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Selective Load Reduction in Power Grids in Order to Minimize the Effects of Complete Power Cut Using Smart Controller on MQTT Protocol

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Abstract: ***In this Paper a smart switch control system is proposed for smart grid that is connected to various smart devices for Demand side management (DSM) in a smart grid. Demand side management comprises techniques which use to equalizing energy consumption levels over the day. A model is proposed to manage load in power cut (Reduce max demand of consumers at the time of power cut). Electricity cost is increasing day by day as the demand is increasing so to manage the cost effectiveness of electricity a model is proposed which will help the grid to analyses the peak demand and the grid will be able to cut the unnecessary or heavy loads from the houses and the grid will only allow to operate only necessary loads like- one fan, one tube light etc.***
Keywords: smart switch control, DSM, smart grid, algorithms.

I. INTRODUCTION

Project title "Selective load reduction in power grids in order to minimize the effects of complete power cut using smart controller on MQTT protocol", in which we can remotely access and control the house load to turn off and turn on though smart controller which is integrated in energy meter, from energy meter basic parameters (voltage, current, power) are send to the database. And for house load setting server will send a preset load value (Example: 100W) at the time of power cut, microcontroller will compare current load and preset load value for tripping smart controller's relay if current load will be more then preset value, then microcontroller will send tripping signal to relay for disconnect load and if current load not more than preset value connection will remain same this is how load will be minimizing if user use more power than preset value. and preset value is set by independent system operator or by higher authorities, all houses have smart controller labelled with unique code for easy identification (Predefined value of max demand will changes as power cut [100W] and in normal state [Single Phase – 2kW and Three Phase – 6kW])

A. Problem Statement

Project title "Selective load reduction in power grids in order to minimize the effects of complete power cut using smart controller on MQTT protocol" which aims to supply electric Power, the heavy loads which were consuming high power will turn off and the essential appliances will turn on such as ceiling fan, bulbs, etc. while power cut in any section of power system.

II. LITERATURE REVIEW

"In this paper, author proposed smart switch control system using ESP-12E with android app. Smart switch control system is network system that consisting of electrical appliances examples lights, fans, coolers which can controlled remotely. Author developed a home automation system that connects all appliances with android app using Wi-Fi as network communication. Android app used to send commands to the microcontroller and controller trigger the relay to turn ON/OFF the Home appliance, it also integrated with sensors which are used for monitoring purpose and that monitored data display on application. Android app display data like power consumption, current and voltage of appliance that is connected to SSCS (Smart switch control system). A login system is designed to prevent unauthorized access to control over the home appliances, in these system users have to create login credential to access their appliances remotely using application and user's credentials are stored in the ESP-12E microcontroller" [1]. "In this paper Author proposed a scheduling algorithm for smart grid that is connected to various smart devices for Demand side management (DSM) in a smart grid. Demand side management comprises techniques which use to equalizing energy consumption levels over the day.

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Author proposed an algorithm for demand side management to improve the energy efficiency. Over the internet two-way communications is easy for smart devices for sharing data to the DSM server.

The use of smart meters and two-way digital communication technology, implements advanced metering infrastructure for load prediction in the residential areas and thereby helps to improve the energy efficiency two-way communications helps in monitoring energy consumption in smart grid. Smart meters can monitor energy consumption that can used for DSM. The proposed strategy is beneficial for entire SG, particularly at distribution network level. By reduction in peak load demand the distribution network capacity and reliability is increased. This strategy can be employed in the future SG" [2].

"In this paper, Author proposed a model to manage peak load demands from grid using MATLAB/Simulink. Peak demand is a major problem in power system and has to manage by shifted to base/off-peak hours using load management system in order to reduce peak demand and electricity bill saving which can be gained through energy management system was analyzed on consumers. Load management system was modeled in Simulink/MATLAB to control the deferrable loads below specified peak demand limits by taking into account consumer behavior and priorities. The cost of electricity is high during the on-peak periods. Additionally, author also, propose a comprehensive study of the classification of residential loads. Residential loads can be classified into control the devices either locally or remotely, loads such as water heater, pump, hot tubes, ACs etc. can be shut for reducing load in peak hours & improve energy efficiency and these can be turn off for short time period without any major effect on comfort but loads like lighting, televisions, and computers cannot shut even for short time of span" [3].

