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9 -Level Cascaded H-bridge 3-phase Multistage Inverter Topology

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Abstract:** The main objective of this paper is to describe a cascade multistage inverter using MATLAB simulation. In it we are going study of a module of 3-phase cascade H-bridge multilevel inverter for application in electrical machines. Multilevel inverters are best suitable for high power applications as they provide quality output waveform with fewer amounts of voltage and current. Similar the Cascaded H-bridge inverter, this topology uses cells connected in cascade using 4 inverter legs are in series. The detailed analysis of the structure and development of an equation for n levels are carried out using PWM phase-shifted multicarrier modulation.

Keywords: Cascaded H-Bridge inverter, Total Harmonic Distortion (THD).

I. INTRODUCTION

Multilevel inverters have been attracting wide industrial interests. It is considered an attractive alternative to reduce switches stress. The main characteristic of these converters is that they provide an output waveform with many voltage levels. In recent decades, an extensive array of multilevel structures has appeared, for instance, the Cascaded H-bridge (CHB) , Neutral point clamped (NPC) and Flying capacitor (FC) . Cascaded H-bridge multilevel inverter is a popular converter topology and has found widespread applications in industry, for instance, in high-power medium-voltage drives and reactive power compensating. It is composed of multiple units of single-phase H-bridge power cells, using two inverter legs in parallel powered by isolated dc supply. The inverter dc bus voltage is usually fixed, while its ac output voltage can be adjusted by modulation schemes. The dc supplies are normally obtained by multi pulse diode rectifiers to achieve low line-current harmonic distortion and high input power factor. The H-bridge cells are usually connected in cascade on their ac side to achieve medium-voltage operation and low harmonic distortion. In practice, the number of power cells in a CHB inverter is mainly determined by its operating voltage and manufacturing cost.

The use of identical power cells leads to a modular structure, which is an effective means for cost reduction. Cascaded multilevel inverters have been developed to use unequal dc bus voltages or single dc source, showing the possibility of different alternatives for this topology. Thus, a three-phase cascaded multilevel inverter topology is proposed in this paper. It uses power cells connected in cascade using two inverter legs in series, instead of two parallel inverter legs, as used in CHB power cells. An employed modulation and a load voltage analysis for forecasting the harmonic spectrum, will also be presented.

II. CASCADE H-BRIDGE INVERTER

A. Basics

Cascade inverters are similar to multilevel power convertors. Multilevel convertor is mainly used for medium and high power applications due to usage of power semiconductor switches with different DC source connected in series. Multilevel power convertor has more advantages over single level power converter [1].the disadvantages are higher number of power semiconductor switches, complex control and higher conducting losses.

B. Cascade H-bridge Inverter

A single phase structure of 9 level cascade h-bridge multistage inverter as shown in fig.1.

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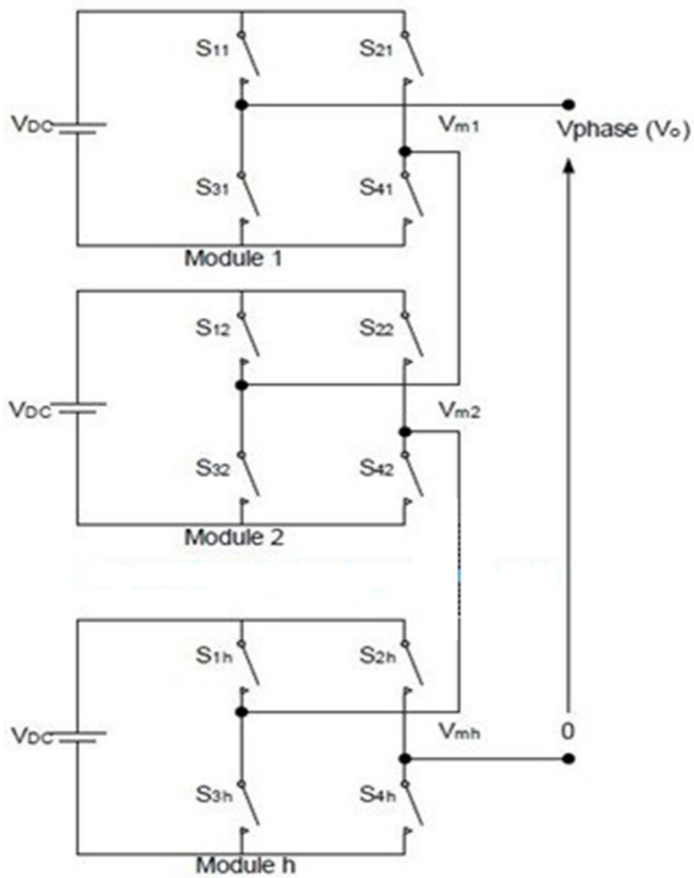

