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Power Economic Dispatch of Thermal Power Plant Using Classical Traditional Method

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Abstract- Scarcity of Energy resources, increasing power generation cost and ever-growing demand of electric energy necessitates optimal economic dispatch in today‘s power systems. The major issue in power system is power economic dispatch (PED) problem. Mainly it is an optimization problem and to reduce total generation cost of units is its main objective, while satisfying constraints. Economic dispatch is the short-term determination of the optimal output of a number of electricity generation facilities, to meet the system load, at the lowest possible cost, subject to transmission and operational constraints. This paper presents an application of the GAMS Method to power economic dispatch (PED) problem with Power loss for 3 & 6 generator test case systems. To power economic dispatch problems are applied and compared its solution quality and computation efficiency to GAMS Method and other optimization techniques Lambda Iteration Method. The simulation results show that the proposed GAMS Method outperforms previous optimization methods.
Keywords: Power Economic Dispatch, Lambda Iteration Method, Power Loss, GAMS

I. INTRODUCTION

Economic load dispatch is one of the key functions of modern energy management system. The economic load dispatch (ELD) problem is one of the non-linear optimization problems in electrical power systems in which the main objective is to reduce the total power generation cost, while satisfying various equality and inequality constraints. The ELD seeks the best ‘generation schedules for the generate plants to supply the essential the total coupled power demand plus transmission losses at least production cost. Economic load dispatch (ELD) is the online dispatch which is used for the distribution of load among the generating units. One of the substantial operating tasks in power system is to reduce the total generation cost. The fundamental issue in modern power system operation is the ED. It is a crucial optimization problem and its main objective is to divide the required power demand among online generators The cost of power generation, particularly in fossil fuel plants, is very high and ELD helps in economy a considerable amount of profits. The Economic load dispatch is the name given to the process of apportioning the total load on a system between the various generating plants to achieve the greatest economy of operation .economic operation is very important for a power system to return a profit on the capital invested. Various investigation on ELD have been undertaken until date, as better clarification would result in major economical profit. Earlier, a number of derivatives–based approach like lambda iteration, based point input factor, gradient method and include lagrangian multiplier method have been apply to solve ELD problems There methods involve that incremental cost curves through quadratic or piecewise monotonically increasing in nature [1][2].

A various investigation has been done in this area to improve solution quality, as better solution would result in significant economical benefits. The classic problem is the economic load dispatch of generating systems to achieve minimum operating cost. For the purpose of optimum economic operation of this large scale system, modern system theory and optimization techniques are being applied with the expectation of considerable cost savings. In the past decade, a soft computing technique known as evolutionary programming [3], Genetic algorithms [4], DE [5], BBO [6-7], ABC [8] ,PSO [9-10] etc and in Literature Survey.

In this paper the used traditional classical techniques of GAMS for power economic dispatch. It requires less computation time and memory and the results are compared with the lambda method.

II. LITERATURE SURVEY

N. V. Subba Rao1, G. Kesava Rao2, S. Sivanagaraju3 [11] presented Transmission Loss allocation with Optimal Power Flow using Gravitational Search Algorithm, In deregulated power systems, the transmission loss allocation plays a key role in planning and designing of the power system. In practice, these losses should be allocated to both generators and loads depending on the amount of contribution in the total power system losses. In this paper, a new methodology to optimally allocate the transmission losses to either generators or loads based on the power flow tracing methodology is presented. In this methodology, trace usage coefficients

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are formulated to allocate transmission losses. In real time, system operator tries to minimize the transmission losses to increase the security of the system. In this paper, for the sack of analysis, the formulated OPF problem with transmission losses as objective is solved while satisfying system constraints using gravitational search algorithm. The minimized transmission losses are then allocated to either generators or loads.