"This paper discusses Uninterruptible power supply Using MQTT Protocols. Here Arduino used as microcontroller connected to the Internet via Ethernet. Message queuing telemetry transport (MQTT) protocol is used for communication that is designed by IBM for light weight communication, Raspberry pi is used for server/MQTT Broker where website and database is stored for UPS monitoring data. This system was intended to display UPS monitoring data in real-time on a web page stored on raspberry. UPS parameter could be monitored using a web-based application. This system allowed the displaying of multiple UPS parameters in Real Time. The parameters that were monitored include the input voltage, output voltage, output power and output current. This system is cheap because it uses Message queuing telemetry transport (MQTT) protocol but it is powerful enough to handle multiple devices at once" [4].

"In this paper author proposed the Internet of Things (IoT) connects users with interconnection of things to facilitate the life. IoT is now shifted towards 'Thing to Thing', Smart home concept brings and convenience in our lives with the aid of IoT. Major issues in current smart home scenario are automation and security. Problem in security. Problem in security arises due to network of devices in the home with internet. Focus is shifted towards providing confidentiality, authenticity, and integrity of data sensed and exchanged by smart home objects. Consumption overhead is also a concern for smart home solutions.

Comfort and user requirements as per scenario or situation are basic need for automation. Automation with learning human behavior is also a major concern with smart home concept. Paper represents IoT based smart home automation approach which is secure and also reduces computation overhead" [5]. "In this paper, a smart home electric energy saving system is implemented by combining smart meter, smart plug, smart mobile devices, and database server. The smart meter consists of a power metering unit, a data storage unit, a meter interface unit and a ZigBee module. The smart plug is composed of a core control unit a remote monitoring module. User can use smart phone to check and control the operation of appliances, and the power consuming information can be remotely monitored by connecting smart plug to the internet via Wi-Fi media.

Besides, the load characteristics in the database server can be employed to identify appliance operation mode by support Vector Machines (SVM) method, which provides effective message for home electric energy saving application. Finally, a prototype was built up and tested; the test results validate the feasibility of the proposed smart home electricity saving system" [6].

III. COMPONENTS TO BE USED

A. MQTT

Message Queuing Telemetry Transport is a light weighted protocol, works in bits or bytes. It is easy to use. It is the base of Internet of things (Iot).

There are some companies that provide MQTT services: -

1) Mosquitto
2) HIVE MQ
3) Cloud MQTT
4) Adafruit

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Our main purpose is Mosquitto because with this software we can create our own server in our own machine or our own cloud. And the rest of the services are online cloud.
"MQTT is a bi-directional communication protocol. This helps in both sharing data, managing and controlling devices"

a) How does it work?

In this sender device publish message on a particular topic to broker and broker will pass the message to the subscriber device of that topic.
And the broker is the program which is hosted on the server which processes all the queries. Lightweights and efficiency of MQTT makes it possible to significantly increase the amount of data being monitored or controlled. MQTT was designed so as to collect data from many devices and then transport that data to the IT companies.

B. ESP-8266

It is a Wi-Fi module, that can connect microcontroller through any Wi-Fi network. And it is open source Iot platform.
Using ESP-8266, we can send data to any website and can also take data from website via Wi-Fi.
Through ESP-8266, we can communicate one microcontroller to another microcontroller via Wi-Fi.
In order to be communicated with ESP-8266, first it has to be connected to the computer. Then we will program ESP-8266 with C language.
ESP-8266 has low energy consumption, integrated support for Wi-Fi network and it is low in cost.

C. PHP, MySQL (Database): PHP is server-side scripting programming language that is especially suited for web development and can be embedded into HTML. It is used to create dynamic website with database.

