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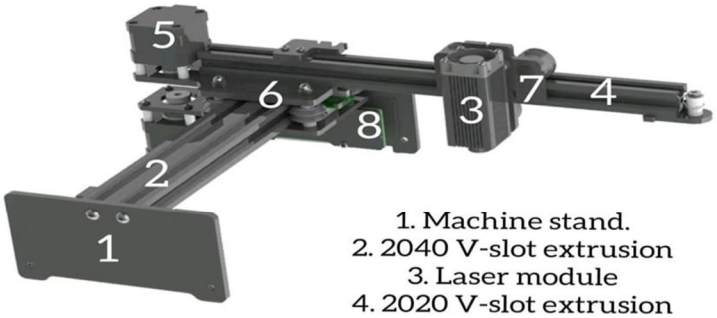
Design and Fabrication of Laser Engraving Machine

T. Gopala Rao[1], N. Naveen[2], Y. Phaleendra Kumar[3], K. J. S. C. Bose[4], G. Gopalakrishna[5]
[1]*Assistant Professor, Department of Mechanical Engineering, Amrita Sai Institute of Science and Technology, Paritala, A.P. India*
[2, 3, 4, 5]*UG Students, Department of Mechanical Engineering, Amrita Sai Institute of Science and Technology, Paritala, A.P. India*

Abstract: ***Nowadays technology is increasing rapidly, because the implementation of CNC system in industries and educations is exponentially increasing but at high cost. The main aim of our project is to design and fabrication of laser engraving machine. The proposed setup has been applied to Glass Fibber Reinforced Plastic [GFRP] composites, plastics, wood, cardboard, etc.., to yield desired profile, contour, information and various drawing. Moreover, this setup has high precision and processing efficiency. This technique involves colour change of the surface due to thermal energy emerged by the laser beam. The simulation of this machine is done using Laser GRBL software.***
Keywords: GFRP, GRBL software, laser diode, CNC.

I. INTRODUCTION

Laser (Light Amplification by Stimulated Emission of Radiation) is a device that generates high intensity light in the form of laser beam. Basically, in LASER engraving, the laser beam burns the top layer of the surface to be engraved. The burnt area is left uncoloured, which makes it appear different from the surrounding surface. In the laser engraving process, a laser beam physically removes the surface of the material to expose a cavity that reveals an image when looked at it. During the engraving process, the laser beam creates high heat, which essentially causes the material to vaporize. This creates a cavity in the surface of the material (Wood, cardboard, etc.) that is noticeable and used for cutting the papers as per the profile created by the laser beam movement. Several passes are to be done to get deeper marks during the engraving process.



II. LITERATURE REVIEW

Lee, J., Park, J., & Kim, H. (2020) he has explored the use of open-source software in laser engravers and found that these systems offer flexibility and customization options that proprietary systems do not. Open-source platforms such as *Laser-GRBL* and *Light-Burn*are widely used in hobbyist-grade systems and provide users with full control over engraving parameters, including laser speed, power, resolution, and image processing.

Powell, J. (2017)., he studied the laser engraving market is expected to grow significantly, driven by the increasing use of laser engraving in various industries such as aerospace, automotive, and consumer electronics. These industries require precise and customizable engraving for parts, labels, and designs, creating an increasing demand for affordable and efficient laser engraving solutions

Zhang, Y., Wang, X., Liu, J., & Zhang, H. (2016). , he has highlighted the use of CO2 lasers in non-metallic engraving, noting that the wavelength of CO2 lasers (10.6 microns) is ideal for engraving materials such as wood, acrylic, glass, and certain plastics. However, when used for engraving metals, the CO2 laser often faces challenges due to its inability to effectively focus on metallic surfaces. This limitation is overcome by Fiber lasers, which have shorter wavelengths (typically around 1.06 microns) and can effectively engrave metals, including stainless steel and aluminium.

