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# Review on Design and Development of IOT Based Food Storage System and Quality Parameters Analysis of Tomato

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***Abstract:*** ***Now a day's people are getting more advanced using different technology for making their life a comfortable one. We can see rapid advancement in technology in the world. People of this generation busy with their personal life. Due to their busy life schedule they cannot go to the market for again and again in a week. They want for storing the foods like fruit and vegetables for a period of time in a bulk. The features of the system are equipped with IOT based technology and controlled by mobile phone. It maintains a control level of temperature. This is called a smart container. Because the temperature inside the system is control by its shelf. The foods are getting spoiled after some months because the humidity and temperature is the main physical quantity that is caused for spoiling of foods. So if we control the environment in a short system then the lifespan of food will increase. But to check the quality of food we had made an experiment to find the pH and titratable acidity.***

***Keywords*****: *IOT based food storage system, Temperature, humidity, controlled environment***

## I. INTRODUCTION

### *A. Requirement of IOT Based Food Storage System*

Food is a basic need of human beings. In today's scenario peoples are getting more advanced technique and applied it in their personal life. They are busy with their personal work so they can't go to the market again and again to buy some foods. Rice is the important food of human. But after rice,fruits and vegetables also their favorite food. So if someone buys some fruits and vegetables for a short period of time around 7days or else 15days he or she wants to store. If we stored the fruits and vegetables gets degrade after some days because of a rapid increase in temperature. Temperature plays an important role to store the food for a period of time. Because if the temperature will change,then the foods will get degraded. So if we control the system where we will store food then the lifespan will increase. PH will not change as more as in ambient condition. So we had made an IOT based food storage system where we stored the fruit and vegetables with a controlled temperature. Microbial activity takes a major role to contaminate the food. If the temperature is change the rate of enzymatic activity will increase. We made an experiment to check the quality parameter analysis of tomato. We took 30 tomatoes, 15 tomatoes inside our IOT based food storage system and other 15 tomatoes outside the food storage system. We were considering pH and titratable acidity to check the quality of food.

### *B. Materials required for development of IOT based food Storage System*

*1)* Storage container
*2)* SMPS(Switched Mode Power Supply)
*3)* Node MCU (Node Micro Controller Unit)
*4)* OLED (Organic Light Emitting Diode)
*5)* DHT11 sensor (Digital Humidity and Temperature)
*6)* Bread Board
*7)* Relay
*8)* Jumper wire
*9)* Peltier
*10)* DC fan
*11)* Extension wire
*12)* Micro USB cable with adapter

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*C. Benefits of food storage in a controlled environment*

*1)* Proper food storage helps to preserve the quality and nutritional value of purchased foods by preventing the increase in rate of spoilage.

*2)* People are busy with their personal life for which it is difficult for them to go to the market again and again. So they can store their foods in a storage system for a period of time.

*3)* Lots of food is getting wasted due to improper storage and post- harvest losses, so it will reduce the wastage of food.

*4)* Cost of storing in refrigerator is also high. So we designed the **IOT Based Food Storage System** where we can store fruits and vegetable for some days.

*5)* Therefore we can store our food in a controlled environment by reducing the rate of quality of degradation of fruits and vegetables.

## II. LITERATURE REVIEW

As per M. G. Gurubasavanna et al (2014), they had conducted an experiment on food storage. They had proposed a system to monitor fruits and vegetables to maintain a controlled environment at home. The proposed system was equipped with auto SMS and email alert system to alert the owner regarding the food storage level and the information related to the food spoilage.[4]

As indicated by Xuechuan Chen et al (2017), they had developed a protocol called ZigBee sensornode for the measurement system in food storage and developed an alternative to the cable system, which showed better efficiencies of the cost and time in the installation and maintenance than a cable system.[6]

As per W.H.McGaughey and R.G.Akins (2020), the work was completed on modified atmosphere. Comparisons were made between storage with and without drying floors, as well as between storage system which were unsealed, those which were well-sealed, and those which were sealed by using a plastic film over the food products surface. So by modified atmosphere we can increase the shelf life of foods as it decrease the quality of fruits and vegetables.[8]