1) Why PHP?

a) cost efficient (open source)
b) object oriented programming
c) works with all servers
d) security
e) huge community

MySQL is a very popular, open source RDMS which handles large database with fast performance. It is commonly used with php scripts

2) Why MySQL?

a) low cost
b) flexible
c) robust
d) secure
e) can easily create a table

D. Relay

It works on the electromagnetic induction. Based on supply there are two relays i.e., AC and DC relay.

1) *AC Relay:* The eddy current losses have been prevented by using relay with laminated cores. Zero current is there in every half cycle because in every cycle the coil losses its magnetism which ultimately makes the rely to disconnect the circuit. To prevent this, shaded coil is placed in Ac relay to offer magnetism within the zero-current position. Relay used for tripping power supply when its Exide predefined value of max demand at the time of partially power cut.
2) *DC Relay:* Direct current (DC) is basically steady and it never reverses. The electromagnet is formed in DC relay because it uses one coil of wire which is wound round iron core. The magnetism which is generated within the core is steady when the DC coil is electrify because the DC just keeps going. Because of the flowing DC the steady magnetism makes the lever engage. The spring-loaded lever will return to its relaxed position when the relay is turned off and the iron core may not be any longer magnetized, and then the electrical contacts will be switched back.

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E. Transformer

In this model two sorts of transformers are used i.e., Current and Potential Transformer.

1) *Current Transformer:* It is basically used to measure the current of high magnitude. These transformers step down the current to that amount of range at which it can be even measured by traditional ammeter too. CT contains one or only a few numbers of primary turns. The first winding could be a conductor placed during a hollow core (as shown in Figure 1). The secondary coil has a greater number of turns which is correctly wounded for specific turns ratio. So, this configuration will increase (steps up) voltage while lowering (steps down) current. In this model CT gets the current from input and then the magnitude is lowered by CT and that current information is sent to microcontroller.

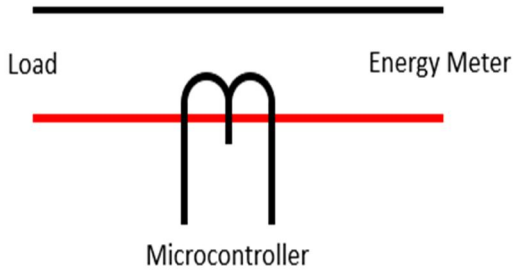

Figure1: Current Transformer

2) *Potential Transformer:* It is also called as voltage transformer and it is step down transformer. It basically measures the voltage of high magnitude. These transformers lower down the voltage to that amount of range at which it can be even measured by standard measuring components/systems. These transformers have greater number of primary turns and smaller numbers of secondary turns. So, this configuration will increase (steps up) current while lowering (steps down) voltage. In this model PT gets voltage from input and then the magnitude of voltage is lowered by PT and that voltage information is sent to microcontroller.

Based on construction there are two types of Potential Transformer:

a) Electromagnetic Potential Transformer

b) Capacitive Potential Transformer

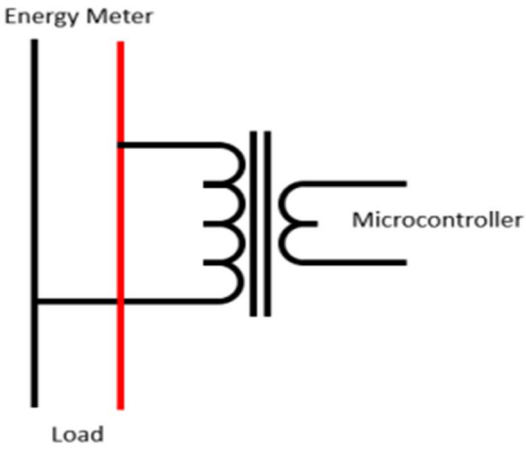

Figure2: Potential Transformer

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IV. WORKING OF THE MODEL

As shown in the figure 3 working diagram of Smart Control system consist of tripping and control circuit, it is used to regulate consumer's electric power in power cut condition. In which Independent system operator (ISO)/ higher authority can remotely access and control the house load to turn on and turn off though smart controller which is integrated with energy meter. Esp8266 microcontroller is connected to internet via Wi-Fi module, it receives voltage and current data from CT and PT both reduce the level of current and voltage. Then microcontroller publish the data on a topic (Topic Name: Consumer's Id) to the MQTT broker and MQTT broker save the data in database using server-side programming language PHP. ISO set the max-demand in database for both normal and power cut condition, in normal condition max-demand will be the standard demand (for single phase and three phase max-demand will be 2000W, 6000W) and in the power cut max-demand will be depend on power availability in grid (example: max-demand will be 100W).

