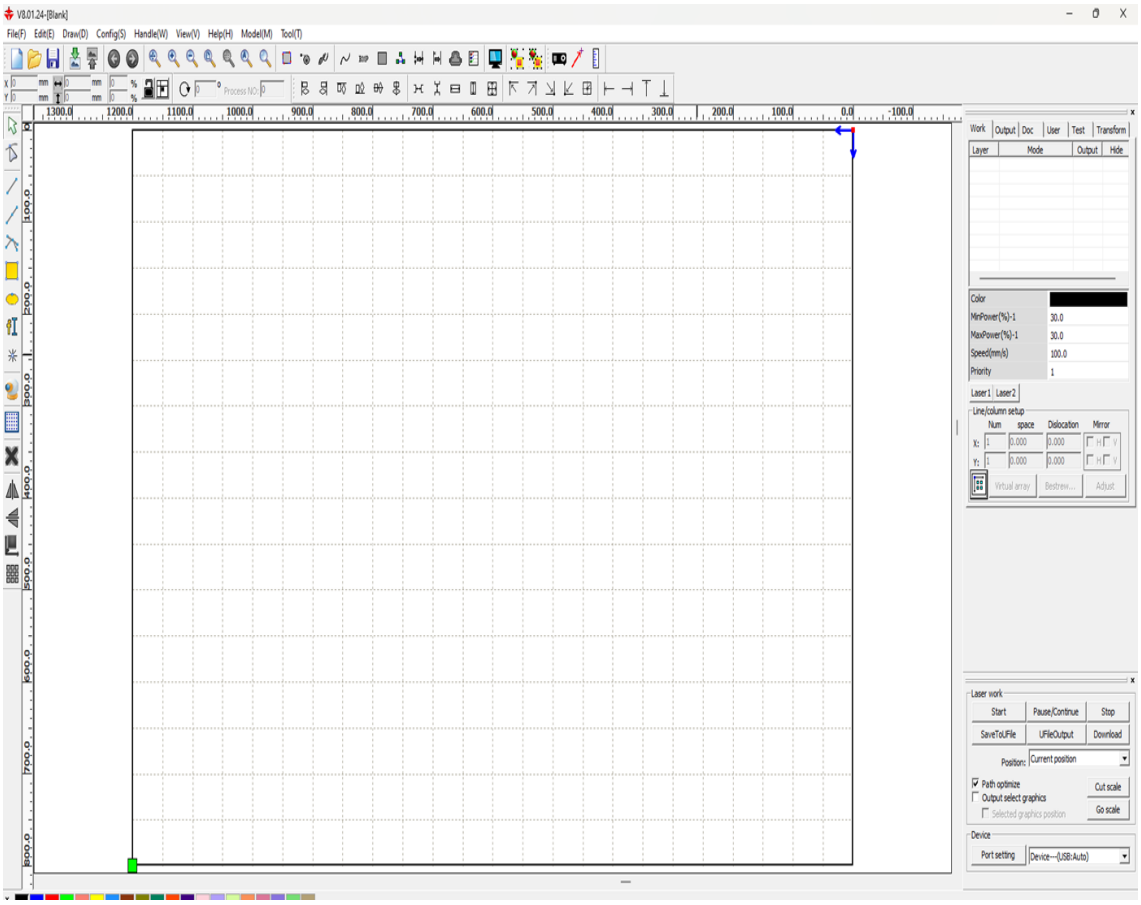
