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A Hybrid BPSO-ST Swarm Intelligence Approach for Resolving Economic Load Dispatch Problem in Power System

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Abstract: Economic load dispatch provides optimization method which divides demand of the power among online generators economically by satisfying different constraints. ELD can concluded as scheduling of committed generating units by meeting up the demands of the consumers while reducing operational cost to the utilities with satisfying equality and inequality constraints. In this work several optimization algorithm have discussed such as Genetic Algorithm, Lambda Optimization Algorithm and Particle Swarm Optimization. These optimization algorithms can be used as per the requirement of the system. A hybrid mechanism i.e. BPSO-ST (Binary Particle Swarm Optimization-State Transition) algorithm for ELD is developed in this study. Resultant graph in the result and discussion section shows that BPSO-ST is better in terms of total power output generation and total generation cost and total Power Loss in comparison to the POS, Lambda and GA optimization algorithm.

Keywords: Economic Load Dispatch, BPSO, State Transition, Power Generation, Transmission Loss, Total cost.

I. INTRODUCTION

Electrical power industry is one of the trending areas in power industry which restructured the vibrant and competitive market in terms of various aspects of the industry. As the progressions have done in the industry, scarcity of the energy resources, ever budding demand for electrical energy, increasing power generation cost necessitate optimal dispatch. Owing to this economic load dispatch provides optimization method which divides demand of the power among online generators economically by satisfying different constraints. Seeing as cost of the power generation is excessive in such case optimum dispatch can helps out in saving considerable amount of money. Accordingly, optimal generation dispatch is one of the imperative problems in power system engineering. This technique is commonly used by operators for system operation in every day. The main idea of using this technique is that it allocates real and reactive power to the power system in order to obtain optimal state which can reduce cost and overall competence of the system [1]. ELD i.e. economic load dispatch problem allocates the real power to the online generating units which leads to the reduction in system cost. In the traditional formulation of economic load dispatch problem there were several problems contradict simplicity of the models. Basic model of the power system is acquired through power balance equation whereas generators are modeled with the smooth quadratic cost functions and last generator through output constraints. Thus in order to improve the power system studies several models have been developed which results in efficient system operation. Several models have developed which provides more accurate representation of the system but on the other hand it may faces increased complexity of the optimization predicament owing to the non-linearity allied with them. Basic property of ELD is that it considers power balance constraint rather than generating capacity limits. Contrary, ELD favors the ramp rate limits, barred operating sectors, value point effects and last but not the least multi fuel options to provide complete formulation of the ELD[4][5]. As a consequence, ELD will be non-convex optimization dilemma which cannot be solved by offered methods of ELD. Virtually, it endures from troubles like non-linear, non-convex type objective function with deep equality and inequality constraints. Therefore in exploration of superior results from intricate optimization problems numerous developments have done. These mechanisms communicated as best substitute global optimal solutions expressly in case of non-continuous, non-convex and extremely solution spaces. This is an aid for obtaining several candidate solutions rather than a single clarification which was applied by classical techniques. Basically these techniques used or explored solution space randomly which then provides alternative solutions for a particular problem. It has a higher accessibility rate due to its capability in finding solution with random exploration of the feasible region instead of exploring the complete region. Application of these algorithms has resultant into better and fast optimization process with less number of computational resources.

II. PROBLEM FORMULATION

Electrical power industry restructuring has created highly vibrant and competitive market that altered many aspects of the power industry. Economic Load Dispatch (ELD) is one of the important optimization problems in power systems that have the objective of dividing the power demand among the online generators economically while satisfying various constraints. Economic load dispatch problem is the sub problem of optimal power flow (OPF). The economic load dispatch is defined as the process of allocating generation levels to the generating units, so that the system load is supplied entirely and most economically. For the connection between the two systems it is important that the expenses should be minimized. To describe the production level, each unit in the system is defined, so that the total cost of the system is calculated. The expenses should be less. Economic load dispatch problem is the sub problem of optimal power flow (OPF). The main objective of ELD is to minimize the fuel cost while satisfying the load demand with transmission constraints. So main aim of ELD is to minimize the expense of the system.

