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3d Building Model Printing

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Abstract: This is a paper on 3D building model printing which has become a new technology for developing 3D model. In this paper discussed on the detailing of the 3D printer types and developing model procedure of one of the type of Additive manufacturing type that is Ultimaker 2+.
Keywords: 3D printing, Additive Manufacturing, Stereolithography, Cura, G-code

I. INTRODUCTION

Additive Manufacturing (AM), commonly known as 3D printing, is defined as "A process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies." [1] 3D printers have been used in many fields like Medicine, Engineering, Construction, Aerospace, Dental, Industrial Design, consumer Products, jewelry, Footwear, etc. It derives from the field of rapid prototyping, developed during the late 1980s and 90s. 3D printing is one automated process that could reduce our carbon footprint and cost of construction. It could increase labor safety and efficiency and drastically reduce time to build. [2]

II. WHAT IS 3D PRINTING?

3D printing is an additive manufacturing technology through which 3 dimensional models can be created by layering successive layers of material. These models can be created via 3D printers which range from many different sizes and purposes.

The main principle of 3D printing is stereolithography, outlined by Charles Hull in a 1984 patent as "a system for generating three-dimensional objects by making a cross-sectional pattern of the object to be formed." [2]

III. HISTORY OF 3D PRINTING

Hideo Kodama of Nayoga Municipal Industrial Research Institute is generally regarded to have printed the first solid object from a digital design. However, the credit for the first 3D printer generally goes to Charles Hull, who in 1984 designed it while working for the company he founded, 3D Systems Corp.

Charles Hull was a pioneer of the solid imaging process known as stereo lithography and the STL (stereo lithographic) file format which is still the most widely used format used today in 3D printing. He is also regarded to have started commercial rapid prototyping that was concurrent with his development of 3D printing. He initially used photopolymers heated by ultraviolet light to achieve the melting and solidification effect. [3]

IV. 3D PRINTER

Although most 3D printers are expensive, recently there has been a steep decline in the prices of 3D printers. This has led to it going from being a niche industry novelty to a hobbyist's item. There are many affordable 3D printers that are available for much less than they are worth, if we take all its production capabilities into account. Companies have also realized the potential of a consumer market for 3D printers and as such have been aggressively courting enthusiasts with cheaper and better models. There are many communities formed around these enthusiast groups which are active on the internet set up to share projects and ideas and new possibilities. One of the most popular is known as RepRap. Its goal is to produce a free and open-source hardware (FOSH) 3D printer licensed under GNU Public License. These printers are also intended to be capable of replicating itself printing many of its own plastic parts to create more machines. [3]

V. TYPES OF 3D PRINTER

A. SLS- Selective Laser Sintering

Selective laser sintering is an additive manufacturing technique that uses a high power laser (for example, a carbon dioxide laser) to fuse small particles of plastic, metal (direct metal laser sintering), ceramic, or glass powders into a mass that has a desired three-dimensional shape. SLS technology is in wide use around the world due to its ability to easily make very complex geometries directly from digital CAD data.

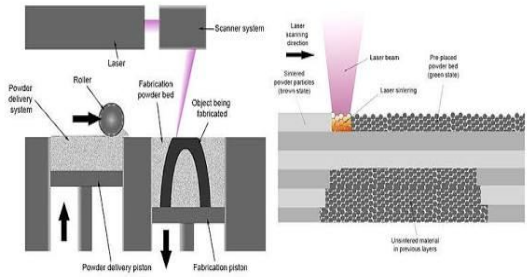

Figure 1: Selective Laser Sintering

B. SLA – Stereolithography

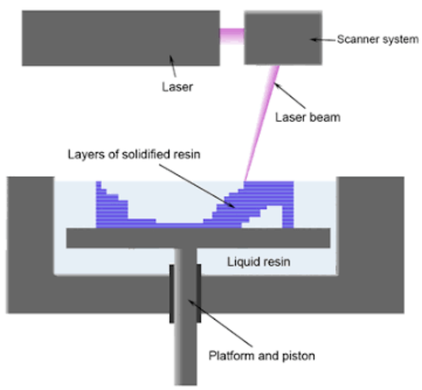

Figure 2: Stereolithography

Stereolithography is an additive manufacturing process which employs a vat of liquid ultraviolet curable photopolymer "resin" and an ultraviolet laser to build parts' layers one at a time. Stereolithography requires the use of supporting structures which serve to attach the part to the elevator platform, prevent deflection due to gravity and hold the cross sections in place so that they resist lateral pressure from the re-coater blade.