Steen, W. M., & Mazumder, J. (2010) has focused on laser shielding and fume extraction technologies to protect users. Shielding mechanisms are essential to prevent direct exposure to the laser beam, and the use of enclosures or glass shields ensures that the laser does not escape the designated work area. Furthermore, proper ventilation and fume extraction systems are necessary to eliminate harmful fumes produced during engraving, especially when working with materials like acrylic or PVC, which release toxic gases when burned.

Berns, M. W., & Stinson, D. (2004). , he has examined the impact of stepper motors and servo motors on the performance of laser engraving machines. The study found that stepper motors, though cost-effective and widely used in smaller systems, suffer from issues such as low torque and mechanical backlash, which can result in less accurate engravings. Conversely, servo motors offer more precise control and higher torque but come with a higher cost. To mitigate these issues, many modern laser engravers utilize high-precision linear guide rails and ball screws that improve the smoothness and accuracy of the engraving process.

III. DESIGN SPECIFICATIONS

Project Name	Laser Engraver
Laser Source	Semiconductor Laser
Size of the Project	420*315*145mm
Max Engraving Area	170*200mm
Laser Wave Length	450-5nm
Light Power	1.6W
Power Required	DC 12V, 3A
Software Operating System	Windows XP above
Operating Temperature Range	0°C to 35°C
File Formats	jpeg/jpg/png/bmp/svg
Software	Creality Laser, Laser GRBL, Light Bum
Testing Capable Materials	Paper, Cardboard, Wood, Plastic, Leather, Rubber.

IV. ENGRAVING PROCESS

The machine moves the laser in left to right, like a printer, following paths for outlines. The laser burns or vaporizes the material, creating the engraved effect. The depth and darkness of engraving depend on the laser intensity and speed.

1) First of all, install the software give all the necessary permissions to install the GRBL software.
2) And after Successful installation open the GRBL Software and connect the laptop to the machine by using a USB cable, and then connect the Laser Engraving machine to the power Supply Unit as shown in Above Figure.
3) After Opening the Laser GRBL application and a new work bench will open as below shown figure.
4) And there on the top left corner we will find file click on the file to select the image which we want to engrave.

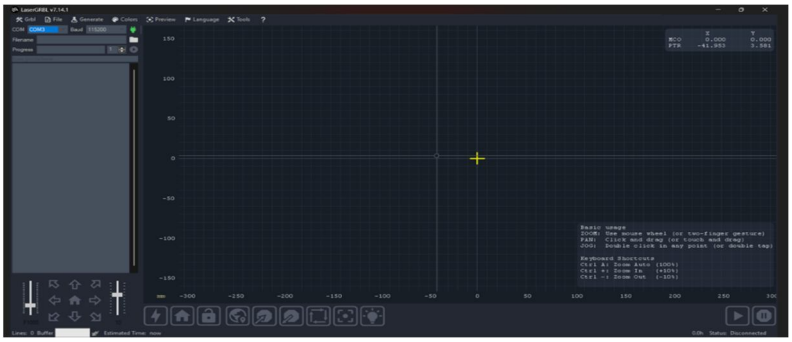


Fig Opening the GRBL Software

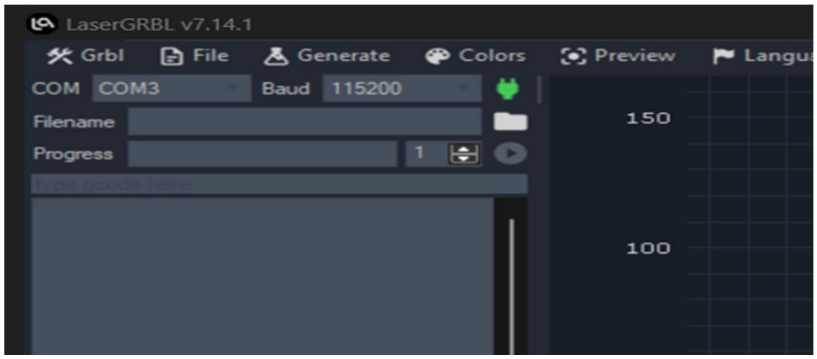


Fig Loading the File

5) And there on the top left corner we will find file click on the file.
6) And then a small display box will open as shown below as
   Open file
   Append file
   Reload File
   Quick save
   Save (Advanced options) etc…….
   Here we select open file