According to Abdel Gawd Saad et al (2020), they had collected a set of data regarding quality analysis of tomatoes by Spectroscopy method and evaluate the parameter like pH and TTA.[11]

As indicated by Xuechuan Chen et al (2020) they had developed a protocol for the measurement system in food storage and developed an alternative to the cable system, which showed better efficiencies of the cost and time in the installation and maintenance than a cable system.[7]

According to Manuel o. Binelo et al (2020) studied and experiment on airflow simulation and inlet pressure profile optimization of a food storage aeration system. The quality and conservation of foods depends directly on the storage system. Storage problems and inefficiency can lead to significant losses of the stored product, and high expenditure in energy and resources. [5]

According to Valmor Giegler et al (2017), they had collected information from their experimental study that effect of temperature and moisture content is the main characteristics of storage of food grains. They studied on vegetables as iso-flavone profile of vegetables is concentrate. With increase in temperature and moisture the lifespan of soy decreases. [4]

Lakhoua et al (2015) , they had conducted an experiment on grain storage system in order to manage the activities of food storage, we identified in this paper the different parameters in particular physical parameters. These parameters are the level of foods, the humidity of food products. [10]

## III. METHODOLOGY

*A. Objectives*

Present work is having following goals:

*1)* To develop an IOT Based Food storage System.

*2)* To study the relationship between temperature and RH of inside environment of food storage system.

*3)* To study the Quality parameter of tomatoes stored in food storage system.

*B. Functional Requirements of Electronic Components*

*1)* SMPS: SMPS is stands for Switched Mode Power Supply. A SMPS is a power electronic converter which converts DC or AC signal to DC loads according to the requirements of voltage and current characteristics.

*2)* Node MCU: Node MCU is stands for Node Micro Controller Unit. This is the main part or we can say it can function like a brain. It carries the coding part where we can give the code to function. In our system it control all the parts, it is connected to the SMPS means how much amount of current and voltage is required to work.

*3)* *OLED:* OLED is stands for Organic light emitting diode. It will display the output as temperature and relative humidity that how much temperature is inside food storage system and how much relative humidity is inside the system.

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4) *DHT 11 Sensor:* DHT is stand as Digital Humidity Temperature. It is sense what amount temperature inside food storage system and how much amount of relative humidity is inside food storage system.
5) *Bread Board:* Bread board is part which holds electronic component as series or parallel.
6) *Relay:* Relay is an electronic component which can be control as high as high voltage circuit with the help of low voltage signal. It is acts like an switch, if requirements is complete then it will turned off or else vice versa.
7) *Jumper Wire:* Jumper wire is used for short circuit.
8) *Peltier:* Peltier is an application of thermo coupling effect. If one side will very hot then other side will very cold. It creates a temperature difference where it transferred in between two electrical signal.
9) *Extension Wire:* Extension wire helps to carry current as required length of distance.
10) *Micro USB Cable with Adapter:* This electronic component required to give power supply to node MCU unit.

### C. *Storage Temperature and Relative Humidity of Fruits and Vegetables*

Table no.1 Storage Temperature and Relative Humidity of Fruits and Vegetables

| Name | Temperature(°c) | Relative Humidity(%) |
|---|---|---|
| Apple | 10-15 | 90-95 |
| Blackberries | 5 | 90-95 |
| Strawberries | 5-10 | 90-95 |
| Grapes | 4-7 | 85 |
| Cherries | 5-10 | 90-95 |
| Beans green | 5-10 | 95 |
| Cabbage | 8-15 | 95-100 |
| Carrots | 10-15 | 95-100 |
| Potatoes | 20-25 | 90-95 |

