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# Improving Incremental Conductance Control Method of Solar Energy Conversion

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***Abstract**: Solar energy is a potential energy source in India. A photovoltaic is needed to harvest this kind of energy, and to be able to gather the most, the PV must have a good efficiency. The maximum efficiency is achieved when PV works at its maximum power point which depends on irradiation and temperature. Since the irradiation and temperature always change with time, a PV system which able to track the maximum power point needs to be developed to produce more energy. This research was aimed to explore the performance of a maximum power point tracking system which implements Incremental Conductance (IC) method. The IC algorithm was designed to control the duty cycle of Buck Boost converter and to ensure the MPPT work at its maximum efficiency. The system performance of IC algorithm was compared to widely used algorithm - Perturb and Observe (P&O) on a Simulink environment. From the simulation, the IC method shows a better performance and also has a lower oscillation.*

***Keywords: MPPT, Incremental conductance, solar cell, photovoltaic cell***

## I. INTRODUCTION

Incremental conductance is one of the important technique used in this system and because of higher steady state accuracy and environment adaptability it is widely used implemented tracked control strategy. The renewable energy is used for to control pollution free environment. India plans to produce 20 GW Solar power by year 2020, whereas we have only realized less than half a Gigawatt of Indian potential as of March 2010. Solar energy is a vital untapped resource in a tropical country like India. Now a days, the advance technology in PV cell so the efficiency increases in low capital cost also. It is examined schematic to extract maximum obtainable solar power from a PV module and use the energy for a DC application. This investigates in detail the concept of Maximum Power Point Tracking (MPPT) which significantly increases the efficiency of the solar photovoltaic system.

## II. PHOTOVOLTAIC CELL

Conversion of light energy in electrical energy is based on a phenomenon called photovoltaic effect. When semiconductor materials are exposed to light, the some of the photons of light ray are absorbed by the semiconductor crystal which causes significant number of free electrons in the crystal. This is the basic reason of producing electricity due to photovoltaic effect. Photovoltaic cell is the basic unit of the system where photovoltaic effect is utilized to produce electricity from light energy. Silicon is the most widely used semiconductor material for constructing photovoltaic cell.

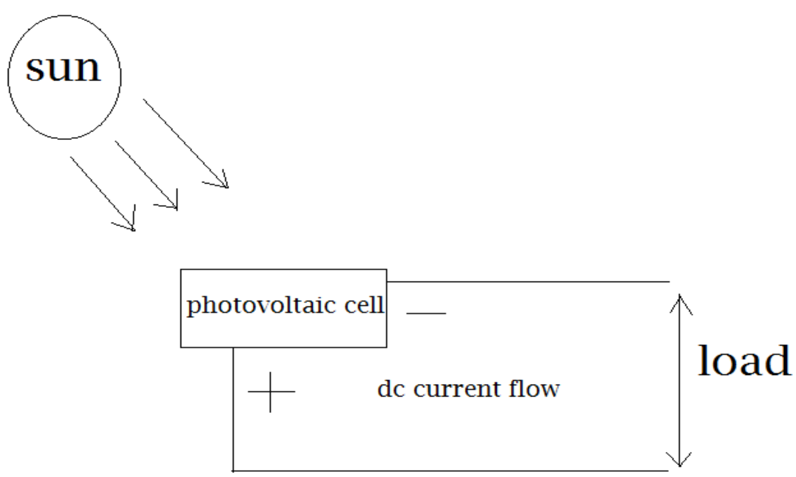


FIGURE 1. PHOTOVOLTAIC CELL.

## III. PV MODELLING

Photovoltaic system is an apparatus for converting solar energy to DC electric power. A PV is characterized by its short circuit current (Isc), open circuit voltage (Voc), maximal voltage (Vmax) and MPP current. Those parameters shape the I -V and P-V characteristic curve. The PV output voltage also depends on the load. A PV commonly can be modeled by one diode and two diodes. Two diodes model is more accurate but it needs more variables hence the model is more complex [4]. Regarding that condition, this research was carried out by using one diode model. The PV itself is a nonlinear system and can be defined as a variable current source as shown on Fig 2.

