iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VI **Month of publication:** June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35493

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Series Compensation by using Shunt Active Filter to Mitigate the Harmonic Currents

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Abstract: ***The rise in power electronic devices in power system has increased the problems of harmonics and power quality. In this paper I have discussed about the harmonics that are developed in power system due to non-linear loads. The damage of harmonics may rise from normal level to high level depending on their duration and the order of harmonic .So to mitigate this harmonics in power system I have introduced shunt active power filter by series compensation method. In this paper it is discussed how harmonics are reduced using shunt active power filter and it is shown through MATLAB/Simulink .The results of the simulation have been shown where the harmonics developed in power supply has reduced.***
Keywords: power quality, distribution transformer, harmonics, shunt active power filter, non-linear loads.

I. INTRODUCTION

The development has lead us to the usage of more advanced equipments which mainly consists of electronic devices. With the advancement of day by day technology power consumption has also been raised exponentially. This raise made the power engineers to supply more electric power to the consumers to satisfy their needs. During this supply it is more important to supply quality power. As it is known due to the advancement rise in electronic devices has increased the complexity in power supplies. This electronics devices has become one of the important factor in non linear loads. Due to advancement usage of semiconductor technology has been rising at the end user side. The use of power electronic devices gives rise to problems like harmonic generation poor power factor, reactive power disturbance, low system efficiency, disturbance to other consumer heating of devices etc. Harmonics are unwanted higher frequencies which superimposed on the fundamental waveform creating a distorted wave pattern. Switching circuits tend to draw current only at the peak values of the ac supply and since the switching current waveform is non-sinusoidal. The resulting load currents is said to contain harmonics. non-sinusoidal complex waveforms are constructed by "adding" together a series of sine wave frequencies known as "Harmonics". Harmonics is the generalized term used to describe the distortion of a sinusoidal waveforms of different frequencies.

In this paper it is discussed how the harmonics are filtered out by using shunt active power filter. Shunt active power filters compensate current harmonics by injecting equal but opposite harmonics compensating current. In this case the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase shifted by 180 degrees. As a result components of harmonic currents contained in the load current are cancelled by the effect of the active filter, and the source current remains sinusoidal and in phase with the respective phase-to-neutral voltage. This principle is applicable to any type of load considered as a harmonic source.

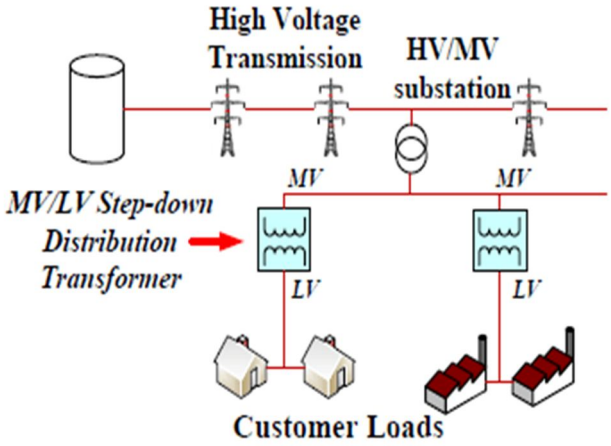

Fig .1 Conventional Step-Down Distribution Transformer in Distribution Grid System

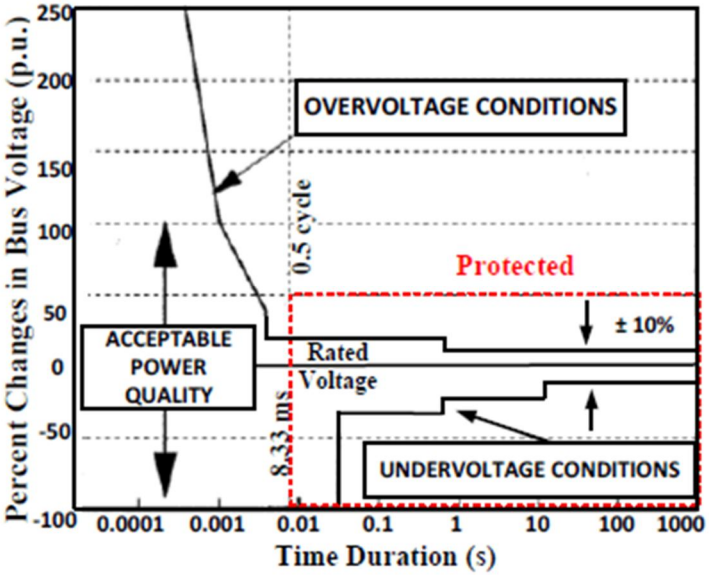

Fig .2The ITIC Power Acceptability Curve

A. Objective

The basic objective of this scheme is to learn how harmonics are developed due to electronic loads, how this harmonics are causing power quality issues in power system and how this harmonics are mitigated using shunt active power filter..