III.PROPOSED WORK

The objective of the Economic Dispatch Problems (EDPs) of electric power generation is to schedule the committed generating units outputs so as to meet the required load demand at minimum operating cost while satisfying all units and system equality and inequality constraints. The Economic Dispatch Problem is solved by specialized computer software which should honor the operational and system constraints of the available resources and corresponding transmission capabilities. Recently, global optimization approaches inspired by swarm intelligence and evolutionary computation approaches have proven to be a potential alternative for the optimization of difficult EDPs. In the proposed work the solution of economic load dispatch will be done by using the swarm intelligence approach mostly the work is done on basis of GA, ACO. PSO etc. out of which the better working is done by using the GA because the binary data is used for the solution which has much capability to provide the variation in the data. So inspired from that the proposed algorithm will work on the binary data based PSO with hybridization of state transition The proposed technique uses the BPSO in order to minimize the cost incurred on power generating and transmission. The methodology of proposed technique is implemented in following steps:

A. First step is to set power generator parameters. Every generator has its own parameters such amount of generated power, amount of total lost transmission etc. The parameters are generated on the basis of some equations.
B. After setting the power generator parameters the power requirement or demanded power of various units will be entered.
C. Now generate random population. In BPSO the generation of random population is an important step.
D. Now calculate the cost incurred on generating the power by using cost characteristic equation**.**
E. Now evaluate the minimum or maximum range of generated power from the above calculated cost.
F. Number of iterations will execute in order to find the best fitness value.
G. Now apply proposed BPSO and state transition for optimizing the fitness value from obtained set of fitness value.
H. Evaluate the final output and various parameters such as total generated power. Total power loss, total cost incurred.

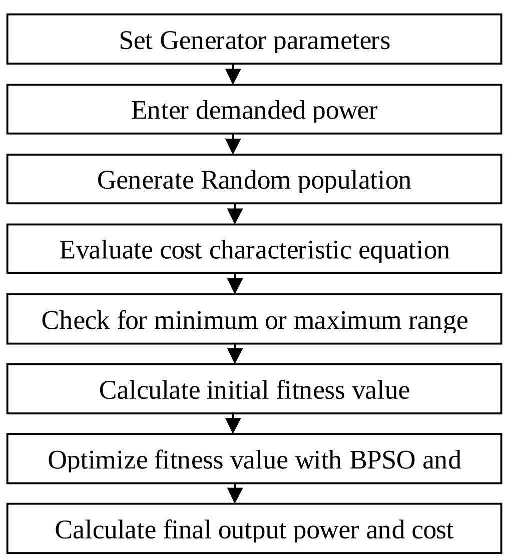

Fig.1 Block diagram of proposed work

IV. RESULTS AND EXPERIMENTS

This section provides a overview to the results that are obtained after implementing the proposed work i.e. Hybridization of BPSO and ST optimization for ELD.Fig.2 depicts the power generation by 6 power plants in case of proposed work. The x axis in the graph shows the number of power plants and y axis calibrates the values corresponding to the power generation. The power generation varies from 0 to 200 MW. The power generation corresponding to P1 is observed to 14 MW, for P2 it is 91 MW, for P3 it is 99 MW, for P4 it is 145 MW, for P5 it is 181 MW and for P6 it is 185 MW.

