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Optimized Perturb and Observe Techniques for Sudden Irradiance and Temperature Change

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Abstract: ***Solar Power generation plays vital role in RES due to its natural abundance and environment friendly. The efficiency of the PV System depends on the more optimized MPPT Technique. Several methods for extracting GMPP are discussed that works better on steady state oscillations and fast tracking time. In this paper all recent techniques for MPPT are discussed and more efficient algorithm and simple in approach is revealed. This paper tries to find more efficient algorithm with fast tracking speed and optimized duty cycle.***
Keywords: MPPT, Perturb and Observe, Steady state Oscillation, Tracking speed, Duty cycle, Hybrid MPPT, PSC.

I. INTRODUCTION

Among the Renewable Energy Sources(RES),solar energy is most promising renewable energy sources as it is available as a clean energy in abundance. Solar PV panels convert solar energy to electricity. This energy can power devices or be saved in batteries. Among many mppt techniques the main goal is minimizing fluctuation systems over maximum power point and increasing maximum point with increasing efficiency and tracking speed under steady state and rapid climate change .To reduce environmental impacts many countries are focusing on power generation from non-conventional energy sources rather than conventional energy sources. Power generated from solar PV is not constant throughout the day because of continuous varying weather condition and also it is available in the day time. Power generated from PV is maximum only at one point for given irradiance(w/m2) and temperature (^{o}C) and is measured as maximum power point of PV [1]. A PV system can be stand-alone or grid connected. In case of grid and commercial aspects the authors discussed a wide range of MPPT algorithms. They are categorized in terms of parameter estimation, usage of sensors, computation time, controller complexity, variable step size perturbation, tracking speed and their implementation cost. The key ideas behind all developed MPPT algorithms are to track the MPP faster and more accurate in varying irradiance condition with low power oscillations. In grid connected PV system, the energy produced is consumed on-site or sold to the grid in surplus production[9].Stand-alone system is used in villages and isolated companies in remote areas. Hence designing maximum power point tracking algorithm plays a vital role in solar PV system. Among many algorithms P &O algorithm focuses on pertebating voltage of the PV panel. Generally in the conventional P&O based MPPT algorithm, the voltage and power of PV system are measured instantaneously, and then the voltage is adjusted as increment or decrement to reach the MPP for appropriate direction with its fixed step size. The main drawback of the conventional P&O algorithm is its tracking direction, step size and oscillation around MPP in During uniform isolation, classical methods are highly preferred as there is only one peak in the P-V curve. However, under (Partial Shading Conditions)PSCs, the P-V curve exhibits multiple peaks, one global maximum power point (GMPP) and remaining are local maximum power points (LMPP's). Under the PSCs, classical methods fail to operate At GMPP and hence there is a need for more advanced MPPT techniques. Every MPPT technique has its advantages and limits, but a more accurate MPPT is drafted in numerous parameters like sensors required, hardware implementation, costviability, tracking speed, tracking efficiency[3].sudden variation in irradiance condition and it requires a PI controller to tune the control parameter. In order to overcome these issues, a modified Perturbation and observation based MPPT algorithm is proposed in [8] . According to the United Nations Environment Program (UNEP) briefing note on its Sustainable Development Goal 7 (SDG 7), electricity is unavailable for billion people in the world while more than three billion people use solid fuels like wood still cook their food and heat their homes.With these wasteful practices and air pollution about four million people die. To reduce human health problems around the globe, UNEP calls for a reduction of emissions caused by fuel combustion by 40%. Achieving SDG 7 will certainly act to have a positive impact on other SDGs such as combating climate change (SDG 13) and helping to end global poverty (SDG1) by achieving energy justice in developing countries [9]. Among the renewable energy sources (RES), solar energy is the promising alternative and the most useful energy from an ecological point of view as it is an available and a clean energy. Fig 1 shows the PV System using MPPT.