Devendra Bisen [12] discusses on Dynamic Economic Load Dispatch with Emission and Loss using GAMS, Dynamic economic dispatch (DED) is a real time problem of electric power system. DED intends to schedule the online generators outputs with the predicted load demands over a certain period of time in order to operate an electric power system most economically within its security limits. This paper introduces a solution of the dynamic economic dispatch (DED) problem including the loss and emission is participated among all generating units over time interval for a system using General Algebraic Modeling System (GAMS). The objective of the collective problem can be expressed by taking the production cost including emission and losses into account with required constraints for 24 hour time interval of each generating unit. The general algebraic modeling system (GAMS) technique is guarantees the global optimality of the solution due to its look-further on capability. To validate practicability and robustness of the GAMS, it is tested on six generating unit system with different cases for determine minimum production cost of individual generating unit over a time period.

Soodabeh Soleymani, Mahdi Hayatdavudi [13] discuss Solving Economic Load Dispatch Using A Novel Method Based On PSO Algorithm And GAMS Software, Economic load dispatch (ELD) problem between power plant units is formulated as a nonlinear optimization with continuous variables. The main target in this problem is optimum planning in power plant units with minimum cost while equal and non-equal constraints consisting load request and unit production capacity are followed. In this paper an effective method based on particle swarm algorithm optimization for solving economic load dispatch optimization problem is presented which has a high ability to give optimum response in a proper time. GAMS software is used for this comparison.

Susheel Kumar Dewangan1, Achala Jain2, Dr. A.P. Huddar3 [20] presented A Traditional Approach to Solve Economic Load Dispatch Problem Considering the Generator Constraints, Economic load dispatch (ELD) problem is very important part of the power system. The purpose of economic dispatch is to determine the generation of different units in a plant such that the total fuel cost is minimum and at the same time the total demand and losses at any instant must be equal to the total generation. Many traditional methods such as lambda iteration, gradient method, Newton's method etc. are applied to determine the optimal combination of power output of all generating units so as to meet the desired demand without violation of generator constraint.

III. GENERATOR OPERATING COST

The total cost of operation includes the fuel cost, cost of labour, supplies and maintenance. Generally, cost of labour, supplies maintenance is fixed percentage of including fuel cost. The power output of fossil plant is increased sequentially by opening a set of valves to its steam turbine at the inlet. The throttling losses are large when a valve is just opened and small when it is fully opened.

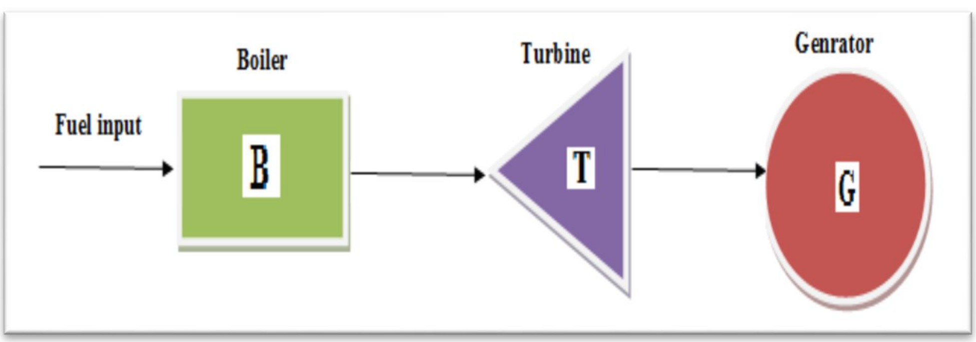

Fig1 model of a thermal plant

Fig1 show the simple model of a fossil plant dispatching purposes. The cost is usually approximated by one or more quadratic segments. The operating cost of the plant has the from shown in Fig 2 for dispatching purposes, this cost is usually approximated by one or more quadratic segments. So, the fuel cost curve in the active power generation, takes up a quadratic form. Given as:

$$F_T = \sum_{i=1}^{n} F_i(P_i) = \sum_{i=1}^{n}(a_i P_i^2 + b_i P_i + c_i) \qquad 1$$