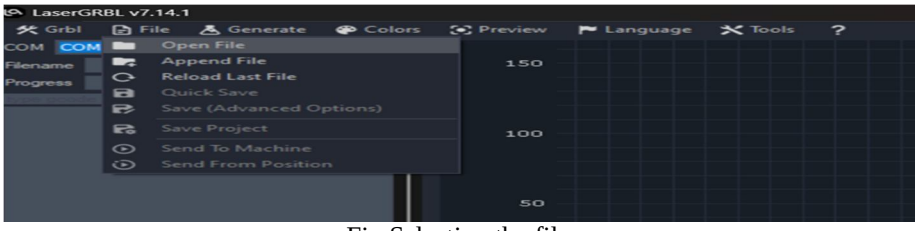


Fig Selecting the file

7) And after selecting new file a new dialogue box will open; there we will select the required design image file and open that files which we want to engrave on a specified part.

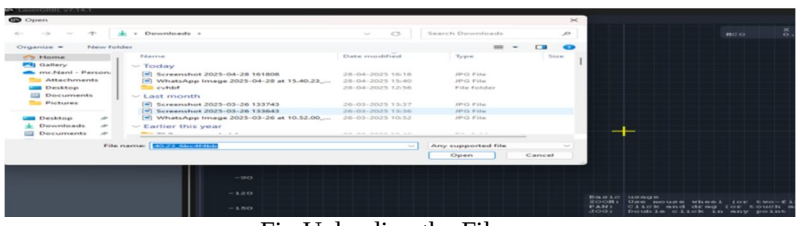


Fig Uploading the File

8) And after selecting the file and opening it a preface will open and enabled to edit the engrave properties before we start the engraving as shown in below figure.

9) Here we select the following properties as per our requirement and the need:

- Brightness
- Contrast
- White Clip
- Black and white (B&W)

And select the Conversion tool i.e.

- Line to Line tracing
- 1 bit BW Dithering
- Vectorial
- Centreline
- Pass through

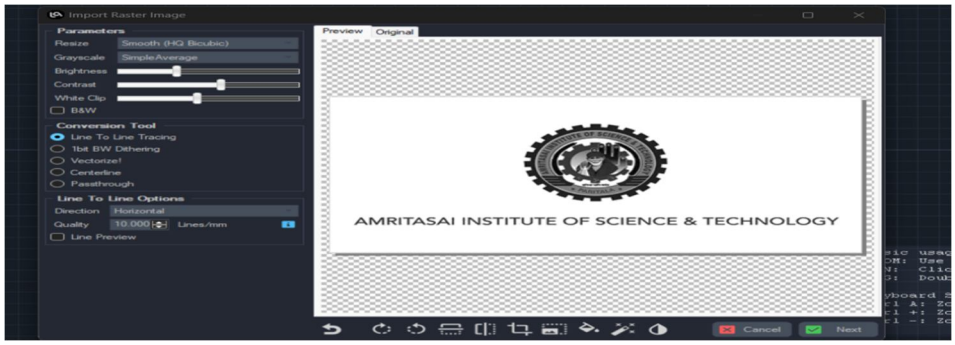


Fig: preview of file

10) Here we select Line to Line tracing.

11) And select the direction and Quality according to the Size and the type of material which is being under engraving.