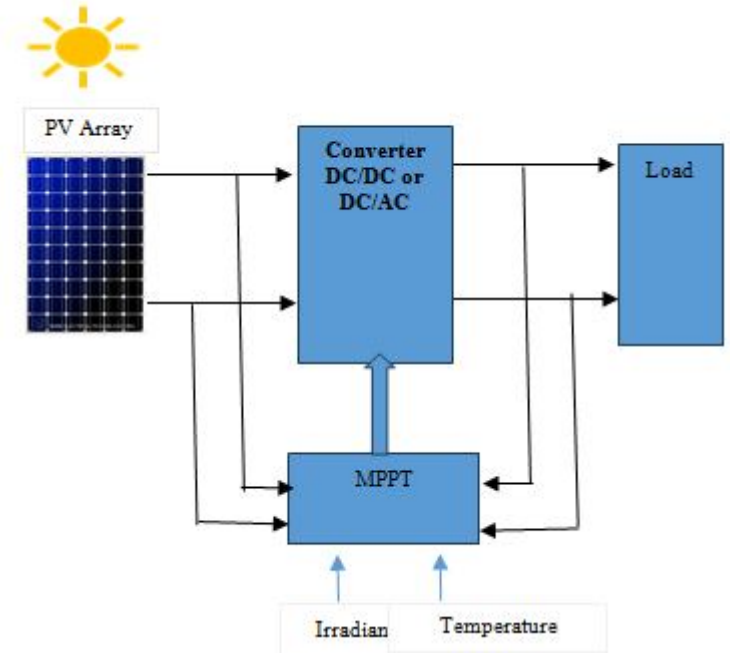

Fig1. Solar PV System with MPPT

II. CLASSIFICATION OF MPPT ALGORITMS

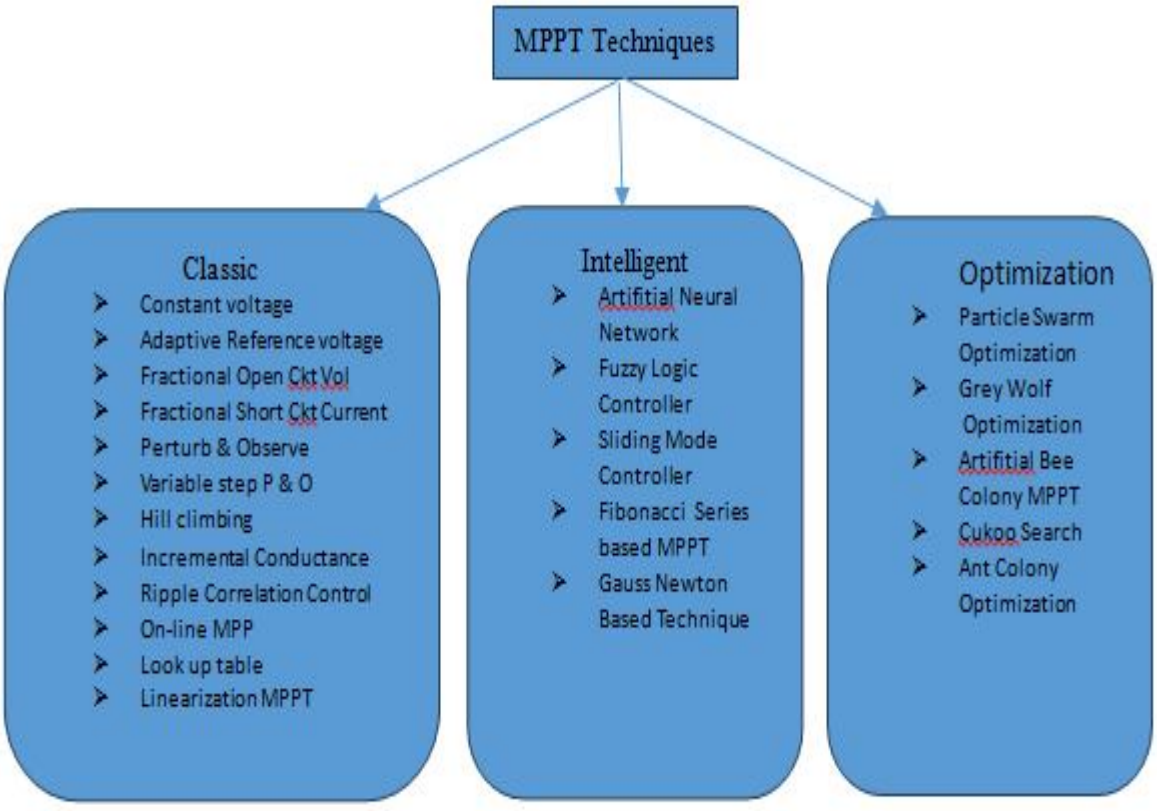

Fig 2. Classification of MPPT approaches on three classes depending on the tracking algorithm: (1) classical algorithms, (2) intelligent algorithms, and (3) optimization algorithms [9].