### D. *Procedure to Developing IOT based Food Storage System*

At first we took a container for making a prototype of our food storage system. The volume of this container is 25L. The capacity to fruits and vegetables is 10Kg.
We required SMPS (Switched Mode Power Supply) for power supply. We took 12V 2A SMPS.
Then we took Node MCU for control the temperature and humidity inside it. It has a major role for this system because
We have to give code for automatic control through this unit. Memory of this MCU is 128bytes and its storage is 4MB.
We required a sensor for sensing the system which gives date to the output. We took DHT11 sensor for our purpose.
To show the output we required a digital display organic light-emitting diode (OLED).
Then we required a relay to switch as like a normal electronic switch for ON and OFF purpose. It is 1.3 inch display.
After this we took peltier. This plays a major role as it gives the cooling effect. DC fan is connected in parallel. As in one side we can extract cool air and give this.
After collecting all the parts, they were assembled. We took jumper wire for making a close circuit and also an extension cord as per our requirement.
Then After assembling all the parts we took jumper wire for making a clo Fig.5 Rear view ın extension cord as per our requirement air.
The OLED displayed the status of the storage system. It shows the temperature, humidity and the status of the DC fan as it is used for addition of cooled air.

*E. Block diagram of IOT based Food Storage System*

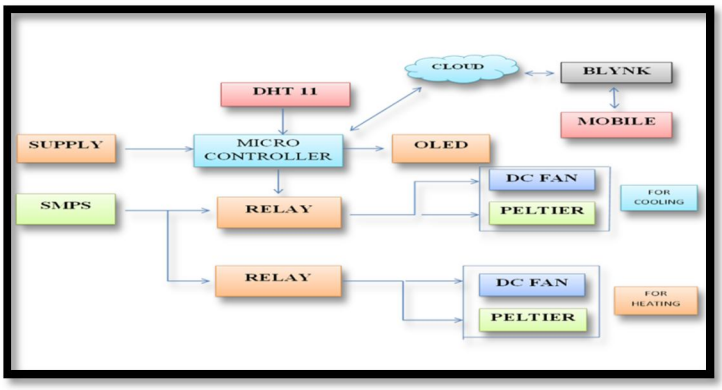



Fig.1 Block diagram of IOT Based Food Storage System

*F. Diagrammatic representation of IOT Based Food Storage System*

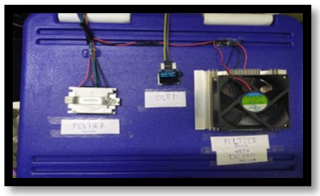


Fig.2 Top view

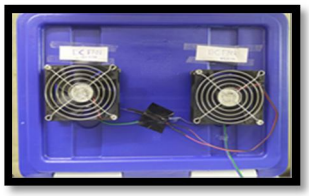


Fig.3 Inner part top view

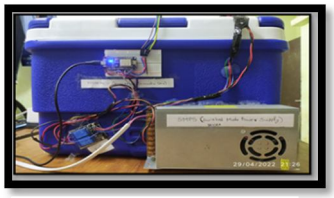


Fig.6 Sensing Part

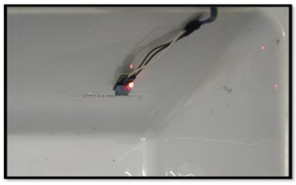


Fig.5 Sensing unit

Fig.4 Rear view

*G. Procedure to Determine the PH of Tomatoes*

To study and evaluate the quality parameter of tomatoes like pH and [illegible] A), we had put 15 tomatoes inside our IOT based Food Storage System about 12 days and another 15 tomatoes in the ambient room temperature. Then with a regular interval of time two days we had made experiment in our laboratory by measuring the pH and Titratable Acidity of both ambient storage and also IOT Based Food storage system to determine the quality of tomatoes. At different humidity we have to make a buffer solution by taking buffer tablet has PH as 7.0 to calibrate the Digital pH meter.




Fig.6 PH of tomato sample testing

*H. Procedure to determine the TTA (Titratable Acidity of Tomatoes)*

In regular interval of two days, we had done our experiment to find the pH and titratable acidity. So first of all, we had made the sample of tomatoes. So we took tomatoes from ambient storage and from food storage system. Then with replication for experiment taking small parts of all these six tomatoes and sliced it and also cut it and crushed it and put it inside a plate

We collected tomatoes from the local market. All the samples were at same maturity stage and were free from any kind of visible microorganisms. The tomatoes were thoroughly cleaned with tap water, dried and then labelled.

Then we took two glass beakers and measured the weight of both sample as we had to consider ambient storage as well as food storage system. Then we took 5-10gm of sample and put it on the hot plate for 5mins.

