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Efficiency Enhancement of Grid Connected PV System using Improved PSO Method

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Abstract: ***This work presents a concept of PV system with grid having optimization with PSO algorithm. This PSO is used to improve its efficiency of system. This work uses a boost converter; (MPPT) to be applied to the system to obtain a maximum output power of the PV system. The objective function of the proposed evolutionary optimization algorithms implemented for design optimization of the PV system is the total profit incurred during the lifetime operational period of PV system, which has to be maximized. Simulation results of design optimization of SPV system by using Particle Swarm Optimization (PSO) technique is obtained. Simulation results are presented using MATLAB/Simulink Tool.***
Keywords: PV system, Efficiency. MPTT Controller, PSO Optimization etc.

I. INTRODUCTION

The increase in energy demands and pollution facilitate the innovation and application of Green Technology. Solar Energy is more versatile than other types of renewable energy due to its abundant availability. Also Silicon, the main constituent of solar cell used to trap solar energy is the second most ample element on the earth's crust. In India, although we have approximately 300 sunny days per year and receives an average hourly radiation of 200 MW/km^2, the energy resource is under-utilized. Also electricity losses in India during transmission and distribution is about 24.7% during 2013-14. Due to shortage of electricity, power cuts are common throughout India and this has adversely affected the country's economic growth. The above cited reasons led to the investment in domestic Photovoltaic (PV) system and it is encouraged by government subsidy in initial installation cost and profit in long run. The main challenge in installation of standalone PV system (SPV) is optimizing space requirement of PV arrays meanwhile extracting maximum energy from the PV system. Therefore in this work we have worked on optimizing the size of the PV system. Optimal sizing ratio of PV system depends on inverter operational characteristics, PV array orientation, no. of PV modules and inverters. A multi-objective optimization is proposed for optimal design of PV system taking into consideration both the technical and economic aspects. Profitability of PV system is influenced by initial capital cost, annual maintenance and repairing cost, subsidy rate, selling price of generated energy. The objective of this methodology is the maximization of system's profit while exploring optimal solutions using different optimization technique. This methodology gives optimum number of PV modules and inverters, PV modules optimum tilt angle, optimum placement of PV modules within given installation zone, maximization of overall economic benefit during system operational lifetime period [1]. This part gives a review of network associated inverters and the PV frameworks. Lattice associated advances have been examined. The significant sun-oriented attributes in relations to temperature and irradiance and how the open circuit voltage is influenced are portrayed in the section. Principles to plan and establishment practices of PV-framework associated frameworks examined in this section assume the critical part at the purpose of regular coupling. These principles helped in the advancement of the proposed PV framework. The remainder of paper is requested as follows. In segment II, it provides the concept of PV inverters with smart grid. In Section III, It characterizes the PV System topologies. Proposed model is presented in Section IV. Results are presented in Section V. At last, conclusion is clarified in Section VI.

II. PV INVERTERS & SMART GRID

Photovoltaic (PV) power provided to the utility matrix is acquiring and greater perceivability, while the politically influential nation's interest is expanding. Strong state inverters have been demonstrated to be the empowering innovation for placing PV frameworks into the matrix. Coordination of PV power age frameworks in the network assumes a significant job in making sure about the electric force supply in an ecologically inviting way. Framework associated PV System involves PV board, a DC/AC converter that proficiently associated with the matrix. This framework is utilized for power age in spots or locales got to by the electric utility matrix. In the event that the PV framework AC power is more noteworthy than the proprietor's necessities, the inverter sends the excess to the utility lattice for use by others.

The utility gives AC capacity to the proprietor around evening time and during times when the proprietor's necessities surpass the ability of the PV framework. Contingent upon the application and necessities PV framework can either be an independent or half breed framework. The idea of savvy lattice is presented in PV frameworks rely upon various methods of intensity usage later on. A keen network development with more strength and higher productivity in force usage is on time around the world. Because of an enormous number of new innovations and administration will be raised, refreshed or supplanted in brilliant matrix from conventional force network, a system of the entire shrewd lattice structure become important for the colossal expensive organization, just as the qualities and functionalities. Savvy Grid is a huge and confounded idea which is as yet holding banter on its definition in view of the normal accentuation tended to by every member [2].