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Where

a_i, b_i, c_i are cost coefficients for i[th] unit

$F(P_i)$ is the total cost of generation

P_i is the generation of i[th] plant

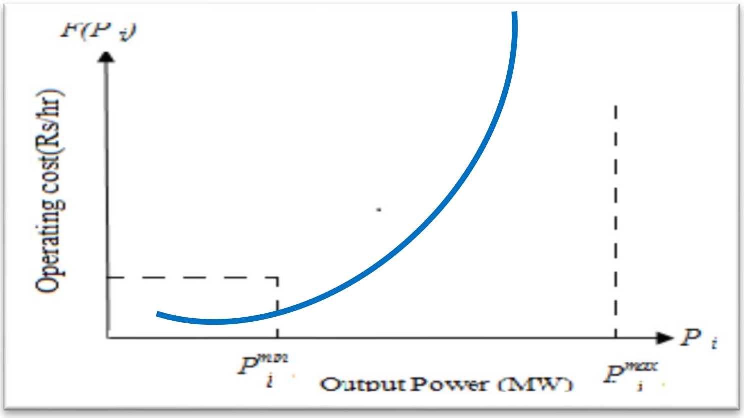

Fig 2 Operating cost of fossil fuel fired generator

The fuel cost curve may have a number of discontinuities. The discontinuities occur when the output power is extend by using additional boilers, steam condensers, or other equipment. They may also appear if the cost represents the operation of an entire power station, and hence cost has discontinuities on paralleling of generator. Within the continuity range the incremental fuel cost may be expressed by a number of short line segments or piece-wise linearization.

The P_i^{min} is the minimum loading limit below which, operating the unit proves to be uneconomical (or may be technically infeasible) and P_i^{max} is the maximum output limit [14]

IV. MATHEMATICAL FORMULATION OF POWER ECONOMIC DISPATCH

The objective of an ELD problem is to find the optimal combination of power generations that minimizes the total generation cost while satisfying equality and inequality constraints. The fuel cost curve for any unit is assumed to be approximated by segments of quadratic functions of the active power output of the generator. For a given power system network, the problem may be described as optimization (minimization) of total fuel cost as defined by (2) under a set of operating constraints [16].

$$F_T = \sum_{i=1}^{n} F_i(P_i) \tag{2}$$

Where F_T is total fuel cost of generation in the system ($/hr),

$$F_i(P_i) = \sum_{i=1}^{n} (a_i P_i^2 + b_i P_i + c_i) \tag{3}$$

Where F_i is the total fuel cost for the i^{th} generator (in $/h) which is defined by, a_i, b_i, and c_i are the cost coefficient of the i^{th} generator,P_i is the power generated by the i^{th} unit and n is the number of generators.

The total generation cost is minimized subjected to the following constraints:

Power balance constraint,

$$P_{i,min} \le P_i \le P_{i,max} \; for \; i = 1,2,\dots,n \tag{4}$$

Generation capacity constraint,

$$P_d = \sum_{i=1}^{n} P_i - P_{loss} \tag{5}$$

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Where P_i, min and P_i, max are the minimum and maximum power output of the i^{th} unit, respectively. P_d is the total load demand and P_{Loss} is total transmission losses. The transmission losses PLoss can be calculated by using B matrix technique and is defined by as,

$$P_{loss} = \sum_{i=1}^{n} \sum_{j=1}^{n} P_i B_{ij} P_j \quad (6)$$

Where B_{ij} „s are the elements of loss coefficient matrix **B** (Transmission losses**).**

V. PROPOSED GENERAL ALGEBRAIC MODELING SYSTEM (GAMS)

The General Algebraic Modeling System (GAMS) is specifically designed for modeling linear, nonlinear and mixed integer optimization problems. The system is particularly very advantageous with large, complex problems. GAMS module allows the user to concentrate on the modeling problem by making the setup simple. GAMS are especially useful for handling large, complex, one-of-a-kind problems which may require many revisions to establish an accurate model. The user can change the formulation quickly and easily, and can even change from one solver to another [17-18].