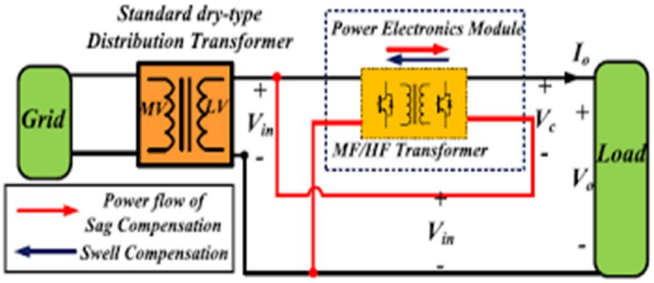

Fig.3 Conceptual Scheme of the Proposed Distribution Transformer with Power Electronic Module

1) *Distribution Transformer:* A distribution transformer or service transformer is a transformer that provides the final voltage transformation in the electric power distribution system, stepping down the voltage used in the distribution lines to the level used by the customer. Normally distribution transformers ratings will be below 200KVA. Distribution transformers are connected to a line of high voltage and they transfer voltage to low level that is used by the customers. Distribution transformers can also be established by individuals for their own purposes. The following graph shows the power flow through the power electronic module. The power flow in power electronic module during the sag condition will be along the direction of grid voltage. In the swell condition the power flow in PE module will be 180° out of phase to reduce the excess voltage.

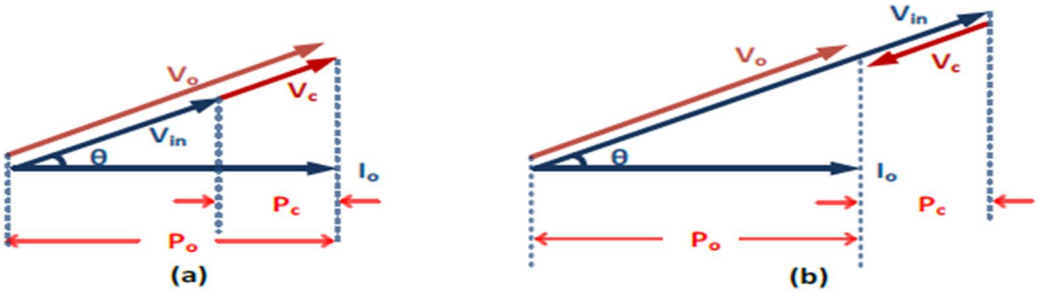

Fig .4 Voltage Vectors for the Compensation of (a) a Voltage Sag (b) a voltage Swell

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
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II. WORKING PRINCIPLE OF THE SHUNT ACTIVE POWER FILTER:

The schematic diagram of the power electronic module have shown in the fig . .This Power Electronic Module consists of four single phase H bridge Converters, MF/HF transformers, static bypass switches, DSP controllers and output filter and in additional we use shunt active power filter.

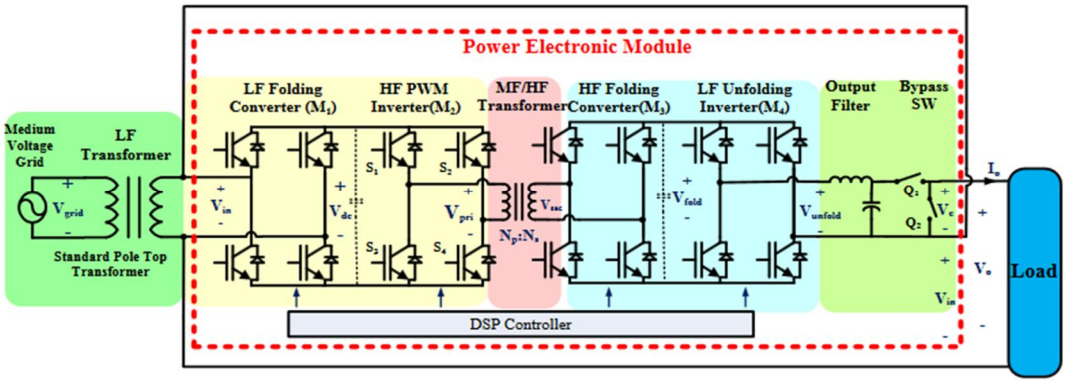


Fig .5 Detailed Power Electronics Module in the Proposed Distribution Transformer

In this procedure we use shunt active power filter in order to reduce the harmonics that are developed due to non linear loads along with the power electronic module. Usually shunt active power filters are connected to compensate for all current-related problems, such as the reactive power compensation, power factor improvement, current harmonic compensation, neutral current compensation, dc-link voltage regulation, and load unbalance compensation,.