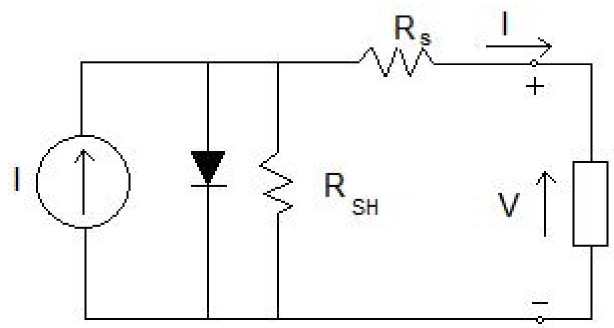


Figure 2. Single model of PV cell [2]

In this model we consider a current source (I) along with a diode and series resistance (Rs). The shunt resistance (RSH) in parallel is very high, has a negligible effect and can be neglected.
The output current from the photovoltaic array is

$$I=I_{SC}-I_D \quad (2.1)$$

$$I_D= I_O\,(e^{qV_D/kT}-1) \quad (2.2)$$

From eq. 2.1 and 2.2

$$I = I_{SC}-I_O\,(e^{qV_D/kT}-1) \quad (2.3)$$

Using suitable approximations,

$$I = I_{SC}-I_O\,(e^{q((V+IR_S)/nkT)}-1) \quad (2.4)$$

where, I is the output current, V is the output voltage, T is the temperature (in Kelvin) and n is the diode ideality factor In order to model the solar panel accurately we can use two diode model but in our project our scope of study is limited to the single diode model.

## IV. MPPT(MAXIMUM POWER POINT TRACKING)

Maximum Power Point Tracking (MPPT) is an electronic system which operates PV to gain a maximum power. MPPT is not a mechanical tracking however a MPPT can be used simultaneously with a mechanical tracking system. Maximal Power Point (MPP) does not lie at a particular point but it moves around P-V curve depends on light intensity and temperature. A typical solar panel converts only 30 to 40 percent of the solar energy into electrical energy. Maximum power point tracking technique is used in PV cell it increase the efficiency. Maximum Power Point Tracking (MPPT) is an electronic system which operates PV to gain a maximum power. MPPT is not a mechanical tracking however a MPPT can be used simultaneously with a mechanical tracking system. Maximal Power Point (MPP) does not lie at a particular point but it moves around P-V curve depends on light intensity and temperature. According to Maximum Power Transfer theorem, the power output of a circuit is maximum when the Thevenin impedance of the circuit (source impedance) matches with the load impedance. The drawback of this method is it introduces an oscillation on the steady state and the voltage variation is large. This method also needs a long tracking time and it has a slow response to the irradiant and temperature changes.