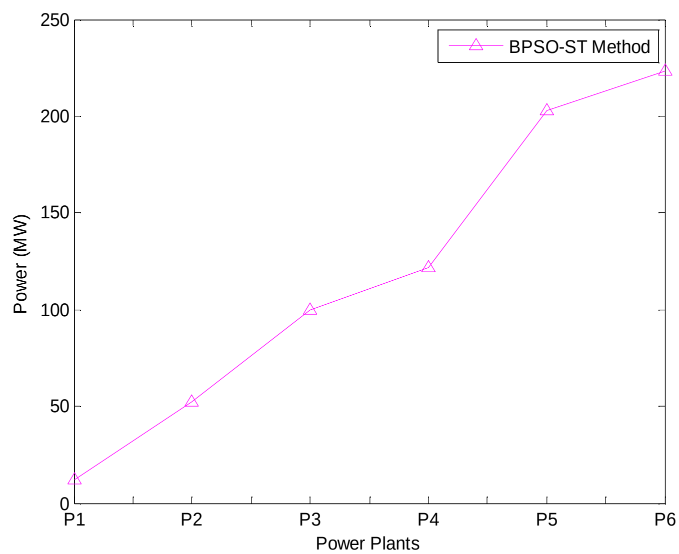

Fig.2 Power Generation by 6 power plants

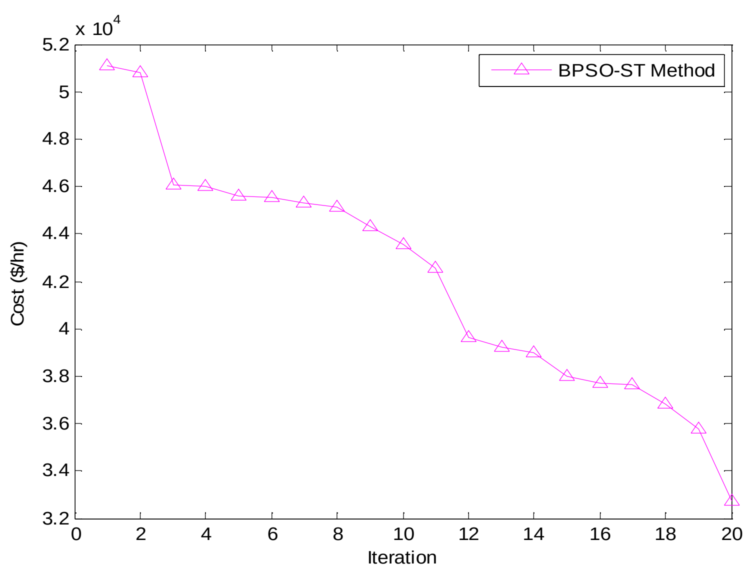

Fig.3 Cost of Power Plant

The fig.3 depicts the overall cost of proposed work with respect to the number of iterations in a power system. The major objective of ELD is to reduce the overall cost incurred on power generation system. The x axis in graph below shows the number of iterations that varies from 0 to 20 and y axis shows the cost in $/hour. As per the observation from the graph below, it can be said that the cost incurred on power generation in proposed work is getting lower as the number of iteration get increase.

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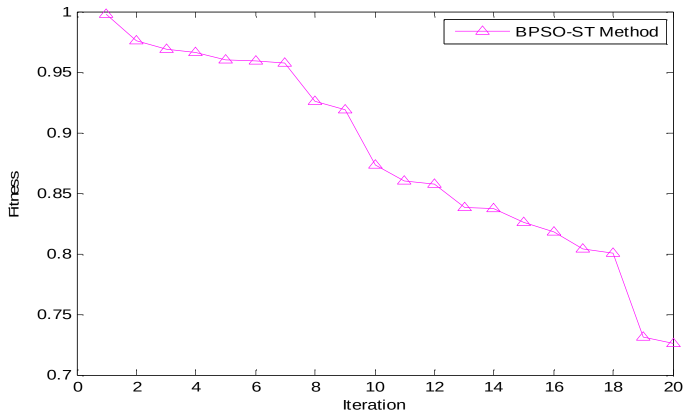

Fig.4 Fitness value achieved by proposed work

The graph in fig.4 shows the fitness value that is achieved in proposed work. The graph shows the fitness value with respect to the number of iterations in power generators. When the iteration number was 2 than the fitness value was 0.9682 which was quite high. At 20th iteration, the achieved fitness value was 0.6244. The proposed work finds the optimal solution continually, thus the decrement in the fitness value can be seen after each iteration. This is done to find out the optimal solution for power generation plant.