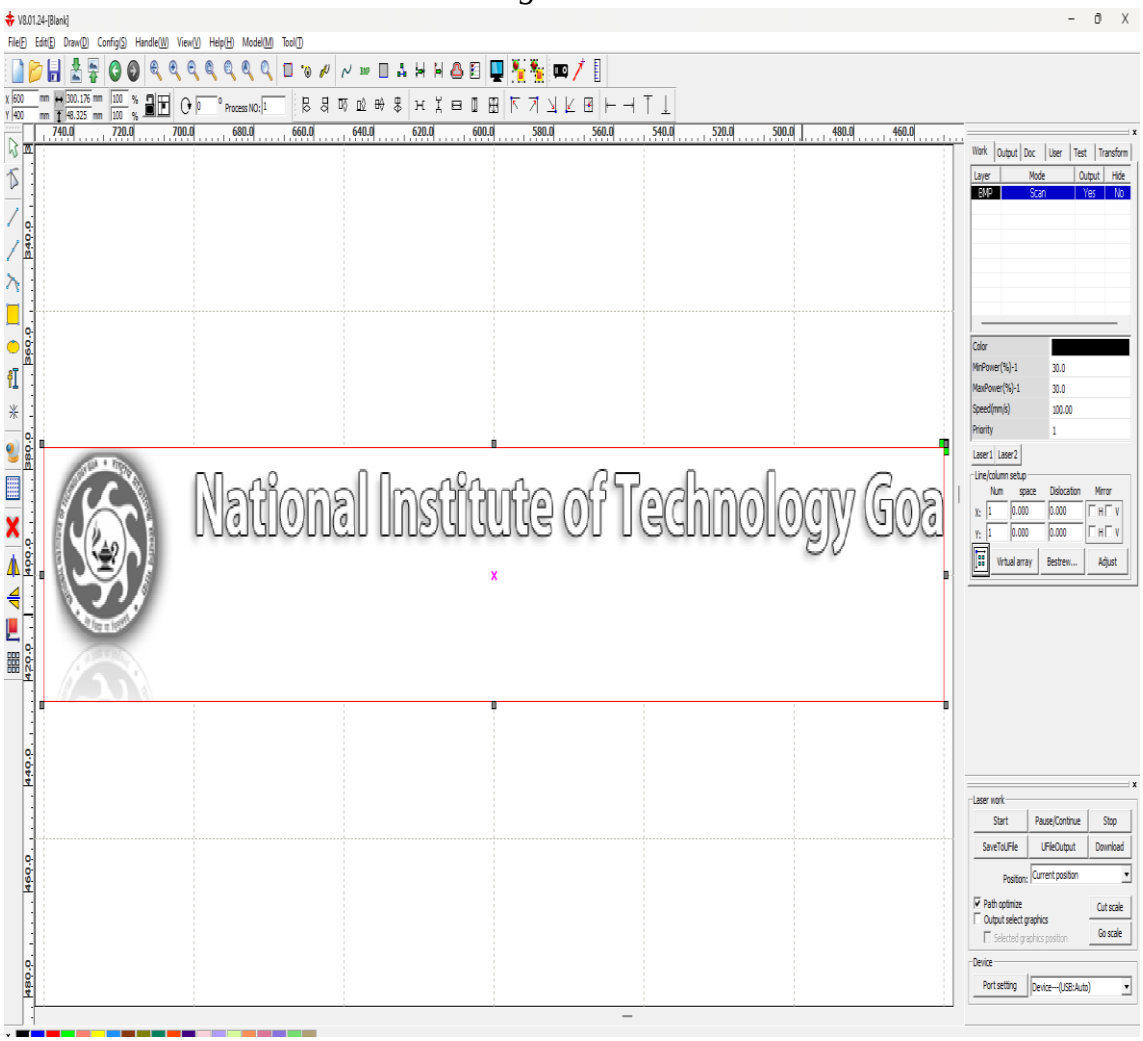


