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Methodology for Assessment of Congestion Problem

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Abstract:** Due to increasing in load demand, blackout or unexpected failure in any component of power system including generator, transformer, transmission lines, lead to congestion and over loading in power system this leads the power system to reach on its verse of emergency state ,therefore there should be a proper management or control action for that condition. Several methods are there to control congestion management including Generator Rescheduling (GR),Nodal Pricing, Particle Swarm Optimizer(PSO),Genetic Algorithm (GA) ,Grey Wolf Optimizer (GWO),This paper presents proper congestion management based on Grey Wolf Optimizer (GWO) for reducing load shedding, improve voltage profile, voltage stability, active power loss, this shows optimal load shedding is effective control action for congestion management. The algorithm applied on IEEE 30 bus system considering (n-1) contingency.
***Keywords:** Congestion Management, Grey Wolf Optimizer, Contingency analysis, Optimal load shedding*

I. INTRODUCTION

The power industry in many countries is renewing and restructuring with replacement of old monolithic regulated public utilities with competitive markets [1]. In order to meet the increasing load demands around the world at affordable prices.This is the major reason of congestion in transmission lines of deregulated power systems [2] .

Congestion management techniques needed to performed immediately so congested system relieved .

There are many reasons in the technical literature for power system congestion that why congestion occurs in competitive market the congestion occurs in the system when the load demand increases beyond limit and the system unable to accommodate all required transaction due to violation of system operating limits [3] . congestion occurs when the power flow in the lines higher than the follow allowed by operating limits [4] congestion occurs due to overloading transmission lines thermal bound and line capacities violated [5]. Physical parameters are also responsible for the congestion in the power system such as limitation of temperature, thermal limitation, voltage limitation in the node, voltage instability ,dynamic stability ,transient stability are some examples of limitation of physical system in congestion. Congestion occurs because of mismatching of generating and transmission services.It also cause due to unexpected events such as sudden rise in load demand ,generator outage, short circuit of circuit breaker or any equipment failure[7] Congestion in power system should be rectified soon in order to maintain power supply

Congestion also occurs due to regular damage of power system equipment this leads to system disturbance and further causes the outage in interconnected system it also effects the power system quality to prevent in reduction of quality of power system the congestion system need to be corrected immediately [8]. Congestion management is the best method to restore the system into equilibrium state, it provides (1) improved efficiency of power system (2) reliable and secure operation of power system (3) effective power flow management (4) improve stability of system. There are various method of congestion management of power system like optimal load shedding ,generation rescheduling, reactive power supply etc. Optimal load shedding is one of the best method mentioned above ,in this method the the total amount of load required is reduced in order to maintain system stability it help in preventing blackout, voltage collapse, voltage instability. FACTS devices are also used to regulated and maintain the voltage supply during congestion. Elimination and management of congestion in transmission lines by generation rescheduling or load shedding is determined by particle swarm optimization(PSO).congestion management by load shedding include thyristor controlled phase shifting transformer and thyristor controlled series compensator to prevent overloading and voltage instability in the system[9].improve harmony search algorithm used to maintain steady state voltage stability it also improves active power loss, instability, voltage collapse. This paper represents the Grey Wolf Optimizer technique for optimal load shedding for multiple and single objective function. This method is population based meta heuristics algorithm inspired from social headship and hunting approach of grey wolf .by following these approaches (1) reducing the value of load shedding (2) voltage deviation and improved voltage stability (3) reducing value of load shedding and power loss. Contingency analysis is done by using (n-1) .only one line is tripped and is selected by severity index and this shows the overloading of transmission lines. if the value of index is smaller the line are in working range otherwise it violates the rule [10]

II. CONTINGENCY ANALYSIS

Power system safety and security refers to capability of system to work within the safe limits when it follow all the rules and remain secure the system is not congested but when the defined limits of any power system violates the system enters into the emergency state and contingency state arises. It can be divided into two types [11]

A. Outage of power

1) Loss of generation

2) Generation loss

3) Load variation

B. Outage of grid

1) Blackout of transformer

2) Blackout of transmission line

3) Blackout of generator

This paper present single line contingency (n-1) outage of line .the emergency or contingency state represents by severity index [12]

$$Min\ S_L = p_2 \sum_{m=1}^{Nl} \left(\frac{SLm}{S_{Lm}^{max}}\right)^2 \quad (1)$$

p_2 =is weight factor

III. MATHEMATICAL FORMULATION

A. Objective Functions

1) Single Objective

Case 1 : Reducing the load shedding value

The load shedding is applied by squaring the difference value between active and reactive power that is nominal load and supplied demand, shows by equation as,[13]

$$\text{Min } F_1 = [\ \sum_{i=1}^{nb} \alpha i\, |P_{di} - P_{di}^{s}|^2 + \sum_{i=1}^{nb} \beta i\, |Q_{di} - Q_{di}^{s}|^2 \quad (2)$$