The graph in fig. 5shows the curve of power loss in power system with respect to the given number of iterations. There are total 20 iterations. On the basis of the graph drawn it can be concluded that the power loss in proposed work is 37.92 MW at the time of first iteration which is quite highest but it comes to the 12.97 MW at 20th iteration.

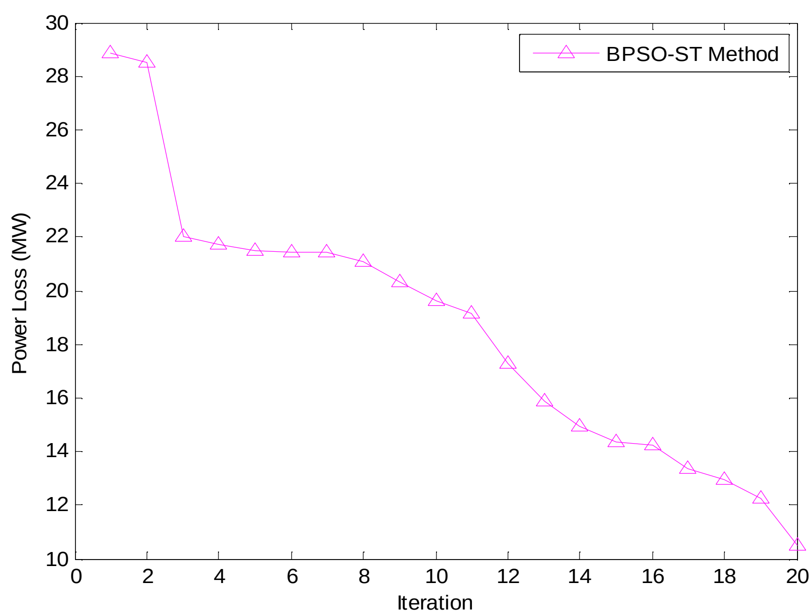

Fig. 5Power Loss in case of proposed work with respect to iterations

The graph in fig.6 shows the comparison of proposed work, Lambda Method, GA Method, PSO Method. The comparison is done on the basis of power generation in different power plants. The y axis calibrates the data in the terms of power that varies from 0 MW to 250 MW. The curve in blue color depicts the performance of the Lambda method, the curve in black color shows the performance of GA method, curve in red color shows the performance corresponding to the PSO method and curve in magenta color shows the performance of BPSO-ST method.

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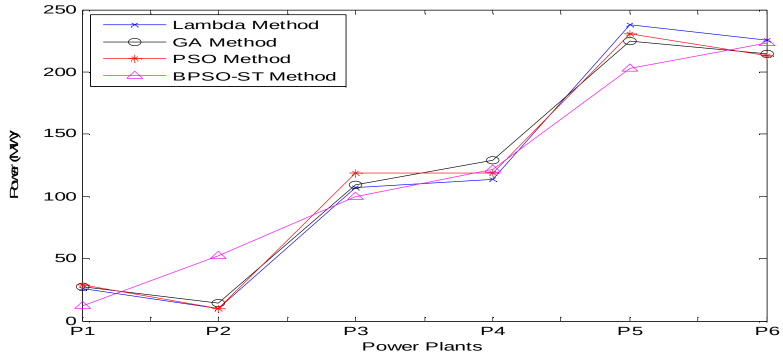

Fig.6 Comparison of proposed and traditional optimization approaches

The graphs make it sure that the proposed work has best power generation in comparison to the traditional optimization techniques. The table I below comprised of the power generation by the all of the optimization technique in all power plants. On the basis of the values of the table I, it is concluded that the BPSO-ST is the optimization technique that optimizes the power generation to a better level in comparison to all of the techniques.