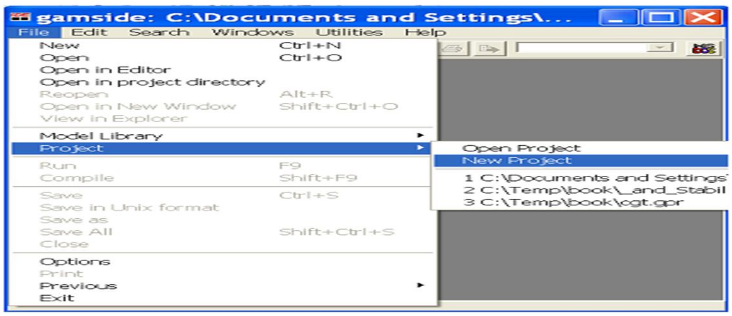

Fig 3 min window of General Algebraic Modeling System

Show Fig 3 min window of General Algebraic Modeling System. There are Six Types Model Libraries Used In GAMS, Model Library, GAMS Test Library, GAMS Data Utilities, EMP Library, API Library and Practical Financial Option Model.

VI. THE STRUCTURE OF GAMS PROGRAMMING

The basic structure of a mathematical model coded in GAMS has the components: sets, data, variable, equation, model and output show in given Fig.4. In general, any optimization problem can be formulated using these components. The data presentation in GAMS can be done in its most elemental form using tables, columns etc 19].

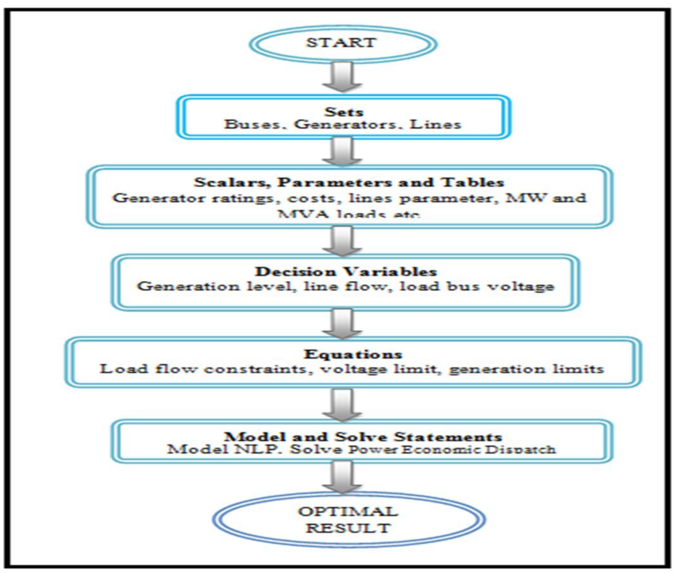

Fig 4 the structure of GAMS programming

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VII. RESULTS ANALYSIS WITH CASE STUDY

Test Case (A) Comparative case study 3 units

Table 1 and table 2 are provides a comparison of Power economic load dispatch results classical GAMS and Lambda Iteration Method for a 3 unit thermal system without loss and with loss. In this case study different load **120 MW, 150 MW and 170 MW**, these results show improvement in the solution of the problem while satisfying all the constraints. It can be seen that classical GAMS is computationally quite efficient to compare with Lambda methods with both the case without loss and with loss. Hence, the proposed method improves the results.

Table 1 Results of Three Unit System (Without Loss)

Classical methods	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method
Pg1 MW	22.0625	**22.042**	31.9375	**31.937**	38.5625	**38.534**
Pg2 MW	58.5	**58.482**	67.2778	**67.277**	73.1667	**73.141**
Pg3 MW	39.5	**39.476**	50.7857	**50.785**	58.3571	**58.325**
Power load MW	120	**120**	150	**150**	170	**170**
Thermal power plant Fuel Cost ($/hr)	1357.2	**1356.744**	1579.71	**1579.699**	1731.63	**1730.974**

Table 2: Results of Three Unit System (With Loss)