Fig.1 single-phase cascade H-bridge inverter with three different DC sources

It is possible to create more voltage level at output side of cascade inverter. Every h-bridge converter can create positive, negative and zero voltage at output side.
Number of output phase voltage levels is:

$$N=2y+1$$

Where,
y=number of DC sources.

This inverter uses many H-bridge inverters connected in series to give a sine wave output voltage. The output voltage generated by this multilevel inverter is the sum of all the voltages generate by each cascade i.e. if there are "y" cells in an H-bridge multilevel inverter. The number of output voltage levels will be 2y+1. This type of inverter has advantage As it requires less aspect as compared with the other types of inverters and so its overall price is also less.
In single phase inverter, each phase is connected to dc source. Each level generates three voltages which are +ve, -ve and 0. This can be access by connecting AC source with the DC output and then using different combinations of the four switches. The inverter will remain ON when two switches with the opposite positions will remain ON. It will turn OFF when all the inverters switch ON or OFF. To reduce the total harmonic distortion, switching angles are defined and implemented. The calculations for the measurement of switching angle will remain the same. This inventor can be categorized further into the following types:
1) 5 levels cascaded H Bridge Multilevel Inverter
2) 9 levels cascaded H Bridge Multilevel Inverter
In 5 level cascaded H Bridge Multilevel Inverters, Two H-Bridge Inverters are cascaded. It has 5 levels of output and uses 8 switching devices to control. In 9 level cascaded H Bridge Multilevel Inverters, Four H-Bridge Invertors are cascaded. It has 9 output levels and use and use 16 switching devices.

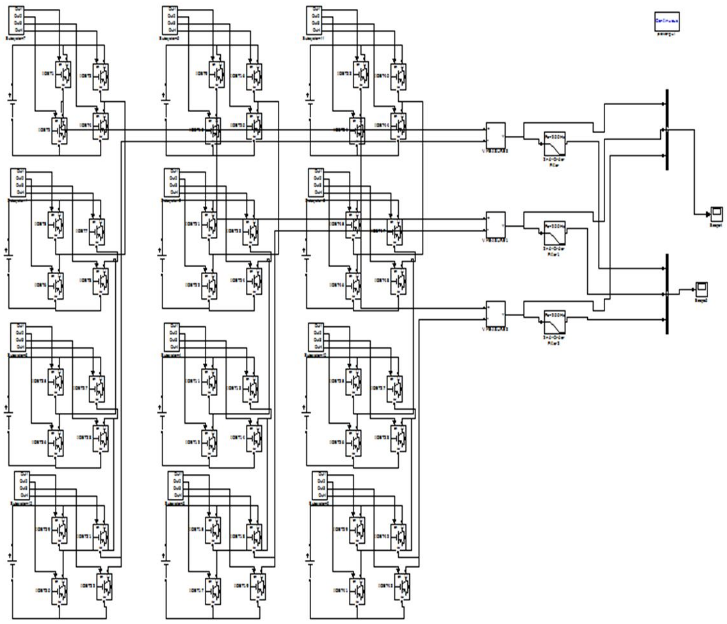

Fig.2 main circuit of 9-level cascade h-bridge 3-phase invertor

C. Proposed Topology

The three-phase multilevel inverter proposed is shown in Fig. 2. This inverter is composed of (3nL – 3) switches and a (3nL –3)/2 isolated dc voltage sources, where nL is the number of voltage levels of the line-to-line output voltage. The load can be connected in delta. When switches Sn-1 and Sn conduct, the output voltage in the power cell is vC(t) = VDC. Similarly, with Sn-1' and Sn' switched on, vC(t) = - VDC. To obtain the level zero, the switches Sn-1 and Sn' or Sn-1' and Sn should be switched on.