For the most part, the PV framework contains PV generator which is a bunch of arrangement equal electrically interconnected sun-oriented boards. PV boards are conveyed by the producers and are given regarding the ostensible pinnacle intensity of the board at standard test conditions (STC). PV generator gives the all-out introduced power which is the amount of ostensible pinnacle intensity of each sun based board present in the PV establishment. This PV generator is associated with an inverter which associated with an AC/DC load and additionally network. Since the normal irradiance in the actual area of the PV establishment is lower than the ostensible or standard one, a current practice is to choose the inverter greatest force than the ostensible pinnacle intensity of the PV generator. This training is the thing that is known as under estimating of the Inverter and has been talked about in the ostensible intensity of the PV generator compares to standard irradiance conditions. Nonetheless, this irradiance is unordinary. Under low irradiance, a PV exhibit produces power at just a piece of its ostensible limit and the inverter hence work s under part load conditions with lower framework productivity. Regardless of the irradiance level influencing the PV generator attributes, it is additionally imperative to consider the impacts of temperature while choosing inverters. The two variables add to inverters most extreme force and effectiveness at the hour of plan and estimating.

III. GRID CONNECTED PV SYSTEM TOPOLOGIES

Inverters are significant force hardware gear in lattice associated PV frameworks. Their significant job is to change over DC power into AC power. Moreover, inverter interfacing PV module(s) with the network guarantees that the PV module(s) is worked at the greatest force point (MPPT). In view of the photovoltaic clusters yield voltage, yield power level and applications, the photovoltaic framework associated framework can embrace various geographies. These arrangements depict the development of matrix associated inverters as from past, present and future innovations.

A. Grid Connected Inverters Technology

There are various advancements and geographies accessible for lattice associated PV frameworks which are arranged dependent on the quantity of intensity stages. In PV plants applications, different innovative ideas are utilized for interfacing the PV cluster to the utility lattice. Every innovation has its favourable position and additionally hindrances contrasted with other, understudies of productivity and greatest force point following.

1) *Centralized inverters:* This is the previous innovation as represented in Fig. 1 (a) depended on unified inverters that interfaced an enormous number of PV modules to the framework. The PV modules were partitioned into a string, each creating an adequately high voltage to evade further intensification. These arrangement associations were then associated in equal, through string diodes, to arrive at high force levels. For this design, the PV exhibits are associated in corresponding to one focal inverter.

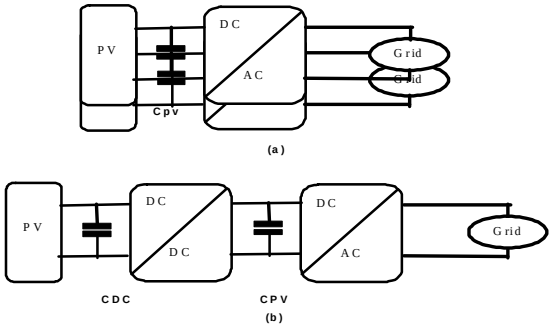

Fig 1: Single and Dual Stage Inverter Topology with Coupling Capacitances [2]

2) *String Inverters:* The current innovation comprises of the string inverters and the air conditioner module. The string inverter, is a diminished rendition of the incorporated inverter, where a solitary line of PV modules is associated with the inverter. The information voltage might be sufficiently high to keep away from voltage intensification. This setup arose on the PV market in 1995 to improve the disadvantages of focal inverters. Contrasted with focal inverters, in this geography the PV strings are associated with discrete inverters.

B. DC- DC Converter Topologies

DC-DC converters have a wide scope of employments today and are getting progressively more significant in ordinary use. DC power supplies are presumably the biggest utilization of the converters and are considerably more reduced and effective. There are three essential sorts of DC/DC converters from which converters and Full extension converters are gotten from these converters.

The inverters incorporate;

1) The help converter as a stage up converter is utilized for cases in which a higher yield voltage than input is required;
2) A buck converter as a stage down converter is utilized for cases in which a lower yield voltage than input is required; and
3) A buck-help converter, which decreases or expands the voltage proportion with a unit pick up for an obligation proportion of half.