C. FDM – Fused Deposition Modelling

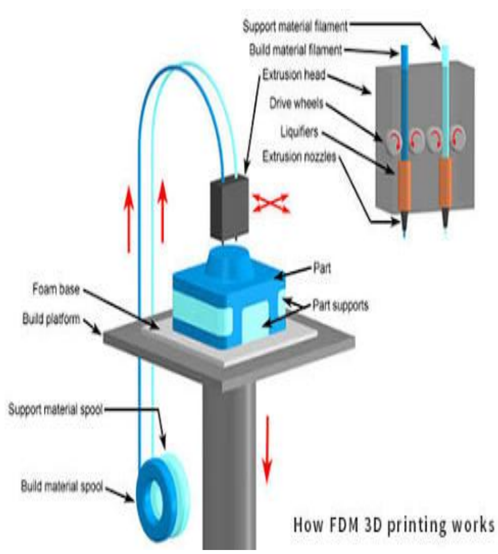

Figure 3: Fused Deposition Modelling

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Fused Deposition Modelling, is an additive manufacturing technology commonly used for modelling, prototyping, and production applications. The term Fused Deposition modelling™ and its abbreviation FDM™ are trademarks of Stratasys Ltd. Fused Filament Fabrication (FFF) is equivalent to Fused Deposition Modelling (FDM) and is used by the rest of the world.

FDM, a prominent form of rapid prototyping, is used for prototyping and rapid manufacturing. Rapid prototyping facilitates iterative testing, and for very short runs, rapid manufacturing can be a relatively inexpensive alternative. [4]

VI. FUSED DEPOSITION MODELLING (FDM)

A. General Mechanism of Fused Deposition Modelling (FDM)

In order to create a complex physical object from a digital set of instructions, many mechanical systems must work together to get the job done correctly. In addition to these mechanical systems, software used to control the nozzle temperature, motor speeds & direction, and methods in which the printer lays out the material are equally important to create a highly accurate model.

The nozzle in a 3D printer has one of the most important jobs of all the mechanical systems. It is the last mechanical device that is used to build up a 3D object and its design and functionality is extremely important when it comes to the accuracy and build quality of the printer. The nozzle size used on many 3D printers is 0.4mm.

This size is small enough to produce high quality parts while maintaining reasonable build times. Depending on the over-all goal of the part being printed however, these nozzles can be changed to larger diameters in order to increase the speed of the print job. It is important to never set the layer height higher than the the nozzle size. For example, if a 3D printer is using a 0.6mm nozzle, then the maximum layer height should not exceed 0.5mm. While the nozzle is used to direct molten plastics in a precise manner, its other job is to convert the solid coil of plastic material into the molten state by utilizing a heating element within the extruder assembly. In addition to the heating element, there is usually a thermistor (temperature sensor) integrated into the extruder assembly to control the required temperature for the specific material being used.

For example, one of the most common materials used in FDM is PLA (poly-lactic acid) which has a melting temperature of around 160 degrees Celsius. It is very important to use the correct extrusion temperature in order to minimize the risk of the nozzle jamming and also maximize the bond between bead layers. The design of the extruder is very important to not only the printing accuracy, but also to the overall performance and maintenance of the printer.

While the bottom end of the extruder must be able to heat the material to a desired temperature within a few degrees, the upper end must remain as cool as possible in order to avoid jamming.

This is due to the feed mechanism located above the extruder, which requires the filament material to be in a completely solid state in order to function properly. De-pending on the type of model being printed, and the type of material being used, a heated bed may be important to maintain the structure's shape while it cools. Since plastics shrink as they cool, a quick temperature drop could cause the corners of a part to curl up off of the printer bed.