D. Trigger Circuit

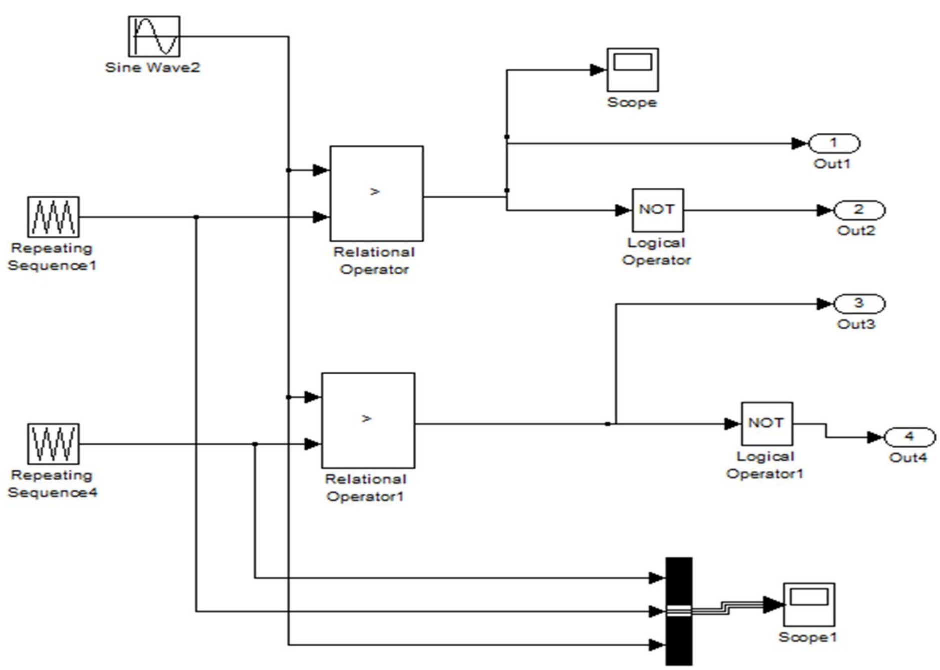

Fig.3 trigguring circuit for 9 level cascade h-bridge multistage inverter

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E. THD of Inverter

The grid connected in system is an electrical energy generator. There are two main point of view while considering system. It is important for high energy outturn and get standards for generating system (frequency, THD).

The lower THD is achieved by improving output filters.

As lower THD, the filters required are bulky and costly. This will have higher power losses. The cascade multistage inverter can achieved lower THD than single h-bridge inverter. It can reduce switching frequency and lower du/dt. And the Cascade H-bridge multistage inverter can produce higher quality electrical energy. The THD of grid current is simulated in MATLAB for various frequencies. The simplest low pass filter used at output side of cascade inverter. The results are shows as follows:

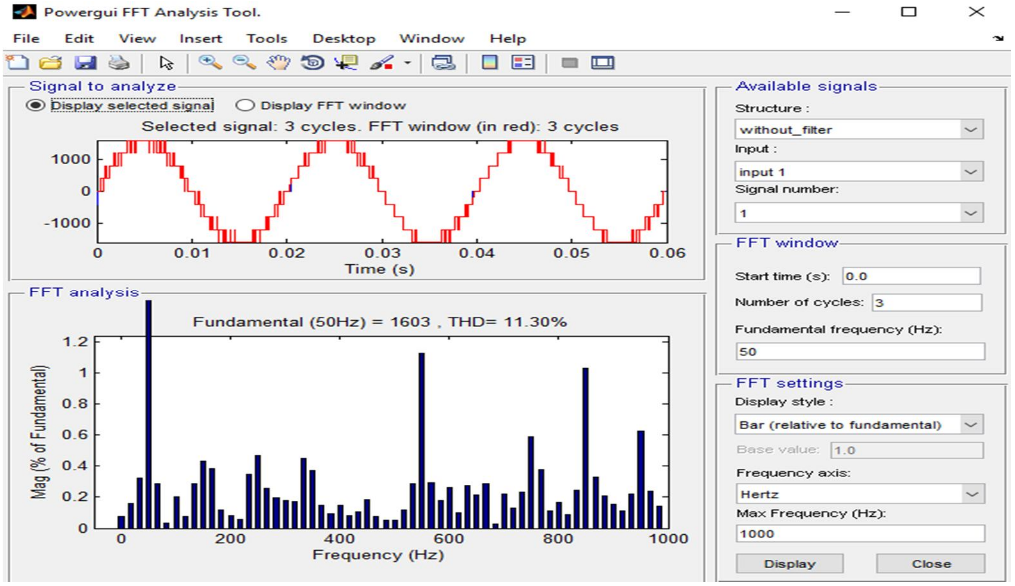

Fig.4 9level cascade multistage inverter THD without filter , 13.10%

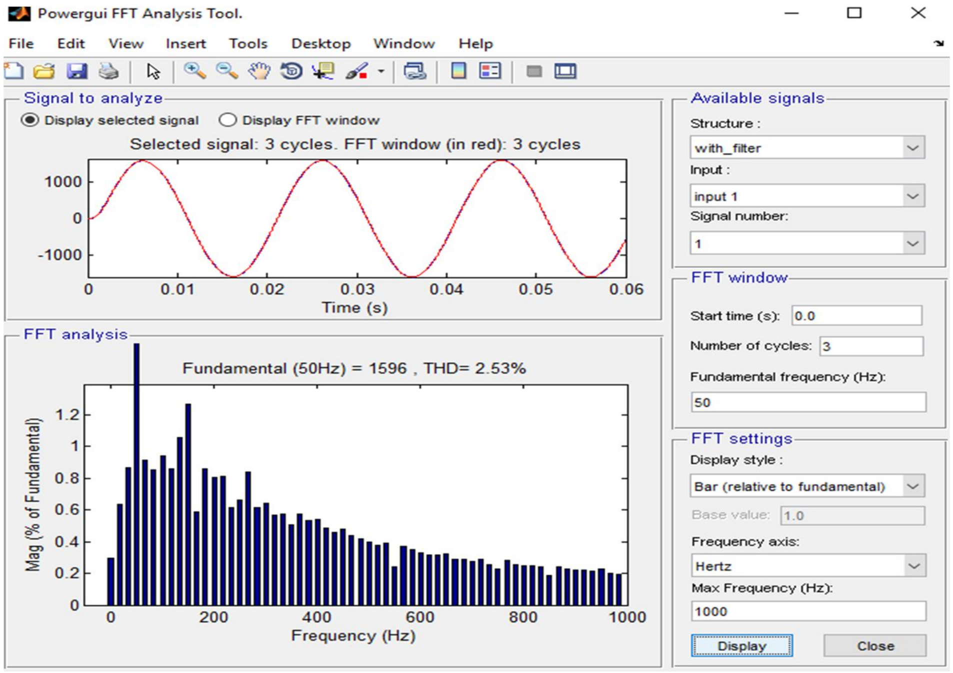

Fig.5 9level cascade multistage inverter THD with filter , 7.07%

The desired values of THD = 3% , this never meet with single H-bridge inverter but THD was lower than 3% for the cascade H-bridge inverter above 10kHz.

The efficiency of inverter is not easy to show because changing current of semiconductor switches. The above calculation are based on average value of current. The switching losses will be same for the cascade H-bridge converter as single H-bridge. Because there are three

H-bridges in the cascade H-bridge inverter and only one H-bridge in the single H-bridge inverter. the switching losses are reduced in the cascade H-bridge inverter.

The VCE (ON) voltage of the IBGT is very important when considering the efficiency in cascade H-bridge inverter. To increase efficiency of H-bridge cascade inverter its gives more opportunity to choose more suitable semiconductor switches.