The force phase of matrix associated PV inverter introduced in this postulation utilizes full extension switch mode DC-DC converter. The lift converter is the essential structure and the decision is presented for most exceedingly terrible defense situation when the PV cluster voltages will be extremely low, and consequently voltage enhancement is significant. The lift converter will likewise be significant for MPPT control.

The activities, application and qualities of lift converter have been talked about in as the fixed DC yield voltage is consistently more noteworthy than the shifting information DC voltage. There are numerous geographies accessible for the DC/DC converter as in and they can be utilized in single stage inverter circuit geography with no seclusion. Every geography has its bit of leeway and drawbacks when utilized.

As clarified in obligation proportion, exchanging recurrence, voltage taking care of capacities and exchanging power misfortunes has been brought up as difficulties to every one of the circuit arrangement. For single stages geographies and with low yield voltages , fly-back converters, help converters and converters have demonstrated a few difficulties when utilized alone as converters.

a) *Full bridge DC-DC Converter:* Full extension DC-DC converter is picked in the plan among the diverse converter geographies talked about above. This converter is utilized in the DC-DC input stage, in which it will change over the low and shifting voltage from the PV cluster through the information capacitor CPV to a consistent 400V DC voltage at the capacitor connect, CDC. The geography has various favourable circumstances as examined in. The essential advantage of utilizing a Full-Bridge DC/DC converter in the DC-to-DC stage is its capacity taking care of abilities, dependability, and evenness. In addition, the utilization of high recurrence transformer assumes an exceptionally enormous part in picking the sort of the converter to be utilized.

b) *Full Bridge DC-AC Inverter:* In this postulation single stage full scaffold inverter is utilized. This is the DC-AC stage that changes over DC power into AC power at wanted yield voltage and recurrence. The force stage planned in this theory changes over the 400V DC yield voltage of the full extension converter to the matrix voltage of 230V AC – 240V AC at 50 Hz/60 Hz recurrence. The full-connect inverter can deliver a yield power double that of the half-connect inverter with a similar info voltage. As this being one of the unmistakable highlights it is utilized at high force levels since it requires less resembling gadgets and the single-stage full extension geography is which comprises of four exchanging gadgets, two of them on every leg.

c) *Voltage Source and Current Source Inverters:* Inverters can be comprehensively ordered into two kinds dependent on their activity as Voltage Source Inverters (VSI) and Current Source Inverters (CSI). In and clarifies Voltage Source Inverters as one in which the DC source has little or insignificant impedance. What's more, Voltage Source Inverter is the sort of inverter where the freely controlled ac yield is a voltage waveform. The yield voltage waveform is generally staying unaffected by the heap. Because of this property, the VSI have numerous modern applications, for example, flexible speed drives and furthermore in Power framework for FACTS.

IV. PROPOSED WORK OF SYSTEM

This work presents a PV system with optimization with PSO method. The main key of this method is choosing a reference voltage, and keep changing the output PV voltage signal to decrees the power variation. (MPPT) is applied between the energy source and load, due to utilizing the available maximum power output of the PV. In the current work, a hybrid system is actualized for effortlessness. After determination and hybrid, presently we have another age, some are straightforwardly duplicated, and others are created by hybrid.

To guarantee that the people are not all precisely the equivalent, the following stage is to take into account a little possibility of transformation. In this progression a couple of people are picked haphazardly from the new age. This choice activity is finished with uniform likelihood and not founded on its wellness esteem. In every one of the picked chromosome, a spot is picked arbitrarily and that touch is turned to its correlative piece (0 or 1). Change activity is a more self-assertive cycle than hybrid activity and its likelihood is less. Still it is done considering the way that it might assist with making a practical element that is absent in the current age. The likelihood of transformation is typically somewhere in the range of 0.001 and 0.002. At last, the new populace is assessed and the calculation ends when greatest number of cycles have been delivered.