Table 1. Hybrid based MPPT Techniques[3]

Parameters	FPSO	ANFIS	GWO-P&O	PSO-P&O	HC-ANFIS
Tracking Speed	High	High	Medium	High	High
Tracking accuracy	High	Medium	High	Medium	High
Control strategy	FIS and bio-inspired	Sampling Mode	Bio-inspired	Fine tuning of D	Two step process
Sensed Parameters	V &C	V&C	V	V &C	V & C
Complexity	Simple	Medium to Complex	Medium	Medium to complex	Simple
Parameter tuning	No	Yes	Yes	Yes	No
Stability	Very Stable	Stable	Stable	Stable	Very Stable
Analog/Digital	Digital	Digital	Digital	Digital	Digital
Grid Integration	Yes	Yes	Yes	Yes	Yes
Cost	Very Expensive	Expensive	Affordable	Affordable	Expensive
Ability to track under PSC's	High	High	High	High	High
Efficiency	-	99.562	99.77	100	-

MPPT Techniques on different approaches is depicted in the fig 2. New trends on GMPP is discussed in Table 1.This discussion shows that use of metaheuristic and algorithms like PSO,GWO, etc. Comparative analysis between most used Metaheurestic methods with high ability to track GMPP under PSC's is shown in Table 1. Conventional methods like Perturb and Observe ,INC and HC used for comparative studies with new proposed methods are simple but less accurate under PSC's. The intelligent prediction methods such as FLC, ANN are efficient but are more expensive[9]. New Swarm algorithms and improved ones have shown better performance. The contribution of the new swarm algorithms was proved in terms of stability, oscillations around MPP, efficiency, settling time, robustness, and sensitivity to different shading scenarios and dynamically varying isolation conditions.

A. Comparison table for more optimised mppt Algorithm

To explore the new trends around MPPT approaches, Table 2 shows the Analysis of different algorithms .It show that use of metaheuristic swarm algorithms including PSO,GWO,ACO and so on. Comparative analysis shows that Conventional methods like P&O, INC, and HC with new proposed methods are simple but less exact in PSC's[9].However their responses are slow under PSC's .The intelligent prediction methods such as FLC,ANN, or ANFI have the abilities to manage non-linearities. but they are expensive, complex to implement and not efficient for simple applications. Further they need huge amount of data which imposes extreme load on process memory.

Hence by proposing new hybrid approaches .The objective is to improve the performance of GMPP algorithms by increasing the tracking efficiency and lowering computation burden of hardware. Further by combining online like perturb and observe ,Incremental conductance, Hill climbing etc and off-line methods like constant voltage, constant current, Look-up table etc can lead to better performance always[9].

The various parameters for Hybrid based MPPT Technique is given in the Table 1 [3]. Further P&O Algorithm is discussed which when combined with other methods can be applied for its simplicity and easy implementation. They can be applied for their algorithm lower complexity making them the best Techniques for simple application not requiring high performance.

Table 2: Algorithms with high ability to track GMPP under PSC's[9]

MPPT Algorithm	Tracking Speed	Tracking Accuracy	Steady State Oscillation	Stability	Controller Cost	Algorithm Complexity	Efficiency	Sensitivity
PSO	Slow	Medium	Yes	Stable	Affordable	Medium	99.9	High
GWO	Slow	High	Yes	Stable	Affordable	Simple	-	-
ACO	High	High	No	Stable	High	Complex	99.97	Medium
ABC	High	Medium	Yes	Stable	Expensive	Medium	99.78	Low
CS	High	High	-	Stable	Expensive	Simple	99.89	Medium
FA	High	High	No	Stable	Affordable	Simple	98	High
Jaya	Medium	-	No	-	Medium	Medium	Medium	-
BAT	High	-	No	-	High	High	High	-
SS	Very High	Very High	No	Stable	-	-	99	-
FPA	High	High	No	-	-	Complex		Low
OTCA	Very High	Very High	No	-	-	Simple	99.98Low	

III. P & O ALGORITHM(FOR STABLE CONDITION)

For every PV System there is a single operating point known as Maximum Power Point in I-V and V-P curves for each temperature and irradiation condition. Whenever temperature changes the MPP changes its position. Hence MPPT Algorithm is designed to track the MPP . They play an important role in Solar PV System. The general system is depicted in Fig 1.

Perturb & Observe Algorithm is designed to increase or decrease the terminal voltage or current at regular interval and comparing the output power of PV with previous samples[6]. The P&O algorithm is known for its simple implementation and good excellent tracking efficiency. MPPT P & O algorithm is used to study the behaviour of the PV I-V curve . Through this P&O method, the MPPT controller will observe the PV output power and it will perturb the PV output power either increment or decrement depends on the increment of PV voltage or current as predicted in Fig 2. In this method the present value is compared with PV output power that was calculated with the past value that gives the differences in power. The algorithm will continue to perturb the PV operating voltage by a small increment. If the changes in power (ΔP) value is positive, it will move towards the direction of maximum power point and the operating voltage will continue to be perturb in the same direction. If the result of the perturb process leads to negative in ΔP. It will move away from the maximum power point and the sign of the perturbation is changed[6].