Classical methods	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method
Pg1 MW	22.9577	**22.050**	32.8204	**31.945**	39.4269	**38.541**
Pg2 MW	55.7822	**58.451**	64.6008	**67.247**	70.5116	**73.111**
Pg3 MW	42.8176	**39.514**	54.9443	**50.832**	63.0889	**58.377**
Power load MW	120	**120**	150	**150**	170	**170**
Power loss	1.52698	**0.015**	2.34274	**0.023**	2.99255	**0.029**
Thermal power plant Fuel Cost ($/hr)	1368.35	**1356.857**	1597.66	**1579.873**	1754.26	**1731.199**

Test Case (B) Comparative case study 6 units

Table 3 and table 4 are provides a comparison of Power economic load dispatch results classical GAMS and Lambda Iteration Method for a 3 unit thermal system without loss and with loss. In this case study different load **600 MW, 800 MW, 1000MW, 1263 MW and 1450 MW**, these results show improvement in the solution of the problem while satisfying all the constraints. It can be seen that classical GAMS is computationally quite efficient to compare with Lambda methods with both the case without loss and with loss. Hence, the proposed method improves the results.

Table 3 Results of 6 Unit Systems (Without Loss)

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Classical methods	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method
Pg1 MW	271.879	**271.875**	342.221	**342.215**	391.664	**391.659**	446.707	**446.707**	485.664	**485.668**
Pg2 MW	50	**50.000**	94.2684	**94.264**	130.7	**130.696**	171.258	**171.258**	199.963	**199.966**
Pg3 MW	128.128	**128.125**	182.839	**182.834**	221.294	**221.291**	264.106	**264.106**	294.406	**294.409**
Pg4 MW	50	**50.000**	50	**50.000**	82.4056	**82.402**	125.217	**125.217**	150	**150.000**
Pg5 MW	50	**50.000**	80.6937	**80.688**	123.956	**123.952**	172.119	**172.119**	200	**200.000**
Pg6 MW	50	**50.000**	50	**50.000**	50	**50.000**	83.5933	**83.593**	119.953	**119.957**
Power load MW	600	**600**	800	**800**	1000	**1000**	1263	**1263**	1450	**1450**
Thermal power plant Fuel Cost ($/hr)	7187.41	**7187.344**	9458.09	**9457.827**	11887.30	**11887.017**	15275.99	**15275.930**	17802.96	**17802.793**

Table 4: Results of 6 Unit Systems (With Loss**)**

Classical methods	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration[20]	GAMS method	Lambda Iteration [20]	GAMS method
Pg1 MW	273.436	**271.890**	341.757	**341.730**	391.011	**391.654**	447.122	**446.713**	496.776	**485.732**
Pg2 MW	50.000	**50.000**	95.2846	**95.265**	131.737	**130.707**	173.22	**171.279**	200	**200.000**
Pg3 MW	129.552	**128.139**	182.325	**182.306**	220.404	**221.282**	263.962	**264.105**	300	**294.454**
Pg4 MW	50.000	**50.000**	53.5857	**53.565**	93.3534	**82.514**	139.093	**125.358**	150	**150.000**
Pg5 MW	50.000	**50.000**	82.5827	**82.562**	121.621	**123.924**	165.617	**172.040**	200	**200.000**
Pg6 MW	50.000	**50.000**	50	**50.000**	50	**50.000**	86.6583	**83.630**	120	**119.977**
Power load MW	600	**600**	800	**800**	1000	**1000**	1000	**1263**	1450	**1450**
Power loss	2.98958	**0.030**	5.43591	**5.428**	8.0945	**0.081**	12.4204	**0.125**	16.7313	**0.163**
Thermal power plant Fuel Cost ($/hr)	7220.73	**7187.663**	9523.64	**9522.377**	11989.60	**11888.033**	15446.1	**15277.585**	18035.4	**17805.050**

VII. CONCLUSION

Power Economic dispatch problem being attempted using classical GAMS method for 3 and 6 generator test system evaluates the performance of the proposed approach. The solution results are high accuracy and fast computational time. Therefore, this results shows that proposed GAMS optimization is a promising technique for solving complicated problems in power system.