A. Use of Particle Swarm Optimization

PSO mimics the social behaviour of a swarm of bees or flock of birds. In swarm intelligence, each particle moves to a new position using the velocity. Then the best position of each particle p_{best} and the best position of the swarm of particles best is updated. The velocity of each particle is then updated based on the experiences of the particle. The population initialization is done with a random velocity and position. Then fitness of the population is evaluated and compared with previous *pbest* and *gbest*. Their positions are updated where needed. Hence a new swarm or population is created. The velocity and position is updated till maximum generations or convergence is reached. Some of the main advantages of PSO algorithm compared to other methods are that no calculation of derivative is required, the information of best solution is held by all particles and those particles offer data among them.

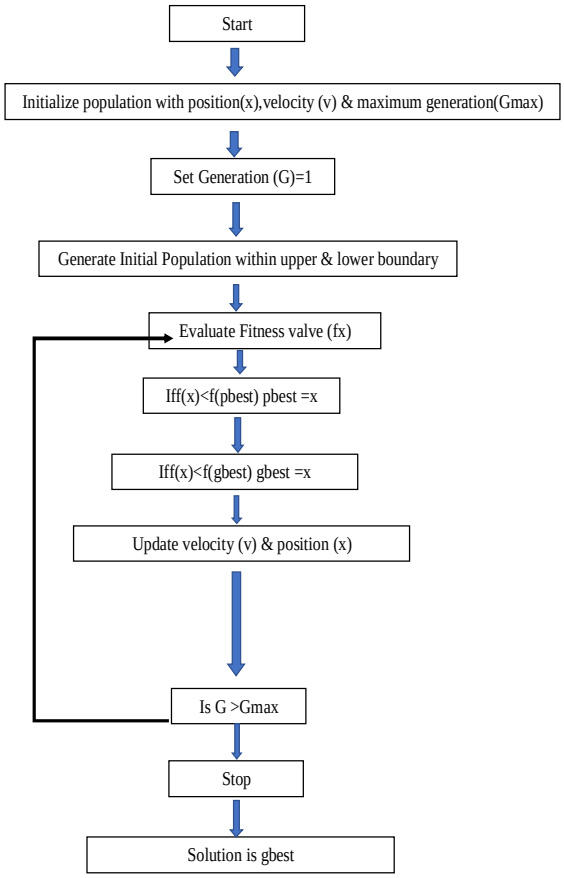

Fig 2: Flowchart of PSO Algorithm

The primary goal of using PV system is to extract electric energy from the sun radiation, the core device in that system is the PV. The cells combine together to make a module, and a group of modules create the PV array. In this design, there are five modules in series and sixty six in parallel to generate 48V DC bus and power to the system as shown. During the day hours, the load energy source is the PV arrays while in parallel charging the battery bank. Moreover, during the night hours, the battery bank will supply the load by electricity as discharging process.

Since output voltage is nearly constant (as defined by battery voltage), the variations in the duty cycle balance the changes in the input voltage. As such, this maintains the current. The DC link capacitor sometimes called power decoupling is normally achieved by means of electrolytic capacitor. For years design engineers have chosen electrolytic capacitor technology for use as the bus link capacitor on inverter designs. The DC link capacitor is very important in the life time of the converter, and it should be kept as small as possible and preferably substituted with film capacitors. Unfortunately, film capacitors are far more expensive than the electrolytic ones in term of cost per farad and hence the size of the capacitance has to be smaller to keep the price of the capacitor acceptable. However, smaller capacitance would weaken the power decoupling ability of the DC-link capacitor which may cause DC-link voltage fluctuations that lead to distortion of the inverter output current to the grid. On the other hand, since the PV modules are current sources, a capacitor has to be added in parallel when using a voltage source inverter (VSI), in this way the inverter sees a voltage source.