Fig No 11- Interface of RDworks V8

Figure.13



Home Screen

Figure.12 Before engraving Rd works software

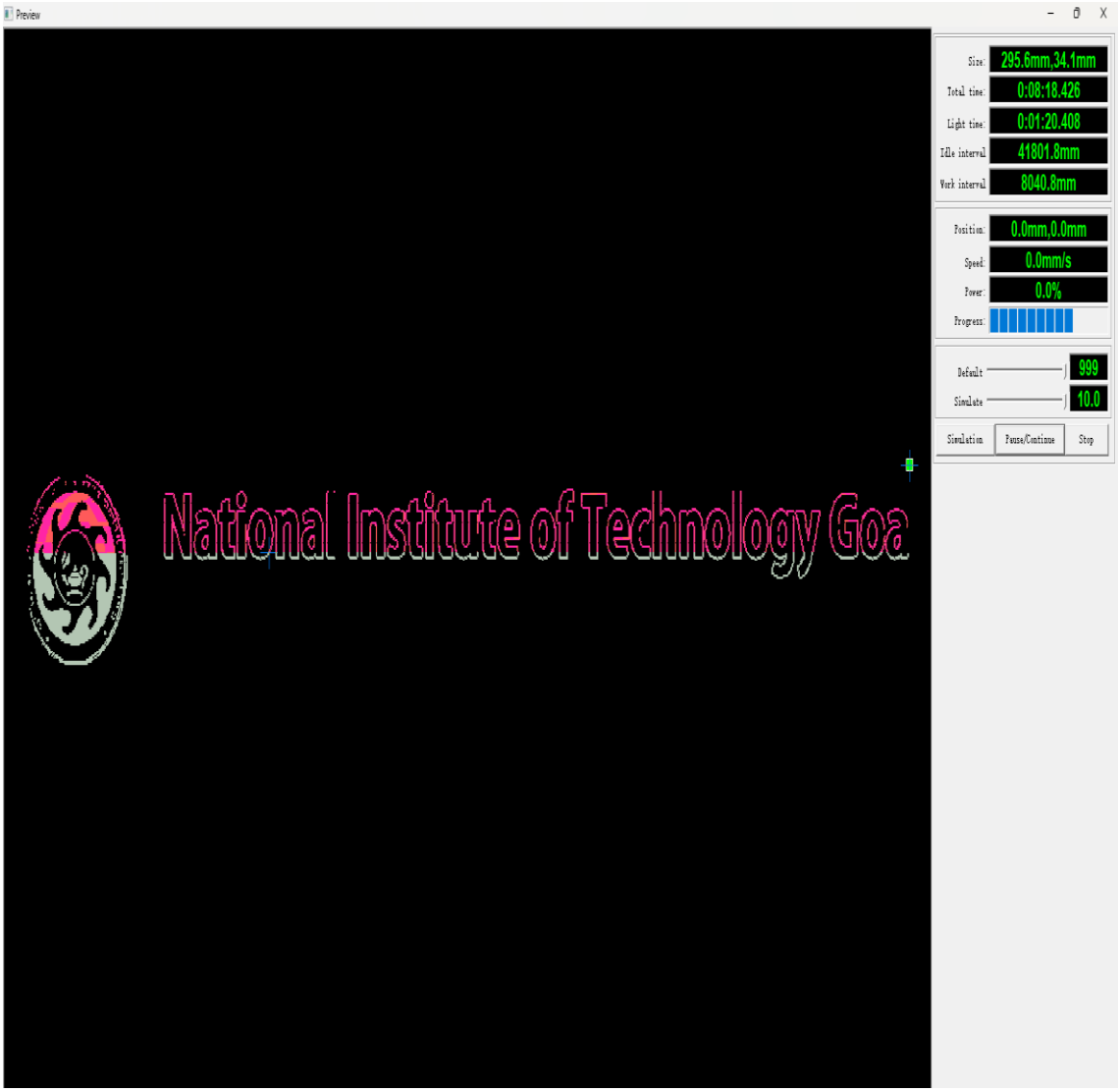


Fig No13 - Engraving process

Solidworks model

Fig No –14 Solidworks model view1

Fig No -15 Solidworks model view 2

Summary & Conclusion

Making three-dimensional solid products from a digital file is known as 3D printing or additive manufacturing. The use of additive techniques results in the production of 3D-printed objects. By adding materials one at a time until the desired item is formed, an additive process creates an object. Each of these layers may be thought of as a cross-section of the item that has been lightly cut.