Shunt active power filter is basically a power electronic device which is used for producing harmonic current of same magnitude and opposite in phase to that generated by the nonlinear load. Voltage source inverter is the main source of the shunt active power filter which gives the necessary compensation

Shunt active power filter are connected in shunt across the source in order to monitor the current .On monitoring the source current reference compensating current are generated by the active power filter The main function of the shunt active power filter is to eliminate the harmonic current generated by the nonlinear load by injecting the same amount of current but opposite in the phase

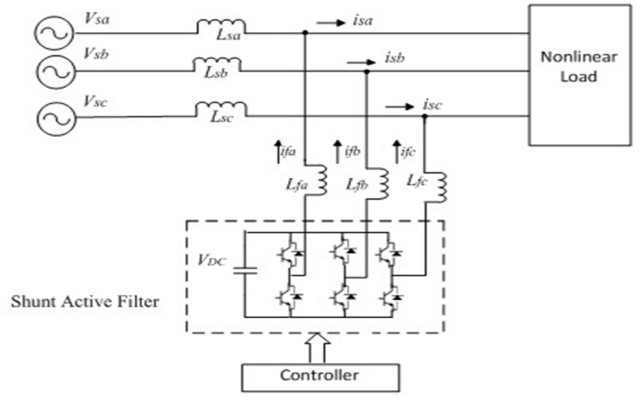


Fig .6 Synchronous Reference frame Control Theory(Control Algorithm)

III. CONTROL ALGORITHM

The synchronous reference frame theory or d-q theory is based on time domain reference signal elimination technique. It performs the operation in steady state or transient state as well as for generic voltage and current waveforms. Synchronous reference theory can be used for the separation of harmonic current from the fundamental component of current. For this separation reference current will be generated by this method. Using this technique synchronous d-q frame will be obtained and three phase a-b-c quantity are converted into the d-q coordinate using park transformation. D-q coordinate are rotating with the angular frequency, whereas the a-b-c coordinate are stationary. Harmonics are appeared as ac component in d-q frame but the fundamental component of the current are appeared as dc. It is necessary to convert the quantity into the d-q frame because in d-q frame analysis are appeared as dc and control of dc quantity are more easy then ac

The conventional SRF method can be used to extract the harmonics contained in the supply voltages or currents. For current harmonic compensation, the distorted currents are first transferred into two-phase stationary coordinates using α−β transformation. After that, the stationary frame quantities are transferred into synchronous rotating frames using cosine and sinus functions from the phase-locked loop (PLL). The sinus and cosine functions help to maintain the synchronization with supply voltage and current. Similar to the p−q theory, using filters, the harmonics and fundamental components are separated easily and transferred back to the a−b−c frame as reference signals for the filter. The conventional SRF algorithm is also known as d−q method, and it is based on a−b−c to d−q−0 transformation (park transformation), which is proposed for active filter compensation