Table I
POWER GENERATION WITH RESPECT TO THE DIFFERENT POWER PLANTS

Power Plant	Lambda Method	GA Method	PSO Method	BPSO-ST Method
P1	28.81	28.81	28.81	14
P2	10	14.38	10	91
P3	109	109	119	99
P4	114	128.7	118.7	145
P5	238.1	224.5	230.8	181
P6	225.4	214.9	214.9	185

The graph in fig.7 shows the comparison of proposed and existing optimization techniques for optimizing the performance of the power generation systems. The comparison is done on the basis of the optimized power generated by the system. The graph depicts that the proposed work is more efficient to generate the optimized power generation system. The proposed work generates the 715 MW, Lambda system generates the 720 MW, GA method generates the 719 MW, and PSO generates the 719 MW. Thus it is proved that the more optimized power is generated by the BPSO-ST method. The table II depicts the values that are obtained from the graph below.

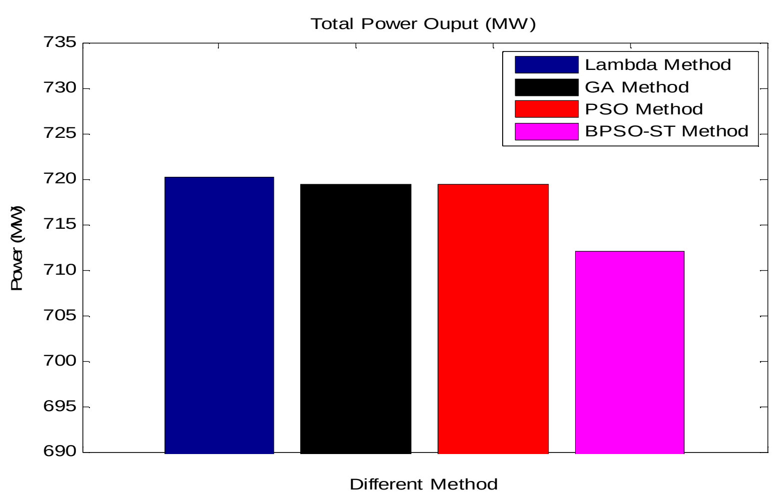

Fig.7 Comparison of optimization techniques with respect to the Power Generation

Table II
POWER GENERATION

Techniques	Value
BPSO-ST	717MW
PSO	719MW
GA	719MW
Lambda Optimization	720MW

The graph in fig. 8 shows the comparison of BPSO-ST method with rest of the considered optimization technique in the terms of total generation cost incurred on the system. The objective of the ELD system is to reduce the total power generation cost to make it more feasible for the customer. The graph below illustrates that the generation cost of BPSO-ST optimization technique is quite lower in comparison to the Lambda method, GA and PSO. The table III depicts the values of total generation cost of all the considered techniques

