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Simulation of H-Bridge Inverter using Pulse Width Modulation Technique

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Abstract: The world today has seen a rise in power demand with the expansion in industry and technology. Coal powered plants alone cannot meet this, due to the harmful emissions and greenhouse gases emitted, which are a contributor to heating. to assist with this, many countries have turned to alternative energy. In this paper, Cascaded H-Bridge Multilevel inverter is intended using the pulse width modulation (PWM) Technique. The system is intended with a photovoltaic array, a lift converter to accelerate the output of the panel which uses Maximum electrical outlet Tracking (MPPT), and an H -bridge inverter for conversion from DC to AC. A Multilevel inverter using Cascaded H-Bridge may be a DC-AC inverter to cut back total harmonic distortion with different sinusoidal pulse width modulation (PWM) like phase disposition, phase opposition disposition, and space vector.
Keywords: Multilevel inverter, Cascaded H Bridge, Harmonic distortion, MPPT, Pulse Width Modulation.

I. INTRODUCTION

Humans have relied on burning fossil fuels like oil, gas, and coal to return a copy with energy. This has led to the drastic accumulation of greenhouse gases within the atmosphere, which may be a significant reason for warming. Hence, we've got moved towards renewable energy which is clean, inexhaustible, and increasingly competitive. Their costs are falling at a sustainable rate, whereas the last word cost trend for fossil fuels is within the other way despite their present volatility. Various renewable energy sources like wind, solar, geothermal, ocean thermal, and biomass are often used for the generation of electricity and for meeting our daily energy needs.

Energy from the sun is that the foremost suitable choice for electricity generation because it's offered everywhere and is liberal to harness. The obtained powers are often used as Grid Connected or Standalone System. A grid-connected photovoltaic installation is connected to the utility grid. Storage typically implemented employing battery banks or fuel cells. Power drawn directly from the battery is DC extra low voltage, and this can be used especially for lighting moreover as for DC appliances. An inverter is employed to return a copy with AC low voltage, which more typical appliances are often used with Stand-alone photovoltaic power systems are independent of the utility grid and will use solar panels only or could even be used in conjunction with a diesel generator, a turbine or batteries.

Multilevel inverters are the favoured choice of industry for applying in high voltage and for prime power applications. Multilevel inverter technology has emerged recently as an awfully important alternative within the planet of high-power medium-voltage energy control. The benefits of multi-level inverters include:

A. Higher voltage is often generated using the devices of a lower rating.
B. An increased number of voltage levels produce better voltage.

II. LITERATURE SURVEY

As mentioned in [1], the objective of multilevel inverters (MLIs) has become predominant in low medium to high voltage applications due to its attractive features towards power quality improvement. The nature of the modulation technique just in case of carrier-based PWM depends upon the common-mode signal adding to the modulating signal. If the carrier frequency increases, then voltage THD% decreases, and switching losses increase. Also, it's noted that the voltage THD% increases with the increase within the modulation index (M) from 0 to unity.

As per [2], the basic concept of a multilevel converter is to realize higher power using power semiconductor switches along with numerous low voltage DC sources. It provides flexibility in interfacing capacitors, batteries, or even renewable energy sources like wind energy, photovoltaic energy, and fuel cells because of the DC voltage sources. The MLI has the facility to chop back the THD, EMI, and DV/DT problems. Cascaded H bridge inverter is found to the foremost effective as compared to other inverters.

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[3]Multilevel inverters are efficient in terms of power quality, lower total harmonic distortion, and lower stresses on the switches. They're preferred since they're going to overcome limitations on the quantity of power that will be converted, by using multiple devices of lower ratings to realize the required rating.

[4]Higher rating devices are dearer and thus multilevel inverters provide an economic alternative. The number of power losses within the facility semiconductor switches is often reduced by using appropriate power semiconductor switches in numerous switching conditions. Multilevel inverters are progressively getting utilized in high-power medium voltage energy control industrial drive applications due to their superior performance compared to traditional two-level inverters. There is a kind of topology applied in recent years. The foremost widely applied topologies are DCLI, CCLI, CHBI. The CBI requires no additional diodes or capacitors and it's easier to implement but it requires two DC sources.