IV. SIMULATION MODEL

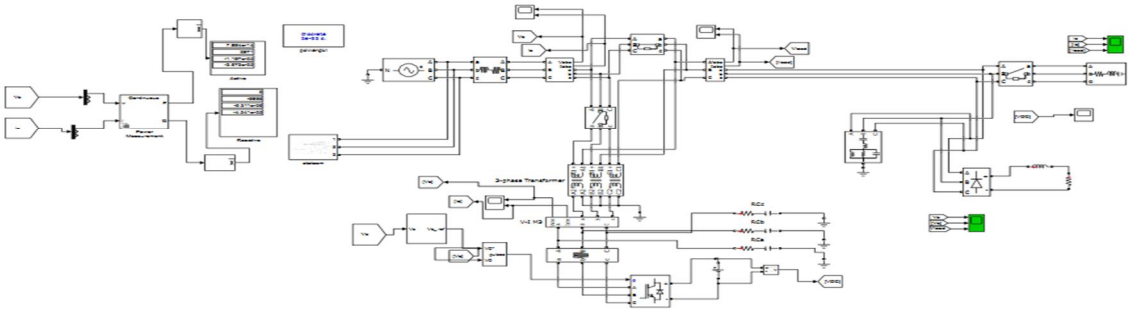


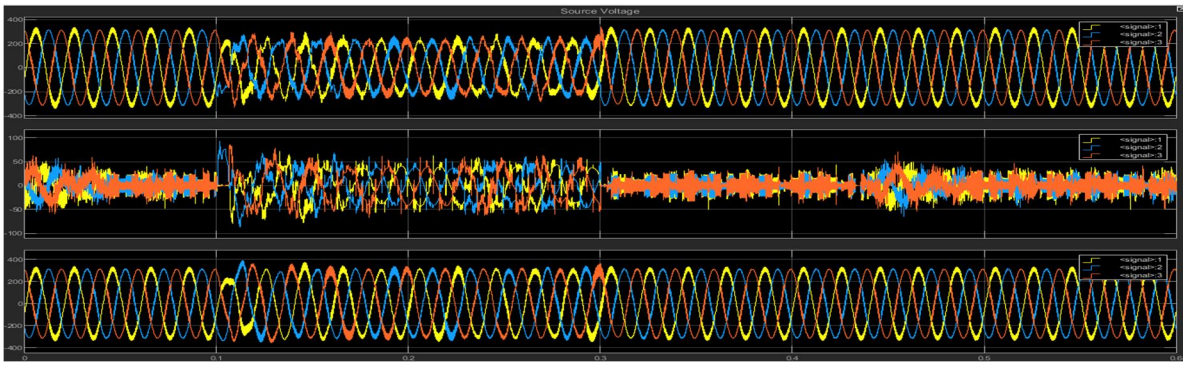
Fig .7 Simulation model of the power electronic module.

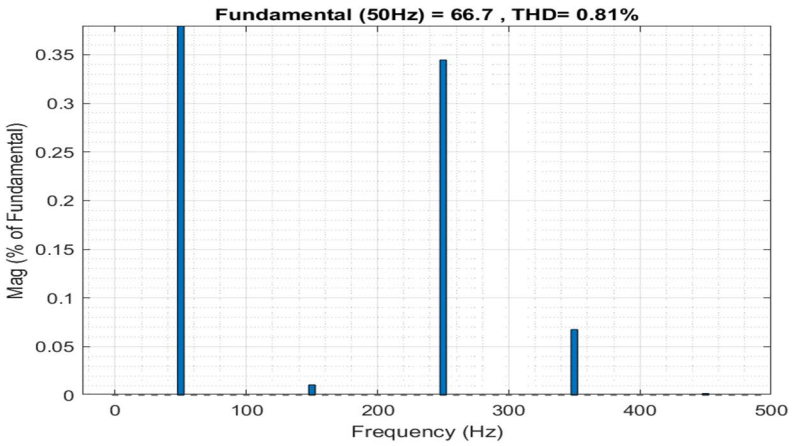
In this simulation model the 3 phase AC power has been provided by the 3 phase AC programmable voltage. This voltage source is connected to the 3 phase VI measurement which measures the 3 phase voltage and current. Most importantly we use snubber (rc) circuit it limits or stops the switching voltages and also the over voltage spikes. In this simulation it is mentioned as Universal bridge. There is also a 3 phase linear transformer, it has 12 terminals apart from this a linear transformer has 4 terminal device in which the voltage and currents in the primary coils are linearly related, in this the input and output voltage fixed according to the turns ratio.by implementing a 3 phase breaker block implements that where the opening and closing times can be controlled either from an external signal or from an internal control signal. In this source side we connect parallel a shunt active filter to compensate harmonics on source side. To measure how much harmonic distortion present in the signal will go by check through FFT analysis. It is the measure of THD (Total Harmonic Distortion) in the voltage and current wave forms, it tells about how much the distortion in the voltage and current due to harmonics in the signal and it also it is an important aspect in the power system