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PRINTER AND PRINTING PROPERTIES	
Print technology	Fused Filament Fabrication (FFF)
Print head	Swappable nozzle
Build volume	223 x 223 x 205 mm
Filament diameter	2.85 mm
Layer resolution	0.25 mm nozzle: 150 to 60 micron 0.4 mm nozzle: 200 to 20 micron 0.6 mm nozzle: 400 to 20 micron 0.8 mm nozzle: 600 to 20 micron
X, Y, Z accuracy	12.5, 12.5, 5 micron
Print head travel speed	30 to 300 mm/s
Extrusion speed	0.25 mm nozzle: up to 8 mm3/s 0.4 mm nozzle: up to 16 mm3/s 0.6 mm nozzle: up to 23 mm3/s 0.8 mm nozzle: up to 24 mm3/s
Build plate	Heated glass build plate (20° to 100° C)
Supported materials	PLA, ABS, CPE, CPE+, PC, Nylon, TPU 95A (Open Filament System)*
Nozzle diameter	0.25, 0.4, 0.6, 0.8 mm
Nozzle temperature	180° to 260° C
Build plate temperature	50° to 100° C
Nozzle heat up time	~ 1 minute
Build plate heat up time	< 4 minutes
Average operating sound	50 dBA
File transfer	Standalone 3D printing from SD card
Build plate leveling	Manual, assisted leveling process
*Ultimaker printers can be used with third party filament. However for the best printing results we recommend you use Ultimaker PLA, ABS or CPE.	

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There are many factors that contribute to the build quality of a 3D printed part. As mentioned previously, the extruder assembly which includes the extruder, heating element, & nozzle contribute greatly to the overall build quality. [5]

VII. ULTIMAKER

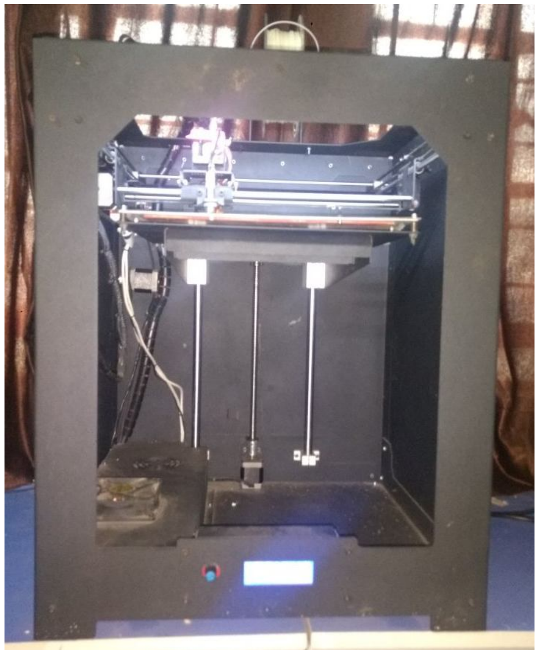

Figure 4: Ultimaker 2+

There are various types of FDM printers like Big-Rep, Baam, Prusa, Drag, Felix, Ultimaker, Kossel, Polar 3D, etc.[9] Ultimaker is one of the type of FDM printer which we used for printing Ultimaker 3D printers are designed and built for fused deposition modeling for various high quality plastics like PLA, ABS, and CPE within a commercial/business environment. The mixture of precision and speed makes the Ultimaker 3D printers the perfect machines for concept models, functional prototypes and also the production of small series. Although we achieved a very high standard in the reproduction of 3D models with the usage of Cura, the user remains responsible to qualify and validate the application of the printed object for its intended use. While being an open filament platform the best results will be achieved with Ultimaker certified filament, while effort has been made in order to match material properties with machine settings. [6]

A. Specifications Of Ultimaker 2+ 3d Printer

PHYSICAL DIMENSIONS	
Dimensions (excluding bowden tube and spoolholder)	357 x 342 x 388 mm
Dimensions (including bowden tube and spoolholder)	493 x 342 x 588 mm
Nett weight	11.3 kg
Shipping weight	18.5 kg