We had leaved it for boiling of sample solution around 5mins.

After starting boiling of sample solution we leave it for cooling. After cooling we took a volumetric flask and put it inside flask for further process.

Then we had started the titration process to find the titratable acidity. Previously we took 50ml solution in which 5-10gm solution was tomatoes sample and other 40ml of water. Then after heating we again add 50ml water inside 100ml volumetric flask. After doing this, 10ml of solution was pipetted out into a conical flask and to this 2-3drops of phenolphthalein indicator was added .This solution was then titrated against 0.1N NaOH solution taken in a burette till a permanent pale pink colour was obtained. We had read the initial and final burette reading then calculate the titratable acidity from this. This process is same for all the reading as we consider two sample solutions in a day which was carried from tomatoes which was stored in our food storage system and in ambient storage.

Again after two days of regular interval of time this process was repeated to found the readings of pH and Titrable Acidity of both ambient storage as well as IOT based storage.

## IV. RESULT AND DISCUSSION

*A. PH of Ambient Storage and food Storage*

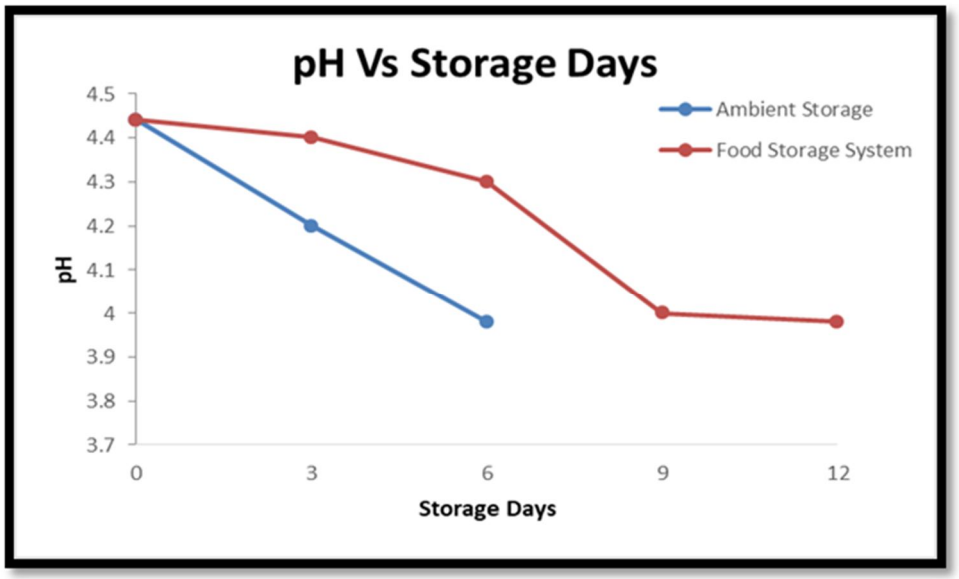



Fig.7 PH v/s storage days of tomatoes

The pH value values showed a significant decrease during 12days of experiment. The pH of fresh tomatoes on 1st day was 4.44. The pH of tomatoes that was stored in room temperature decrease from 4.44 (1st day) to3.98 ( after 6th days). The tomatoes that were stored in room temperature got spoiled in 6th days. While the tomatoes that were stored in IOT based food storage system could be stored for 12days inside it. The decrease in pH (4.44 to 3.98) was less as compare to the tomatoes stored in room temperature.

The similar result were found by Saad et al (2014) and Garcia et al (2014) where pH value decreases with increase in storage time. The less decrease in pH of IOT based food storage system is due to micro environment created around the tomatoes that decreases enzymatic degradation, respiration rate, moisture migration etc.