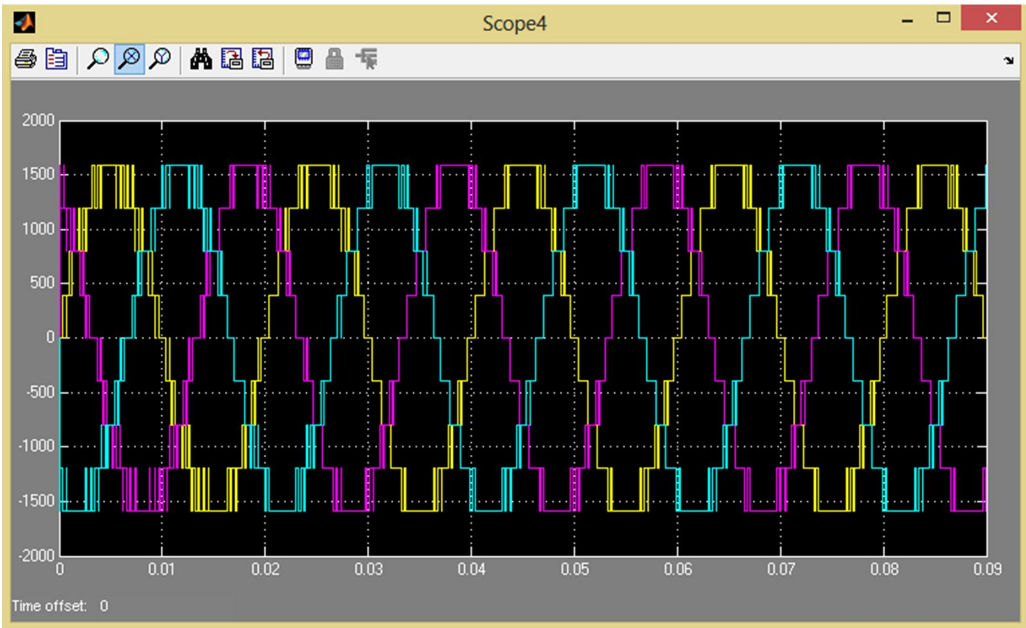

Fig.6 Inverter output (without filter)

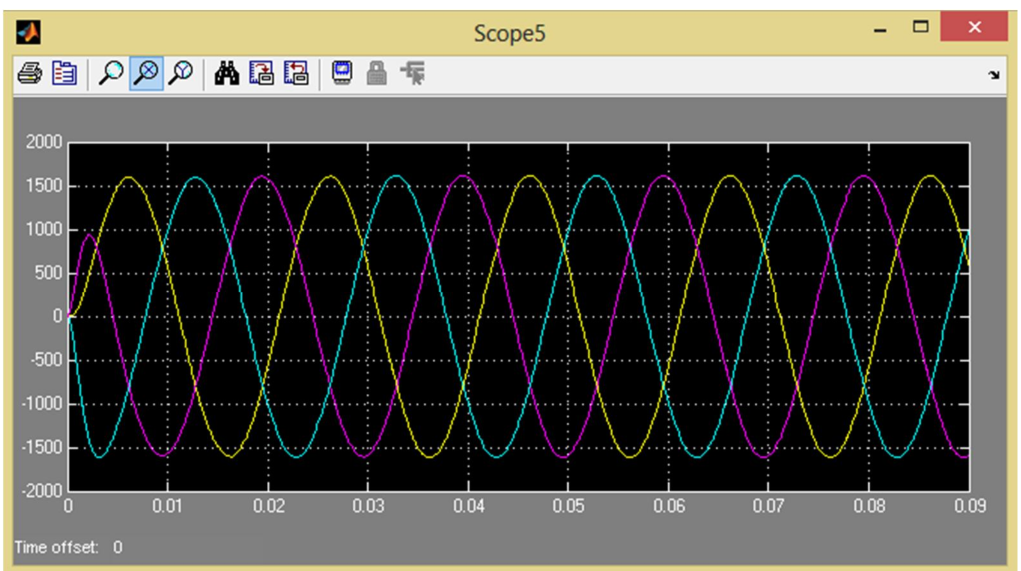

Fig.6 Inverter output (with filter)

III. CONCLUSION

Cascaded H Bridge Multilevel Inverters are mostly used for static VAR applications i.e., in renewable resources of energy and battery based applications. Cascaded H-Bridge Multilevel Inverters can be applied as a delta form. This can be understood by looking at the work done by old scientist where they used an electrical system parallel with a Cascade H-Bridge. Here inverter is being controlled by regulating the power factor. Best application is when we used as photovoltaic cell or fuel cell. This is the example of Parallel connectivity of the H Bridge Multilevel Inverter.

H-Bridge can also be used in car batteries to run the electrical components of the car. Also this can be used in electrical braking system of the vehicles.