POWER REQUIREMENTS	
Input	100 - 240 V 4 A, 50 - 60 Hz 221 W max.
Output	24 V DC, 9.2 A

AMBIENT CONDITIONS	
Operating ambient temperature	15° to 32° C
Nonoperating temperature	0° to 32° C

SOFTWARE	
Print preparation	Cura - Official Ultimaker Software (free)
Supported OS	(prepared for nozzle size selection) Mac OS X, Windows, Linux
Supported file types	STL, OBJ, DAE

B. Procedure Of 3d Printing

1) First the Revit file is converted into a STL format by using STL converter.

2) STL file : It is also called Standard Tessellation Language. There are other types of files, but the STL file is the standard for every additive manufacturing process. The slicing process introduces inaccuracy to the file because here the algorithm replaces the continuous contour with discrete stair steps. To reduce this inaccuracy, the technique for a feature that has a small radius in relation to the dimension of the part is to create STL files separately and to combine them later. The dimension in *z* direction should be designed to have a multiple of the layer thickness value. [8]

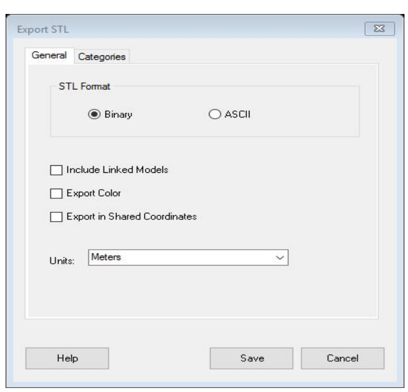

Figure 5: Export Revit File into STL file format

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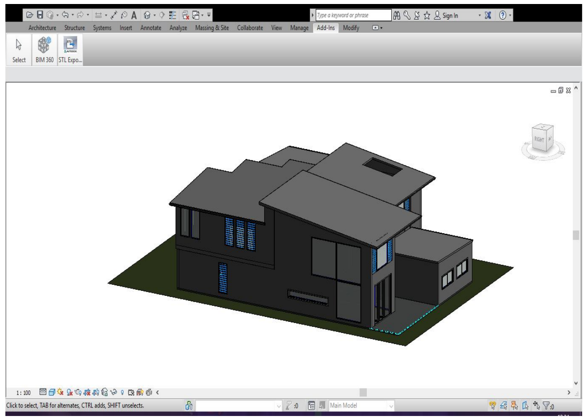

Figure 6: *STL Plug-ins*

3) Then this STL file is open into a CURA software which is support to the Ultimaker 2+ printer which we used.

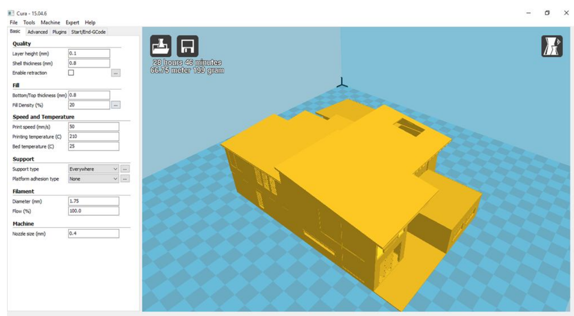

Figure 7: STL file in cura

Cura prepares the model for printing. Cura is slicing software for 3D printers. It accepts a digital 3D model, typically in the STL format, as input. It computes the tool path that the print head (s) need to take to print the model.It emits the instructions to the printer, in the Gcode format, to a file. [9] code is a language that humans used to tell a machine how to do something with the 3D printing, g-code contains commands to move parts within the printer. G-code consist of G- and M-commands that have an assigned movement or action. [6] For printing it is very important that the first layer is nicely squished into the glass plate and sticks well. If the distance between the nozzle and build plate is too big, your print will not stick properly to the glass plate. On the other hand, if the nozzle is too close to the build plate, it can prevent the filament from extruding from the nozzle. To get the correct distance between the build plate and the nozzle, you need to level the build plate. You must do that before using the Ulitmaker 2+ for the first time and then periodically. Always re-level the build plate when you notice that the plastic is not equally placed on the glass plate. After transportation of your Ultimaker 2+, it is also advised to re-level the build plate to ensure your 3D prints stick well to the build plate. [7]