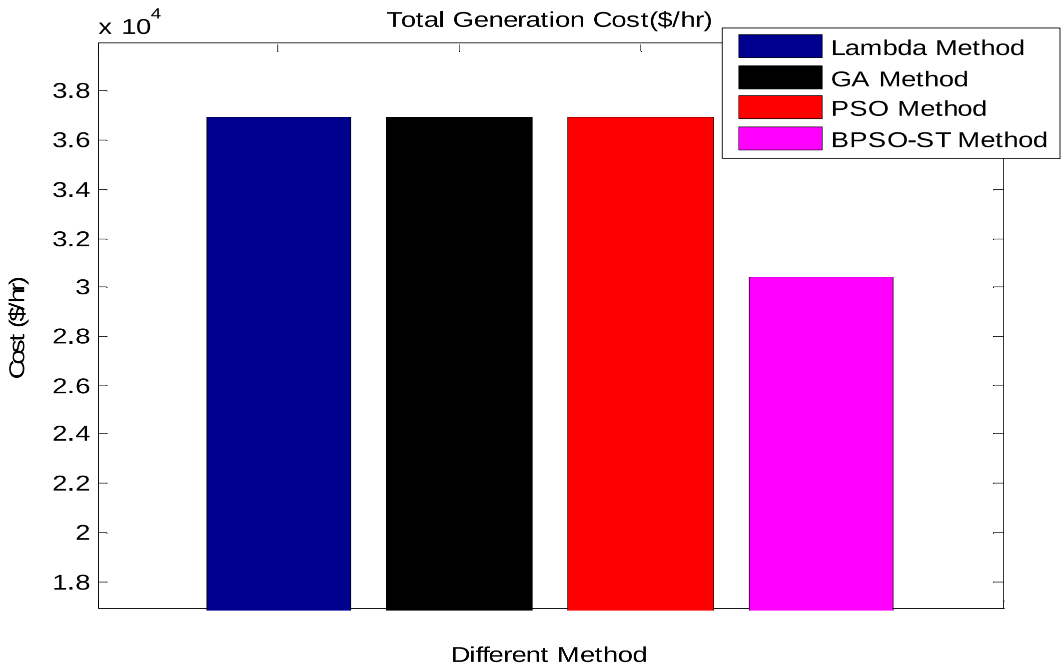

Fig. 8 Comparison of optimization techniques with respect to the Total Generation Cost

Table III
TOTAL GENERATION COST

Techniques	Cost($/hr)
BPSO-ST	36900
PSO	36900
GA	36900
Lambda Optimization	30400

The comparison graph in fig.9 depicts the total power loss in BPSO-ST, PSO, GA and Lambda optimization techniques. The total power loss should be low always in a power generation system. The obtained total power loss in BPSO-ST is 8.9 MW and it is much lesser than 19.4 MW, GA 19.4 MW, 20.2 MW in PSO, GA and Lambda optimization respectively. Table IV shows the Total power Loss of BPSO-St, PSO, GA and Lambda Optimization mechanism.

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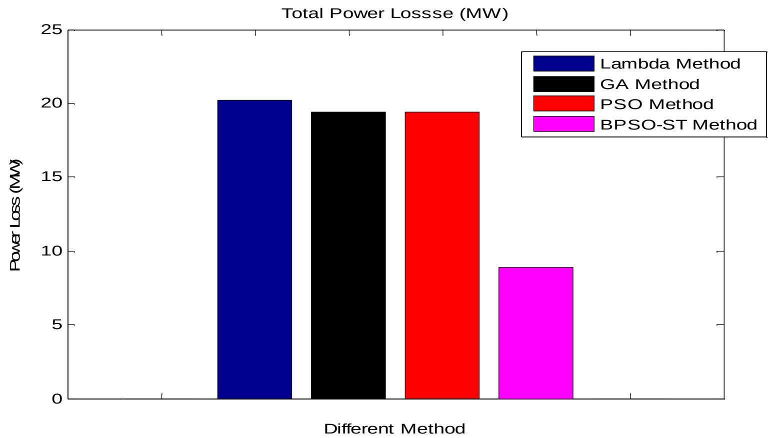

Fig. 9Comparison of optimization techniques with respect to the Total power loss

Table IV
TOTAL POWER LOSS

Techniques	Total Power Loss(MW)
BPSO-ST	8.9
PSO	19.4
GA	19.4
Lambda Optimization	20.2

V. CONCLUSION

Economic Load Dispatch is the process known for distributing load in such a way so that economic cost of the power system should be used less and requirement of the consumer fulfilled. Thus in this work different optimization algorithms have been studied which can be used to evaluate proper distribution of load over the power systems. Evaluation has been done between PSO, GA, Lambda optimization and proposed hybrid BPSO-ST which ensures that BPSO-ST outperforms among them. Several parameters such as total power output, total generation cost and total power loss have been discussed. These parameters conclude that BPSO-ST is efficient, effective and optimized than other optimization technique. As various optimization algorithms have been evaluated in this work where BPSO-ST declares as an efficient technique.

In future, more amendments can be done by collaborating the chaotic map search mechanism with present work in order to enhance the procedure of population generation. This will be an aid to consider multiple cases also.