Fig 2 shows the flowchart of P & O Algorithm operation and PV I-V curve.

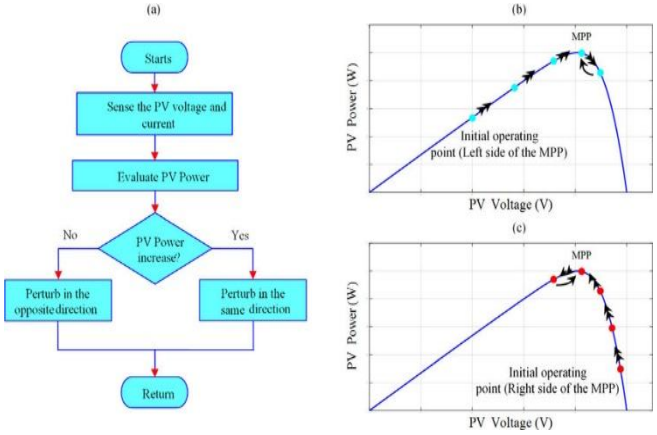

Fig 2. Perturb & Observe Algorithm and PV I-V curve

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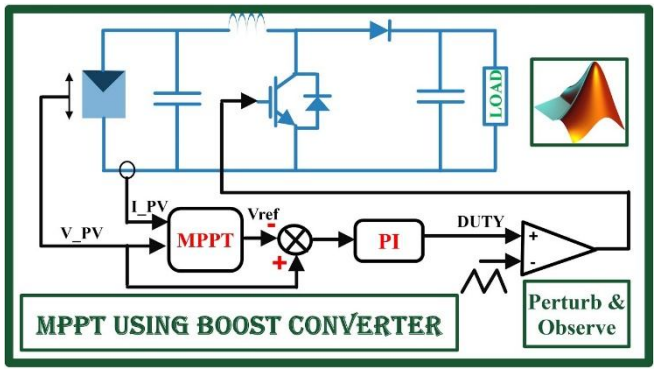

Fig 3. MPPT circuit Design[6]

Fig 3. Shows P & O algorithm implemented with analog block. The circuit is designed using MATLAB Simulink. As shown in the figure the MPPT will extract V_{ref} and compare it with V_{pv} and the PI controller will convert it into duty cycle. The Duty Cycle is converted into PWM and sent to DC-DC Boost converter.

IV. MODIFIED P & O ALGORITHM(FOR PARTIAL SHADING CONDITIONS)[8][1]

An improved Perturb And Observe Algorithm focuses on steady-state response of power output of PV Array.The main key point in optimized Algorithm is to concentrate on reducing the fluctuations around MPP, which is the source of power loss. As discussed earlier the perturbation stops .whenever ΔP=0.But for steady state oscillations the algorithm is improved to track the MPP with less tracking period and it has to stop if ΔP=0 and continues for further oscillations. The flowchart for the optimized P&O Algorithm is shown in the fig4.

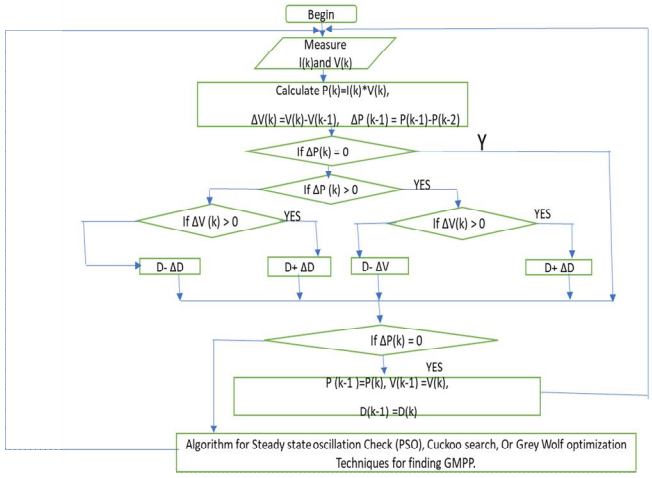

Fig 4 Optimized Perturb and Observe Algorithm

Slight change in the algorithm results in big difference under steady state oscillations that is PSC's. Table 1 shows when Perturb &Observe Algorithm is combined with other algorithms like PSO, Particle Swarm Optimization and GWO, Grey Wolf Optimization the Tracking time is High and gives 100% efficiency under PSC's. This is how the efficiency of a particular Algorithm can be improved with different parameters and further simulation results which can be analyzed with different parameters up to grid level PV System.