III.BLOCK DIAGRAM

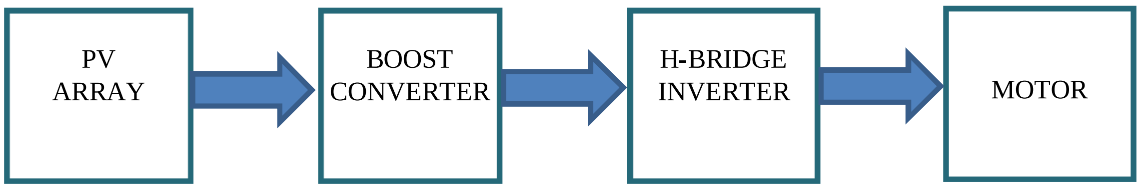

Fig.1 Block Diagram

Fig.1 represents the diagram of the proposed system. As represented in the diagram, the solar is taken into account as a source, and PV Array is intended as per the circuit requirement. The output of the PV Array is connected top of the H- bridge inverter through the boost converter to spice up DC voltage. The output of the inverter is given to the motor to manage its speed. The whole system is simulated in MATLAB/Simulink.

A. Photovoltaic (PV) Array

Photovoltaic solar panels absorb sunlight as a source of energy to return up with electricity. A photovoltaic (PV) module could even be a packaged, connected assembly of photovoltaic solar cells. Photovoltaic (PV) array which consists of modules is taken into consideration because of the essential power conversion unit of a PV generator system. the first component of a practical cell is silicon, which might be a semiconductor material at its core. Silicon is suitably doped with certain impurities to use a solar photovoltaic (PV) cell to capture energy from the sun and convert it into electricity.

The principle operation of solar cells is that when a photon reaches a semiconductor, it ejects an electron resulting in the creation of two conductors: the electron and also the electron-hole. When the PN junction is exposed to light, photons with energy greater than the bandgap of silicon cells are absorbed, causing the emergence of electron-hole pairs. Solar cells are connected serially to create PV modules thereby increasing the output voltage. The panels are connected serial and parallel to create a PV array.

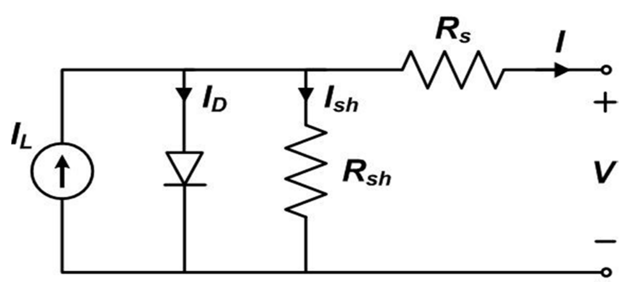

Fig.2 Equivalent Circuit Diagram of PV cell

The equivalent circuit of a PV cell is shown in Fig.2. The current source of I_{ph} represents cell photocurrent. Ru_{sh} and R_s are the intrinsic shunt and series resistances of the cell, respectively. Usually, the price of Rsh is incredibly large which of Rs is incredibly small, hence they're going to be neglected to simplify the analysis. Practically, PV cells are grouped in larger units called PV modules and these modules are connected asynchronous or parallel to create PV array which is used to generate electricity in PV generation systems.

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B. Boost converter

The Boost converter is employed to produce a regulated DC output with the given DC input. These are widely used as an interface between the photovoltaic panel and therefore the load in photovoltaic generating systems. The load must be adjusted to match this and the voltage of the solar battery soon delivers maximum power. The boost converter could be a step-up DC-DC switching converter. With the assistance of the boost converter, the low input-voltage level will be boosted up to a useful high output voltage level. The equivalent circuit diagram for boost converter is given in Fig.3.