Quality 10 lines/mm
Direction Horizontal
Brightness- As per Requirement
Contrast- As per Requirement
White Clip- As per Requirement
And place the material on which we want to engrave under the laser diode as shown in the figure:

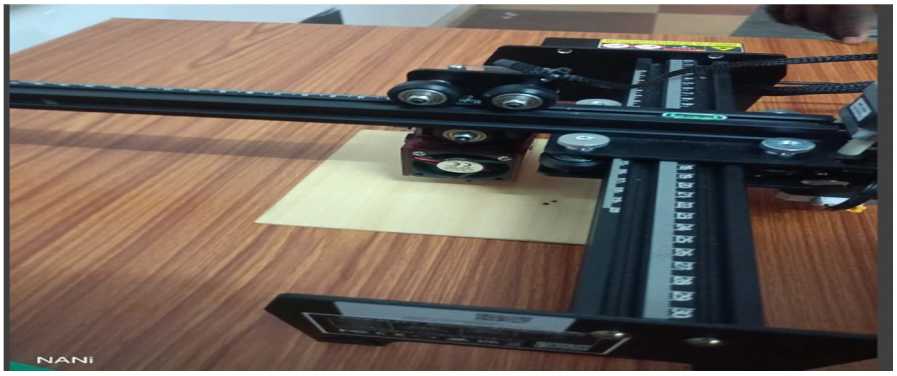


Fig: Material Loading

12) And adjust the height of the laser diode by using an adjusting screw as required thickness of the material to suitable height as shown in below figure:

Fig: Height Adjusting

13) And then click on the next option and a new Target Image dialogue box will open like this.

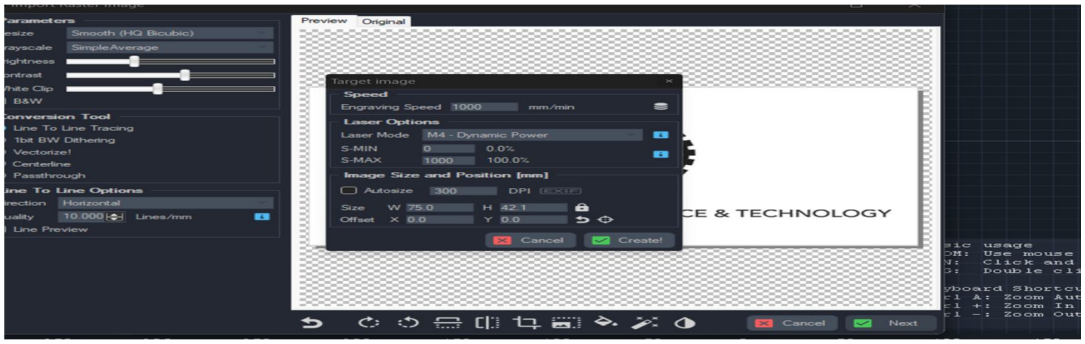


Fig: Pre Image-Settings

14) Here we can give the process parameters like:

- Engraving speed
- Laser Mode:
  - (a) Dynamic power
  - (b) Constant power
- Quality (lines per one mm)
- S-min
- S-max
- Size
- Offset

15) And then finally start the process by clicking next so that the engraving process will be done on the required material according to our given design and parameters.

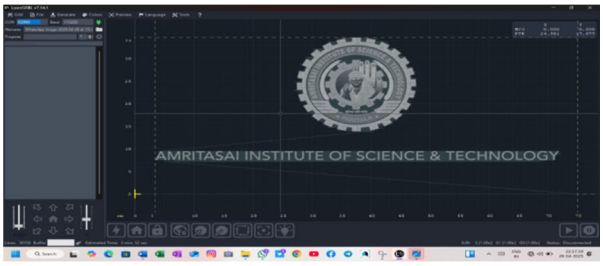


Fig: Engraving Started

- Here we can check framing once to verify that the laser module movement from starting to ending is within the object surface so that it did not over travel.
- And finally start the process of engraving and the Engraving will be done like this.

Fig Engraving in Progress

And the Input image is engraved on the given component.

Post-Processing

The engraved surface may be cleaned using a cloth, brush, or air blower to remove debris. Some materials may need additional finishing, such as polishing or sealing. Post-processing for laser engraving involves cleaning and finishing the engraved surface to enhance its appearance, protect it, and ensure its longevity. This includes removing debris, applying finishes like stains or sealants, and addressing any residue from the laser engraving process.