Where,nb= number of buses

P_{di}, Q_{di} active and reactive power for nominal load

P_{di}^{s} Q_{di}^{s} active and reactive power of supplied load

α , β Weighting factors

2) Multi-objective

Case 2: reducing the load shedding and voltage deviation with improve voltage stability

We guess the voltage stability index for finding the operating point of power system ,which causes voltage collapse.various other methods are used for finding voltage stability ,this is based on load flow analysis value ranging from 0(no loading) to 1(voltage collapse) condition it shows as L-index Lj of bus jth is calculated as [15]

The relation between current and voltage shown as $I_{bus} = Y_{bus} \times V_{bus}$ (3)

With separation of generator bus(PV) and load bus (PQ) it shows as

$$\begin{matrix} Ig \\ Il \end{matrix} = \begin{matrix} Ygg & Ygl \\ Ylg & Yll \end{matrix} \quad \begin{matrix} Ig \\ Il \end{matrix} \quad (4)$$

Where Ig, I_l and Vg ,V_l shows current and voltages at generator and load buses.

$$F_{lg} = -[Y_{ll}]^{-1} \times [Y_{lg}] \quad (5)$$

The L-index of jth node shows as : Lj

$$L_j = |\ 1- \sum_{i=1}^{Ng} Fij \frac{Vi}{Vj}\ | \quad j=1,2,3.........Nl \quad (6)$$

L-index is found for all PQ buses.The maximum value of L-index (Lmax) is shown as ,

$$L_{max} = (\ max\ (L_j)\ ) \quad j= 1,2,3.......Nl \quad (7)$$

$$\text{Min } F_2 = [\ \sum_{i=1}^{nb} \alpha i\, |P_{di} - P_{di}^{s}|^2 + \sum_{i=1}^{nb} \beta i\, |Q_{di} - Q_{di}^{s}|^2 + p_1 L_{max} + p_2 \sum_{i=1}^{NPQ} |V_i - Vref|] \quad (8)$$

Case 3: reducing the load shedding with reducing power loss and with improving voltage stability. The active power loss is calculated by

$$F = \min \sum_{k=1}^{NTL} gk V_i^2 + Vj^2 - 2\, Vi\, Vj \cos \alpha ij\,)] \qquad (9)$$

g_k = conductance of kth branch connected between ith and jth buses.In this case three objective function are calculated as ,

$$\text{Min } F_3 = [\, \sum_{i=1}^{nb} \alpha i \mid P_{di} - P_{di}^{s}|^2 + \sum_{i=1}^{nb} \beta i \mid Q_{di} - Q_{di}^{s}|^2] + p_1 L_{max} + P_{loss} \qquad (10)$$

B. Operating Constraints for Power System

1) Equality Constraints

The equality constraints represented as :

$$P_{Gi} - P_{Di} = |V_i| \sum_{j=1}^{NB} Vj (G_{ij} \cos\delta ij + Bij \sin\delta ij) \qquad (11)$$

$$Q_{Gi} - Q_{Di} = |Vj| \sum_{j=1}^{NB} Vj (G_{ij} \sin\delta ij - Bij \cos\delta ij) \qquad (12)$$

C.Inequality constraints

The inequality constraints contains:

a) Generators Constraints

$$V_{Gi}^{min} \leqslant V_{Gi} \leqslant V_{Gi}^{max} \qquad i= 1,2,3\ldots\ldots\ldots NG \qquad (13)$$

$$Q_{Gi}^{min} \leqslant Q_{Gi} \leqslant Q_{Gi}^{max} \qquad i= 1,2,3\ldots\ldots\ldots NG \qquad (14)$$

$$P_{Gi}^{min} \leqslant P_{Gi} \leqslant P_{Gi}^{max} \qquad i= 1,2,3\ldots\ldots\ldots NG \qquad (15)$$

b) Security constraints

$$S_{Li} \leqslant S_{Li}^{min} \qquad i=1,2,3\ldots\ldots\ldots NTL \qquad (16)$$

c) Transformer constraints

$$Ti^{min} \leqslant T_{Gi} \leqslant Ti^{max} \qquad i= 1,2,3\ldots\ldots\ldots NT \qquad (17)$$

d) Shunt VAR compensator constraints

$$Qci^{min} \leqslant Q_{Ci} \leqslant Qci^{max} \qquad i= 1,2,3\ldots\ldots\ldots NT \qquad (18)$$