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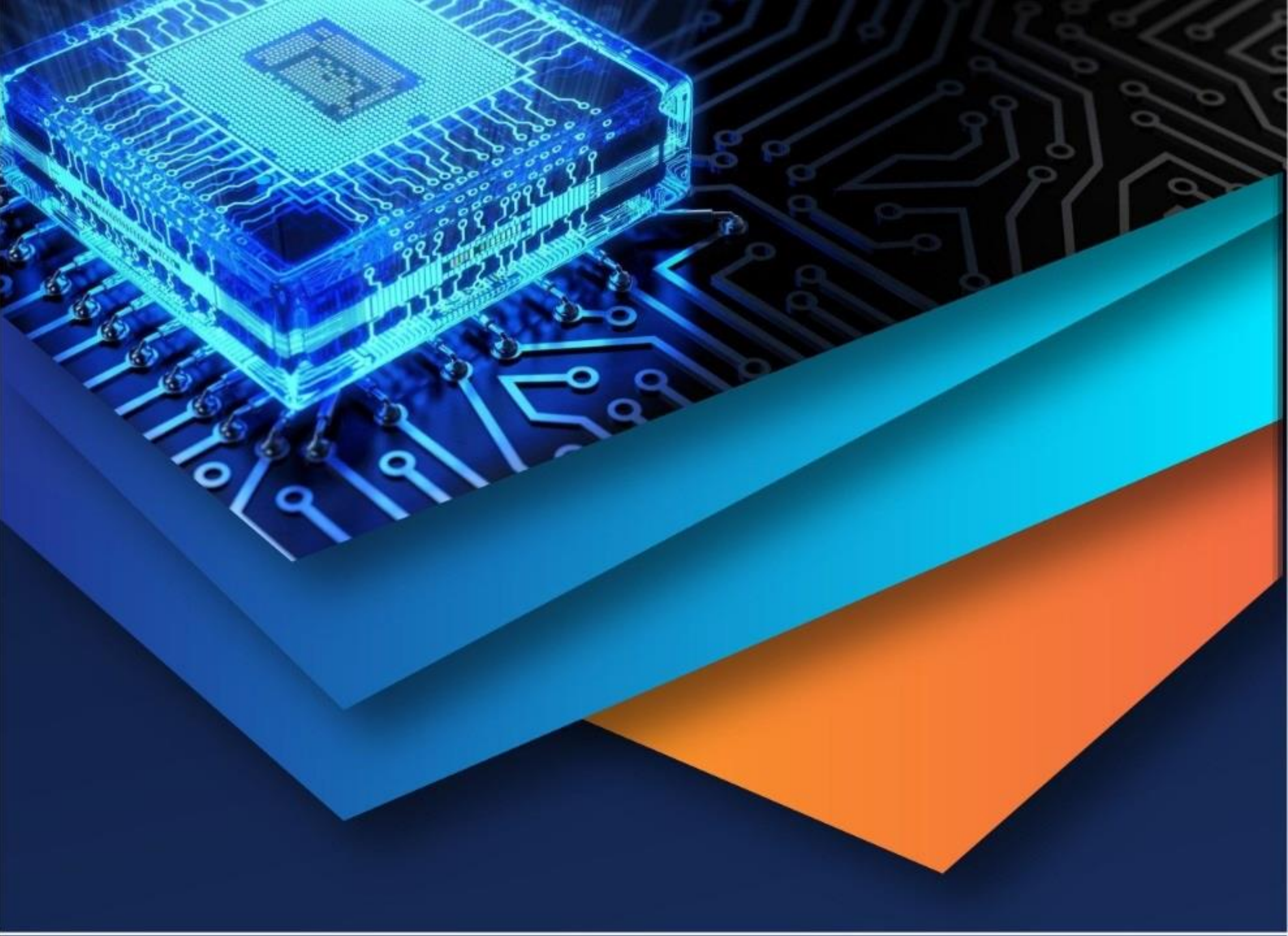

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