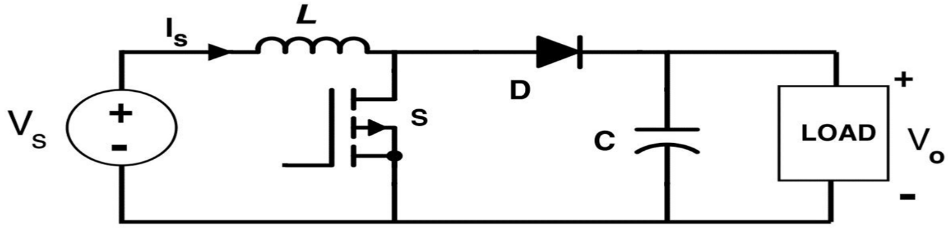

Fig.3 Equivalent Circuit Diagram of Boost converter.

When the switch S is turned on by the pulse, current flows through the inductor (L), and energy is stored in it. When the switch is turned off, energy stored within the inductor within the variety of force field provides an induced voltage across it which adds to the input voltage. The input voltage and voltage across the inductor are serial and collectively charge the output capacitor (C) to a voltage more than the input voltage. This is often the voltage across the load. The DC-DC boost converter circuit consists of Inductor (L), Diode (D), Capacitor (C), a load resistor (RL), the control switch (S). These components are connected in such a way with the input voltage source (Vin) so on accelerate the voltage.

C. H-Bridge Inverter

The power device which converts the DC power into AC power is named an inverter and is employed in several industrial applications that require sinusoidal waveforms with minimum distortion at high power. In earlier days simplest two-level inverter was used which produces output with two different voltage levels but had harmonic voltage and high switching losses. In recent times, because of increased advancement in technology, the concept of multilevel inverters was introduced to reduce the percentage of losses. H-bridge inverter is that the most advanced topology available. It uses a series string of single-phase full-bridge inverters to construct multilevel phase legs with separate dc sources. The output of every H-bridge can have three discrete levels. Higher levels may be obtained by cascaded connection of those H – Bridge units and therefore the resultant output to be the integrated sum of those individual units.