IV. GREY WOLF OPTIMIZER

Grey wolf optimization technique is based on hunting procedure and leadership ranking system of grey wolves[16].the grey wolves living in four clumps and each clump having 5 to 12 wolves. The social ranking is made up of four types first named as alpha the leader of the group responsible for taking all the important decision for the group such as hunting,sleeping,walking. The second named beta who is the counselor for alpha and helping him in taking decisions and activities and the third one is delta who controls omega and give information to alpha and beta. The lowest one is omega. The GWO algorithm can be as follows[17]

A. Encircling the Prey

$$D = |\, c\, x_p(t) - x(t)\, | \qquad (19)$$

$$x(+1) = X_{xp}(t) - A.D \qquad (20)$$

Here ,t = current iteration x_p is the placement vector for prey ,and x= placement vector of grey wolf. A and C are the coefficient vector calculated as follows:

$$A= 2a_{n1} - a \qquad (21)$$

$$C = 2n_2 \qquad (22)$$

Here a = value decreased from 2 to 0 with iteration n_1 and n_2 are random numbers having range of [0,1]

B. Hunting

In this procedure the grey wolves notice the placement of prey .the above three solutions are best solutions (α, β and δ) and other providing the locations of prey expressed as :

$$D\alpha = |\, C_1 x\alpha - x| \qquad (23)$$

$$D\beta = |\, C_2 x\beta - x| \qquad (24)$$

$$D\delta = |\, C_3 x\delta - x| \qquad (25)$$

$$x_1 = x\alpha - A(D\alpha) \qquad (26)$$

$$x_2 = x\beta - A(D\beta) \qquad (27)$$

$$x_3 = x\delta - A(D\delta) \qquad (28)$$

$$X(t+1) = (x_1 + x_2 + x_3) / 3 \qquad (29)$$

C. Attacking

The grey wolves attack when prey became stationary it can be obtained by decreasing the value of a from 2 to 0 , A varies randomly with variation of a having range [-1,1],when |A|<1,the wolves attack the prey

D. Searching

The searching of the prey depends on the position of alpha,beta,and delta. The wolves apart from each other in search of prey and again recollected to attack on it,when |A|>1 ,called global search means the wolves search the better prey

The GWO for the best solution can be as follows

1) Finalize the upper and lower control variables for the system.
2) Start the maximum number of iteration and umber of search agents(N)
3) "Start the population according to"

$$X_n = x_n^{min} + rand(0,1)(x_n^{max} - x_n^{min})$$

4) Calculate the fitness function for each of the agent
5) Select

   X - finest search agent

   X - is the second finest search agent

   X - is the third finest search agent

6) Set the position of each search agent according to the equation (23) to (28)and find fitness function for new set positions
7) Modernize the a,A,C parameter according to equation (23) to (29)
8) Iterate the steps from 5 to 7 till the maximum iteration.
9) Stop.

V. RESULT AND DISCUSSION

The maximum load shedding is 20% of the total connected load at each bus. The maximum iterations = 500, no.of agents = 50. The bus system IEEE 30 used in this algorithm. The qualities of system are given in the table 1 .

Table 1.Characteristics of IEEE 30-BUS Test System

Characteristics	Value	Details
Buses	30	
Branches	41	
Generators	6	Buses (1,2,5,8,11,13)
Tap transformer	4	Branches (6-9,6-10,4-12,27-28)
VAR compensation	9	Buses (10,12,15,17,20,21,23,24,29)
Voltage limit		(0.95-1.1)
Connected load		283.4 MW,126.2MVAR