Fused deposition modelling, a 3D printing technique, has been employed in this project. Based on this technique, we created the model. We created the model and then integrated it to the Internet of Things (IoT). For this IoT integration, we are creating an app and software.

The filaments that we are using for making end products are made up of plastics. It is polylactide(PLA) plastic.

We are building a 3D printer. It is based on the 3D printing technique known as fused deposition modelling. We will incorporate this 3D printer with IoT. As of right now, we have purchased every component required to make a 3D printer. Stepper motor, extruder, SMPS, hot end, and fan testing were completed successfully. Wireframes for the Android 3D printer app have been developed by us.

PROGRESS TILL NOW

- ☐ Literature Review
- ☐ Purchased parts and testing
- ☐ Assembling of all parts
- ☐ Creating Software Design

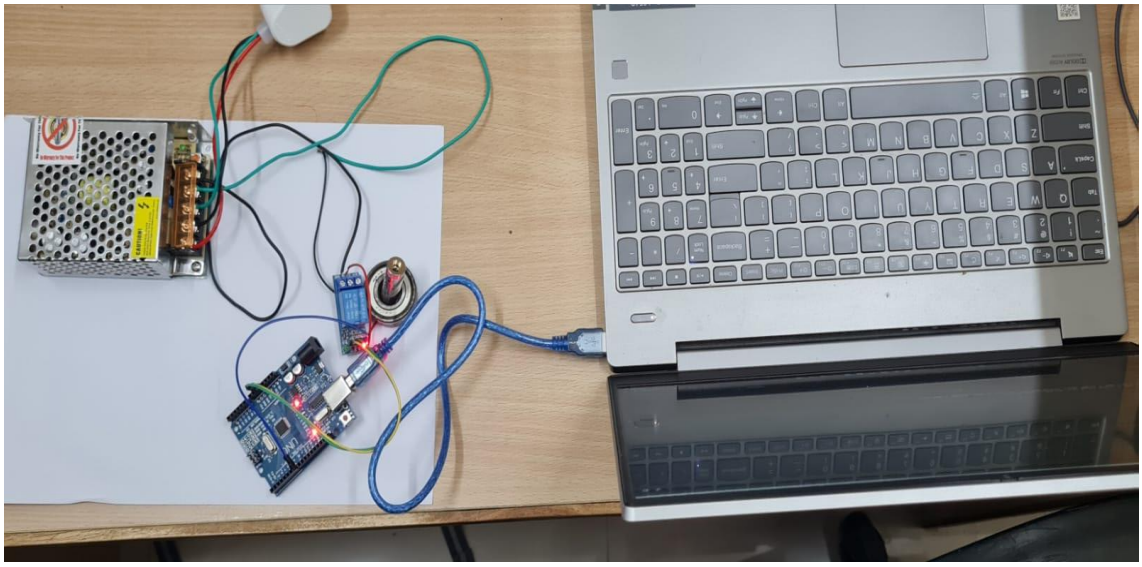


Figure.18 3D printer

FUTURE WORK

- ☐ Connecting all electrical parts
- ☐ Making mechanical frame
- ☐ Thesis preparation
- ☐ Engraving a 2D shape on wood

f

SCOPE FOR FUTURE WORK

Present design can be modified in various ways as there is no end to innovation. The most important aspect to be worked upon is the control of laser movement, from manual to automatic or input to be feed from modelling software. This will help to achieve accuracy and increase the usefulness of the machine. As laser cutting is an exothermic process, a lot of heat is generated during the process so to reduce the heat a cooling system should be introduced to decapitate the heat produced. It was seen during the experiments that long working on laser causes the diode to stop working so better laser diode should be used. As there is no end to this modification, as need is felt the improvement work is carried on.

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