IV. CIRCUIT DIAGRAM WITH DESIGN

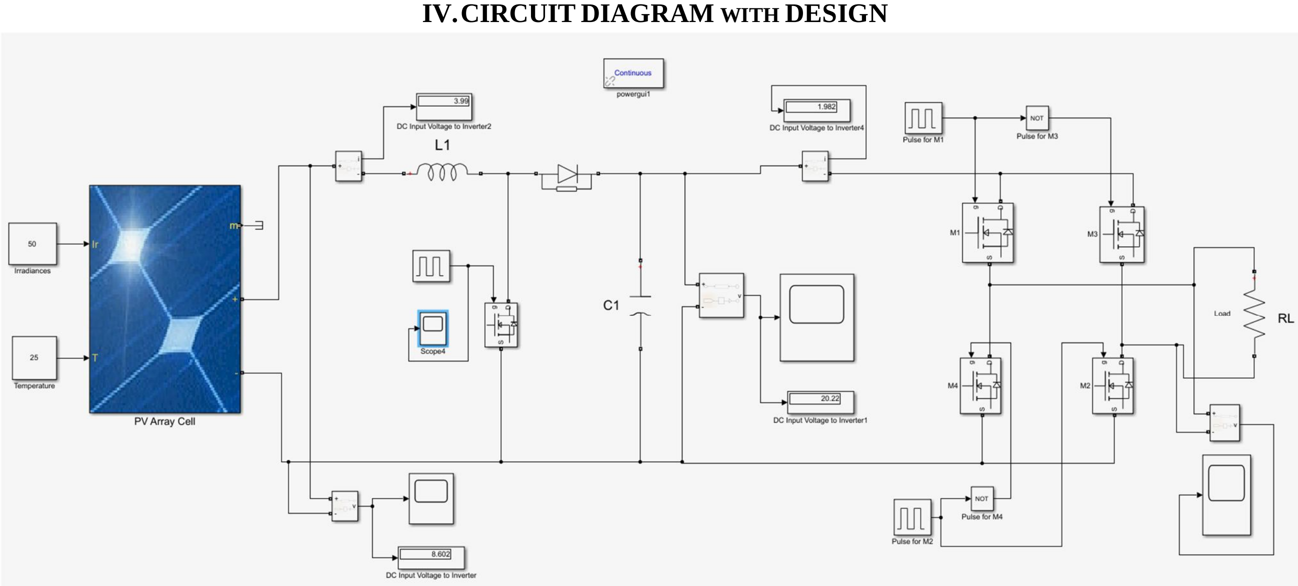

Fig.4 Simulink model of cascaded H-bridge inverter

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The Fig.4 represents Simulink circuit model. Photovoltaic solar panels absorb sunlight as a source of energy to come up with electricity. A photovoltaic (PV) module may be a packaged, connected assembly of photovoltaic solar cells. Photovoltaic (PV) array which consists of modules is taken into account because of the fundamental power conversion unit of a PV generator system. The power device which converts the DC power into AC power is termed an inverter and is employed in several industrial applications that require sinusoidal waveforms with minimum distortion at high power. With the rise within the number of levels within the inverter output, there comes additional complexity within the circuitry furthermore because the control techniques Pulse width modulation (PWM) uses a reference waveform and a carrier waveform to come up with the gate driving signal.

The two signals are compared to every other. If the carrier signal is under the reference signal, the PWM output is high and if the carrier signal is on top of the reference signal then the PWM output is low. Cascaded H-bridge topology of the multilevel inverter was chosen because the series structure allows a scalable, modularized circuit layout because of the identical structure of every H–Bridge, and no extra clamping diodes or voltage balancing capacitors are necessary. Supported this study, Perturb and Observe method of MPPT was selected because it is simple to implement and is accurate operational. The system design with various components of the proposed system is given below. The calculations and equations are shown.

A. PV Panel

A Photovoltaic system employs solar modules, each comprising variety of solar cells, which generate power. Maximum wall plug tracking (MPPT) or sometimes just wall plug tracking (PPT)) may be a technique used commonly with photovoltaic (PV) solar systems to maximize power extraction under all conditions.

B. Boost Converter

It's a category of switch-mode power supply (SMPS) containing a minimum of two semiconductors and a minimum of one energy storage element: a capacitor, inductor, or the two.

The inductor and capacitor equations are given below

The inductor value of the Boost converter is calculated using

$L = \frac{Vin*D}{fs*\Delta I*L}$ 1

Where fs is that the switching frequency and L ΔI is that the input current ripple.

The current ripple factor (CRF) is the ratio between input current ripple and output current. Permanently estimation of inductor value CRF should bound within 30%. i.e.

$\frac{I1}{\Delta Io} = 0.3$ ………...2

The capacitor value of the Boost converter is calculated using $C = \frac{Iout*D}{fs*\Delta Vo}$ …….3

Where ΔVo is that the output voltage ripples.