V. SIMULATION RESULTS

A. Sag and Harmonics

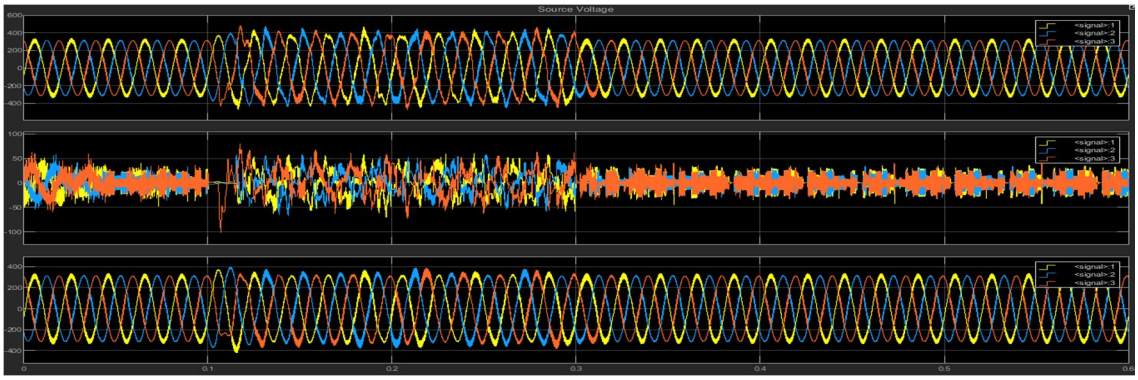
In the first wave among the above waves sag and harmonics has been introduced manually and there distortion has been created. Later to compensate that compensating voltage has been introduced into the supplying voltage as shown in second graph. The final output has been shown in the 3rd wave. The filtered and continuous wave without any voltage disturbances such as harmonics and also the below chart shows that Total Harmonic Distribution.

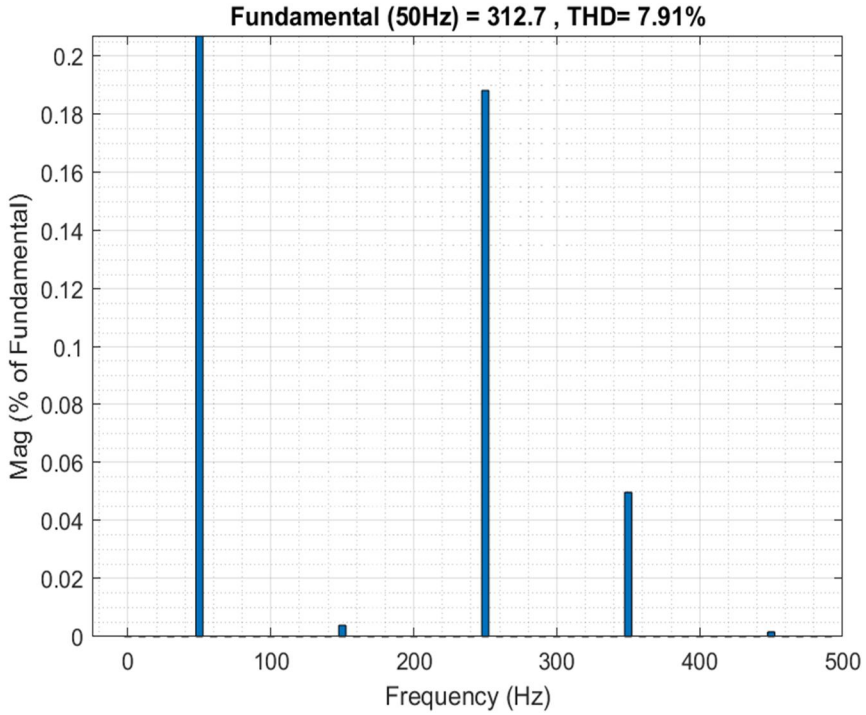




B. Swell and Harmonics

Among the 3 waves the first wave shows the developed swell and harmonics in the input ac voltage supply .And to compensate that compensating voltage has been introduced into the supply and the filtered output has been shown in the 3rd wave without any distortions and then after graphs shows that total harmonic distortion it represents that how much harmonics percentage present in the waveform





VI. CONCLUSION

We conclude that, in this paper it is discussed how the harmonics that are developed due to non-linear loads are those were eliminated by using shunt active power filter. Harmonic components that are present in the current of the three phase system due to non linear loads are mitigated using synchronous reference frame control technique. In this Phase Locked loop has also been used .The simulation using MATLAB and SIMULINK has shown the results by using Shunt Active power filter with a pure sinusoidal waveform.