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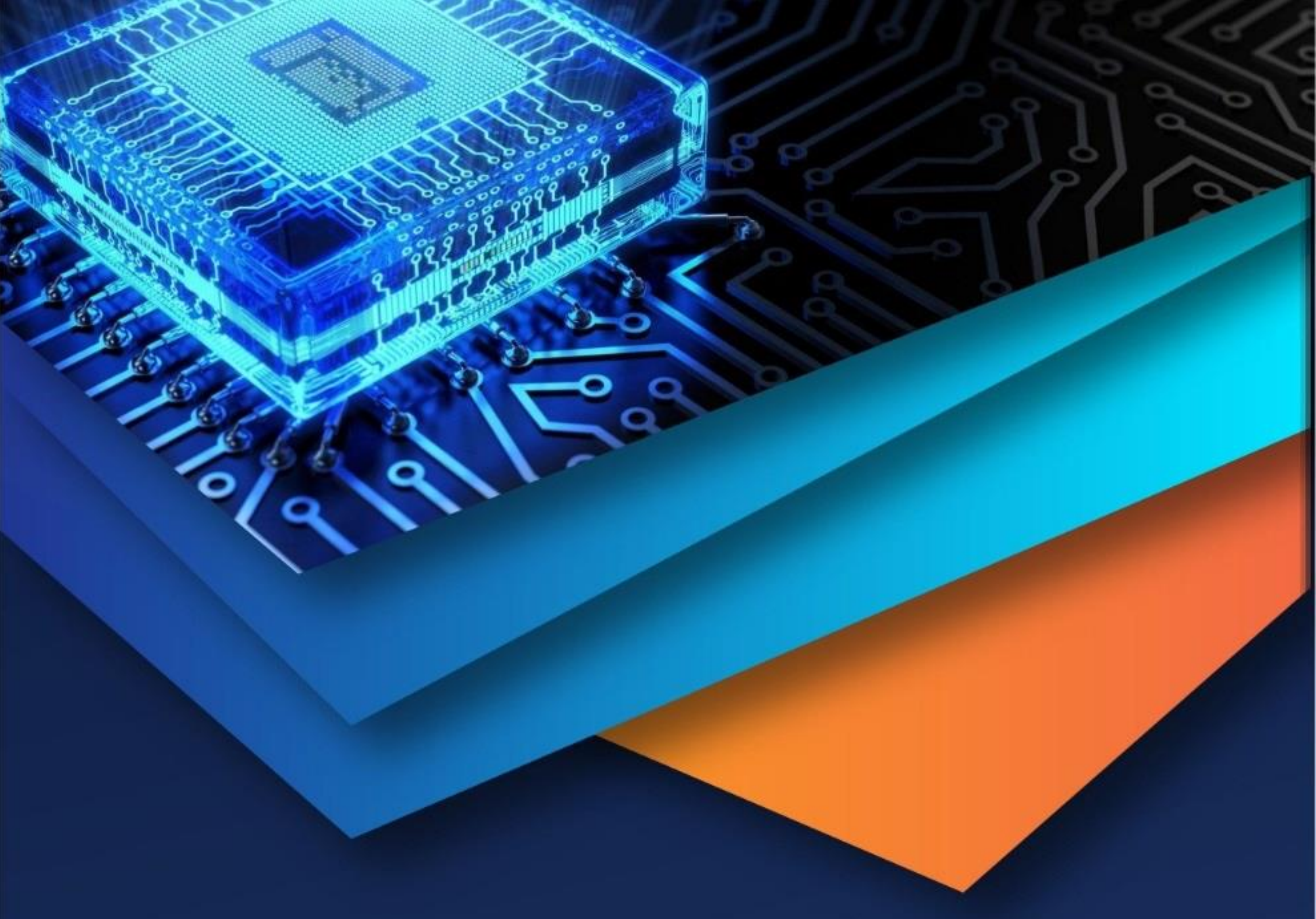

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