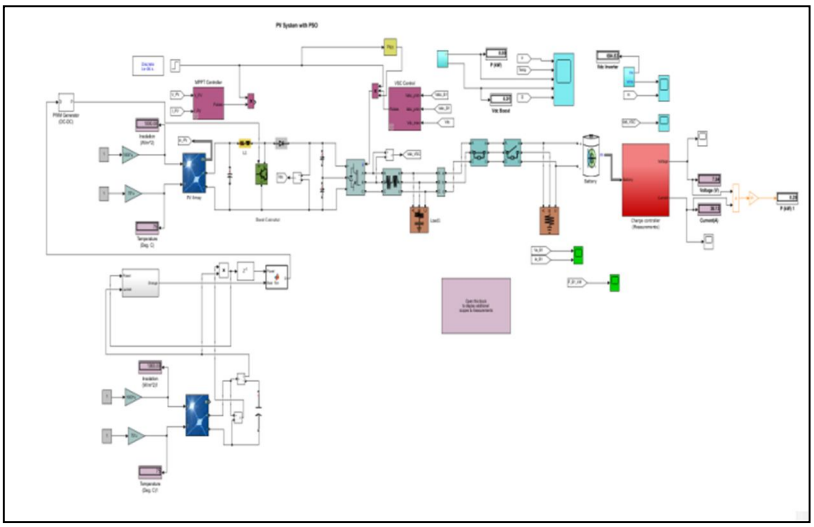

Fig 3:Proposed System Model using PSO

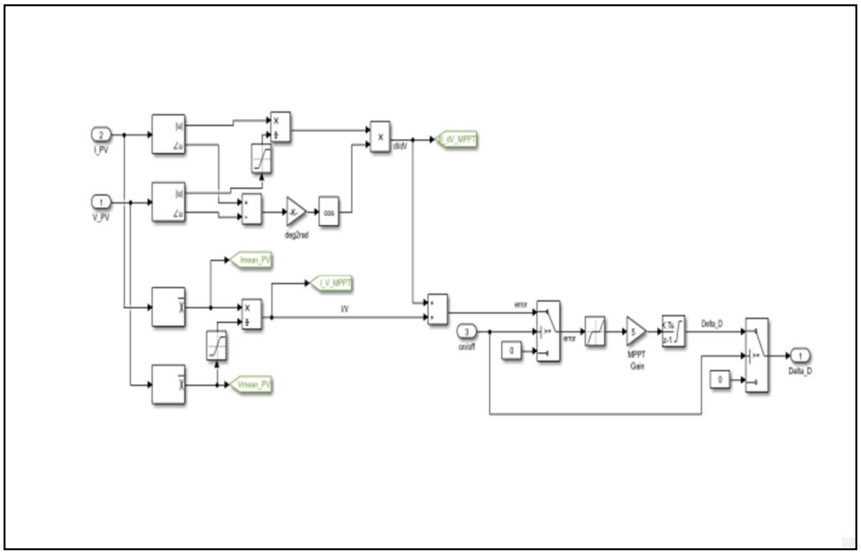

Fig 4: MPTT Controller Design

V. RESULTS & DISCUSSION

This work explains the details of the PV system with optimization method to boost power stage designed in this work. The circuit is designed using MATLAB R2019a. The application of the proposed optimization methodologies brings about convergence to the global optimum solution where the net profit function is maximized. Two of the main factors that affect the PV module's output are the temperature and sunlight. In this design, the sun irradiation and temperature fluctuate. However, the value of irradiance fluctuates around 1000 W/m^2, and the temperature curve also oscillates around 75 C. The boost converter will charge the 48V battery bank. The main parameters in the converter are: MPPT, PWM, Inductor and capacitor. The designed boost converter can deliver 17 kW DC power. To make the inductor accumulate and raise the current, the frequency switch is implemented in the design. The capacitor stores and increases the DC voltage through an electric field effect. The Pulse Width Modulation (PWM) drive is implemented in the model to stabilize the converter output voltage. A capacitor unit is added to the system to store and smooth the voltage signal.