VII. FUTURE SCOPE

As the technology increases it is our duty to introduce the modern methods in various sectors and at the same time we should also decrease the size of the devices and increase its rigidness along with vulnerability. The power electronic module not only in size but also in compensating voltage sag/swell shows great results and the application of this module will also developed to use at the household goods to protect them from the unwanted voltage surges.

VIII. ACKNOWLEDGEMENT

We would like to express our sincere thanks to our project supervisor Asst. Prof. Dr. P.S. Puhan, Department of Electrical Engineering, Sreenidhi Institute of science and Technology for his constant support, timely help, guidance, sincere co-operation during the entire period of my work. We are grateful to him for providing all the necessary facilities during the course of the project work, for the help provided during various stages of the project.

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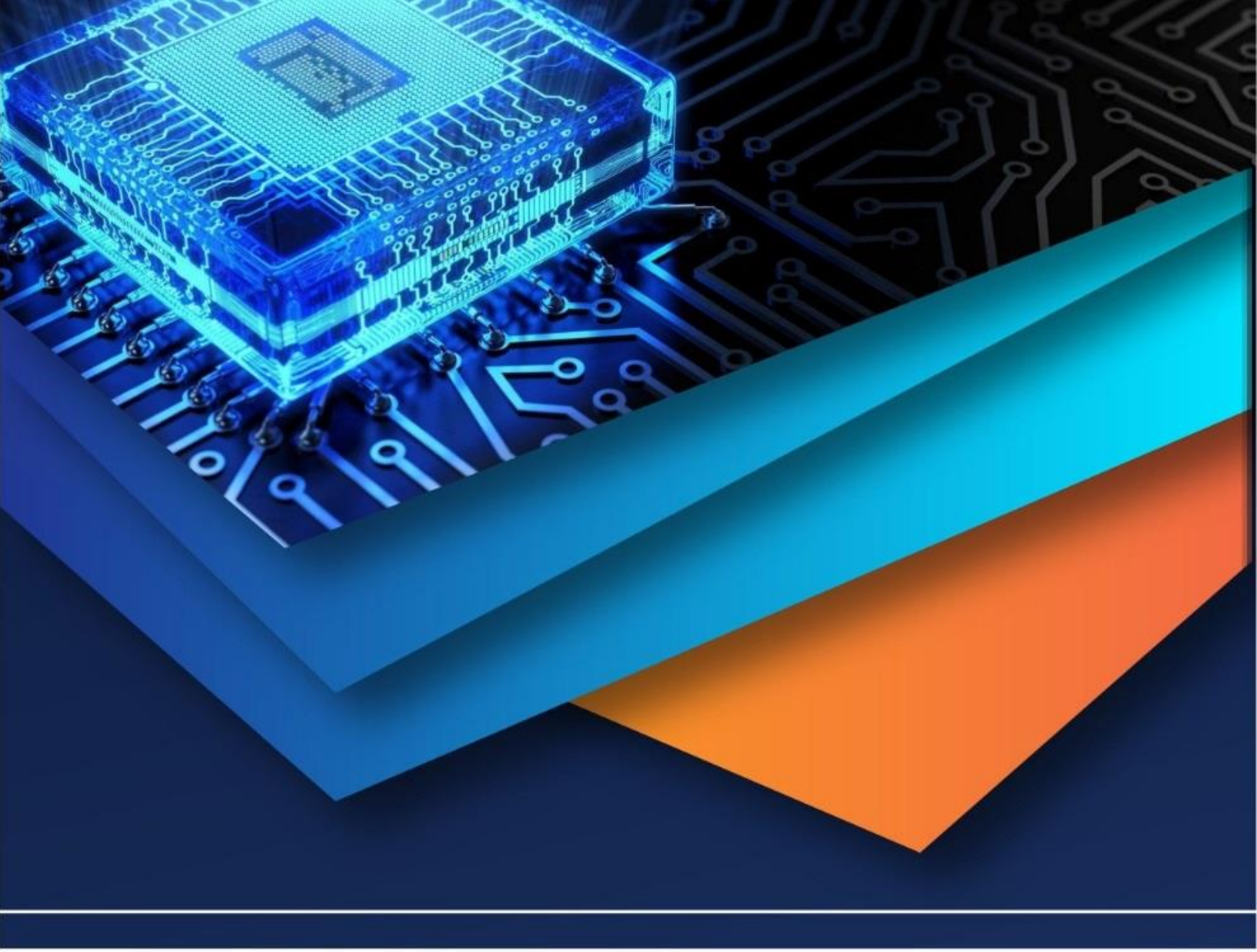

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