A. Normal State

Case 1: reducing amount of load shedding

Table 2 presents active and reactive power of loads

Table 3 presents active and reactive power generation

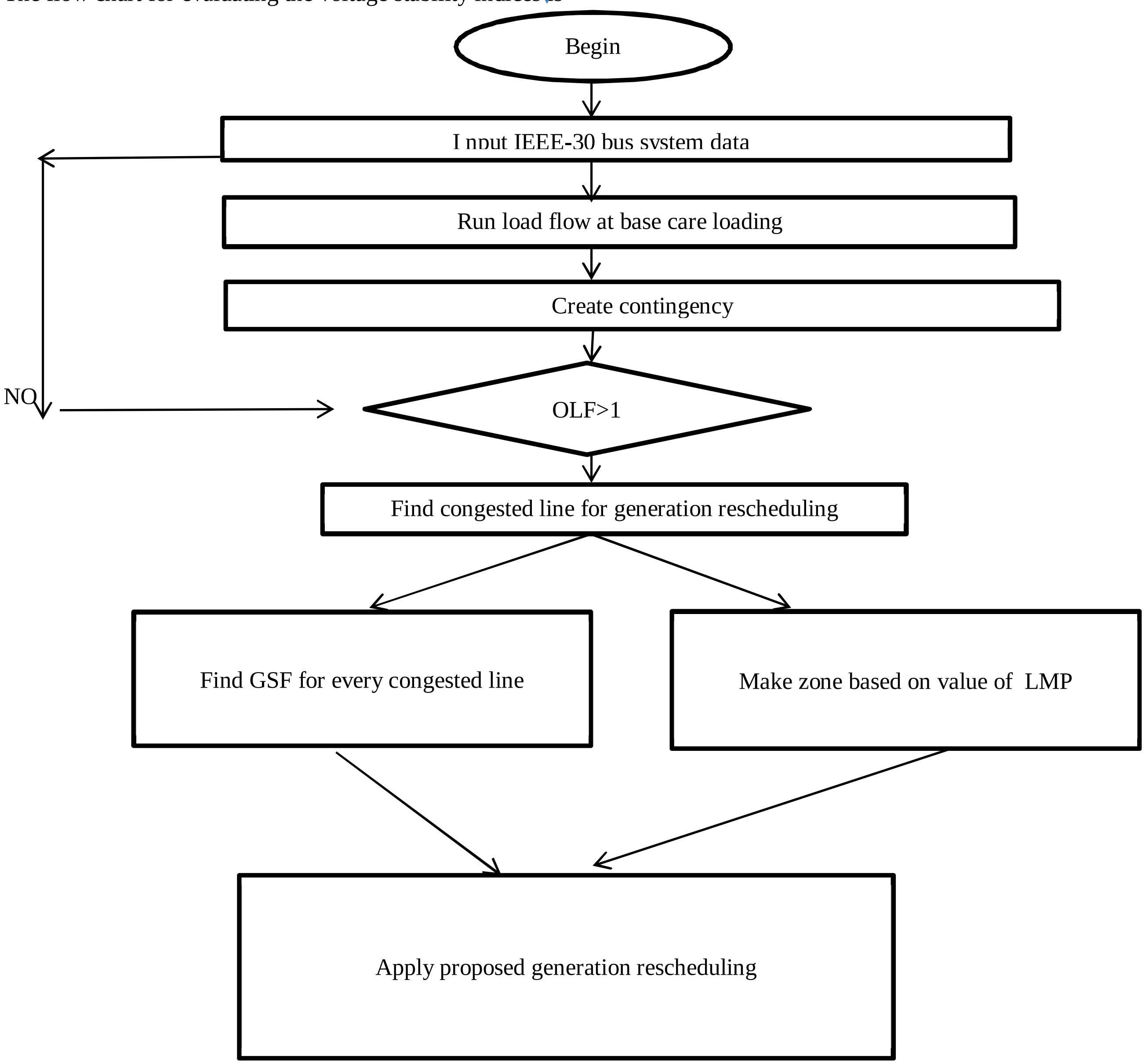
Table 4 presents maximum values of different objective functions.The least value of load shedding 1.718 MW which is lesser than obtained in case 2 and case 3(3.331 MW, 5.7373). The voltage deviation is 0.2856 p.u and voltage stability index is 0.1331 p.u and power loss is 8.0927 MW and generator cost is 817.0292 $/h .Fig1shows normal condition the convergence curve .

Case 2: reduction of load shedding ,voltage deviation and improve voltage stability
The three objective functions taken ,the voltage profile improvement achieved by decreasing the voltage deviation of load bus voltage from unity.The voltage deviation is 0.4538 p.u,voltage stability index is 0.1356 ,amount of load shedding is 848.5081 $/h.Fig 2 show convergence curve under normal condition under case 2.

Case 3: reducing load shedding and power loss with improved voltage stability. The active power loss is reduced from 4.1479 MW compared to case 1,case 2 (8.0927 MW,7.0236 MW)and voltage stability is 0.1192 p.u which is lesser than obtained results in case 1,case 2 (0.1331 p.u,0.1356 p.u)and voltage deviation is 1.5186 p.u and generation cost is 899.926 $/h.Fig 3 shows the convergence curve for case 3 under normal condition.