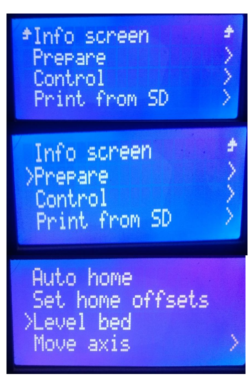

Figure 8: Prepare Bed Level

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4) Set the Z offset from control-Motion- Z Offset

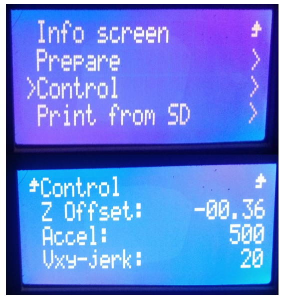

Figure 9: Set Z-offset

5) Store and load the setting memory: control-store memory- load memory

Figure 10: Store Memory

6) Select the file for printing from SD card i.e. Print from SD card- Select file

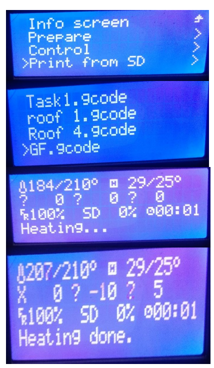

Figure 11: Select file for printing

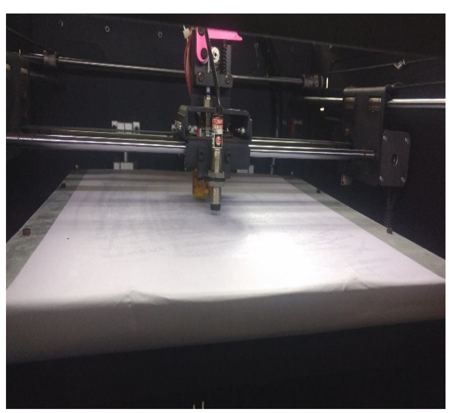

Figure 12a: Initial Stage of printing

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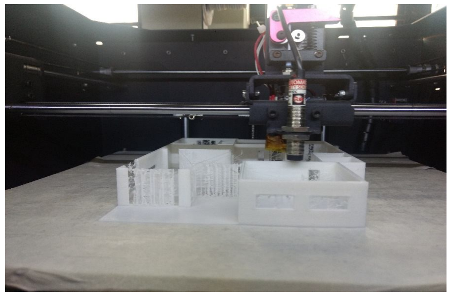

Figure 12b: During Printing

7) After Completion of Printing, Model will be done as like given below

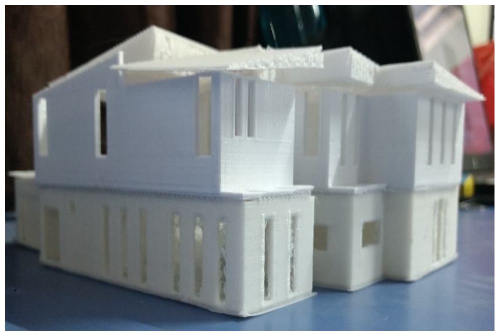

Figure 48: 3D Building model after printing

VIII. CONCLUSION

The 3D printers can save up to 40% of the designer's time in making 3D models. 3D printing reduces the financial costs of 3D models. Greater details can easily be created with the help of 3D printers.3D printers are easy to use. Complex assemblies could be made by 3D printers that are actually hard or even impossible to make by hand. The limited materials are one of the most important issues in 3D printing. -Currently, 3D printers only manufacture products out of plastic, resin, certain metals, and ceramics. 3D printing of products in mixed materials and technology, such as circuit boards, are still under development. The size of the 3D-printed model is also an issue - Currently, 3D printers are limited with the size of the products that they can create. Certain and limited sizes of models can be formed by 3D printers make it hard sometimes to print a whole 3D model at once.