Removing debris:

After laser engraving, it's crucial to remove any residue or debris left behind by the process, ensuring a clean and polished finish.

Cleaning methods:

For wood, this might involve brushing off loose debris or wiping with a damp cloth. For plastic and acrylic, mild cleaners can be used to remove smoke residue, followed by a clean, dry cloth.

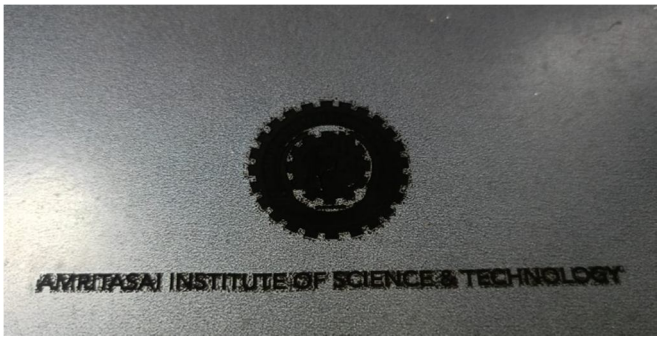
Finishing:

Wood finishes: Various finishes can enhance the appearance and protect wood from wear and tear.
Stains: Can be applied to create different colour and visual effects.
Varnish: Adds a protective coating and enhances the wood's natural appearance.
Sealants: Help protect against moisture, UV damage, and general wear and tear.
Oils: Tung oil, linseed oil, Danish oil, and mineral oil offer different levels of protection and aesthetic appeal.

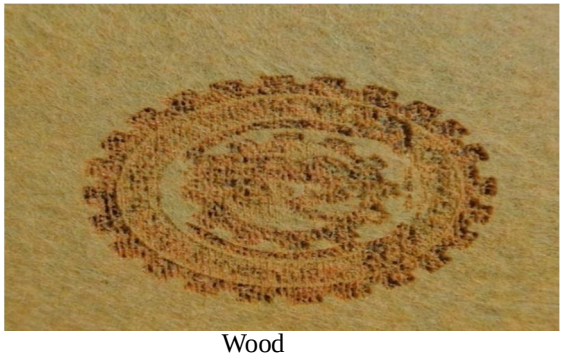
V.RESULTS

There are different materials are used to engrave by using CNC diode engraving machine as shown in below figures

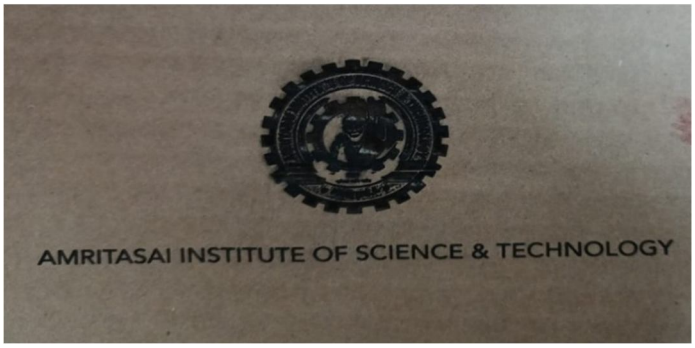
Mild sheet



G-I SHEET



Wood



paper

The following Table Shows the Parameters of Engraving Process While Performing on the Different Materials:

MATERIAL	SPEED (mm/min)	QUALITY (LINES/mm)	TIMES
GI SHEET	1000	10	1
PLASTIC	800	10	1
WOOD	800	10	1
Metal	500	15	1

VI. CONCLUSION

The laser engraving machine project successfully demonstrated the capabilities of laser technology in engraving different materials with precision and efficiency. Through systematic experimentation, the project identified the optimal settings for various materials, ensuring high-quality engravings with minimal errors

VII. FUTURE SCOPE

Using higher resolution settings for detailed images.
Experimenting with different engraving techniques (e.g., 3D engraving).
Exploring new materials like ceramics or coated metals.
Integrating colour marking for metals using fiber lasers