V. SIMULATION RESULTS

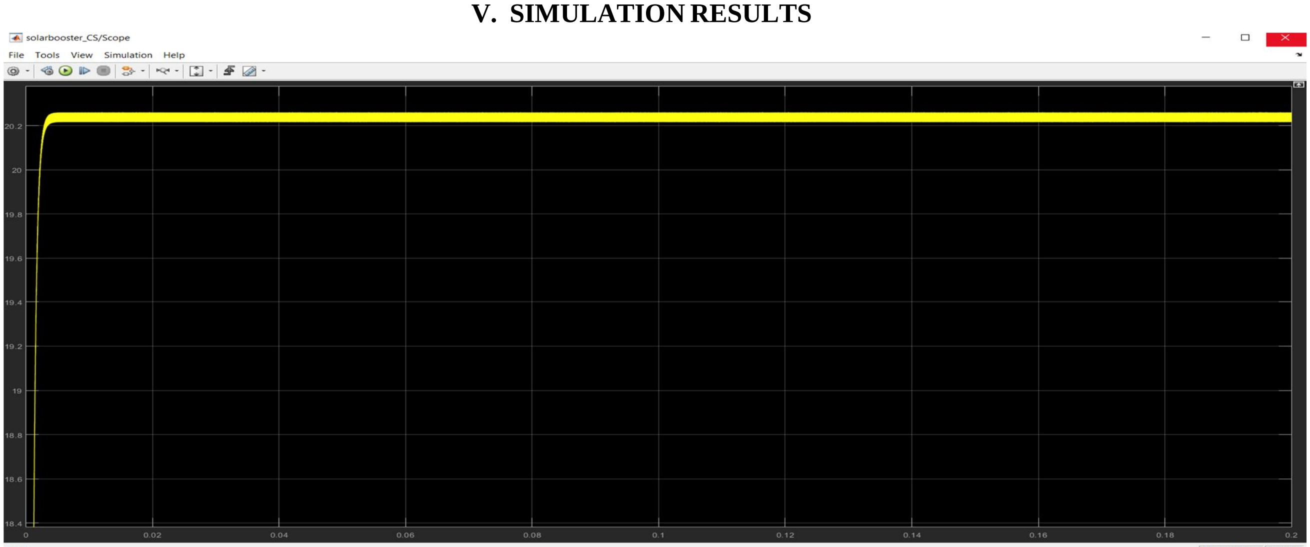

Fig.5 PV Array simulation results

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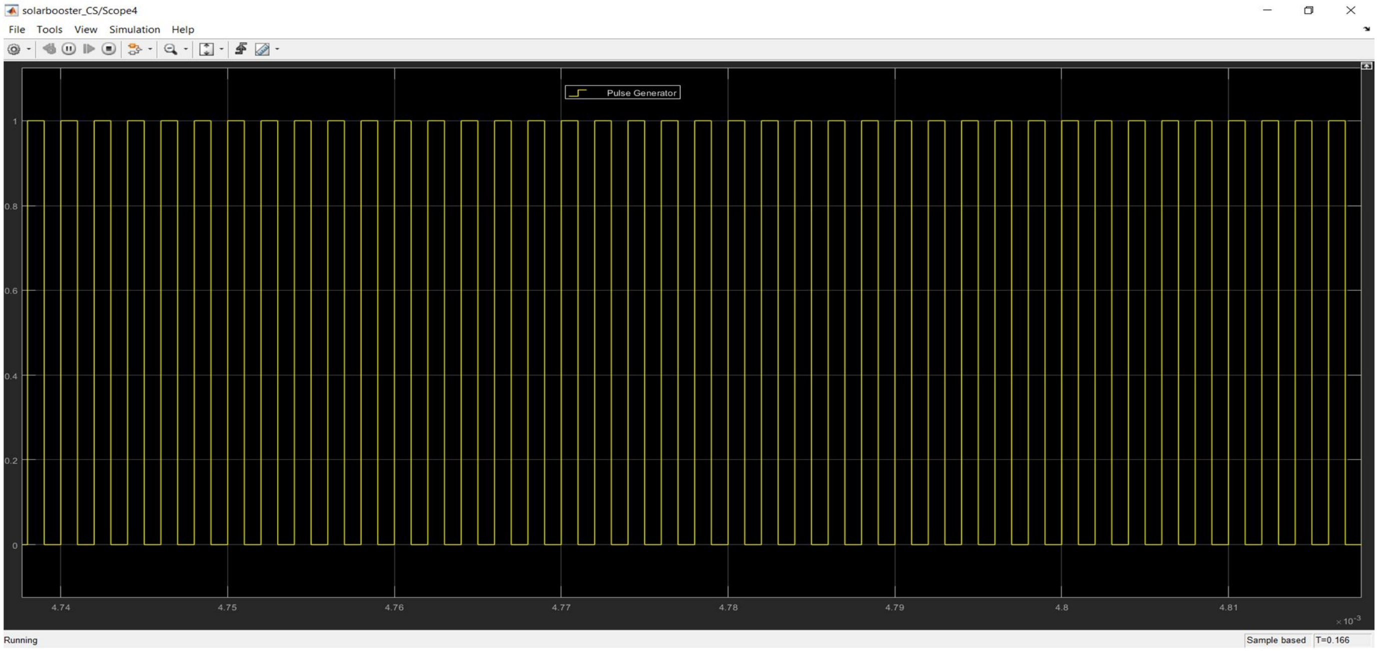