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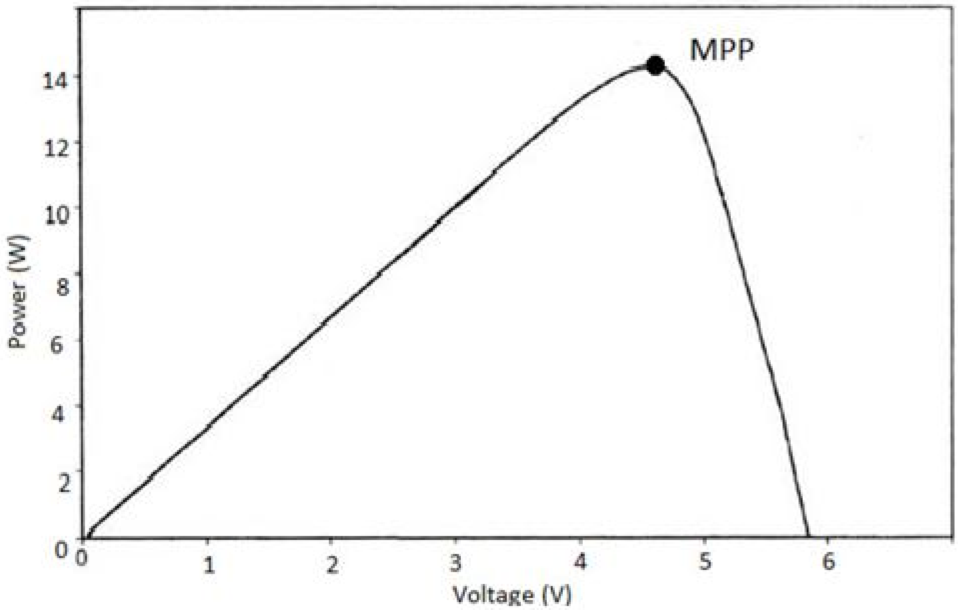


FIGURE 3. PV CHARACTERISTICS OF CURVE PHOTOVOLTAIC CELL

## V. INCREMENTAL CONDUCTANCE

Incremental Conductance was designed based on an observation of P-V characteristic curve. Incremental conductance method uses voltage and current sensors to sense the output voltage and current of the PV array. At MPP the slope of the PV curve is 0.

$$(dP/dV)_{MPP} = d(VI)/dV \tag{4.1}$$

$$0 = I + V\, dI/dV_{MPP} \tag{4.2}$$

$$dI/dV_{MPP} = -I/V \tag{4.3}$$

If MPP lies on right side, $dI/dV < -I/V$ and then the PV voltage must be decreased to reach the MPP.IC methods can be used for finding the MPP, improve the PV efficiency, reduce power loss and system cost. Implementation IC on a microcontroller produced more stable performance when it compared to P&O. The oscillation around MPP area also can be suppressed in trade of with its implementation complexity. When this instantaneous conductance equals the conductance of the solar then MPP is reached. Here we are sensing both the voltage and current simultaneously. Hence the error due to change in irradiance is eliminated. However the complexity and the cost of implementation increases. As we go down the list of algorithms the complexity and the cost of implementation goes on increasing which may be suitable for a highly complicated system. This is the reason that Perturb and Observe and Incremental Conductance method are the most widely used algorithms [5].

## VI. INCREMENTAL CONDUCTANCE ALGORITHM

In this method, the ratio of change in output conductance is equal to the negative output Conductance Instantaneous conductance. We have,

$$P = V I$$

Applying the chain rule for the derivative of products yields to

$$\partial P/\partial V = [\partial(VI)]/\partial V$$

$$\text{At MPP, as } \partial P/\partial V = 0$$

The above equation could be written in terms of array voltage V and array current I as

$$\partial I/\partial V = -I/V$$

The MPPT regulates the PWM control signal of the dc – to – dc boost converter until the condition:

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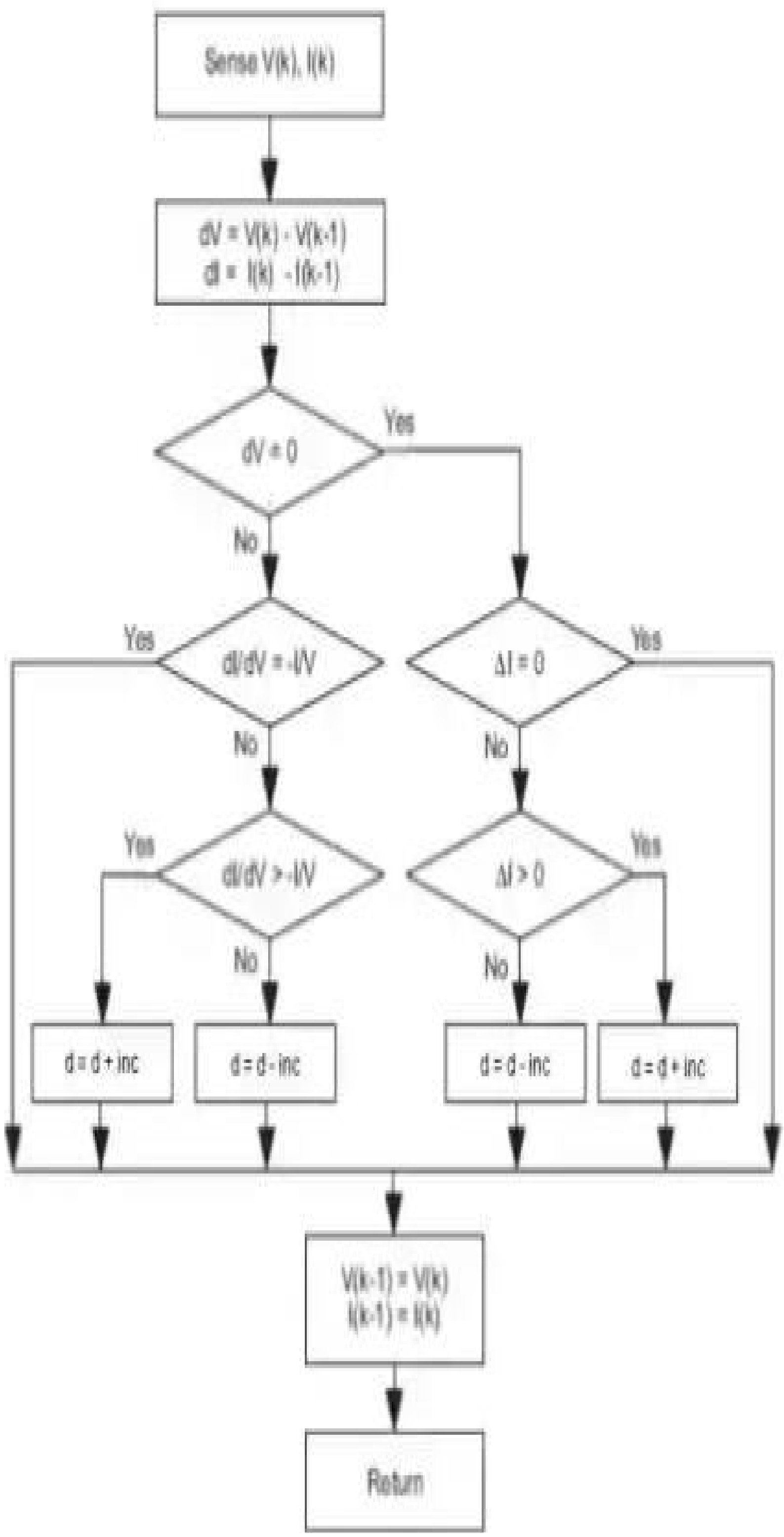
$$(\partial I/\partial V) + (I/V) = 0$$

is satisfied. In this method the peak power of the module lies at above 98% of its incremental conductance. The Flow chart of incremental conductance MPPT is shown below