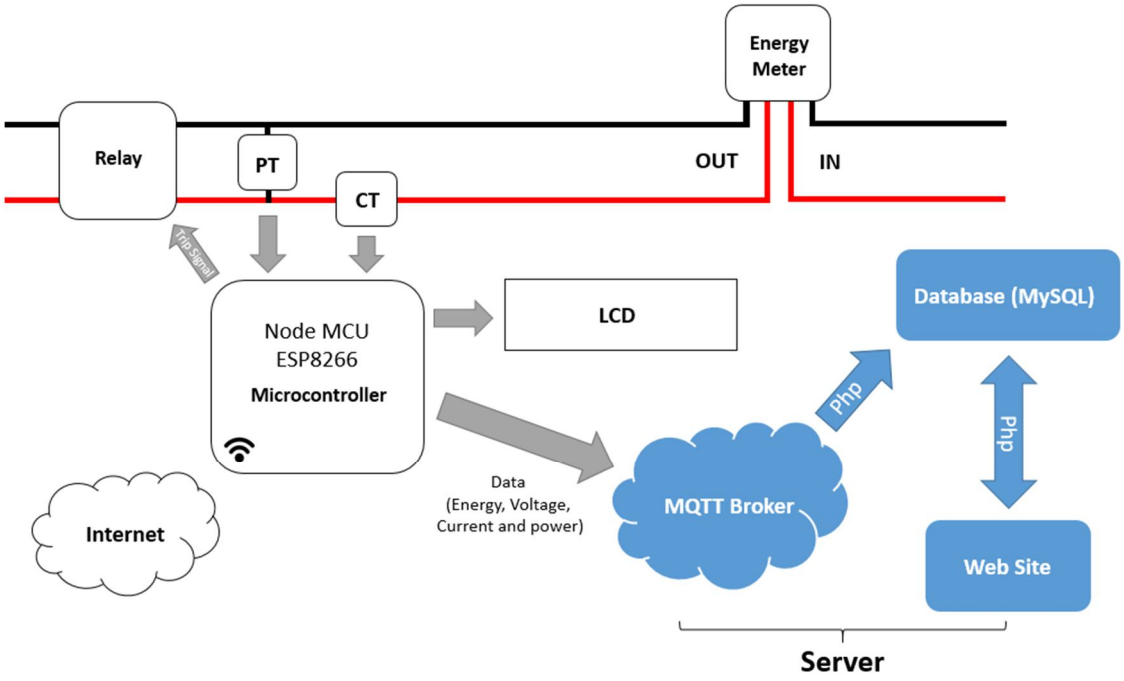

Figure 3: Basic Model of Smart Controller

At the state of power cut, microcontroller will compare power and pre-set max-demand for tripping smart controller's relay if power will be more then pre-set max-demand then microcontroller will send tripping signal to relay for disconnect load and if power is not more than max-demand connection will remain same this is how load will be minimized if user use more power than pre-set max-demand. Every house has smart controller labelled with unique code (Consumer's Id) for easy identification. ISO can alter max-demand using website which is hosted on a Linux server for remotely access

V. STRENGTHS AND WEAKNESSES

1) *Strengths:* The system is low-cost due to its lightweight MQTT protocol. The savings in the electricity bill is 11.28% because of enforcement of proposed load management system. The proposed model is helpful for entire substation Grid, mainly at distribution network level. It basically does not require IP connection for MQTT-SN client. And this project will also help to maintain data that can be used for advance billing. It also uses U-Mosquitto which will render fast messages as compared to standard MQTT.
2) *Weaknesses:* The project uses SSCS which has range limitation. We cannot use Raspberry as MQTT because Broker cannot handle more traffic. A secret key management for system security is needed whenever the number of nodes increases. And Smart meter system requires fast internet service to send power consumption data. And moreover U-Mosquitto does not transfer every message fast it only transfers listed messages. The basic limitation is that it has Security issues as in standard MQTT protocol.