Fig.6 Pulse generator

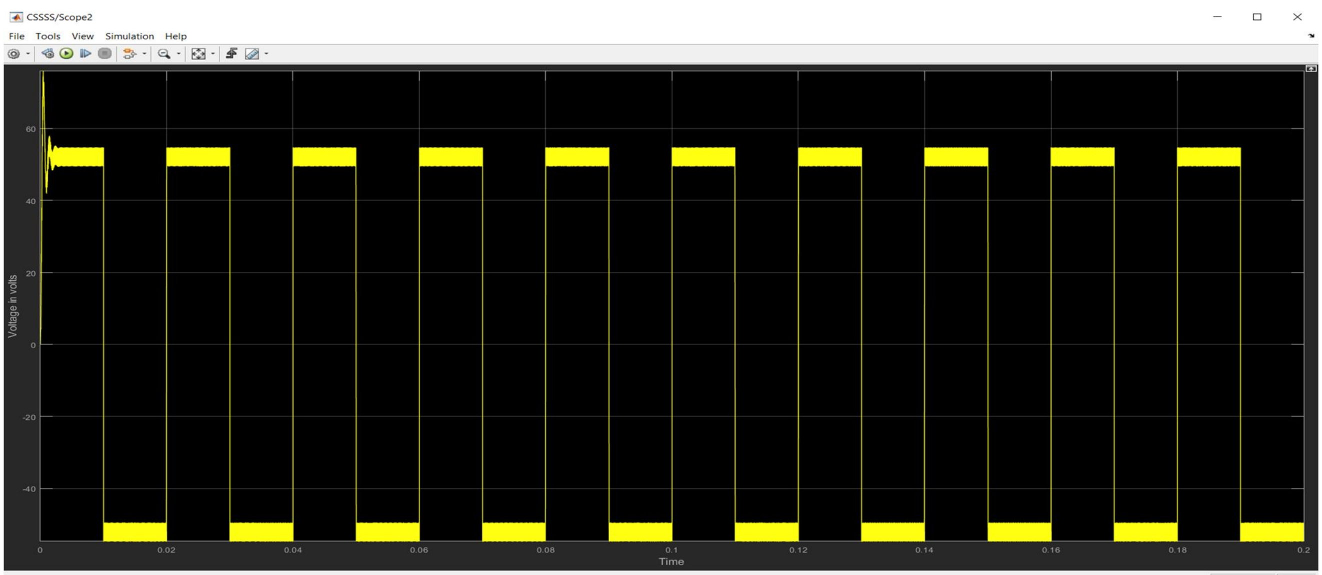

Fig.7 Output waveform of the simulated H-bridge inverter using PWM technique

The simulation is carried out by modeling the circuit in Simulink. This is achieved by connecting the PV Array in series with the Boost converter; the stepped-up voltage is given to the inverter circuit which converts the DC Voltage to AC Voltage, which in turn can be fed to the load. The output voltages are designed for 50V. The efficiency of the boost converter is assumed to be 90% (standard value). The duty cycle is found to be 55%.The output waveform of the PV Array simulation is shown in the Fig.5.The pulse generator results are displayed in Fig.6.The switching frequency (fs) is 20KHz.The input current ripple is 3.75A. The inductor and capacitor values are calculated to be 0.16Mh and 27.7 microfarads. The 12V output from the PV Array is fed to the Boost converter, which steps up the voltage to 20V and this DC voltage is given to the Cascaded H Bridge circuit. The inverter circuit converts DC Voltage to AC Voltage and is supplied to the load. The load can be a resistive load such as a lamp. The switches are turned on and off as per switching frequency to obtain the output voltage and current waveforms. The figure shows the pulse width modulated signal seen on the output side. The complete simulation of the H Bridge inverter using PWM Technique is shown in Fig.7.

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VI. CONCLUSION

It can be concluded that with the inclusion of Maximum Power Point Tracking the voltage output of the boost converter is significantly better. With the help of a boost converter, the input voltage to the inverter can be maintained constant without many fluctuations. In terms of performance - it boosts the value closer to the designed value, and in terms of wave shape - lesser distortions. The overall output voltage value of the inverter is also seen to improve. The advantages of H-bridge inverter are high efficiency, low loss and this circuit can be placed in small places. Some application of the H-Bridge circuit as the motor driver circuit, In Robotics Technology-bridge circuits is used. H-Bridge circuit is also used as Inverter circuit.