V. CONCLUSION

Since from many years effort is being made to improve the efficiency of the PV System. Algorithms should be carefully evaluated to bring simplicity and consistency and improve overall efficiency in terms of high tracking efficiency and less steady state oscillations in rapidly changing weather conditions.

With all the above discussions of different algorithms. Perturb and Observe algorithm when modified by comparing different parameters leads to more simple and to be a more accurate Algorithm. Most efficient MPPT Technique which is more efficient in terms of simplicity in implementation and accuracy can be found. They work very well for fast convergence, precision, and ability to predict non-linearities of a PV cell without falling to local MPP under Partial Shading Conditions. For further work ,P & O Algorithm can be modified by combining other algorithms and simulation results can be analyzed with grid level PV System.

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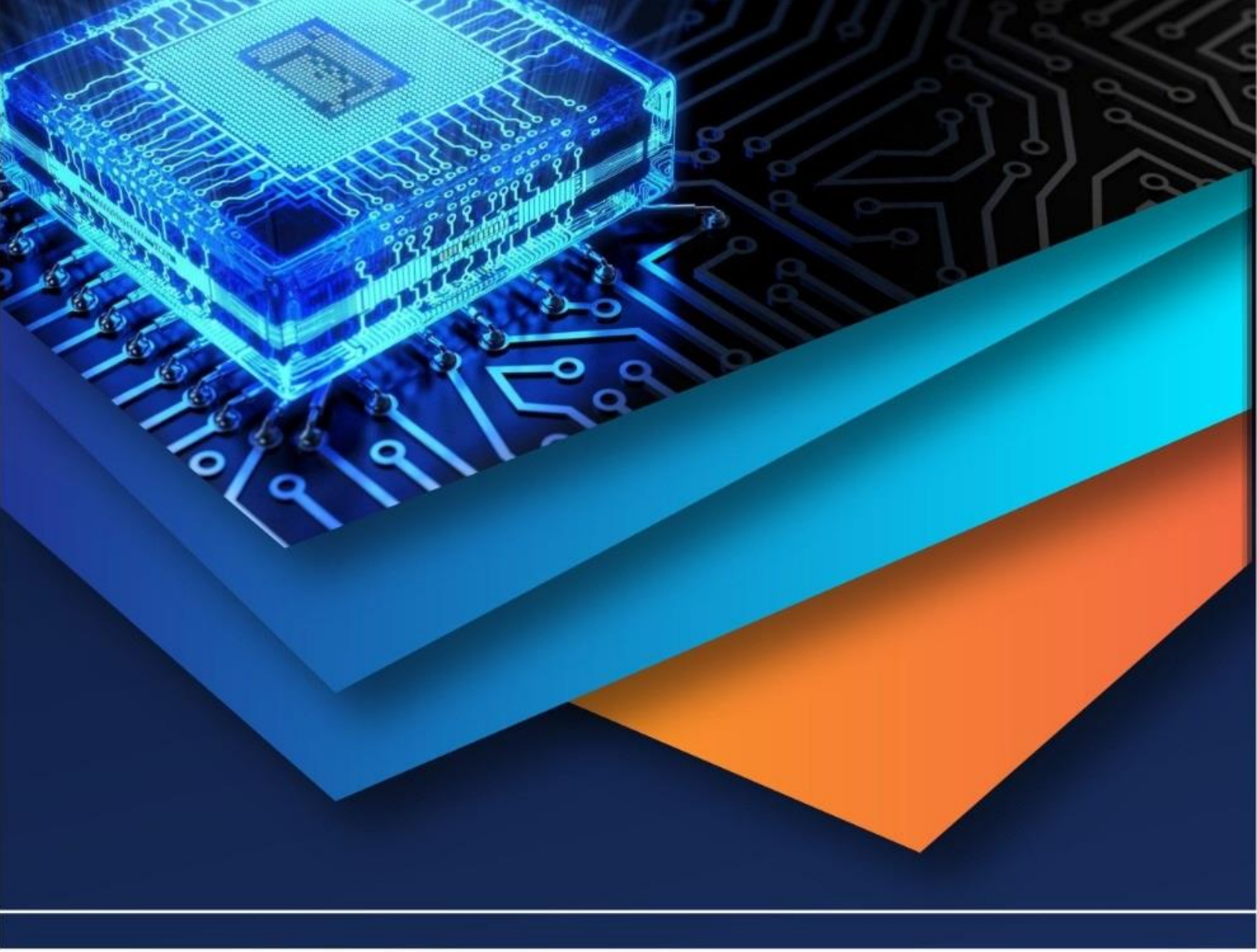

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