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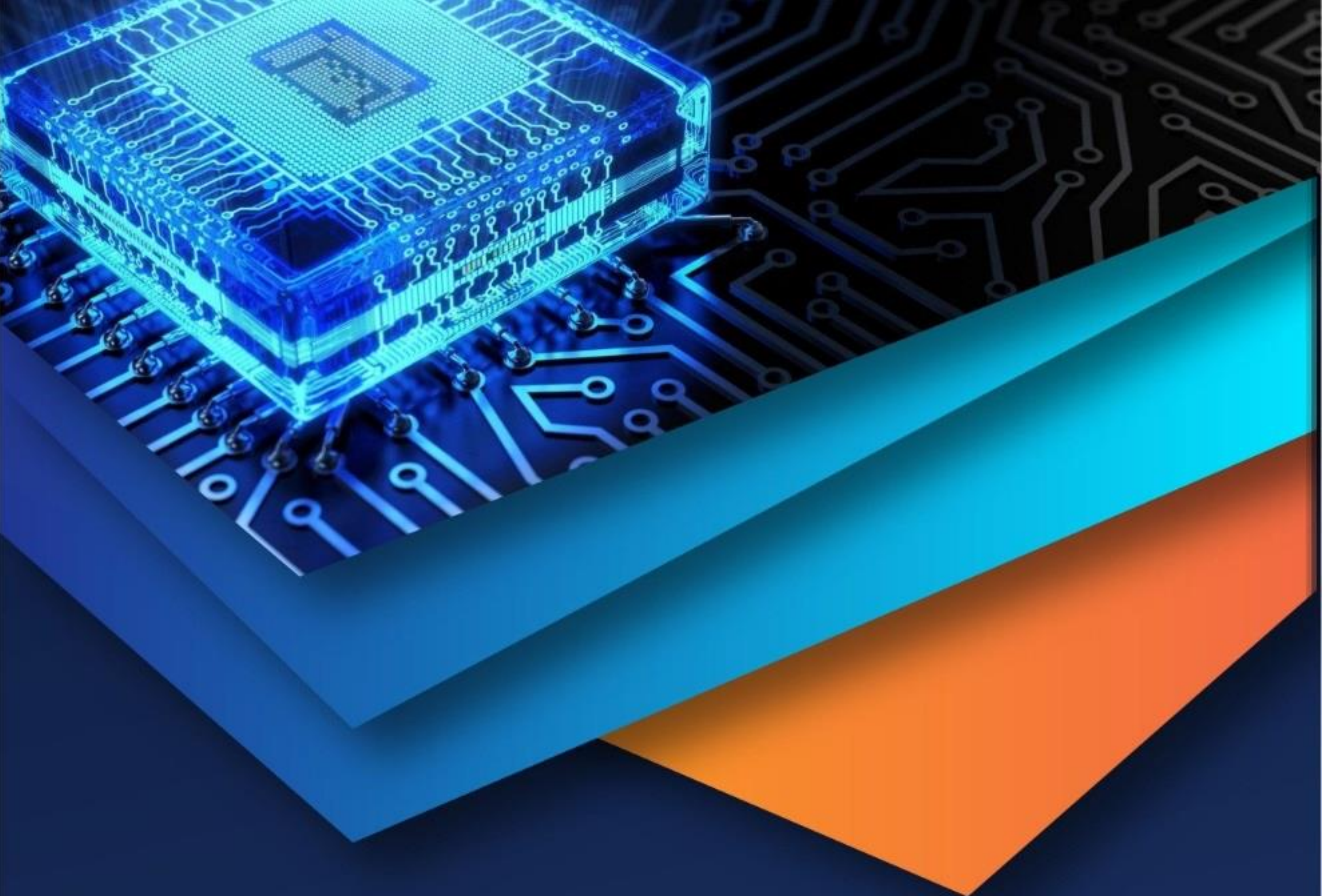

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