*B. Total Titratable Acidity (TTA)*

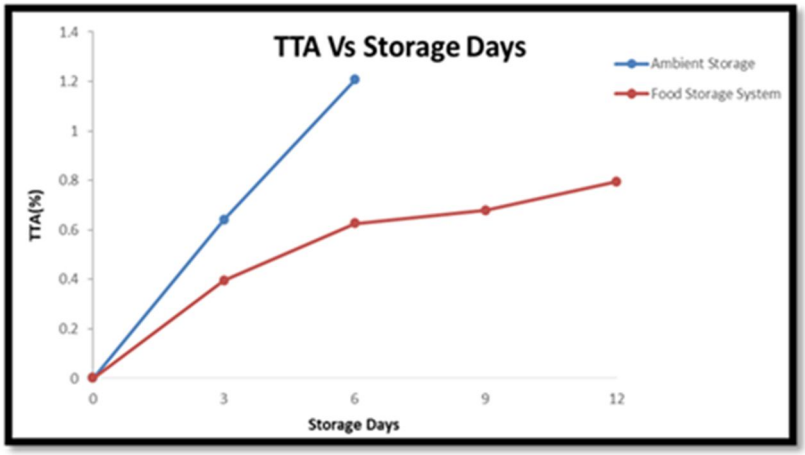



Fig.8 Total Titratable Acidity (%) v/s Storage days of tomatoes

The total titratable acidity for tomatoes were studied inside IOT based Food Storage System and in room temperature for 12days. The tomatoes stored in room temperature spoiled after 6 days of storage. But the tomatoes inside IOT based food storage system to stay up to 12$^{th}$ days.

We get the result by taking the TTA formula as

Total Titratable Acidity (g citric acid/kg of tomatoes) = (V*0.1*1000*0.064)/m

Where,

0.1 is normality of NaOH (N), 0.064 is the conversion factor for citric acid, V is the volume of NaOH required (mL) and m is the mass of tomato juice sample (g)

The TTA value showed a significant increase during 12$^{th}$ days of experiment. The change in TTA value under ambient condition increase from 0.640 % to 1.206 % after 6days of storage. The change in TTA value stored in IOT based Food Storage System increased from 0.394 % to 0.794% after 12days of storage. The change in TTA is IOT based Food storage system is less as compare top storage in ambient temperature similar result were found by Saad et al (2014) and Garcia et al (2014). This is due to the control temperature created inside the IOT Based Food Storage System as compared to ambient storage. The Microbial activity is more in ambient storage as compared to IOT Based Food Storage System for which rate of degradation is more as shown in Fig.4.7 below. IOT Based Food Storage System could decrease the microbial activities, Enzymatic browning as well as respiration rate which decreased the spoilage of tomatoes till 12$^{th}$ days.



Fig.9 On 1$^{st}$ day of FSS



Fig.10 On 1$^{st}$ day of ambient storage



Fig.11 On 6$^{th}$ day of ambient storage

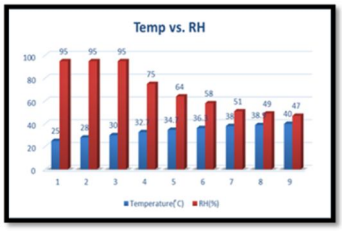


Fig.12 On 12$^{th}$ day of FSS

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### *C. Relationship Between Temperature and Relative Humidity*

To find the relation between temperature and relative humidity we made an experiment on this system for hotness and coldness. The result was shown below.



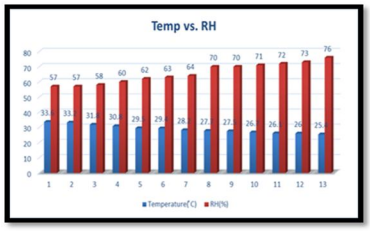




Fig.13 Hotness of food storage Fig.14 Coldness of Food storage

## V. CONCLUSION

IOT based Food Storage System was developed and assembled in our GIFT college premises. The quality parameters of tomatoes like pH and Total Titratable Acidity was studied for 12days in our laboratory. The tomatoes stored in room temperature spoiled after 6days whereas tomatoes stored in IOT based Food Storage System could be stored for 12days with minimal spoilage.PH and Total Titratable Acidity of tomatoes stored in room temperature was 4.34 and 0.9578 in 1$^{st}$ days of storage respectively and 4.10 and 1.038 in 6$^{th}$ days of storage respectively. But in IOT based Food Storage System there is lesser change in pH and Total Titratable Acidity as the controlled environment helps to stored the tomatoes by retains its quality. IOT based Food Storage System was able to retain the quality parameter of tomatoes as compare to ambient temperature. IOT based Food Storage System could control the microbial activity decreased the respiration rate and enzymatic degradation. This helped in increased the shelf life of tomatoes.