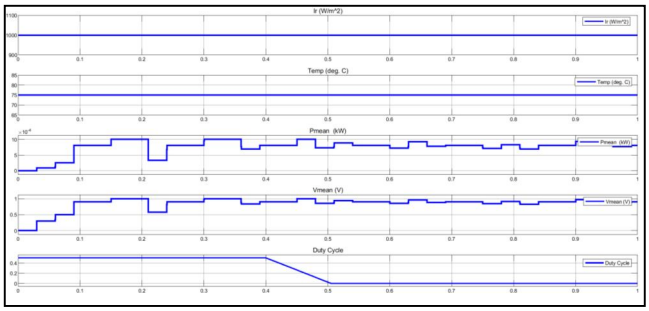

Fig 5: Performance Parameters of PV system using PSO

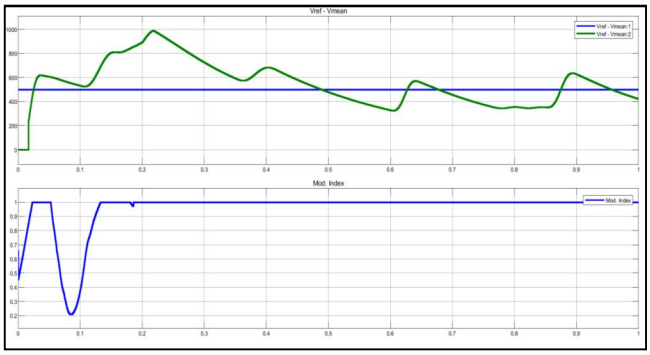

Fig 6: VSC Performance using PSO

In PSO algorithm, each particle is represented as solution and a swarm of particles is collectively known as population. The population initialization is done with a random velocity and position. Their positions are updated where needed. Hence a new swarm or population is created. The velocity and position is updated till maximum generations or convergence is reached. Some of the main advantages of PSO algorithm compared to other methods are that no calculation of derivative is required, the information of best solution is held by all particles and those particles offer data among them.

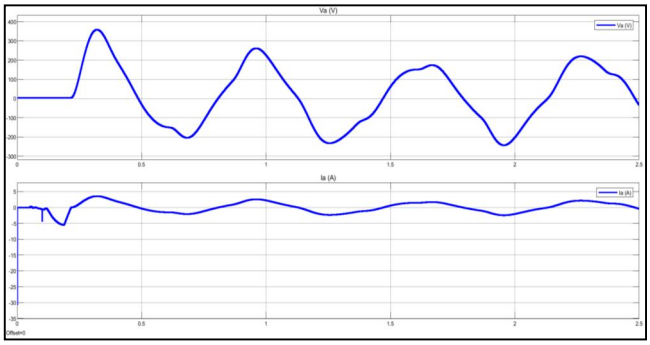

Fig 7: Voltage & Current of Battery using PSO

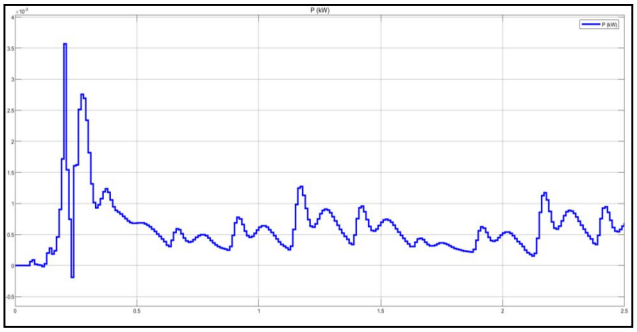

Fig 8: Power Display of Battery using PSO

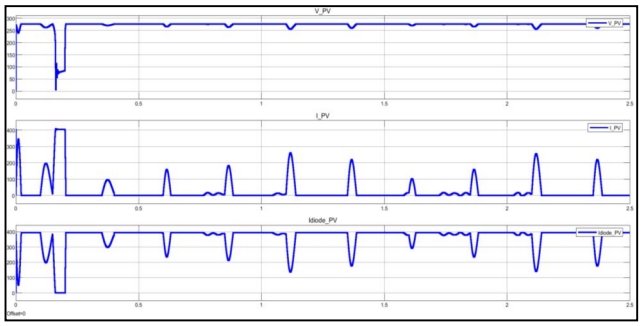

Fig 9: Voltage & Current Display of PV using PSO

VI. CONCLUSIONS

The PV systems are widely used either for small scale users like domestic PV system or for large scale users like grid connected photovoltaic system. The demerits of grid connected PV system are they are less popular due to harmonics problem on DC side and also synchronizing problem with grid. Though the PV systems have some challenges, they meet continuously increasing energy demands and also reduce pollution which are caused by thermal, diesel, nuclear power plant. Many countries provide subsidy to encourage installation and usage of PV system. So the main objective of PV system design is profit maximization during its operational period. In this work, a methodology for design optimization and economic analysis of PV system. The objective of the methodology is to find optimal tilt angle of PV module, optimal arrangement of PV modules in the available installation area and the optimal number of PV modules, so that the net profit incurred during the lifetime operational period of PV system is maximized. The maximization of the economic benefit is the objective function of the proposed optimization algorithm PSO.