Scientist and engineers have also proposed the multiplicative factor on Cascade H-Bridge Multilevel. It means that rather than using a dc voltage with difference in levels, it uses a multiplying factor between different levels of the multilevel i.e., every level is a multiplying factor of the previous one.

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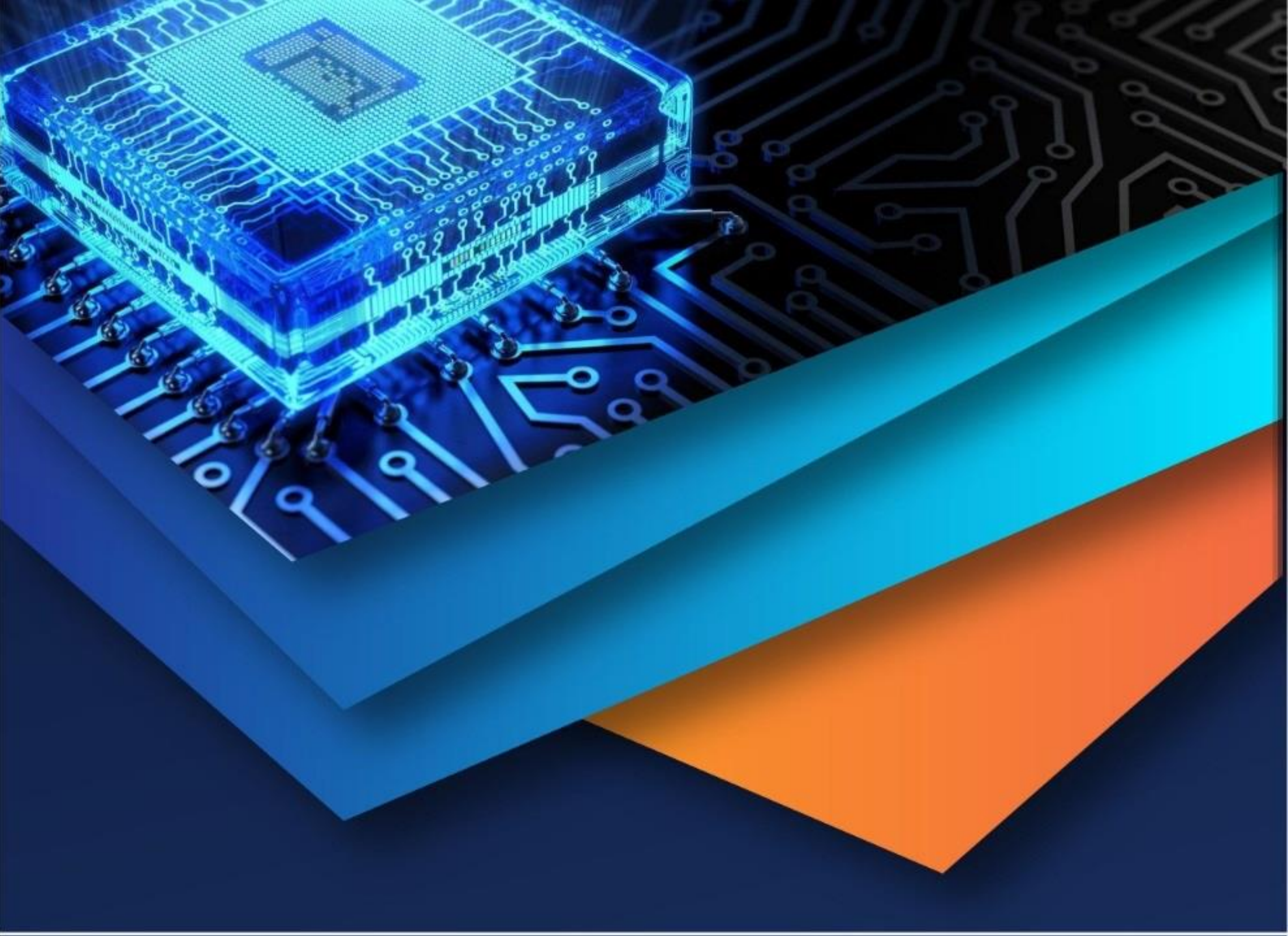

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