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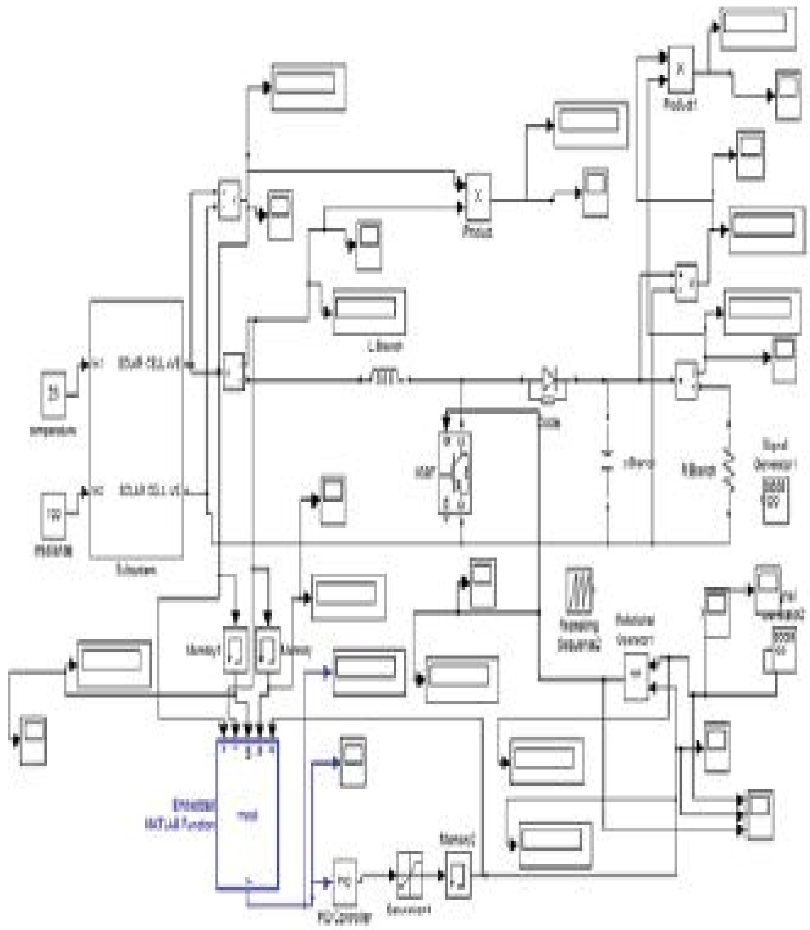
## VII. SIMULATION




## VIII. RESULT

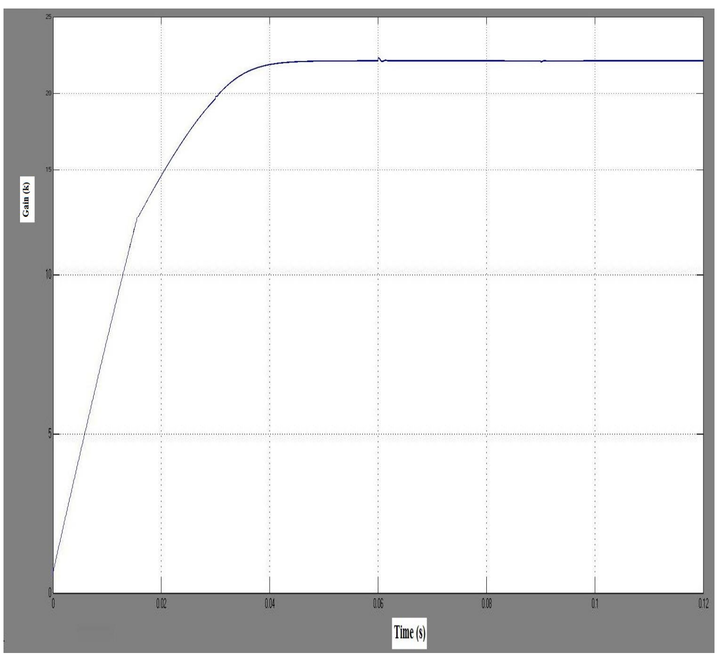



FIGURE 4. PI CONTROL GAIN V/S TIME WITH MPPT

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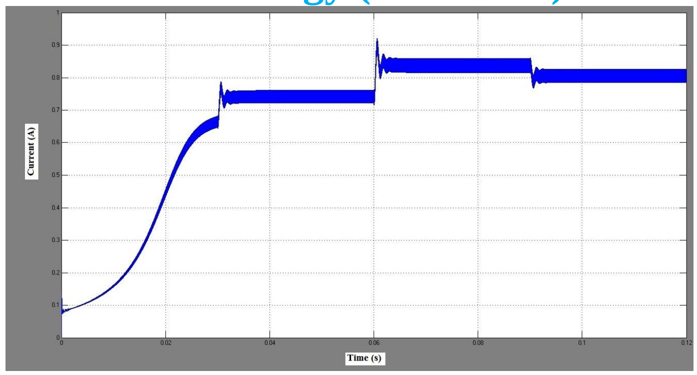