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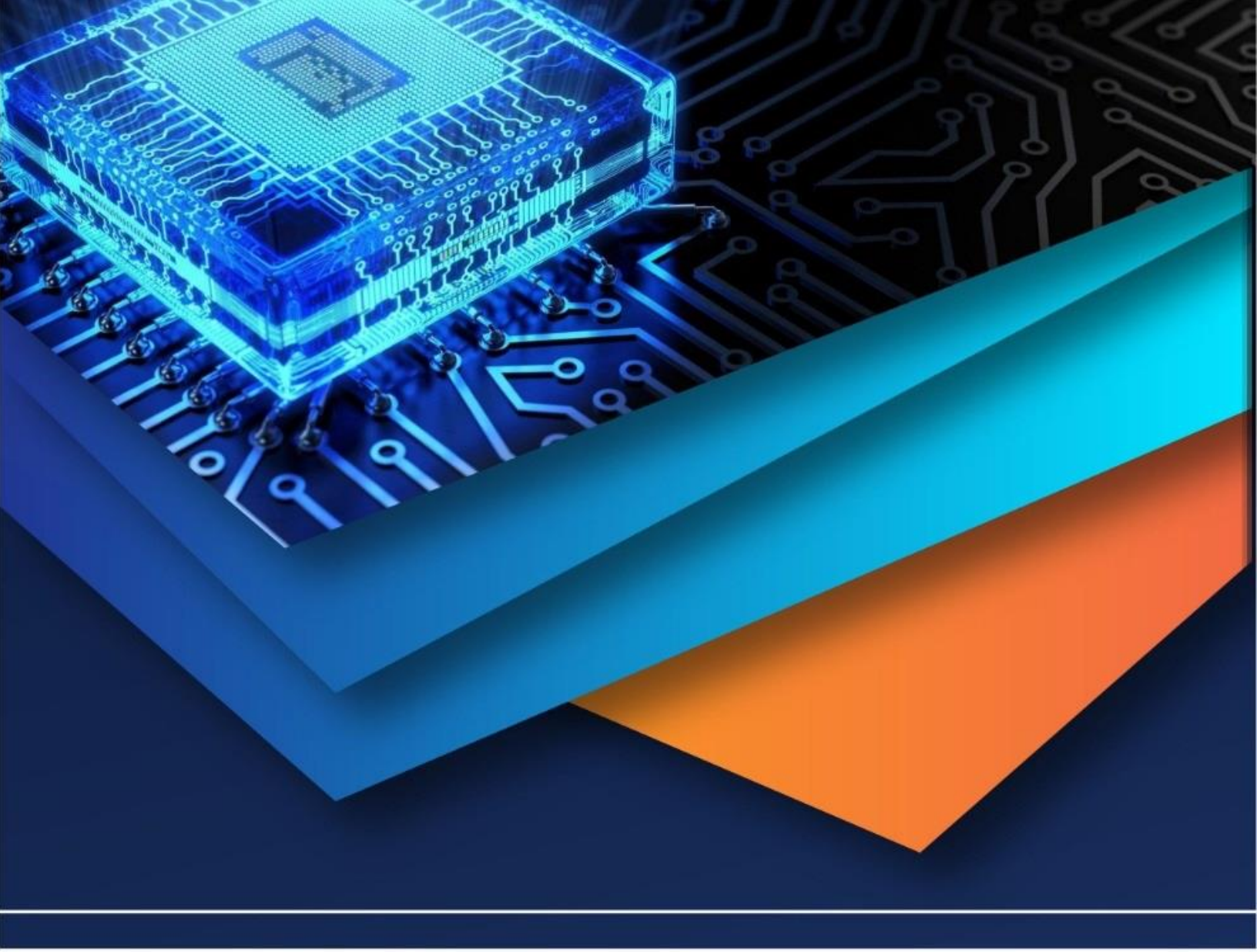

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