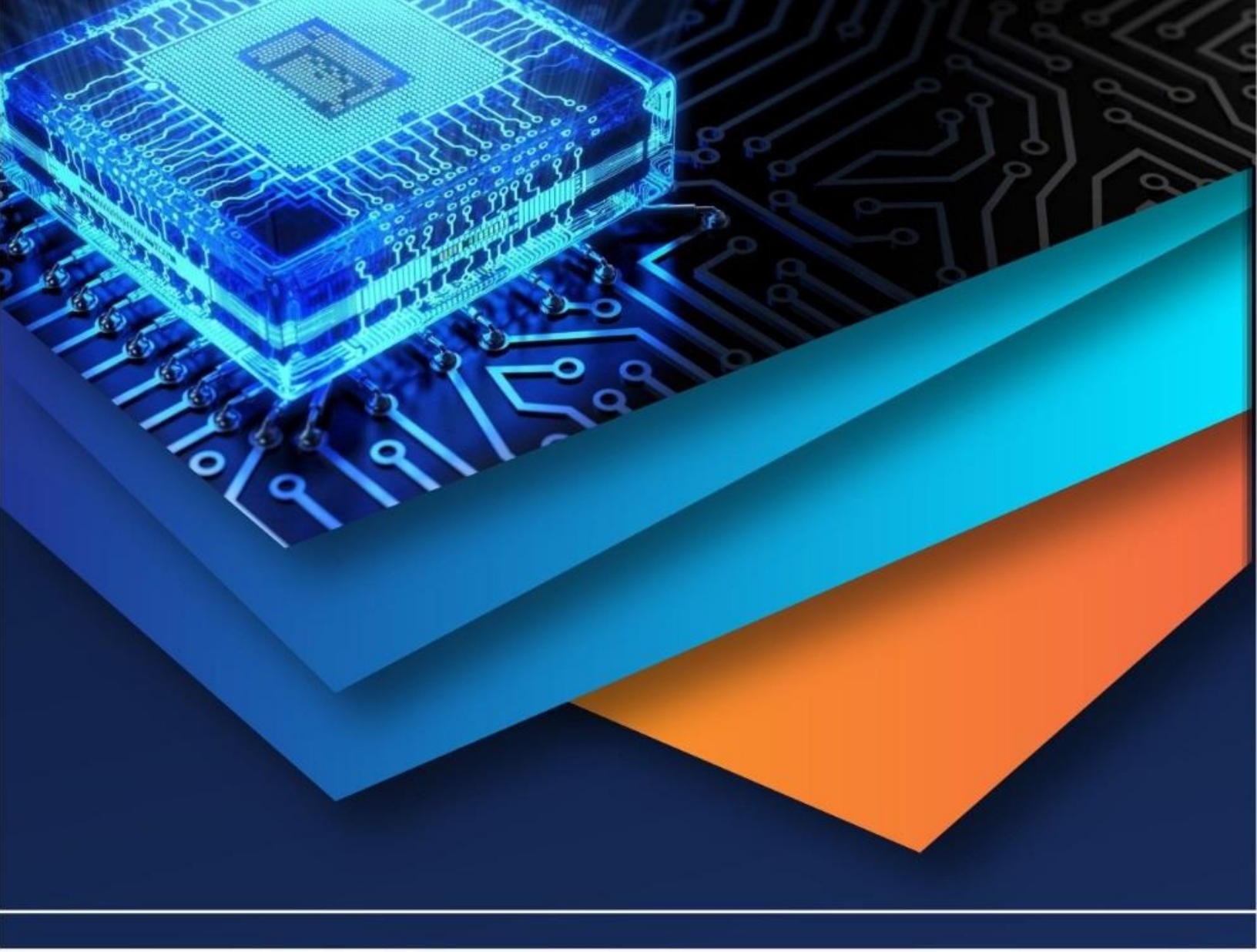
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