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VI. EXPERIMENTAL RESULTS &ANALYSIS

The Project "Selective load reduction in power grid in order to minimize the effects of complete power cut using smart controller on MQQT protocol" has been done successfully using real time values of current and voltage on 1 meter only in Jaipur city as shown in figure 4. A situation has been shown one utilization of this case: The goal is to decide or minimize the effects of complete power cut. If the load of a house is less than or equals to maximum demand the load will be connected and the essential appliances will run in its normal condition but if load of a house is increased than maximum demand then the relay will actuate and load will get disconnected and the house will suffer complete power cut.

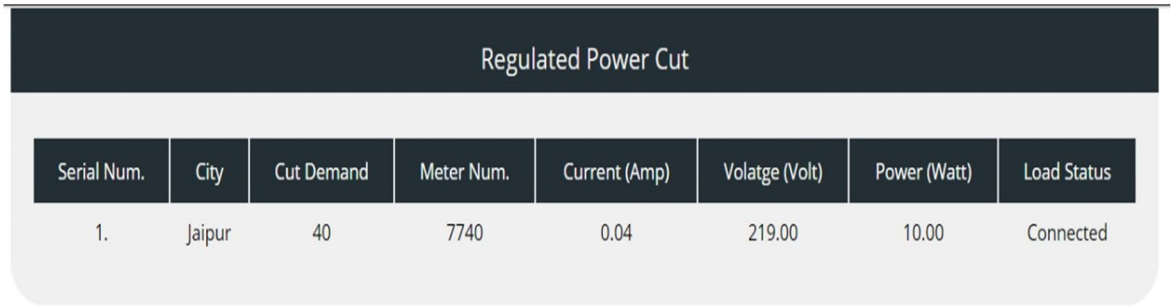

Figure 4: Regulated Power Cut

A. Main Panel

This is the main panel which is designed in php, where we will select the city in which power cut will be done and then there will be maximum demand for the city during power cut as shown in below figure 5.

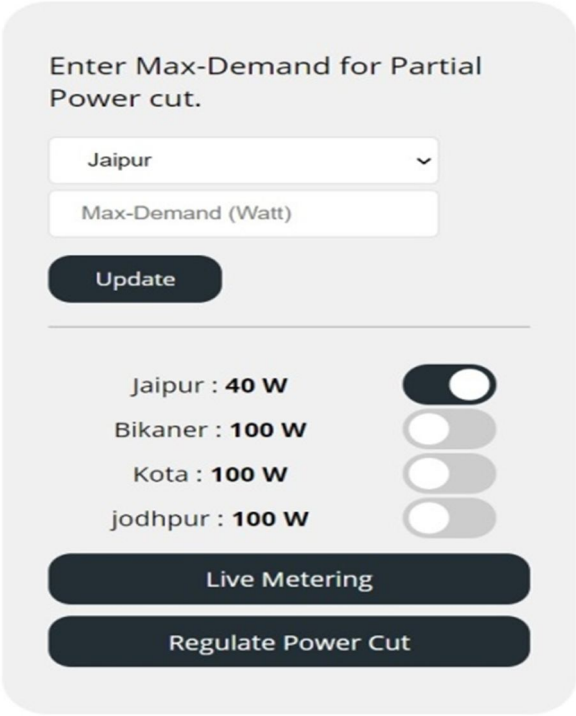

Figure 5: Main Panel

Jaipur is the only city whose meter is getting real time values during power cut and the rest of the meter values of the city is already defined in the program as shown in figure6.

Different city is assigned with different meter number (shown below in figure6) which will help the supplier to differentiate between different cities during time of power cut.