B. *Methodology for Assessment of Congestion Problem-*

In this chapter, the algorithm and for assessment of congestion problem and control is presented. To calculate the value of overload factor (OLF) for analysing the congested transmission lines and then perform the control actions for optimum quantity of generation rescheduling for the system.
The flow chart for evaluating the voltage stability indices is



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VI. CONCLUSION

This paper presents method for eliminating by optimal load shedding by GREY WOLF OPTIMIZATION(GWO) technique to maintain power system in stable, secure, and reliable state. Exact prediction against overloading is done by

Severity index .Single line contingency can be obtained by tripping one line and this line is selected based on severity index. single and muti valued functions have been performed in this paper by using standard IEEE30 bus system. investigating by using grey wolf optimization it shows efficiency of optimization by reducing value of load shedding, by reducing active and reactive power losses, by reducing voltage deviation enhance voltage stability and make system more stable.

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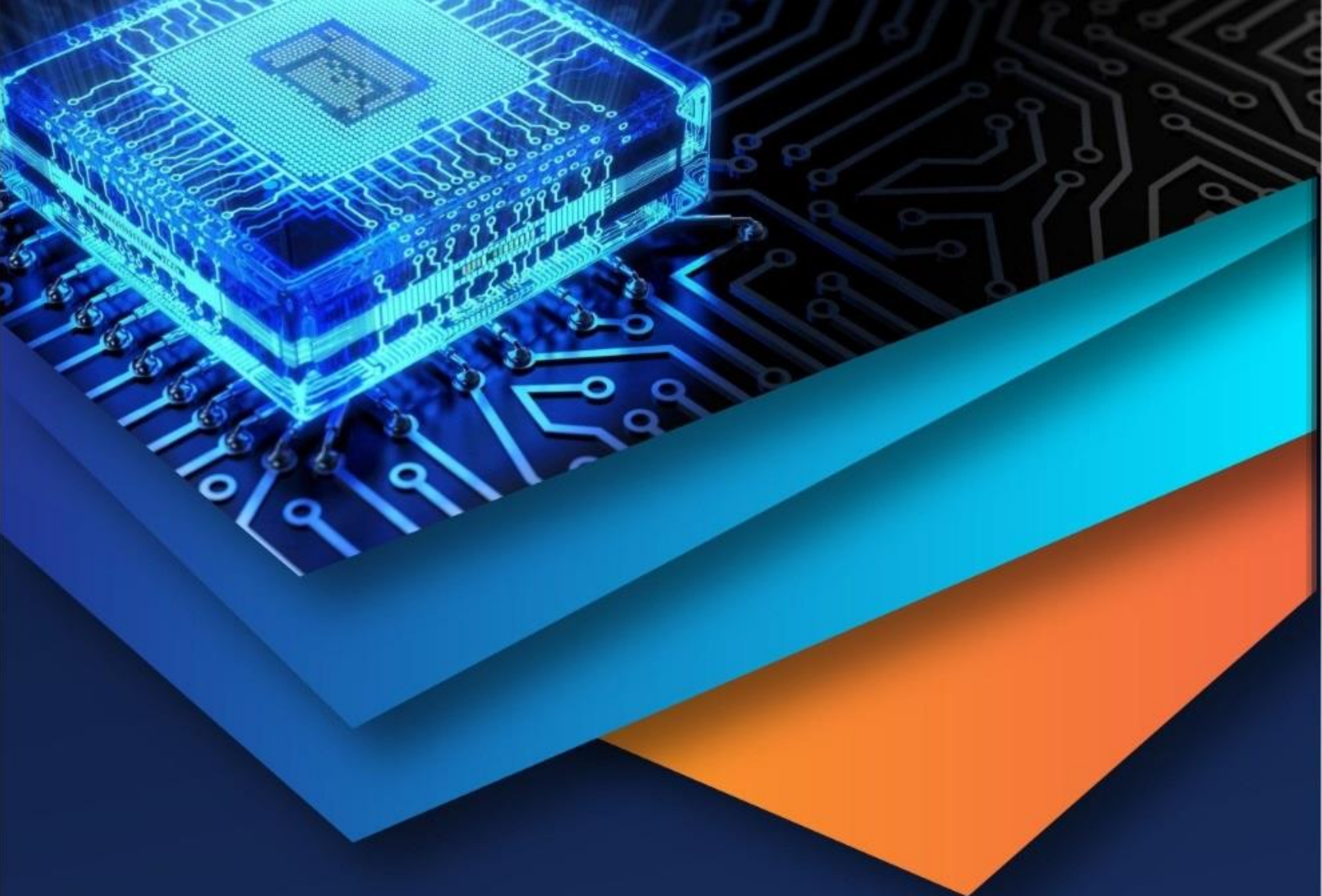

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