FIGURE 5.PLOT OF OUTPUT CURRENT AT LOAD SIDE V/S TIME WITH MPPT

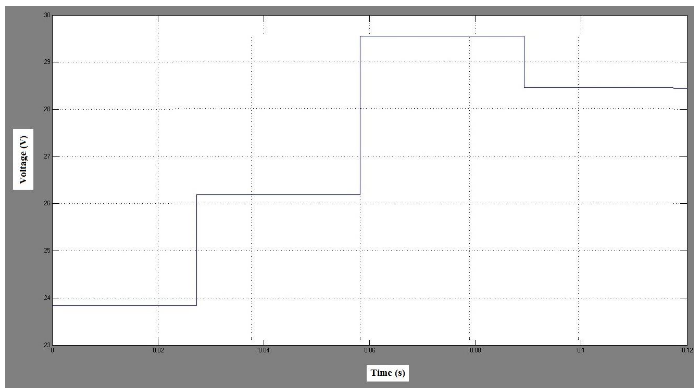


FIGURE 6. PLOT OF CALCULATED MPPT $V_{REF}$VOLTAGE V/S TIME WITH MPPT

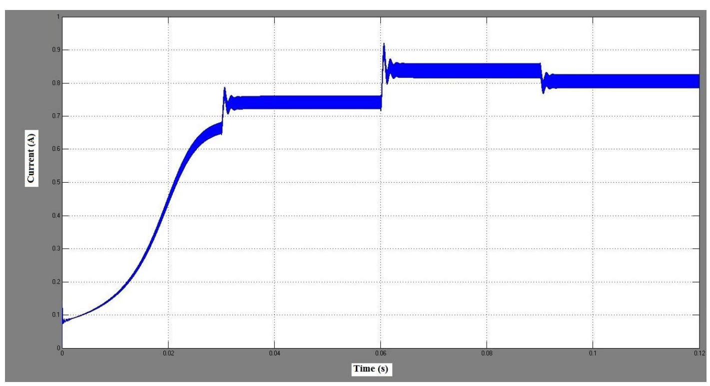


FIGURE 7. PLOT OF OUTPUT CURRENT AT LOAD SIDE V/S TIME WITH MPPT

## IX. CONCLUSIONS

This research was targeted to analyse MPPT implementation on buck-boost converter by using Incremental Conductance method. The model shown in Fig. was simulated using SIMULINK and MATLAB. The simulation was first run with the switch on no MPPT mode, bypassing the MPPT algorithm block in the circuit. It was seen that when we do not use an MPPT algorithm, the power obtained at the load side was around 95 Watts for a solar irradiation value of 85 Watts per sq. cm. It must be noted that the PV panel generated around 250 Watts power for this level of solar tts. irradiation. In this case, however, the power obtained at the load side was found to be around 215 Watts, thus increasing the conversion efficiency of the photovoltaic system as a whole. The loss of power from the available 250 Watts generated by the PV panel can be explained by switching losses in the high frequency PWM switching circuit and the inductive and capacitive losses in the Boost Converter circuit. Therefore, it was seen that using the Incremental Conductance MPPT technique increased the efficiency of the photovoltaic system by approximately 44% from an earlier output power of around 95 Watts to an obtained output power of around 130 Watt.