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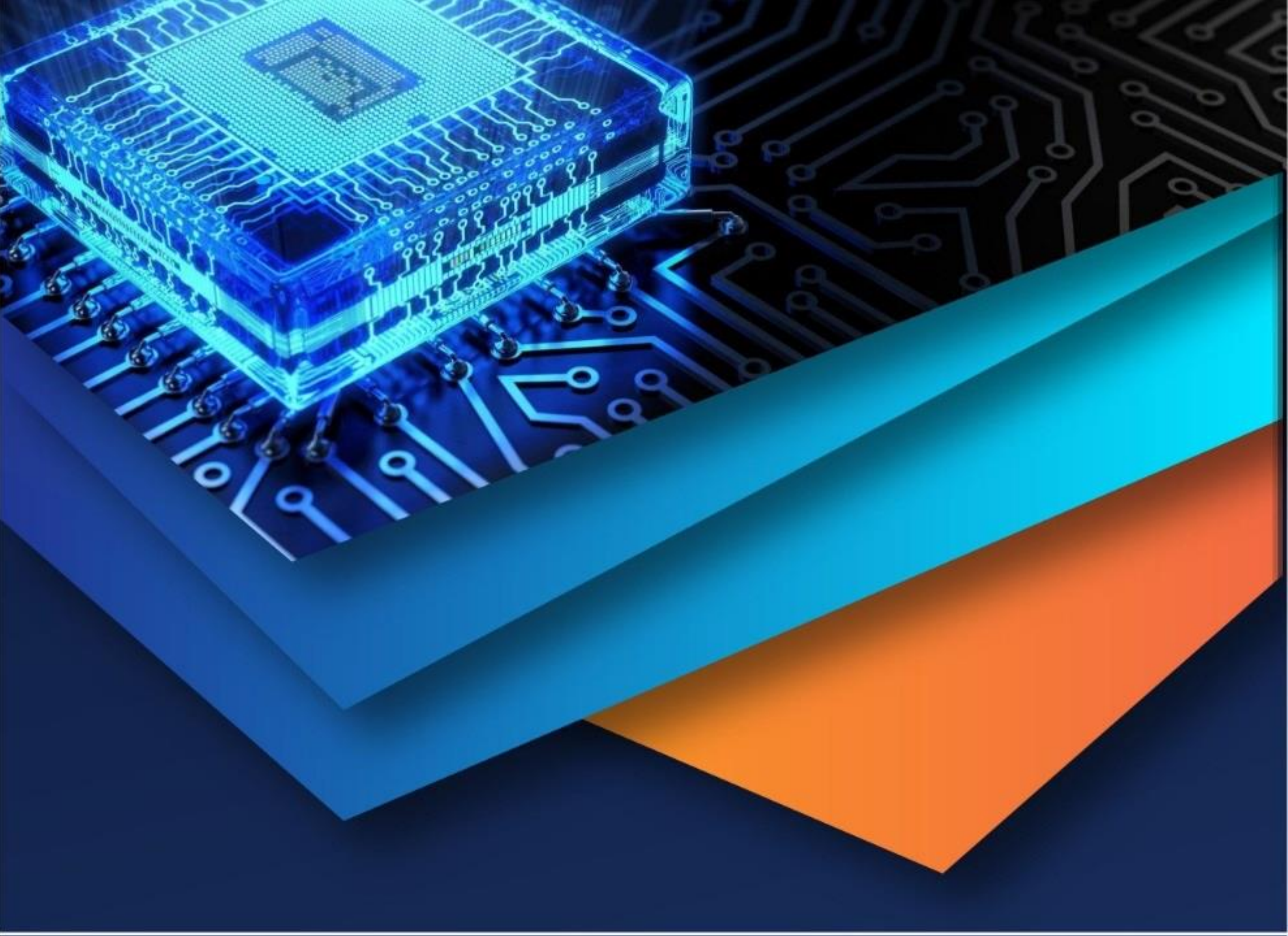

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