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B. Live Metering

Live Metering

Serial Num.	City	Meter Num.	Current (Amp)	Volatge (Volt)	Power (Watt)
1.	Bikaner	7840	1.08	220.00	237.60
2.	Bikaner	7841	0.43	220.00	94.60
3.	Bikaner	7842	0.39	220.00	85.80
4.	Bikaner	7843	0.34	220.00	74.80
5.	Bikaner	7844	0.30	220.00	66.00
6.	Kota	7941	0.30	220.00	66.00
7.	Kota	7942	0.43	220.00	94.60
8.	Kota	7943	0.39	220.00	85.80
9.	Kota	7944	0.26	220.00	57.20
10.	jodhpur	7841	0.26	220.00	57.20
11.	jodhpur	7842	1.08	220.00	237.60
12.	jodhpur	7843	0.43	220.00	94.60
13.	jodhpur	7844	0.39	220.00	85.80

Figure 6: Live Metering

C. Figure Below Represents a model of Proposed Work

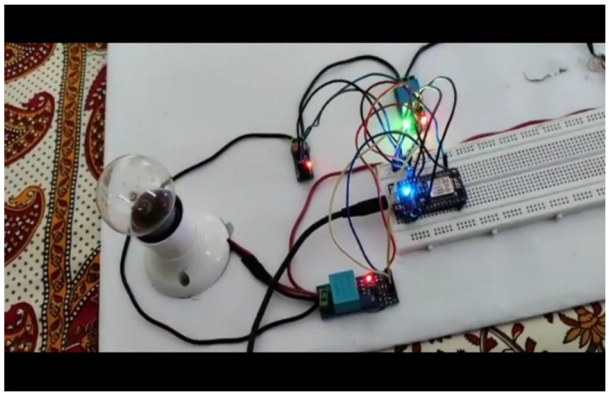

Figure 7: Proposed Model

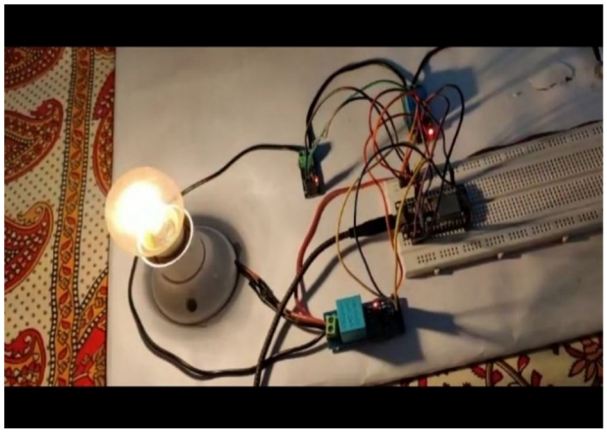

Figure 8: Working of the model

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VII. SUMMARY

The proposed model uses Esp8266 microcontroller which is connected to internet via Wi-Fi module, it receives voltage and current data from CT and PT both reduce the level of current and voltage. load setting server will send a pre-set load value (Example: 100W) at the time of power cut, microcontroller will compare current load and pre-set load value for tripping smart controller's relay if current load will be more then pre-set value, then microcontroller will send tripping signal to relay for disconnect load and if current load not more than pre-set value connection will remain same this is how load will be minimized if user use more power than pre-set value. and pre-set value is set by independent system operator or by higher authorities, all houses have smart controller labelled with unique code for easy identification. We concluded that, the system will analyse the unnecessary or heavy loads which is not essential will turn off by the help of grid and then the essential home appliances were able to turn on.
This is how this project will help to remove complete power cut and allow the user to utilize the power in continuing manner.

VIII. CONCLUSION AND FUTURE SCOPE

Due to the growing number of household electrical appliances, and its power consumption. In this paper, smart controller is integrated in energy meter through which house load can be control by smart switches using relays. We have presented step by step procedure of selective load reduction to reduce the complete power cut. The working of the proposed model was experimentally shown with the help of light bulb which is glowing when the load is under pre-set maximum demand value. Live metering shows the city which is under pre-set maximum demand value (i.e., 100W). And regulated power cut (Jaipur) shows the cities which is disconnected due to its power consumption over pre-set maximum demand value. Proposed system has two advantages. First, using the smart controller we can monitor or access the appliances remotely which will definitely will prove to be energy efficient. Secondly, it will reduce the complete power cut which will also help the society to become a smart city. For future work we would like to add more controlling units that can make our power consumption more reliable and efficient.