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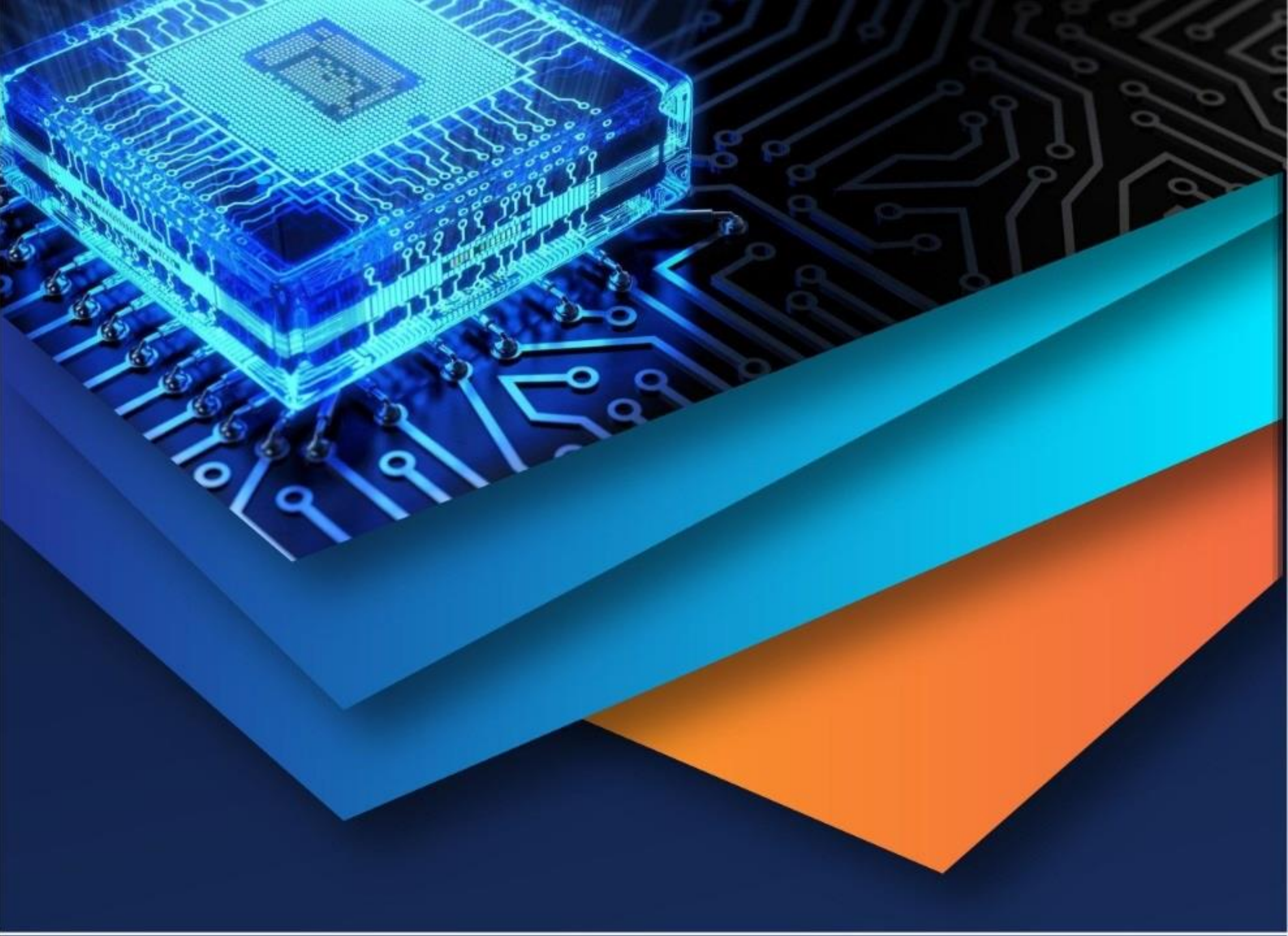


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