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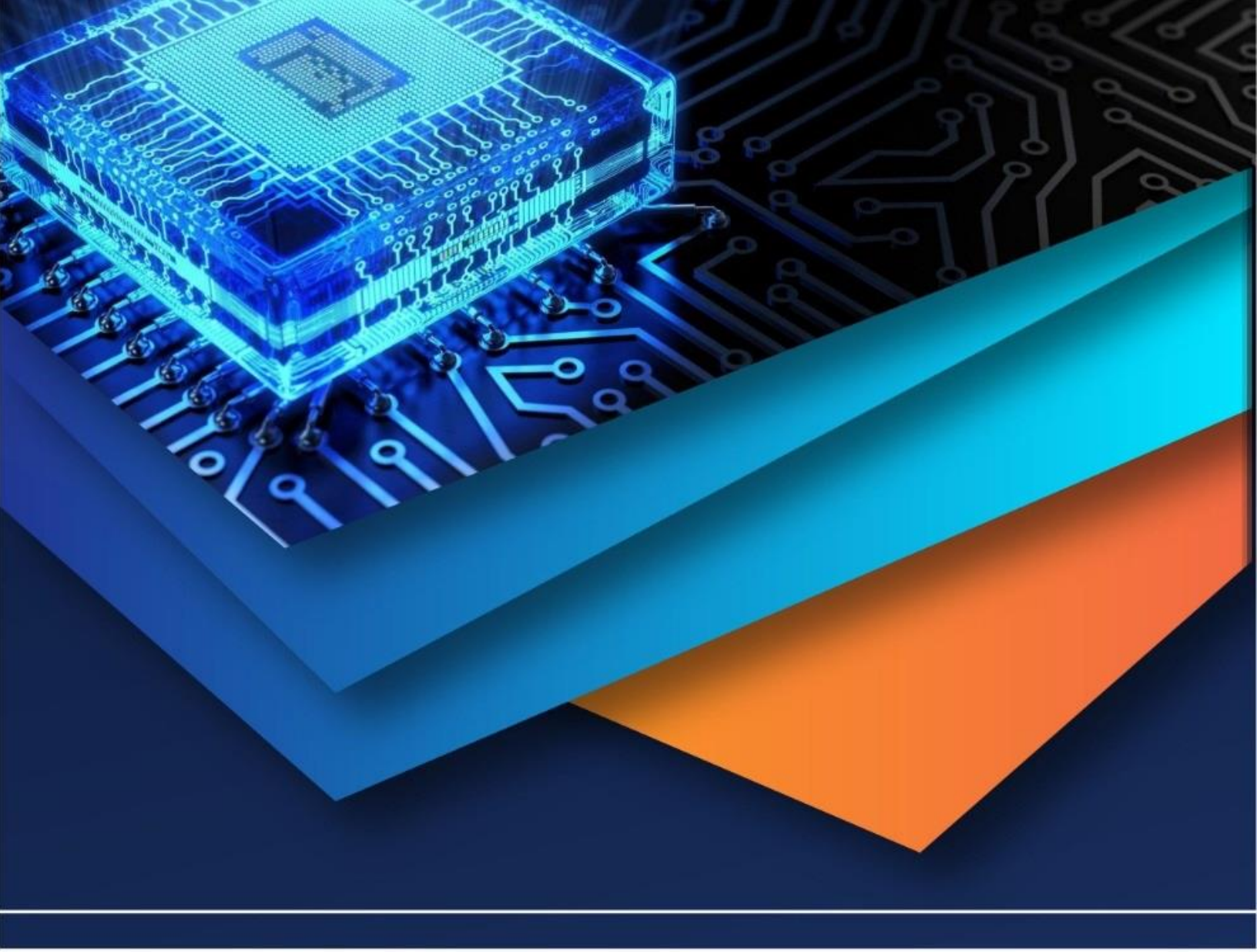

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