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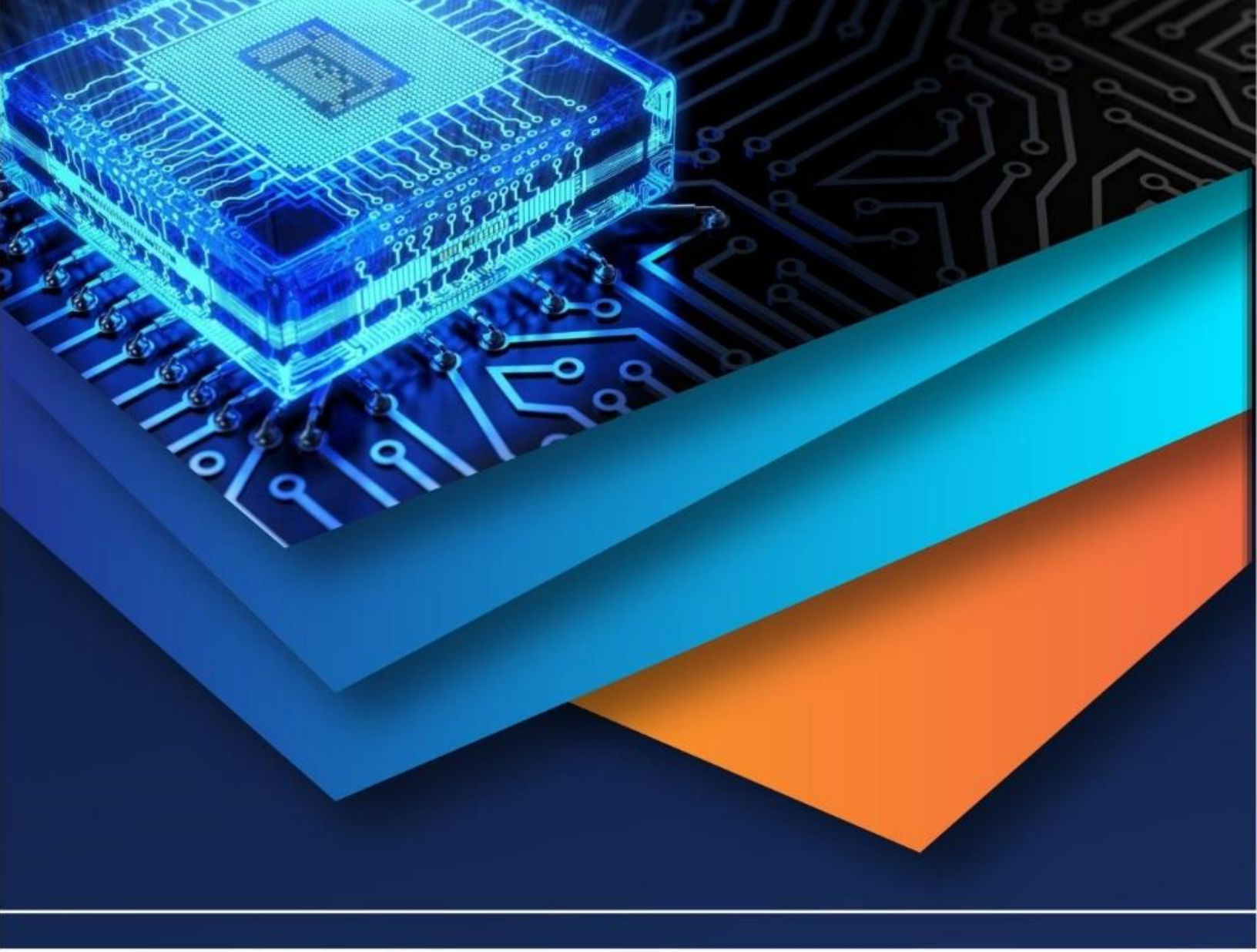

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